AEROSPACE ENGINEERING

LIST OF NEW COURSES

Sl. No.	Course Code	Course Title	Credits			
			L	T	P	C
1	21AE2001	Aircraft Engine Maintenance	3	0	0	3
2	21AE2002	Atomization and Sprays	3	0	0	3
3	21AE3006	Advanced Propulsion Technology	3	0	0	3
4	21AE3007	Modeling and Simulation of Aerospace Vehicles	3	0	0	3
5	21AE3008	Advanced Propulsion Laboratory	0	0	2	1
6	21AE3009	Advanced Avionics	3	0	0	3
7	21AE3010	Advanced Aircraft Materials	0	0	2	3
8	21AE3013	Data Analytics and Visualization	3	0	0	3
9	21AE3014	Artificial Intelligence and Machine Learning in Aerospace Applications	3	0	0	3
10	21AE3015	Digital Manufacturing Laboratory	0	0	2	1
11	21AE3016	Artificial Intelligence and Machine Learning Laboratory	0	0	2	1
12	21AE3017	Avionics Laboratory	0	0	2	1
13	21AE3018	Fundamentals of Aerospace Engineering	3	0	0	3
14	21AE3021	Wind Turbine Design and Performance	3	0	0	3
15	21AE3022	Applied Mathematics For Engineers	3	0	0	3
16	21AE3023	Data Analytics and Visualization Laboratory	0	0	2	1
17	22AE2001	Basics of Fluid Mechanics	3	0	0	3
18	22AE2002	Boundary Layer Theory	3	0	0	3

Course Code	AIRCRAFT ENGINE MAINTENANCE	L	T	P	C
21AE2001		3	0	0	3

Course Objectives:

Enable the student to:

1. understand the basics of aeroncarft engine components.
2. expalain aircraft engine maintenance procedures.
3. compare the overhaul procedures of different engines.

Course Outcomes:

The student will be able to:

1. Recognize the Components and identify Maintenance needs of Piston Engines.
2. Explain the Jet Engine Components and their Maintenance procedures.
3. Identify the overhauling procedures of different aircraft Engines.
4. Illustrate various inspection procedures for jet engine maintenance.
5. Explain inspection and overhauling procedures of Gas turbine Engine.
6. Interpret and troubleshoot problems in aircraft engines.

MODULE: 1 | CLASSIFICATION OF PISTON ENGINE COMPONENTS | 8 Hours

Types of piston engines – Principles of operation – Function of components – Materials used – Details of starting the engines – Details of carburetion and injection systems for small and large engines – Ignition system components – Spark plug details – Engine operating conditions at various altitudes – Maintenance and inspection check to be carried out.

MODULE: 2 | INSPECTIONS OF PISTON ENGINES | 8 Hours

Inspection and maintenance and troubleshooting – Inspection of all engine components – Daily and routine checks – Overhaul procedures – Compression testing of cylinders – Special inspection schedules – Engine fuel, control and exhaust systems – Engine mount and super charger – Checks and inspection procedures.

MODULE: 3 | OVERHAULING OF PISTON ENGINES | 8 Hours

Symptoms of failure – Fault diagnostics – Tools and equipment requirements for various checks and alignment during overhauling –Tools for inspection – Tools for safety and for visual inspection – Methods and instruments for nondestructive testing techniques – Equipment for replacement of part and their repair. Engine testing: Engine testing procedures and schedule preparation – Online Maintenance.		
MODULE: 4	**CLASSIFICATION OF JET ENGINE COMPONENTS**	**8 Hours**
Types of jet engines – Principles of operation – Functions of components – Materials used – Details of starting and operating procedures – Gas turbine engine inspection & checks – Use of instruments for online maintenance – Special inspection procedures: Foreign Object Damage – Blade damage.		
MODULE: 5	**JET ENGINE MAINTENANCE**	**7 Hours**
Maintenance procedures of gas turbine engines – Trouble shooting and rectification procedures – Component maintenance procedures – Systems maintenance procedures. Gas turbine testing procedures – test schedule preparation – Storage of Engines –Preservation and de-preservation procedures.		
MODULE: 6	**OVERHAULING OF TURBINE ENGINES**	**6 Hours**
Engine Overhaul procedures – Inspections and cleaning of components – Repairs schedules for overhaul – Balancing of Gas turbine components. Trouble Shooting - Procedures for rectification – Condition monitoring of the engine on ground and at altitude - Ground support equipment – engine health monitoring and corrective methods.		
	Total Lectures	**45 Hours**

Text Books	
1.	Kroes, M. J., & Wild, T. W. (1995). *Aircraft powerplants (7th ed)*. McGraw Hill.
2.	Turbomeca, (1993). *Gas Turbine Engines*. The English Book Store.
Reference Books	
3.	Pratt & Whitney, (1988). *The Aircraft Gas turbine Engine and its Operation*. The English Book Store.
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course Code	**ATOMIZATION AND SPRAYS**	**L**	**T**	**P**	**C**
21AE2002		3	0	0	3

Course Objectives:

Enable the student to:

1. understand the types of atomizers, atomization process and their applications.
2. explain drop size distribution methods and performance of automizers.
3. discuss on drop evaporation, drop spray and patternation methods.

Course Outcomes:

The student will be able to:

1. understand the working principle of various types of atomizers.
2. understand the factor influencing atomization process.
3. evaluate the performance of various types of atomizers.
4. design atomizers for various applications.
5. evaluate the performance using various patternation methods.
6. analyze the evaporation constant and drop lifetime.

MODULE: 1	**INTRODUCTION TO ATOMIZATION**	**6 Hours**
Introduction to atomization, atomizers types, pressure atomizers, rotary atomizers, air-assist atomizers, airblast atomizers, factors influencing atomization, liquid properties, ambient Conditions, spray characteristicsand applications.		

MODULE: 2	PROCESS IN ATOMIZATION	8 Hours
Introduction to static drop formation, breakup of drops, drop breakup in flowing air, drop breakup in turbulent flow fields, disintegration of liquid jets, influence of jet velocity profile, stability curve, disintegration of liquid sheets, flat sheets, conical sheets, fan sheets and prompt atomization.		
MODULE: 3	**DROP SIZE DISTRIBUTION OF SPRAYS**	**8 Hours**
Introduction graphical representation of drop size distributions, mathematical distribution functions, normal distribution, log-normal distribution, log-hyperbolic distribution, empirical distribution functions, Nukiyama and Tanasawa, Rosin–Rammler, modified Rosin–Rammler upper-limit function, mean diameters, representative diameters, drop size dispersion, droplet uniformity index, relative span factor dispersion index, dispersion boundary factor,joint size and velocity distributions.		
MODULE: 4	**FLOW IN ATOMIZER**	**7 Hours**
Introduction to Flow Number, plain-orifice atomizer, discharge coefficient, pressure-swirl atomizer discharge coefficient, film thickness, velocity coefficient further perspective rotary atomizer, critical flow rates film thickness, toothed designs and airblast atomizer		
MODULE: 5	**ATOMIZER PERFORMANCE AND PATTERNATION METHODS**	**8 Hours**
Introduction plain-orifice atomizer, quiescent environment, crossflow, pressure-swirl atomizers effect of variables on mean drop size, drop size relationships rotary atomizers, drop size equations for smooth flat vane-less disks, drop size equations for atomizer wheels, drop size equations for slinger injectors,patternationtechniques, mechanical methods and optical methods		
MODULE: 6	**DROP EVAPORATION**	**8 Hours**
IntroductionSteady-State Evaporation, Measurement of Evaporation Rate, Theoretical Background Calculation of Steady-State Evaporation Rates, Evaporation Constant, Influence of Ambient Pressure and Temperature on Evaporation Rates, Evaporation at High Temperatures, Drop Lifetime, Effect of Heat-Up Phase on Drop Lifetime, Effect of Prevaporization on Drop Lifetime, Determination of Evaporation Constant and Drop Lifetime, Influence of Evaporation on Drop Size Distribution and Drop Burning.		
	Total Lectures	**45 Hours**

Text Books

1	Lefebvre, A. H., & McDonell, V. G. (2017). *Atomization and sprays (2nd ed.)*. CRC Press, Taylor & Francis Group.
2	Ashgriz, N. (2011). *Handbook of atomization and sprays: Theory and applications*. Springer.

Reference Books

1	Mikhael Gorokhovski. (2017). *Turbulence and Atomization and Sprays: Stochastic Processes and Computational Approaches*. Iste Press. Elsevier.
2	Williams, A. (2014). *Combustion of Liquid Fuel Sprays*. Elsevier Science.
3	Fritsching, U. (Ed.). (2016). *Process-Spray: Functional Particles Produced in Spray Processes* (1st ed. 2016). Springer International Publishing : Imprint: Springer. https://doi.org/10.1007/978-3-319-32370-1

Recommended by Board of Studies	
Approved by Academic Council	18th December 2022

Course Code	ADVANCED PROPULSION TECHNOLOGY	L	T	P	C
21AE3006		3	0	0	3

Course Objectives:

Enable the student to:

1. understand the working principles, operation, performance and health monitoring of various gas turbine engine.

2. differentiate the various chemical rocket propulsion systems. 3. analse green propellants, ramjet, scramjet and advance propulsion systems.		
Course Outcomes:		
The student will be able to: 1. illustrate the performance of various cycles of turbine engine. 2. estimate the performance of aircraft engines. 3. design the subsystems for chemical rockets. 4. analyse and compare the performance of chemical rockets. 5. design the subsystems for green propulsion systems 6. evaluate the performance of space thrusters.		
MODULE: 1	**ELEMENTS OF AIRCRAFT PROPULSION**	**7 Hours**
Classification of power plants, method of aircraft propulsion, propulsive efficiency, specific fuel consumption, thrust and power, factors affecting thrust and power, illustration of work cycle of gas turbine engine, characteristics of turboprop, turbofan and turbojet, ramjet, scram jet, methods of thrust augmentation.		
MODULE: 2	**AIRCRAFT ENGINE PERFORMANCE**	**8 Hours**
Design & off-design performance, surge margin requirements, surge margin stack up, transient performance, qualitative characteristics quantities, transient working lines, starting process and wind milling of engines, thrust engine start envelope, starting torque and speed requirements, calculations for design and off-design performance from given test data, engine performance monitoring, matching of components of GTE.		
MODULE: 3	**CHEMICAL ROCKET PROPULSION**	**8 Hours**
Introduction to rocket propulsion, classification of rockets, performance parameters, Chemical Rocket propulsion- solid, liquid and hybrid rockets: propellants and processing, combustion process, Metal Combustion for chemical rocket applications, Gel Propellants – Formulation atomization and combustion process.		
MODULE: 4	**GREEN PROPELLANTS AND PROPULSION SYSTEMS**	**7 Hours**
Introduction to green propellants – Need and Importance, Green propellant for solid rockets – Ammonium Di-nitrate (ADN), Potassium Di-nitrate (KDN), ways to reduce toxic pollutants form Ammonium Perchlorate based propellants, Liquid Rockets – Hydrazine based propellants, Alternatives for Hydrazine based propellants, Hydrogen Peroxide, Nitrous Oxide, Ionic Liquid Propellants, Hybrid Rockets – Paraffin wax-Hydrogen Peroxide, Nitrous oxide as green candidates for hybrid rockets.		
MODULE: 5	**ELECTRIC AND NUCLEAR PROPULSIONS SYSTEMS**	**8 Hours**
Electric propulsion, classification electro-thermal, electro-static, electro-magnetic thrusters, plasma rocketry, magneto plasma dynamic thrusters (MPD), pulsed plasma thrusters (PPT), Variable Isp Plasma Rockets (VASIMR), laser rockets, solar thermal rockets, photon rockets, solar sail.Nuclear propulsion – Fission and Fusion Propulsion, Applications of Nuclear Propulsion systems.		
MODULE: 6	**FUNDAMENTALS OF HYPERSONIC AIR-BREATHING PROPULSION**	**7 Hours**
Introduction to hypersonic air-breathing propulsion, overview of hypersonic propulsion, hypersonic intakes, supersonic combustors, expansion systems, engine cooling, liquid air-cycle engines, challenges in system design, system performance and analysis, space plane applications, experimental and testing facilities.		
	Total Lectures	**45 Hours**
Text Books		
1.	Ganesan, V. (2010). *Gas turbines (3rd ed.)*. Tata McGraw-Hill.	

2.	Sutton, G. P., & Biblarz, O. (2001). *Rocket propulsion elements (7th ed.)*. John Wiley & Sons.
Reference Books	
1.	Treager, I. E. (1996). *Aircraft gas turbine engine technology (3rd ed.)*. Glencoe.
2.	Saravanamuttoo, H. I. H., Rogers, G. F. C., & Cohen, H. (2017). *Gas turbine theory (7th ed.)*. Pearson.
3.	F. El-Sayed, A. (2016). *Fundamentals of aircraft and rocket propulsion*. Springer Berlin Heidelberg.
4.	Segal, C. (2011). *The scramjet engine: Processes and characteristics*. Cambridge university press.
5.	Mattingly, J. D., & Von Ohain, H. (2014). *Elements of gas turbine propulsion*. McGraw-Hill Education.

Recommended by Board of Studies	
Approved by Academic Council	18th December 2022

Course Code	**MODELING AND SIMULATION OF AEROSPACE VEHICLES**	**L**	**T**	**P**	**C**
21AE3007		3	0	0	3

Course Objectives:

Enable the student to:

1. understand requirements for various system models and simulation.
2. gain knowledge on the concepts of modeling elements and systems.
3. define and simulate the problems related to modeling, analysis and design of aerospace vehicle and systems.

Course Outcomes:

The student will be able to:

1. analyse the concepts of system models.
2. practice system simulation for cockpit systems.
3. model and design aircraft elements.
4. comprehend the principles behind system assessment, validation and certification.
5. relate system dynamics and mathematical models for flight simulation.
6. relate to the usage of flight simulator for various aircrafts.

MODULE: 1	**SYSTEM MODELS**	**6 Hours**

Continuous and discrete systems, System modeling, Static models, Dynamic models, Principles used in modeling techniques for simulation, Numerical computation techniques for models, Distributed lag models.

MODULE: 2	**SYSTEM SIMULATION**	**8 Hours**

Discrete events, Representation of time, Generation of arrival patterns, Simulation programming tasks, Gathering statistics, Counters and summary statistics, Simulation language, Simulation of an autopilot, Interactive systems.

MODULE: 3	**MODELING OF AIRCRAFT ELEMENTS**	**8 Hours**

Basic Aerodynamics, Aircraft Forces and Moments, Static Analysis, The Nonlinear Aircraft Model, Linear Models, State Space Models, Transfer Function Models, Stability Derivatives and performance assessment, Aircraft Models for Simulation.

MODULE: 4	**SYSTEM ASSESSMENT, VALIDATION AND CERTIFICATION**	**8 Hours**

Fault tolerant systems and Hardware and Software, Evaluating system design and Future architecture, FARs guide certification requirements-Fault Tree analysis – Failure mode and effects analysis, Criticality and damaging modes and effects analysis, Software development process models, Software Assessment and Validation -Civil standards, Certification of Civil Avionics.

MODULE: 5	**SYSTEM DYNAMICS AND MATHEMATICAL MODELS FOR FLIGHT SIMULATION**	**10 Hours**
Historical background, growth and decay models, system dynamics diagrams, representation of time delays, dynamo model language, elements of mathematical models, equation of motion, representation of aerodynamics data, aircraft systems, structure and cockpit systems, motion system, visual system, instructor's facilities.		
MODULE: 6	**SIMULATORS**	**5 Hours**
Introduction, advantage of simulator, effectiveness of Simulator, flight simulator as a training device and research tool, User's role, Simulator Certification, Data sources, Validation, in- flight simulators.		
	Total Lectures	**45 Hours**

Text Books	
1.	Gordon, G. (2002). *System Simulation.* Prentice – Hall Inc.
2.	Stables, K. J., & Rolfe, J. M. (1988). *Flight Simulation.* Cambridge University Press.
Reference Books	
1.	Tewari, A. (2007). *Atmospheric and Space Flight Dynamics: Modeling and Simulation with MATLAB and Simulink.* Birkhuser.
2.	Brian, L. Stevens, Frank, L. Lewis. (2003). *Aircraft Control and Simulation.* John Wiley & Sons,
3.	NASA Handbook. *System Engineering*.
4.	Lennat Ljung, & Tokel Glad. (1994). *Modeling of Dynamic System.* Prentice Hall.
5.	Williamson, & Skelton. (2021). *Vehicle Dynamics and Control (1st Ed.).* Elsevier.
Recommended by Board of Studies	
Approved by Academic Council	18th December 2022

Course Code	ADVANCED PROPULSION LABORATORY	L	T	P	C
21AE3008		0	0	2	1

Course Objectives:

Enable the student to:

1. understand the various sub systems of rocket motors.
2. analyse the performance of air-breathing engines.
3. identify various engine components.

Course Outcomes:

The student will be able to:

1. design experiments for the qualification of subsystems in rocket propulsion.
2. assess the real time situation and corrective measures associated with rocket motors.
3. analyse the working of different parts of aircraft engine.
4. get knowledge on ignition and combustion.
5. identify suitable fuel injector.
6. assess the performance of ramjet engine.

List of Experiments

1	To calibration pressure transducer, load cell and temperature sensor using Lab view software for propulsion application
2	To determine mechanical properties of fuel grains for hybrid.
3	To determine the regression rate for hybrid motor for PMMA.
4	To determine combustion efficiency of hybrid motor.
5	To determine the flame speed measurement for the given fuel.
6	To determine the flame flash back velocity for gaseous fuel.
7	To determine ignition delay time of the given propellant using shock tube.
8	Performance of various types of injectors using injector test facility.

9	To determine calorific value of the given fuel using bomb calorimeter at various pressures and with O2 and air.
10	To characterize the over-expanded and under-expanded flow through a CD nozzle using high altitude test facility.
11	To evaluate the performance of altitude compensating nozzle for over-expanded and under-expanded flow using high altitude test facility.
12	To evaluate the performance of ramjet engine.
Total Lectures	**15 Hours**

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Recommended by Board of Studies	
Approved by Academic Council	18th December 2022

Course Code	ADVANCED AVIONICS	L	T	P	C
21AE3009		3	0	0	3

Course Objectives

Enable the student to:
1. understand the various aircraft avionics systems and its connectivity.
2. explain the function of cockpit avionic systems.
3. gain knowledge on interworking of various aircraft avionic systems.

Course Outcomes:

The student will be able to:
1. evaluate various aircraft avionics architectures and bus systems.
2. identify various flight display system elements.
3. comprehend the principles behind flight communication protocols.
4. examine flight management system and their working principles.
5. assess various elements of flight control systems.
6. analyze the functioning of on flight communication system.

MODULE: 1	**AVIONICS ARCHITECTURE**	**8 Hours**

Digital Avionics bus systems, Protocols overview MIL-STD-1553B, ARINC 429, AFDX. Federated system and Integrated modular Avionics Architectures, Line Replaceable Units.

MODULE: 2	**FLIGHT DISPLAY SYSTEM**	**8 Hours**

Trends in display technology, Alphanumeric displays, character displays etc., Civil and Military aircraft cockpits, MCDU, MFDs, MFK, HUD, HDD, HMD, DVI, HOTAS, Synthetic and enhanced vision, situation awareness, Panoramic/big picture display.

MODULE: 3	**FLIGHT COMMUNICATION PROTOCOLS**	**9 Hours**

Uplink and Down link, ACARS – Requirements, principles and implementation, Requirements of ATN, Data and Voice communication, HF, VHF, SATCOM systems Principles. Functional diagram of different communication systems. Principle of Software defined radios.

MODULE: 4	**FLIGHT MANAGEMENT SYSTEMS**	**7 Hours**

Performance functions of the FMS, Altitude and speed constraints, Guidance – Vertical and Horizontal, Flight planning, trajectory prediction, route constraints and performance selections, FMS F-PLN pages, Types of Flight plan.

MODULE: 5	**FLIGHT CONTROL SYSTEMS**	**6 Hours**

Types of FCS, Classification of A/C, Flight envelop, Flight Phases, HQ ratings, reliability requirements, Automatic Flight Control System (AFCS), Aircraft sensors and airdata systems for AFCS, Autopilot Flight Director System, Typical AFDS architectures, Fly-by-wire system.

MODULE: 6	**FLIGHT COMMUNICATION SYSTEMS**	**7 Hours**

CMU requirements, Hardware architecture, Software Architecture, Advance communication techniques WiMAX, 4G wireless.		
	Total Lectures	**45 Hours**
Text Books		
1.	Collinson, R. P. G. (2011). *Introduction to avionic (3rd Ed.).* Springer.	
2.	Randy Walter. (2015). *Digital Avionics Handbook (3rd Ed.*). CRC Press.	
Reference Books		
1.	Yosif Golfman. (2012). *Hybrid anisotropic materials for wind power turbine blades.* CRC Press.	
2.	Mishnaevsky, L., Branner, K., Petersen, H., Beauson, J., McGugan, M., & Sørensen, B. (2017). *Materials for Wind Turbine Blades: An Overview. Materials*, 10(11), 1285. https://doi.org/10.3390/ma10111285	
3.	Muyiwa Adaramola. (2014). *Wind Turbine Technology: Principles and Design, Taylor and Francis.* CRC Press.	
4.	Jha, A. R. (2011). *Wind Turbine Technology*. CRC Press.	
5.	Victor Lyatkher. (2013). *Wind Power: Turbine Design, Selection, and Optimization.* Wiley-Scrivener.	
Recommended by Board of Studies		
Approved by Academic Council	18th December 2022	

Course Code	**ADVANCED AIRCRAFT MATERIALS**	**L**	**T**	**P**	**C**
21AE3010		3	0	0	3

Course Objectives:

Enable the student to:

1. explain the mechanical behaviour of various materials that are used in aircraft.
2. differentiate the high-performance alloys used in aerospace applications.
3. gain knowledge on the composite and smart materials used in aerospace industry.

Course Outcomes:

The student will be able to:

1. explore the use of conventional materials for aircraft structures.
2. learn the properties and composition of alloys for aerospace application.
3. design and analyse light weight metals and composite structures.
4. understand the definition and classification of aerospace composites.
5. choose suitable manufacturing method for composite materials.
6. examine smart and intelligent material characteristics and engineering effect.

MODULE: 1	**WOOD AND STEEL**	**8 Hours**

Introduction, advantages and disadvantages of wood, hardwoods and softwoods, structure and composition of wood, engineering properties of wood, application of wood in wing spars and stringers, metallic materials, general properties of materials, definition of physical terms, heat-treatment terms, requirements of aircraft materials, carbon steels, nickel steels, nickel-chromium steels, molybdenum steels, chrome-vanadium steels, special steels, corrosion and heat resistant steels, steels used in aircraft component.

MODULE: 2	**ALLOYS AND SUPER ALLOYS**	**7 Hours**

Aluminium alloys, magnesium alloys, copper alloys, titanium alloys and aluminides, superalloys and coatings, nickel based super alloys, cobalt based super alloys, iron based super alloys, manufacturing processes associated with super alloys, heat treatment and surface treatment of super alloys, alloys used in aircraft engines.

MODULE: 3	**LIGHT WEIGHT METALS AND METAL MATRIX COMPOSITES**	**7 Hours**

Introduction and uses of lightweight metals, aluminum, magnesium, beryllium, titanium, metal-matrix composites, metal-matrix composites with aluminium matrix, fibre reinforced aluminium

laminates, titanium matrix composites, interfaces in metal matrix composites, metal composites used in aircraft components.		
MODULE: 4	**CERAMIC MATRIX COMPOSITES**	**7 Hours**
Non-oxide materials, fabrication and microstructural development of non-oxide ceramics, silicon nitride matrix composites, fracture and fatigue of non-oxide ceramics, oxide materials, imaging microstructures of monolithic carbons and carbon/carbon composites in the TEM, application of high temperature materials in aircraft components such as turbine blades.		
MODULE: 5	**POLYMER MATRIX COMPOSITES**	**8 Hours**
Thermosetting polymers, thermoplastics, elastomers, structural adhesives, mechanical properties of polymers, polymer additives, polymers for radar-absorbing materials (rams), aerospace applications of polymers, advantages and disadvantages, polymer matrix composites, fibers for polymer-matrix composites, sandwich composites, polymer nanocomposites, environmental durability of composites, aerospace applications of fibre–polymer composites, production of prepregs and fabrics, core materials for sandwich composites, composites manufacturing using prepreg, composites manufacturing by resin infusion, machining of composites.		
MODULE: 6	**SMART MATERIALS**	**8 Hours**
Background and history of smart materials, piezoelectric materials: properties, theorem and performance, conducting polymer: properties, working theorem and application, shape memory alloys (smas): properties, engineering effect and application, electrostrictive ceramics: properties, theorem and application, magnetic smart materials: introduction, properties and application, fire resistant composite: background and properties.		
	Total Lectures	**45 Hours**

Text Books	
1.	Horst Buhl. (1992). *Advanced Aerospace Materials.* Springer-Verlag Berlin.
2.	Adrian Mouritz. (2012). *Introduction to Aerospace Materials.* AIAA Education Series.
Reference Books	
1.	Alan Baker, Stuart Dutton, & Donald Kelly. (2004). *Composite Materials for Aircraft Structures (Second Edition).* AIAA Education Series.
2.	George, F. Titterton. (1968). *Aircraft Materials and Processes (5th ed.).* Himalayan Books-New Delhi.
3.	Haim Abramovich. (2019). *Advanced Aerospace Materials: Aluminum-Based and Composite Structures.* De Gruyter.
4.	Maziar Arjomandi. (2007). *Smart Material in Aerospace Industry*. The University of Adelaide, Aeronautical Engineering.
5.	Prasad, N. Eswara, Wanhill, R. J. H. (2017). *Aerospace Materials and Material Technologies*. Indian Institute of Metals Series.

Recommended by Board of Studies	
Approved by Academic Council	18th December 2022

Course Code	**DATA ANALYTICS AND VISUALIZATION**	**L**	**T**	**P**	**C**
21AE3013		3	0	0	3

Course Objectives:

Enable the student to:

1. explain the key techniques and theory behind data visualization.
2. discuss the effective usage of various visualization techniques.
3. select visualization tools and practice.

Course Outcomes:

The student will be able to:

1	examine the concepts of data and visualization.		
2	perform data analysis and categorize data.		
3	perform statistical analysis and abstraction of data.		
4	evaluate various representation of spatial data.		
5	represent data in various charts in power bi.		
6	plot and analyze data in various charts in excel.		
MODULE: 1	**CHARACTERISTICS OF DATA**		**8 Hours**
Data visualization - Basic principles, categorical and continuous variables. - Exploratory graphical analysis. types of data analysis, 5Vs, Value of Visualization – Importance of analytics and visualization, External representation – Interactivity – Difficulty in Validation, Data-Driven Decision Making.			
MODULE: 2	**DATA ANALYSIS**		**8 Hours**
Structured Data and Unstructured Data, Data collection, Analysis of Unstructured Data, Natural language basics, Processing and understanding text, Text similarity and Clustering, Text Summarization, Text classification, Semantic and Sentiment analysis, Dataset types – Attribute types – Semantics, Data Access and Data Security.			
MODULE: 3	**DATA ABSTRACTION**		**7 Hours**
Data Abstraction: Task Abstraction – Analyze, Produce, Search, Query. Four levels of validation – Validation approaches – Validation examples. Arrange networks and trees: Connections, Matrix views – Containment. Map Color: Color theory, Color maps and other channels.			
MODULE: 4	**DATA VISUALIZATION**		**7 Hours**
Regression diagnostics, Residual Plots, Outliers and Influence Points, Assumptions of least-square regression Manipulate view, Change view over time – Select elements – Changing viewpoint – Reducing attributes. Facet into multiple views.			
MODULE: 5	**DATA VISUALIZATION USING POWER BI**		**7 Hours**
Visualization software (Power BI), Create Dashboards with tables, spatial data, tree and network etc.), Histogram, Scatter plots, Case studies.			
MODULE: 6	**DATA VISUALIZATION USING EXCEL**		**8 Hours**
Visualization software (Tableau, Excel, Power BI), Create Dashboards with tables, spatial data, tree and network etc.), Histogram, Scatter plots, Case studies.			
		Total Lectures	**45 Hours**

Text Books	
1.	Munzner, T. (2015). *Visualization analysis & design*. CRC Press.
2.	Cairo, A. (2013). *The functional art: An introduction to information graphics and visualization*. New Riders.
Reference Books	
1.	Murray, S. (2013). *Interactive data visualization for the web (1st ed)*. O'Reilly Media.
2.	Yau, N. (2011). *Visualize this: The FlowingData guide to design, visualization, and statistics*. Wiley Pub.
3.	Hastie, T., Tibshirani, R., & Friedman, J. H. (2009). *The elements of statistical learning: Data mining, inference, and prediction (2nd ed)*. Springer.
4.	Walpole, R. E., Myers, R. H., Myers, S. L., & Ye, K. (Eds.). (2017). *Probability & statistics for engineers & scientists: MyStatLab update* (9th ed.). Pearson.

Recommended by Board of Studies	
Approved by Academic Council	18th December 2022

Course Code	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN AEROSPACE APPLICATIONS	L	T	P	C

21AE3014		3	0	0	3

Course Objectives:

Enable the student to:

1. explain the basic concepts of artificial intelligence (ai) and machine learning (ml).
2. apply the knowledge of AI & ML in aerospace applictions.
3. discuss the details of developing AI systems.

Course Outcomes:

The student will be able to:

1. comprehend the concept of artificial intelligent systems.
2. execute suitable strategy for solving real world problems.
3. design expert systems for specific applications.
4. select and evaluate linear algorithms.
5. compare and contrast nonlinear and ensemble algorithms.
6. implement machine learning techniques.

MODULE: 1	**INTRODUCTION TO ARTIFICIAL INTELLIGENCE**	**6 Hours**

Introduction: Definition – Applications – History – Types. Intelligent agent: Types - Agent environment – Turing test. Examples of AI.

MODULE: 2	**PROBLEM SOLVING AND KNOWLEDGE REPRESENTATION**	**8 Hours**

Search algorithms: Informed – Uninformed – Minimax – Alpha-beta pruning. Knowledge based agent, Knowledge representation, Reasoning in AI: Types – Proababilistic –Bayes theorem.

MODULE: 3	**AI AND EXPERT SYSTEM APPLICATIONS**	**7 Hours**

Expert systems: characteristics – components – development – capabilities – advantages – limitations. Design Considerations for Avionic Applications, Flight Management Expert System, Navigation Systems, Decision Support Systems, Intelligent Monitoring and Diagnostic Systems.

MODULE: 4	**LINEAR ALGORITHMS**	**8 Hours**

Types of Machine learning, Bias-variance trade off, over-fitting and under-fitting, gradient descent, linear regression, logistic regression, linear discriminant analysis, Perceptron algorithm, Support Vector Machine.

MODULE: 5	**NON LINEAR AND ENSEMBLE ALGORITHMS**	**8 Hours**

Classification and Regression Trees, Naïve Bayes, *k*-nearest neighbors, Linear Vector Quantization, Backpropagation, Bootstrap Aggregation, Random forest, Boosting and Adaboost.

MODULE: 6	**MACHINE LEARNING IN AEROSPACE INDUSTRIES**	**8 Hours**

Data collection – Preprocessing (Missing values, Normalization, Adopting to chosen algorithm) – Outlier Analysis (Z-Score) - Model selection & evaluation – Optimization of tuning parameters – Setting the environment – Visualization of results.

	Total Lectures	**45 Hours**

Text Books

1.	Chandra, V., & Hareendran, A. (2014). *Artificial intelligence and machine learning*. PHI Learning.
2.	John Valasek. (2013). *Advances in Intelligent and Autonomous Aerospace Systems*. American Society of Mechanical Engineering,

Reference Books

1.	Jason Brownlee. (2016.). *Master Machine Learning Algorithms*. *Machine Learning Mastery*.
2.	Alpaydin. (2016). *Introduction To Machine Learning*. Phi Learning.
3.	Robbie Allen, James Kotecki, Mike Salvino, & Larry Carin. (2020). *Machine Learning in Practice*. Pearson Education (US).

Recommended by Board of Studies	

Approved by Academic Council	18^{th} December 2022

Course Code	DIGITAL MANUFACTURING LABORATORY	L	T	P	C
21AE3015		**0**	**0**	**2**	**1**

Course Objectives:

Enable the student to:

1. explain the basics of additive manufacturing/rapid prototyping.
2. assess the generation, working and analysis of stl files.
3. build complex geometries, printing and post-processing techniques.

Course Outcomes:

The student will be able to:

1. develop STL file for CAD models with appropriate support structures and orientation.
2. design complex / creative models ready for 3D printing.
3. build complex engineering assemblies in plastic material with minimum build-time.
4. evaluate the process parameters of AM machine to improve the quality of the parts Produced.
5. model and fabricate working models using AM processes.
6. reengineer the existing component for design enhancement.

List of Experiments

1	Designing of complex geometries and generating STL files from CAD Data.
2	Modeling and 3D Printing of Engine components.
3	Modeling and 3D Printing of navigation components
4	Modeling and 3D Printing mechanical Joint.
5	Modeling and 3D Printing of Impeller.
6	Designing and 3D printing of Intricate shapes for medical applications.
7	Processing the CAD data in Catalyst and CURA or any slicing software and optimizing the build time and material consumption.
8	3D printing of machine components using reengineering method.
Total Lectures	**15 Hours**

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Recommended by Board of Studies	
Approved by Academic Council	18^{th} December 2022

Course Code	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING LABORATORY	L	T	P	C
21AE3016		0	0	2	1

Course Objectives:

Enable the student to:

1. interpret the basics of python language.
2. gain knowledge on handling data to support learning models.
3. implement AI/ML algorithms.

Course Outcomes:

The student will be able to:

1. use appropriate data pre-processing techniques.
2. understand the AI/ML implementation procedures.
3. execute software implementation of AI/ML algorithms.
4. choose appropriate machine learning algorithms for the given problem.
5. assess the performance of ml techniques.
6. develop intelligent systems to solve real world problems.

List of Experiments

1.	Data Processing & Evaluation metrics.
2.	Optimization using search algorithm.
3.	Reasoning using Bayes theorem.

4.	Prediction using Linear/Logistic regression.
5.	Prediction using Classification and Regression Tree.
6.	Predictive modeling using Linear Vector Quantization.
7.	Predictive modeling using back propagation algorithm.
8.	Predictive modeling using Random forest.
Total Lectures	**15 Hours**

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Recommended by Board of Studies	
Approved by Academic Council	18th December 2022

Course Code	AVIONICS LABORATORY	L	T	P	C
21AE3017		0	0	0	1

Course Objectives

Enable the student to:

1. distinguish aircraft instruments.
2. measurement of aircraft parameters.
3. explain the sensors and transducers in aerospace application.

Course Outcomes

The student will be able to:

1. measure three axis acceleration.
2. measure velocity using hot wire anemometer.
3. measure temperature using rtd & thermocouple.
4. design a control system for autopilots.
5. estimate the data transferred in a mil-std-1553b data bus.
6. determine position in gps using my rio.

List of Experiments

1.	Study on Global Positioning System.
2.	Longitudinal Autopilot for Jet transport.
3.	Vangaurd missile control system.
4.	Temperature measurement using Resistance Temperature Detector.
5.	Temperature measurement using Thermocouple.
6.	Measurement of air velocity using hot wire Anemometer.
7.	Measurement of acceleration using Accelerometer.
8.	Study on DO-178 based Avionics system development.
9.	Study on communication protocol of Mil-std-1553b data bus.

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Recommended by Board of Studies	
Approved by Academic Council	18th December 2022

Course Code	FUNDAMENTALS OF AEROSPACE ENGINEERING	L	T	P	C
21AE3018		3	0	0	3

Course Objectives:

Enable the student to:

1. understand the basic concepts of aircrafts, rockets, satellites and their applications
2. explain aerospace vehicle components, their functions and construction.
3. distinguish various aerospace propulsion system.

Course Outcomes:

The student will be able to:

1. Relate to the historical evolution of aviation.
2. Correlate Principles of flight.
3. Design and categorize airfoil shapes.

4. Classify the Aircraft instrumentation systems.
5. Categorize the Power plants used in various aircrafts.
6. Understand basic trajectory for space missions.

MODULE: 1	**HISTORY OF AVIATION**	**6 Hours**
Early flying vehicles – Hot air balloons – Heavier than air flying machines - Classification of flight vehicles, airplanes and helicopters – Components of an airplane and their functions.		
MODULE: 2	**BASICS OF FLIGHT**	**9 Hours**
International Standard Atmosphere – Temperature, pressure and altitude relationships – Lift, drag and moment – Airfoil nomenclature – Flow characteristics of airfoils – NACA nomenclature – Propagation of sound, Mach number – subsonic, transonic, supersonic, hypersonic flows.		
MODULE: 3	**AIRCRAFT STRUCTURES**	**7 Hours**
General types of construction – Monocoque and Semi monocoque construction – typical wing and fuselage Structures – Materials used in Aircraft.		
MODULE: 4	**UNMANNED AERIAL VEHICLES**	**6 Hours**
Introduction to UAV's - Types of UAV - Construction and instrumentation – Controls - Scope and application of UAVs.		
MODULE: 5	**POWER PLANTS USED IN AIRCRAFTS**	**9 Hours**
Classification of power plants, Working of piston, turboprop and jet engines - Ramjet and Scramjet – Comparative merits – Principle of operation of rocket – Types of rocket and typical applications.		
MODULE: 6	**SPACE FLIGHT DYNAMICS**	**8 Hours**
Introduction, Earth-Moon Mission – Basic space vehicle trajectory – Kepler's law – Re-entry – Missions of ISRO, NASA.		
	Total Lectures	**45 Hours**

Text Books

1.	Anderson, J. D. (2008). *Introduction to flight (6th ed.)*. McGraw-Hill.
2.	Kermode, A.C. (2008). *Flight without Formulae (5th ed.)*. Pearson Education.

Refrenec Books

1.	Course material of Faculty Enablement Programme on "*Introduction to Aircraft Industry*", conducted by Infosys, Mysore through Campus connect programme.
2.	Segal, C. (2011). *The scramjet engine: Processes and characteristics*. Cambridge university press.
3.	Corda, S. (2017). *Introduction to aerospace engineering with a flight test perspective*. Wiley.
4.	Shevell, R. S. (2004). *Fundamentals of flight*. Pearson education.

Recommended by Board of Studies	
Approved by Academic Council	

Course Code	WIND TURBINE DESIGN AND PERFORMANCE	L	T	P	C
21AE3021		3	0	0	3

Course Objectives:

Enable the student to:
1. explain aerodynamics in wind turbine design.
2. gain knowledge on performance of wind turbines.
3. dicide the materials used in wind turbines.

Course Outcomes:

The student will be able to:

1. Describe a wind power plant on both component and system level. 2. Describe various wind turbine constructions. 3. Design a wind turbine for a particular application. 4. Calculate the performance of wind turbines. 5. Classify the loads on wind turbine blade and requirement of composite materials. 6. Discuss the fabrication techniques for wind turbine blades.		
MODULE: 1	**WIND ENERGY COLLECTORS**	**8 Hours**
Introduction to wind energy, atmospheric circulations, factors influencing wind, variation of wind speed with height and time, turbulence, causes of turbulence, power estimation in wind, wind energy conversion principles, components of wind energy conversion systems (WECS), classification of WECS (mechanical and electrical), wind turbine aerodynamics, influence of terrain on wind energy.		
MODULE: 2	**MOMENTUM THEORY**	**8 Hours**
Rotor aerodynamic theory: Introduction-Aerodynamic Lift - Power in the Wind, Actuator Disc Concept, Open Flow Actuator Disc-Actuator Disc in Augmented Flow and Ducted Rotor Systems-Blade Element Momentum (BEM) Theory -Optimum Rotor Design-Limitations of Actuator Disc and BEM Theory.		
MODULE: 3	**ROTOR DESIGN**	**7 Hours**
Horizontal Axis Wind Turbine (HAWT) & Vertical Axis Wind Turbine (VAWT), power developed, maximum power coefficient (Betz Limit), thrust, efficiency, rotor selection, rotor design considerations, diameter of the rotor.		
MODULE: 4	**DESIGN OF WIND TURBINE BLADE**	**7 Hours**
Aerodynamic design principles, blade profile, blade element theory, choice of the number of blades, choice of the pitch angle, tip speed ratio, power speed characteristics, torque speed characteristics, solidity.		
MODULE: 5	**WIND TURBINE PERFORMANCE**	**7 Hours**
Wind-turbine performance, performance curves, constant rotational speed operation, comparison of measured with theoretical performance, variable-speed operation, estimation of energy capture, wind-turbine performance measurement, wind siting analysis concept of wind form & project cycle, aerodynamic performance assessment of wind turbines, flow analyses over wind turbine blades, effect of geometric modifications and associated noise generation and propagation.		
MODULE: 6	**MATERIALS AND MANUFACTURING TECHNOLOGIES FOR TURBINE ROTOR BLADE**	**8 Hours**
Wind turbine rotor blades: construction, loads and requirements, structural composites, resin advantages, rapid curing resin system, reinforced materials: carbon fibers, glass fiber, core materials: honeycomb sandwich structures and adhesive, wear and tear resistance of material, wet hand lay-up process, filament winding, prepreg technology, resin infusion technology, out-of-autoclave composite prepreg process, developing technology for robust automation winding process, infusion modeling process, rotational molding, manufacturing technologies and defects, mechanical degradation of wind blade composites, recycling of wind turbine blade.		
	Total Lectures	**45 Hours**
Text Books		
1.	Manwell, J. F., McGowan, J. G., & Rogers, A. L. (2010). *Wind energy explained: Theory, design and application*. John Wiley & Sons. https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=589269	
2.	Brøndsted, P. (Ed.). (2013). *Advances in wind turbine blade design and materials*. Woodhead Publishing.	
Reference Books		

1.	Golfman, Y. (2016). *Hybrid Anisotropic Materials for Wind Power Turbine Blades*. CRC Press.
2.	Mishnaevsky, L., Branner, K., Petersen, H., Beauson, J., McGugan, M., & Sørensen, B. (2017). *Materials for Wind Turbine Blades: An Overview. Materials*, 10(11), 1285. https://doi.org/10.3390/ma10111285
3.	Adaramola, M. S. (2014). *Wind turbine technology: Principles and design*. Apple academic press.
4.	Jha, A. R. (2011). *Wind Turbine Technology*, CRC Press,
5.	Liatkher, V. M. (2014). *Wind power: Turbine design, selection, and optimization*. Scrivener Publishing, Wiley.
Recommended by Board of Studies	
Approved by Academic Council	18th December 2022

Course Code	**APPLIED MATHEMATICS FOR ENGINEERS**	**L**	**T**	**P**	**C**
21AE3022		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. review the mathematical methods and tools learned at undergraduate level.
2. develop analytical and mathematical skills to study advanced topics in engineering.
3. explain use of software tools for analytical and numerical solutions for engineering probems.

Course Outcomes:

The student will be able to:

1. Model physical problems and formulate governing equations.
2. Identify types of differential equations and solve them analytically using various techniques.
3. Model and solve mathematical problems using methods of Linear Algebra, Scalar and Vector Fields.
4. Use complex variable therory to solve problems in various fields of engineering.
5. Numerically solve partial and ordinary differential equations, using software tools.
6. Solve engineering problems by symbolic computation using software tools.

MODULE: 1	**ORDINARY DIFFERENTIAL EQUATIONS**	**10 Hours**

Linear ODEs with application to specific engineering problems, Method of Variation of Parameters, Laplace Transform and Initial Value Problems, Convolution Theorem and applications, Sturm-Liouville problems in Engineering, Solution via Special Functions, Non-Linear ODEs.

MODULE: 2	**FOURIER SERIES, PARTIAL DIFFERENTIAL EQUATIONS AND FOURIER TRANSFORMS AND APPLICATIONS**	**8 Hours**

Fourier Series, Separation of Variables, Diffusion and Wave equations, Fourier Transforms, Boundary Value Problems, Application to Vibrations, Image Processing, Signal Analysis etc.

MODULE: 3	**SCALAR AND VECTOR FIELDS**	**4 Hours**

Divergence, Gradient, Curl, Laplacian, Integration on curves, surfaces, and volumes. Gauss and Stokes theorems, Green’s theorem, Applications in Electromagnetics and Mechanics.

MODULE: 4	**LINEAR ALGEBRA**	**6 Hours**

Basic concepts, Matrices, Vectors, Determinants. Solution of linear systems, Eigenvalues and eigenvectors, Diagonalization, Relation to Principle Planes and Principal Stresses, Applications.

MODULE: 5	**FUNCTIONS OF COMPLEX VARIABLES**	**8 Hours**

Functions of Complex Variables, Basic Mappings, Concept of Infinity in the Complex Plane, Analyticity, Complex Integration, Cauchy Integral Formula, Taylor and Laurent series, Residue theorem, Conformal Mapping, Joukowski Transformation, Schwarz Christoffel Transformation, Applications to Electric, Electromagnetic and Fluid Fields.		
MODULE: 6	**NUMERICAL METHODS FOR ALGEBRAIC, ORDINARY AND PARTIAL DiFFERENTIAL EQUATIONS**	**9 Hours**
Newton Raphson, Bisection, Initial Value Problems, Boundary Value Problems, Euler Method, Runge Kutta Methods, Shooting Methods, Predictor-Corrector Method, Parabolic and Elliptical ODE, Introduction to Field Problems and CFD, Programming.		
	Total Lectures	**45 Hours**

Text Books	
1.	Kreyszig, E., Kreyszig, H., & Norminton, E. J. (2011). *Advanced engineering mathematics (10th ed)*. John Wiley.
2.	Shankar Ramamoorthy, (1995). *Basic Traning in Mathematics A Fitness Program for Science Students*, Plenum Press.
Reference Books	
1.	Thomas, G. B., & Hass, J., Heil, Christopher, Weir, Maurice D. (2018). *Thomas' calculus*. Pearson Education.
2.	Greenberg, M. D. (2013). *Foundations of applied mathematics (Dover ed.)*. Dover Publications.
Recommended by Board of Studies	18th December 2022
Approved by Academic Council	

Course code	**DATA ANALYTICS AND VISUALIZATION LABORATORY**	**L**	**T**	**P**	**C**
21AE3023		0	0	2	1

Course Objectives:

To impart knowledge on
1. Key techniques in data visualization using PowerBI and Excel.
2. Various visualization techniques using PowerBI and Excel.
3. Various visualization tools and practices.

Course Outcomes:

The student will be able to
1. Depict data pictorially so that trends and patterns can be visualized, analyzed.
2. Group Structured and Unstructured data using formal techniques for making inferences.
3. Demonstrate design of experiments, hypothesis testing using probability density distributions, ANOVA.
4. Correlate data using regression techniques for single and multivariable curve fittings.
5. Combine data in various charts in Power BI.
6. Design charts in Excel.

List of Experiments:

1.	Regional cash inflows analysis overview using Combo Charts, Cards, Bar Charts, Tables and Line Charts.
2.	Regional customer's product sales, profits Analysis and the customer segmentation analysis using Column Charts, Bubble Charts, Point Maps, Tables.
3.	Marketing Campaign Insights Analysis using Bar Charts, Column Charts.
4.	Financial Performance Analysis for the summary/overview page using Funnel Charts, Combo Charts (Column Charts, Line Charts, Waterfall Charts).
5.	Create Bar Charts, Box plots, Identification of Outliers.
6.	K means Clustering using Excel.

7.	Linear Regression, Goodness of Fit Calculations, Correlation Coefficient, multivariable regression, Covariance Calculations, ANOVA Tables, Hypothesis Testing.
8.	Create Histograms, Scatter Plots, Identifying Positive Negative or Neutral Correlation, Pie Charts.
9.	Engine Performance based on its Dimensional parameters/ Analyse flow variables using data obtained from simulation over an Aerifoil/ Correlation analysis to compare the effective relationship between Aircraft data etc.
Total Lectures	**15 Hours**
The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.	
Recommended by Board of Studies	
Approved by Academic Council	24^{th} September 2022

Course code	**BASICS OF FLUID MECHANICS**	**L**	**T**	**P**	**C**
22AE2001		3	0	0	3

Course Objectives:

To impart knowledge on

1. Fundamental concepts of hydrostatics, fluid kinematics and kinetics.
2. Techniques essential to analyze and solve engineering problems involving fluid flow.
3. Analyzing experimental data on the important parameters that affect fluid flow.

Course Outcomes:

The student will be able to

1. Define properties, conservation laws and non-dimensional numbers that affect fluid flow.
2. Visualize fluid flow and kinematics using streamlines, streak lines and path line.
3. Apply Bernoulli's equation appropriately with simple flow, and flow measurement devices
4. Calculate hydrostatic forces and determine stability requirements for submerged and floating bodies and on structures like dams and gates.
5. Analyze flow fields using exact and approximate solutions of the governing equations.
6. Evaluate drag forces and pressure losses in internal and external flows

Module: 1	**BASICS OF FLUID FLOW AND FLUID STATICS**	**8 Hours**
Definition of a fluid –History of fluid mechanics, Continuum hypothesis – Fluid properties - Pressure, Temperature, Density, Compressibility, Viscosity, Stress-strain rate relationship, Fluid statics – Basic hydrostatic pressure field equation for compressible and incompressible fluids, Measurement of pressure – Manometer equation, U-Tube, Inverted U-Tube and Inclined Manometers, Total Force, Centre of pressure and Centre of buoyancy on submerged surfaces, Stability of submerged and floating bodies.		
Module: 2	**GOVERNING EQUATIONS OF FLUID DYNAMICS AND FLUID KINEMATICS**	**8 Hours**
Lagrangian and Eulerian approach, Velocity and Acceleration, Path lines, Stream lines and Streak lines, Law of conservation of momentum, Bernoulli's equation and applications, Orifice meter, Venturi meter, Nozzle, Pitot tube, Limitations of Bernoulli's equation, Material Derivative, Stress Tensor and Definition of Pressure in a flow situation, Law of Conservation of Mass and Momentum in Differential Form (Euler's Equations)		
Module: 3	**INCOMPRESSIBLE INVISCID FLOW**	**8 Hours**
Implication of Irrotationality on Euler's equation Stream Function, Velocity Potential, Complex Potential, Blasius Integral Formula, Elementary flows- Uniform flow, Source, Sink, Doublet, Vortex, Super imposed Flows- Rankine Half-Body, Rankine Oval, Flow over a Circular Cylinder with and without a Vortex, D'Alembert's Paradox, Kutta-Joukowski Theorem		
Module: 4	**INCOMPRESSIBLE VISCOUS FLOW**	**7 Hours**

Fluid deformation– Translation, Dilatation, Rotation, Deformation, Viscous stress-strain rate relationship, Navier Stokes Equations, Closed form solutions, Plane Poiseuille flow, Couette flow, Hagen-Poiseuille Flow, Darcy-Weisbach and Fanning friction factors, Frictional Losses, Moody Chart, Losses in pipe fittings		
Module: 5	**BOUNDARY LAYER THEORY**	**7 Hours**
Prandtl's boundary layer equations, Blasius solution, Integral momentum equation, Drag on a flat plate, Streamlined and bluff bodies - Flow around circular bodies and aero foils, Calculation of lift and drag		
Module: 6	**DIMENSIONAL ANALYSIS**	**7 Hours**
Dimensional analysis – The Buckingham-Pi theorem – Non-dimensional numbers-Mach Number, Reynolds Number, Strouhal Number, Knudsen Number, etc.		
CONTENT BEYOND SYLLABUS		
Impact of jets Force exerted by a jet on stationary and moving vertical and inclined plates and curved blades		
	Total Lectures	**45 Hours**

Text Books	
1.	Munson B R, Young D F & Okiishi T H, "Fundamentals of Fluid Mechanics", John Wiley & Sons, 2006.
2.	Rathakrishnan E., "Fundamentals of Fluid Mechanics", Prentice-Hall, 2007.
Reference Books	
1.	White F M., "Fluid Mechanics", 7th Edition, Tata McGraw-Hill Education, 2011
2.	Robert W Fox & Alan T Mc.Donald, "Introduction to Fluid Mechanics", John Wiley and Sons, 1995
3.	Yuan S W, "Foundations of Fluid Mechanics", Prentice-Hall, 1987.
4.	Fluid Mechanics: http://nptel.ac.in/courses/112105171/
5.	National Committee of Fluid Mechanics Filmshttp://web.mit.edu/hml/ncfmf.html

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**BOUNDARY LAYER THEORY**	**L**	**T**	**P**	**C**
22AE2002		3	0	0	3

Course Objectives:

Impart knowledge on
1. To familiarize the students with viscous flow phenomena.
2. To introduce the concept of boundary layers and its applications.
3. To impart knowledge on laminar hydrodynamic and thermal boundary layer equations and solutions.

Course Outcomes:

The student will be able to
1. Identify the relationship between different boundary layer transport phenomena.
2. Explain separation of boundary layer and how it affects the form drag and total drag.
3. Analyze flow fields using exact and approximate solutions of the governing equations
4. Solve the flat plate boundary layer equations by similarity and integral methods.
5. Calculate the boundary layer thickness and calculate skin friction drag
6. Evaluate different options for boundary layer control of aerodynamic systems

Module: 1	**REVIEW OF GOVERNING EQUATIONS**	**6 Hours**
Description of Flow fields, Continuity, Stress-Strain rate relationship, Law of conservation of momentum Stokes Hypothesis, Navier-Stokes equations.		
Module: 2	**EXACT SOLUTIONS OF NAVIER-STOKES EQUATIONS**	**8 Hours**

Concept of Fully Developed Flow, Entrance Length, Plane Poiseuille Flow, Couette Flow, Poiseuille Flow, Flow of Immiscible fluids in a Channel.		
Module: 3	**LAMINAR BOUNDARY LAYER EQUATIONS**	**10 Hours**
Boundary Layer Concept, Order of Magnitude Analysis, Boundary Layer equations, Wall friction, Separation and Displacement, Plate boundary layer. Blasius Similarity Solution by Runge Kutta and Semi Analytical Method, Friction Drag, Separation of Boundary Layer over Blunt bodies in Laminar and Turbulent Flow, Integral relations of Boundary Layer-Momentum Integral equation, Energy Integral equation, Advantages of the Integral Method		
Module: 4	**AXISYMMETRIC AND THREE DIMENSIONAL BOUNDARY LAYERS**	**6 Hours**
Hiemenz Flow, Homann Flow, Three–Dimensional Boundary layer on yawed cylinder, Boundary layer of a swept wing.		
Module: 5	**THERMAL BOUNDARY LAYER**	**10 Hours**
Energy Equation, Thermal Boundary Layer, Boundary Layer Energy Equations. Compressible Boundary Layers- Simple Solutions of Energy Equation, Integral methods. Internal flow in Pipes – Hydrodynamic and Thermal considerations, Fully Developed Flows, Graetz problem.		
Module: 6	**BOUNDARY LAYER CONTROL & PRACTICAL ASPECTS**	**5 Hours**
Different Kinds of Boundary Layer Control, Continuous Suction and Blowing-Massive suction, Massive Blowing, Plate flow with uniform suction or blowing.		
CONTENT BEYOND SYLLABUS		
Mangler transformation, Relation between flow over plate and Sharp Cone Develop and execute Matlab/ Python programming to solve boundary value problems for solving boundary layer equations.		
	Total Lectures	**45 Hours**

Text Books

1.	Schlichting, Herrmann, Gersten, Klaus -“Boundary Layer Theory”, 9th edition, Springer-Verlag, 2017
2.	Frank White, “Viscous Fluid flow” – 4th edition, McGraw Hill, 2021.

Reference Books

1.	Introduction to Boundary Layers: https://nptel.ac.in/courses/112/106/112106190/
2.	Boundary layers, Separation and Drag :https://ocw.mit.edu/courses/mechanical-engineering/2-25-advanced-fluid-mechanics-fall-2013/boundary-layers-separation-and-drag/

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

DEPARTMENT OF AEROSPACE ENGINEERING

LIST OF NEW COURSES

Sl. No.	Code No.	Course Title	Credits			
			L	T	P	C
1	20AE2004	Computer Aided Aircraft Drawing	0	0	4	2
2	20AE2005	Strength of Materials	3	0	0	3
3	20AE2006	Strength of Materials Laboratory	0	0	2	1
4	20AE2007	Engineering Thermodynamics	3	0	0	3
5	20AE2008	Thermodynamics and Heat Transfer Laboratory	0	0	4	2
6	20AE2009	Aerodynamics	3	0	0	3
7	20AE2010	CAD/CAM Laboratory	0	0	4	2
8	20AE2011	Aerospace Structures-I	3	0	0	3
9	20AE2012	Propulsion-I	3	0	0	3
10	20AE2013	Propulsion Laboratory	0	0	2	1
11	20AE2014	Airplane Performance	3	0	0	3
12	20AE2015	Aerodynamics Laboratory	0	0	2	1
13	20AE2016	Introduction to Aerospace Materials	3	0	0	3
14	20AE2017	Gas Dynamics	3	0	0	3
15	20AE2018	Aircraft Instrumentation and Avionics	3	0	0	3
16	20AE2019	Space Dynamics	3	0	0	3
17	20AE2020	Aerospace Structures-II	3	0	0	3
18	20AE2021	Aerospace Structures and Composite Laboratory	0	0	4	2
19	20AE2022	Propulsion-II	3	0	0	3
20	20AE2023	Computational Fluid Dynamics	3	0	0	3
21	20AE2024	Computational Fluid Dynamics Laboratory	0	0	2	1
22	20AE2025	Aircraft Stability and Control	3	0	0	3
23	20AE2026	Flight Stability and Aero Modelling Laboratory	0	0	2	1
24	20AE2027	Finite Element Analysis	3	0	0	3
25	20AE2028	Finite Element Analysis Laboratory	0	0	2	1
29	20AE2029	Aircraft Design Project	0	0	8	4
30	20AE2030	Technical Aptitude	1	0	0	1
31	20AE2031	Helicopter Aerodynamics	3	0	0	3
32	20AE2032	Theory of Elasticity	3	0	0	3
33	20AE2033	Design and Analysis of Composite Structures	3	0	0	3
34	20AE2034	Introduction to Non Destructive Testing	3	0	0	3
35	20AE2035	Structural Vibration	3	0	0	3
36	20AE2036	Aeroelasticity	3	0	0	3
37	20AE2037	Cryogenic Propulsion	3	0	0	3
38	20AE2038	Rocket and Missiles	3	0	0	3
39	20AE2039	Advanced Space Dynamics	3	0	0	3
40	20AE2040	Air Traffic Control and Aerodrome Details	3	0	0	3
41	20AE2041	Aircraft Systems	3	0	0	3
42	20AE2042	Basics of Acoustics	3	0	0	3
43	20AE2043	Experimental Stress Analysis	3	0	0	3
44	20AE2044	Boundary Layer Theory	3	0	0	3
45	20AE2045	Introduction to Hypersonic Flows	3	0	0	3
46	20AE2046	Fatigue and Fracture Mechanics	3	0	0	3
47	20AE2047	Fundamentals of Combustion	3	0	0	3
48	20AE2048	Unmanned Aircraft Systems	3	0	0	3
49	20AE2049	Industrial Aerodynamics	3	0	0	3
50	20AE2050	Navigation, Guidance and Control of Aerospace Vehicles	3	0	0	3
51	20AE2051	Aircraft Instrumentation and Control Laboratory	0	0	2	1
52	20AE2052	Wind tunnel Techniques	3	0	0	3
53	20AE2056	Basics of Aerospace Engineering	3	0	0	3
54	20AE2057	Road Vehicle Aerodynamics	3	0	0	3
55	20AE2058	Wind Turbine Design	3	0	0	3
56	20AE2059	Building Aerodynamics	3	0	0	3
57	20AE2060	Introduction to Unmanned Aircraft Systems	3	0	0	3

58	20AE2061	Foundations of Space Engineering	3	0	0	3
59	20AE2062	Heat and Mass Transfer	3	0	0	3
60	20AE3001	High Speed Jet Flows	3	0	0	3
61	21AE3001	Advanced Aerodynamics	3	0	0	3
62	21AE3002	Advanced Structural Analysis	3	0	0	3
63	21AE3003	Advanced Aerodynamics Laboratory	0	0	2	1
64	21AE3004	Structural Analysis Laboratory	0	0	2	1
65	21AE3005	Elements of Data Analytics	2	0	0	2
66	21AE3006	Advanced Propulsion Technologies	3	0	0	3
67	21AE3007	Modeling and Simulation of Aerospace Vehicles	3	0	0	3
68	21AE3008	Advanced Propulsion Laboratory	0	0	2	1
69	21AE3009	Advanced Avionics	3	0	0	3
70	21AE3010	Advanced Aircraft Materials	3	0	0	3
71	21AE3011	Simulation and Model based Systems Engineering	3	0	0	3
72	21AE3012	Aviation 4.0	3	0	0	3
73	21AE3019	Gas Turbine Technology	3	0	0	3
74	21AE3020	Rotor Dynamics	3	0	0	3

Course code	COMPUTER AIDED AIRCRAFT DRAWING	L	T	P	C
20AE2004		0	0	4	2

Course Objectives:

Impart knowledge on

1. Basic commands in drawing software.
2. Drawing basic shapes.
3. Reading and understanding the 2D drawings.

Course Outcomes:

The student will be able to

1. Understand the basic commands in modeling software.
2. Draw the basic shapes using AutoCAD.
3. Understand drawing the basic shapes.
4. Dimension the parts.
5. Read the drawing from three orthographic views.
6. Draw aircraft components.

List of Experiments

1.	Projection of Points and Lines
2.	Angle of Projections and Sectional views of simple geometries.
3.	Methods of Drawing Lines.
4.	Methods of Drawing Circles.
5.	Methods of Drawing Arcs.
6.	Application of Arcs.
7.	Rectangular and Polar Array.
8.	Application of Polar Array Command.
9.	Dimensioning and layers.
10.	Drawing of 2D wing structure - surface modelling.
11.	Drawing of three views of a RC aircraft.
12.	Drawing of three views of an aircraft
13	Solid Modelling and Details on drawing (Tolerance and Materials).
Total Lectures	**30 Hours**

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	STRENGTH OF MATERIALS	L	T	P	C
20AE2005		3	0	0	3

Course Objectives:

Impart knowledge on

1. Properties of conventional metals.

2. Stresses and strains due to different loading. 3. Deflection of the beam and shaft under different loading conditions.		
Course Outcomes:		
The student will be able to 1. Describe the characteristics of conventional metals. 2. Understand the effect loads acting at different sections of the beam. 3. Calculate the stresses developed in beams. 4. Compare different methods of beam deflection. 5. Analyze the stresses developed in the shaft and spring. 6. Analyze the states of stress in a 2D oblique plane.		
Module: 1	**AXIAL LOADING AND CONCEPT OF STRESSES AND STRAINS**	**8 Hours**
Normal stress and strain, Mechanical properties of materials, Study of stress-strain curves for steel and aluminium, Elasticity, Hooke's Law, Poisson's ratio, Volumetric strain, Bulk modulus, Analysis of uniform, Varying cross sections bars and composite bars, Thermal stresses in bars.		
Module: 2	**ANALYSIS OF BEAMS**	**8 Hours**
Types of Beams, Supports and loads. Shear force and bending moment diagram for different beams carrying point, uniformly distributed and gradually varying loads.		
Module: 3	**STRESSES IN BEAMS**	**8 Hours**
Bending equation and assumptions, Bending stress, Shear stress due to bending, Pure bending.		
Module: 4	**DEFLECTION OF BEAMS**	**7 Hours**
Relationship between deflection, Slope, Radius of curvature, Shear force and bending moment, Deflection by double integration method and Area moment method.		
Module: 5	**TORSION OF SHAFTS AND SPRINGS**	**7 Hours**
Torque equation, Shear stress produced in a shaft, Torque and power transmitted by a solid and circular shaft, Strength of a shaft, Types of spring, Shear stress in springs.		
Module: 6	**IN-PLANE STRESSES AND THIN PRESSURE VESSELS**	**7 Hours**
Principle planes and stresses, Analytical and graphical methods for determining stresses on oblique section, Eigen values and Eigen vectors of stress tensor, Thin cylindrical and spherical vessels subjected to internal pressure.		
CONTENT BEYOND SYLLABUS		
Curved beams. 3D-Mohr's circle.		
	Total Lectures	**45 Hours**

Text Books

1.	James M. Gere, Barry J. Goodno, "Mechanics of Materials", 8th edition, Cengage Learning India Pvt. Ltd, 2013
2.	H.J. Shah, S.B. Junnarkar, Mechanics of Structures Vol 1, 31st edition, Charotar, 2014.

Reference Books

1.	Stephen Timoshenko, "Strength of Materials: Elementary Theory and Problems", 3rd edition, CBS Publishers &Distributors PVT.LTD, 2002.
2.	Rajput R K, "Strength of Materials", S Chand & Co Ltd, New Delhi, 2006.
3.	Sun C T, "Mechanics of Aircraft Structures", Wiley, India, 2010.
4.	Dr Sadhu Singh, "A Textbook on Strength of Materials", Khanna Publishers Pvt. Ltd, New Delhi, 2013.
5.	Bansal R K., "Strength of Materials", Laxmi Publishing Co, New Delhi, 2007.
6.	Ramamurtham. S. "Strength of Materials" Dhanpat Rai Publishing Co, New Delhi, 2008.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	STRENGTH OF MATERIALS LABORATORY	L	T	P	C
20AE2006		0	0	2	1

Course Objectives:

Impart knowledge on

1. Structural mechanics of real specimens.
2. Training and testing of real specimens.
3. Nature of failure in materials.

Course Outcomes:

The student will be able to

1. Determine properties of materials.
2. Characterize materials behavior.
3. Verify theorems in structural mechanics.
4. Understand the structural behavior based on various loads, supports and shape.
5. Estimate stiffness of springs.
6. Choose materials based on requirement.

List of Experiments

1.	Tensile Test of solid rod using Universal Testing Machine.
2.	Verification of Maxwell Theorem on Cantilever Beam.
3.	Verification of Maxwell Theorem on Simply Supported Beam.
4.	Torsion Test of shaft and Beam.
5.	Rockwell's Hardness Test.
6.	Brinell's Hardness Test.
7.	Vickers Hardness Test.
8.	Charpy's Impact Test.
9.	Izod Impact Test.
10.	Compression of open coil helical spring.
Total Lectures	**15 Hours**

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	ENGINEERING THERMODYNAMICS	L	T	P	C
20AE2007		**3**	**0**	**0**	**3**

Course Objectives:

Impart knowledge on

1. A comprehensive and rigorous treatment of classical thermodynamics while retaining an engineering perspective.
2. An intuitive understanding of thermodynamic systems by emphasizing physical arguments and the feasibility of engineering solutions.
3. Real world engineering examples to give students a feel for how thermodynamics is applied to practical engineering problems.

Course Outcomes:

The student will be able to

1. Understand the basic concepts of thermodynamics, laws of thermodynamics and types of work and heat interactions.
2. Evaluate the properties of pure substances, ideal gases and real gases from property tables or state equations.
3. Apply the first law of thermodynamics for closed and open systems undergoing different thermodynamic processes and cycles.
4. Understand the concept of entropy and properties of pure substances and real gases
5. Perform energy calculations of engineering systems and analyze the feasibility of the processes undergone by the systems.
6. Evaluate the efficiency of efficiency and co-efficient of performance of thermal systems and vapor power cycles.

Module: 1	BASIC DEFINITIONS AND ENERGY INTERACTIONS	3 Hours

Thermodynamics - definition and scope, Microscopic and Macroscopic approaches, Thermodynamic properties; intensive, extensive properties, Thermodynamic state, path and point function, Quasi-static process, cyclic and non-cyclic processes, Thermodynamic equilibrium, definition, Thermodynamic definition of work; examples, sign convention, Shaft work; Electrical work, Heat and work exchange with a system, units and sign convention, Zeroth law of thermodynamics, Temperature; concepts, scales, - thermometer, Joules experiments, First law of thermodynamics, steady state-steady flow energy equation, applications.		
Module: 2	**PROPERTIES OF PURE SUBSTANCES**	**3 Hours**
Ideal gas equation, Compressibility, Universal Compressibility chart, Pure Substances, PVT Surfaces, PV, TV, and PT diagrams of water and other substances and differences of the same, Phase-change processes, Concept of Vapor Pressure, Properties of steam, Saturation temperature and pressure, Use of property tables, TS diagrams, Mollier Chart.		
Module: 3	**FIRST LAW OF THERMODYNAMICS**	**6 Hours**
First law of thermodynamics, Applications to closed and open systems, Uniform and non-uniform processes, Steady state and unsteady state processes, General energy equation and applications to thermal equipment.		
Module: 4	**SECOND LAW OF THERMODYNAMICS**	**15 Hours**
Kelvin –Planck & Clausius statement of Second law of Thermodynamics, PMM I and PMM II, Carnot cycle, Carnot theorem, Thermodynamic temperature scale, Deduction of the third law of thermodynamics , Types of Irreversibility, Available and unavailable energy, Refrigeration and Heat Pump, Clausius theorem, Property of Entropy, Clausius inequality, Entropy principle, Applications of entropy principle, Maximum work obtainable from finite heat reservoirs, Entropy generation in closed and open systems, Isentropic processes, Entropy balance, Isentropic work in a steady flow open system, Available energy referred to a cycle, Maximum work in a reversible process, Reversible work-open cycle and closed system, Availability and Irreversibility, Second law efficiency.		
Module: 5	**THERMODYNAMIC RELATIONS**	**9 Hours**
Properties of ideal gases, Equations of state, Law of corresponding states, Properties of mixtures, Thermodynamic relations, Maxwell's equations, Joule Kelvin effect, Clausius-Clapeyron equation, Avogadro's law, Equation of state of a gas - Ideal gas – Compressibility factor for real gases, Equations of state, virial expansions - Law of corresponding states - Properties of mixtures – Dalton's Law of partial pressures - Properties of gas mixtures.		
Module: 6	**POWER AND REFRIGERATION CYCLES**	**9 Hours**
Air cycles, Air standard efficiency, Gas power cycles, Rankine cycle, Vapor compression and vapor absorption refrigeration cycle.		
CONTENT BEYOND SYLLABUS		
Proeprties of air, Psychrometry, Air conditioning and cooling load calculations		
	Total Lectures	**45 Hours**

Text Books	
1.	Yunus Cengel & Michael Boles , Thermodynamics – An Engineering Approach, McGraw Hill Education (India), 9th edition, 2019.
2.	Nag P K, "Engineering Thermodynamics", McGraw Hill Education (India), 6th edition, 2017
Reference Books	
1.	Sonntag, Borgnakke, Van Wylen, Fundamentals of Thermodynamics, Wiley India, SI Edition, 2020
2.	Moran, Shapiro, "Fundamentals of Engineering Thermodynamics", Wiley, 8th edition, 2015
3.	Zemansky, Dittman, Heat and Thermodynamics, McGraw Hill Education (India), 8th edition, 2017
4.	https://nptel.ac.in/courses/112/108/112108148/
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**THERMODYNAMICS AND HEAT TRANSFER LABORATORY**	**L**	**T**	**P**	**C**
20AE2008		0	0	2	1
Course Objectives:					
Impart knowledge on 1. Performance evaluation of heat engines, Refrigeration and air-conditioning systems.					

2. Performance characteristics of blower and compressor. 3. Conducting experiments on various modes of heat transfer.			
Course Outcomes:			
The student will be able to 1. Evaluate the performance of refrigeration, heat pump and air–conditioning cycles. 2. Analyze the efficiency and performance of two stage reciprocating air compressor. 3. Calculate and compare the performance parameters of air blower. 4. Calculate and compare the thermal conductivity of different materials. 5. Predict the convective heat transfer coefficient by free convection. 6. Evaluate the performance of radiation from black and gray bodies.			
List of Experiments			
1.	Measurement of coefficient of performance in a vapour compression refrigeration cycle.		
2.	Measurement of coefficient of performance in a heat pump apparatus.		
3.	Determination of coefficient of performance in air–conditioning cycle.		
4.	Measurement of performance parameters of an air blower.		
5.	Measurement of performance parameters on two stage reciprocating air compressor.		
6.	Measurement of thermal conductivity through a composite wall.		
7.	Measurement of thermal conductivity in a lagged pipe.		
8.	Determination of thermal conductivity in a guarded plate.		
9.	Measurement of heat transfer coefficient in a vertical cylindrical rod by free convection.		
10.	Measurement of heat transfer coefficient in a flat plate by natural convection.		
11.	Determination of heat transfer coefficient in a pin–fin by free convection.		
12.	Determination of heat transfer coefficient in a pin–fin by forced convection.		
13.	Measurement of heat transfer coefficient in a forced convection apparatus.		
14.	Determination of emissivity of a given test surface.		
15.	Determination of Stefan–Boltzmann constant in radiation heat transfer.		
16.	Determination of overall heat transfer coefficient in parallel flow heat exchangers.		
17.	Determination of overall heat transfer coefficient in counter flow heat exchangers.		
		Total Lectures	**30 Hours**
The faculty conducting the laboratory will prepare a list of minimum 12 experiments and get the approval of HoD and notify it at the beginning of the semester.			
Recommended by Board of Studies			
Approved by Academic Council	25th September 2021		

Course code	**AERODYNAMICS**	**L**	**T**	**P**	**C**
20AE2009		3	0	0	3
Course Objectives:					
Impart knowledge on 1. Basics of air flow. 2. Flow over aerofoils and wings. 3. Forces and moments over an aerofoil.					
Course Outcomes:					
The student will be able to 1. Understand the aerodynamic variables connected with airflow. 2. Understand the concept of basic flows and its characteristics. 3. Develop the knowledge of incompressible flow over airfoil. 4. Assess the flow field over a finite wing span. 5. Estimate the flow parameters over aircraft wings and fuselages. 6. Understand the concept of the boundary layer and its characteristics.					
Module: 1	**FUNDAMENTALS PRINCIPLES AND EQUATIONS**	**9 Hours**			
Fundamental aerodynamic variables- Aerodynamic forces and moments- Centre of pressure- Aerodynamics Centre, Types of flow- Gradient of Scalar and vector fields- Line- surface and volume integrals and the relationships between them. Conservation laws – Conservation of mass - Conservation of linear momentum equation and drag of a two dimensional body – Energy equation.					
Module: 2	**FUNDAMENTALS OF INCOMPRESSIBLE AND INVISCID FLOWS**	**7 Hours**			

Euler and Bernoulli's Equation, Pitot static tube; Relation between stream function and velocity potential function. Laplace Equation. Elementary flows- non-lifting and lifting flow over cylinders. Kutta – Joukowski theorem and generation of lift.		
Module: 3	**INCOMPRESSIBLE FLOW OVER AIRFOIL**	**8 Hours**
Joukowski transformation and conformal mapping. -Airfoil characteristics. The concept of vortex sheet- The Kutta condition. Kelvin's circulation theorem. Introduction to classical thin airfoil theory – symmetric and cambered airfoil.		
Module: 4	**INCOMPRESSIBLE FLOW OVER FINITE WINGS**	**7 Hours**
Down wash and induced drag. Vortex filament, Helmholtz theorems. Biot-Savart law. Prandtl's classical lifting line theory - Elliptic lift distribution. Aerodynamics of delta wings- Leading edge extensions – Asymmetric loads on fuselage at high angle of attack- Flow field of aircrafts at high angle of attack- Factors affecting lift at low subsonic speeds.		
Module: 5	**NUMERICAL METHODS**	**7 Hours**
2-D Panel Methods-Source panel method-vortex panel methods, Vortex Lattice Methods.		
Module: 6	**BOUNDARY LAYERS**	**7 Hours**
Introduction to boundary layers and Reynolds number effects. Development of boundary layer equations. Boundary layer thickness- Displacement thickness – Momentum thickness – Energy thickness. Momentum integral theorem and applications.		
CONTENT BEYOND SYLLABUS		
Helicopter aerodynamics and ground effect.		
	Total Lectures	**45 Hours**

Text Books	
1.	John D. Anderson, Jr., "Fundamentals of Aerodynamics", Sixth edition, McGraw-Hill publications, 2016.
2.	E. Rathakrishnan., "Theoretical Aerodynamics", John Wiley & Sons, 2013.
Reference Books	
1.	E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012.
2.	L.M Milne Thomson, "Theoretical Aerodynamics", 1996.
3.	Jan Roskam, Chuan-Tau Edward Lan, Airplane Aerodynamics and Performance, DAR Corporation, 1997.
4.	John J Bertin, "Aerodynamics for Engineers", Sixth edition, Edward Arnold publications, 2012.
5.	https://www.edx.org/course?search_query=Aerodynamics.
6.	http://www.nptel.ac.in/courses/101105059/.
7.	https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-100-aerodynamics-fall-2005/.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	CAD/CAM LABORATORY	L	T	P	C
20AE2010		0	0	4	2

Course Objectives:

Impart knowledge on

1. The usage of computer in design and manufacturing.
2. Visualization of objects in three dimensions and producing orthographic, sectional and auxiliary views of it.
3. Drafting of simple components.

Course Outcomes:

The student will be able to

1. Understand CAD packages like Solid Works.
2. Develop 2D and 3D aircraft parts.

3. Create parts and assemble these for functional assembly. 4. Draw the drafting diagram for manufacturing. 5. Write CNC Program for different machining process. 6. Obtain hands-on experience of CNC manufacturing		
List of Experiments		
Computer Aided Design (CAD)		
1.	2D Sketch.	
2.	Solid Modelling.	
3.	Surface modelling.	
4.	Sheet Metal Design.	
5.	Assembly of the Aircraft parts.	
6.	Drafting of Different parts.	
Computer Aided Manufacturing (CAM)		
1.	CNC -Profile cut using Linear and circular interpolation codes.	
2.	CNC - Step turning.	
3.	CNC - Taper turning.	
4.	CNC - Circular pocketing and slotting.	
5.	CNC – Drilling.	
6.	CNC -Thread cutting.	
	Total Lectures	**30 Hours**
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**AEROSPACE STRUCTURES-I**	**L**	**T**	**P**	**C**
20AE2011		3	0	0	3
Prerequisite: 20AE2005 Strength of Materials					
Course Objectives:					
Impart knowledge on 1. Linear static analysis of determinate and indeterminate aircraft structural components. 2. Advanced concepts in the stress analysis of aircraft structures. 3. Column theory and practical column design.					
Course Outcomes:					
The student will be able to 1. Determine the forces of each member in a truss. 2. Analyze statically indeterminate beam under different support/ loading conditions. 3. Find the deflection of an elastic structure based on strain energy of the structure. 4. Analyze the indeterminate trusses using energy method. 5. Compare the buckling of columns with different support conditions. 6. Predict failure of the structures made of conventional metals.					
Module: 1	**STATICALLY DETERMINATE STRUCTURES**	**7 Hours**			
Analysis of plane truss. Method of joints. 3D-truss. Plane frames.					
Module: 2	**STATICALLY INDETERMINATE STRUCTURES**	**7 Hours**			
Shear force and bending moment diagram statically indeterminate beams. Clapeyron's three moment equation. Moment distribution method.					
Module: 3	**ENERGY METHODS APPLICABLE TO BEAMS**	**8 Hours**			
Strain energy due to axial, bending and torsional loads. Castigliano's theorem. Unit load method – application to beams.					
Module: 4	**ENERGY METHODS APPLICABLE TO TRUSSES**	**8 Hours**			
Indeterminate trusses – Redundant member forces - unit load method, dummy load method.					
Module: 5	**BUCKLING OF COLUMNS**	**7 Hours**			
Columns with various end conditions. Euler's buckling load. Rankine's formula. Columns with initial curvature. South well plot.					
Module: 6	**THEORIES OF FAILURE**	**8 Hours**			

Failure of ductile and brittle Materials, Theories of failure, maximum normal stress, maximum shear stress theory, distortion energy theory, octahedral shear stress failure theory. Failure Envelopes.	
CONTENT BEYOND SYLLABUS	
Fatigue failure of structures made of conventional metals and composite materials.	
Total Lectures	**45 Hours**

Text Books	
1.	Megson, T.H.G., "Aircraft Structures for Engineering Students", Sixth edition, Elsevier Ltd, 2016.
2.	David.J. Peery, "Aircraft Structures", McGraw–Hill, N.Y., 2012.
Reference Books	
1.	Donaldson B K, "Analysis of Aircraft Structures", Cambridge Aerospace Series, 2008.
2.	Aslam Kassimali, "Structural Analysis", Fourth edition, Cengage Learning, 2015.
3.	E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 1980.
4.	Rajput R K, "Strength of Materials",S.Chand (P)LTP, 2006.
5.	G Lakshmi Narasaiah "Aircraft Structures", BS Publications,2010.
6.	Sun C T, "Mechanics of Aircraft Structures", Wiley India,2010.
7.	Introduction to Aerospace Structures and Materials: https://www.edx.org/course/introduction-to-aerospace-structures-and-materials.
8.	Structural Mechanics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-20 structural-mechanics-fall-2002/.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**PROPULSION-I**	**L**	**T**	**P**	**C**
20AE2012		3	0	0	3

Course Objectives:

Impart knowledge on
1. Aircraft propulsion systems.
2. Working principles of compressors, combustion chamber and turbines.
3. Concept of matching of compressors and turbines and off design performance.

Course Outcomes:

The student will be able to
1. Estimate the performance of Brayton cycle.
2. Analyze the performance of various air breathing engines.
3. Understand the working of sub-systems of jet engines.
4. Assess the performance of compressor and turbine
5. Evaluate combustion chamber, cooling and afterburner performance.
6. Understand the procedure for matching compressor and turbine.

Module: 1	**FUNDAMENTALS OF AIR-BREATHING ENGINES**	**7 Hours**
Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, cycle analysis jet engines. Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust.		
Module: 2	**AIR-BREATHING ENGINES PERFORMANCE**	**8 Hours**
Efficiency and engine performance of turbojet, turboprop, turbo shaft, turbofan and ramjet engines, thrust augmentation of turbojets and turbofan engines. Principles of pulsejets and ramjets, thermodynamic cycle, performance parameters.		
Module: 3	**CENTRIFUGAL COMPRESSOR**	**7 Hours**
Thermodynamics of compressors, types of compressor, centrifugal compressor: centrifugal compressor stage dynamics, inducer, impeller, diffuser, work done and pressure rise, velocity diagrams.		
Module: 4	**AXIAL COMPRESSOR**	**7 Hours**
Angular momentum, work and compression, characteristic performance of a single axial compressor stage, efficiency of the compressor and degree of reaction, velocity triangles, degree of reaction.		
Module: 5	**COMBUSTION CHAMBERS**	**7 Hours**
Classification of combustion chambers, important factors affecting combustion chamber design, combustion process, combustion chamber performance, effect of operating variables on performance, fuels and their		

properties, fuel injection systems, flame tube cooling, flame stabilizers, application of flame holders and after burners.		
Module: 6	**TURBINES**	**9 Hours**
Thermodynamics of turbines, types of turbines, principle of operation of axial and radial turbine, turbine design considerations, performance parameters, turbine stage efficiency, basics of blade design principles, choice of blade profile, pitch and chord. impulse and reaction blading of gas turbines, velocity triangles and power output. Estimation of stage performance, limiting factors in gas turbine design, overall turbine performance, methods of blade cooling		
CONTENT BEYOND SYLLABUS		
To estimate the effect of various fuel on the performance parameter.		
	Total Lectures	**45 Hours**

Text Books

1.	V. Ganesan, “Gas Turbines”, Tata Mc Graw - Hill Publishing Company Ltd, 2010.
2.	Ahmed F. El-Sayed “Aircraft Propulsion and Gas Turbine Engines” CRC press, 2017

Reference Books

1.	Irwin E. Treager, `Gas Turbine Engine Technology`, GLENCOE Aviation Technology Series, 7th Edition, Tata McGraw Hill Publishing Co. Ltd. Print 2003.
2.	Cohen, H, Rogers. G.F.C. and Saravanamuttoo. H.I.H., “Gas Turbine Theory”, Pearson Education, 1989.
3.	Mathur. M.L, and Sharma. R.P., “Gas Turbine, Jet and Rocket Propulsion”, Standard Publishers & Distributors, Delhi, 1999.
4.	Jet Aircraft Propulsion: http://nptel.ac.in/courses/101101002/.
5.	Aerospace Propulsion: http://nptel.ac.in/courses/101106033/.
6.	Introduction to Propulsion Systems: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsion-systems-spring-2012/index.htm.
7.	Internal Flows in Turbomachines: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-540-internal-flows-in-turbomachines-spring-2006/.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**PROPULSION LABORATORY**	**L**	**T**	**P**	**C**
20AE2013		0	0	2	1

Course Objectives:

Impart knowledge on

1. Basic concepts and operation of various parts of jet engine.
2. Operation of various propulsion systems.
3. Shock waves.

Course Outcomes:

The student will be able to

1. Understand the working of jet engine.
2. Estimate the calorific value of solid and liquid fuels.
3. Estimate the performance of injector.
4. Evaluate the performance of axial compressor blades.
5. Estimate ignition delay of fuels using shock tube.
6. Evaluate the performance of nozzle.

List of Experiments

1.	Study of an aircraft jet engine
2.	To determine injector performance of single element injector
3.	Shock speed measurement for various gases using shock tube
4.	Ignition delay studies of hydrocarbon fuels using shock tube.
5.	Cascade testing of a model for axial compressor blade row (symmetrical)
6.	Cascade testing of a model for axial compressor blade row(cambered)
7.	To estimate C-D nozzle performance in high altitude test facility.
8.	Study of turbine and compressor blades by making wooden models.
9.	Measurement of premix flame velocity.
Total Lectures	**15 Hours**

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.	
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**AIRPLANE PERFORMANCE**	**L**	**T**	**P**	**C**
20AE2014		3	0	0	3

Course Objectives:		
Impart knowledge on 1. The concepts of flight performance. 2. Various parameters affecting the performance. 3. Various theories of propeller analysis and design.		
Course Outcomes:		
The student will be able to 1. Understand the preliminary design of aircraft based on the performance. 2. Differentiate performance characteristics of jet engine from propeller engine. 3. Estimate the performance characteristics in level flight. 4. Assess the climbing performance characteristics of aircraft. 5. Estimate the turning performance characteristics of aircraft. 6. Realize the ground effects on performance.		
Module: 1	**BASICS OF AERODYNAMICS AND WING GEOMETRY**	**7 Hours**
Introduction – Source of aerodynamics force- Aerodynamic lift, drag component- Aerodynamic center. Effects of the Reynolds number. Lift for finite wing- Wing body combination. Drag- Types-Reduction techniques, Drag polar, High Lifting Devices.		
Module: 2	**EFFECTS OF ENGINE CHARACTERISTICS ON PERFORMANCE**	**8 Hours**
Introduction – Performance – Variation of power and specific fuel consumption with Velocity and Altitude –Reciprocating Engines – Gas Turbine Engines. Propeller- momentum theory- Factors affecting propeller performance- Prediction of propeller performance- Propeller Noise, Propeller selection.		
Module: 3	**PERFORMANCE CHARACTERISTICS OF LEVEL FLIGHTS**	**8 Hours**
Steady Level Flight –Fundamental Parameters - Equation of motion-Thrust Required-Fundamental Parameters-Thrust available and maximum speed- Power Required- Power available and maximum speed -Effect of Drag Divergence on Maximum Velocity- Minimum Drag Condition.		
Module: 4	**PERFORMANCE CHARACTERISTICS OF CLIMBING FLIGHTS**	**8 Hours**
Range and Endurance –Breguet formula, Rate of climb –Introduction- Graphical method- Analytical method-Maximum Climb Angle- Maximum Rate of Climb- Angle of climb and their variations with altitude- Effect of wind on Rate of Climb-Absolute ceiling and service ceiling ; Hodograph, Factors Influencing the Rate of Climb - Gliding Flight Maneuvering in the Vertical Plane.		
Module: 5	**TURNING CHARACTERISTICS**	**7 Hours**
Introduction- Level Turn- Minimum Turn Radius- Maximum Turn Rate- Instantaneous turn-Pull up and Pull down maneuvers, Cobra Maneuver, V-n diagram.		
Module: 6	**TAKEOFF AND LANDING CHARACTERISTICS**	**7 Hours**
Introduction to Take-off, Estimation of take-off distance-ground roll, obstacle clearing distance and height, Take off assist devices –Spoilers and landing distance–approach distance and flare distance.		
CONTENT BEYOND SYLLABUS		
Design of Propeller driven and Jet propelled Aircraft.		
	Total Lectures	**45 Hours**

Text Books	
1.	Anderson, J D, “Aircraft performance and Design”, McGraw-Hill, New York, 2000.
2.	Roskam, Jan and Lan, Chuan-tau E, “Airplane Aerodynamics and Performance”, DAR Corporation, Lawrence, Kansas, USA, 1997.
3.	Kundu, A K, Price, M A, Riordan, D, “Theory and Practice of Aircraft Performance” John Wiley & Sons, Ltd, 2016.

Reference Books	
1.	Perkins, C D and Hage, R E; “Airplane Performance Stability and Control”, Willey Toppan, 2010.
2.	Houghton, E L, Carpenter, P W, Steven, H C, Valentine, D T,"Aerodynamics for Engineering students", Seventh edition, Edward Arnold publications, 2015.
3.	Filippone, A, “Advanced Aircraft Flight Performance, Cambridge University Press, 2012.
4.	David G. Hull, “Fundamentals of Airplane Flight Mechanics” Springer-Verlag BerlinHeidelberg 2007.
5.	Sadraey, M H,” Aircraft Performance-An Engineering Approach” CRC Press NW, 2017.
6.	Saarlas, M, “Aircraft Performance” John Wiley & Sons, New Jersey, 2007.
7.	Flight Dynamics I: Airplane Performance- https://nptel.ac.in/courses/101/106/101106041/.
8.	Introduction to airplane performance- https://nptel.ac.in/courses/101/104/101104061/
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	AERODYNAMICS LABORATORY	L	T	P	C
20AE2015		0	0	2	1

Course Objectives:

Impart knowledge on

1. Flow over aerofoils and wings.
2. Forces and moments over an aerofoil.
3. Shock wave over various model.

Course Outcomes:

The student will be able to

1. Understand the aerodynamic variables connected with airflow.
2. Draw pressure distribution over various aerofoils.
3. Visualize subsonic flow over various models.
4. Estimate effect of Reynolds number of low speed airfoil.
5. Evaluate the forces and moments over aircraft model.
6. Visualize shock wave and estimate shock angle over various model.

List of Experiments	
1.	Subsonic wind tunnel characteristics and estimation of pressure drop.
2.	The pressure distribution over a symmetric and cambered aerofoil.
3.	Smoke and Tuft flow visualization of symmetric and cambered aerofoil.
4.	Estimation of the Lift and drag of symmetric and cambered aerofoil.
5.	The pressure distribution over a cascade aerofoil.
6.	Identify the trailing vortices over a rectangular wing using smoke and tuft flow visualization technique.
7.	Force and moment measurements of rectangular wing.
8.	Smoke and tuft flow visualization Flow visualization over a car, building and aircraft using Water tunnel facility.
9.	Boundary layer calculation in the test section of subsonic wind tunnel.
10.	Effect of varying Reynolds number on airfoil using subsonic wind tunnel.
11.	Runtime calculation of supersonic wind tunnel for different Mach.
12.	Flow visualization over a sharp and blunt cone model using Schlieren technique.
13.	Flow visualization over a double wedge model using Schlieren technique.
14.	Flow visualization over a sharp and blunt cone model using shadowgraph technique.
15.	Flow visualization over a double wedge model using shadowgraph technique.
16.	Flow visualization over a sharp and blunt edge delta wing model using shadowgraph and Schlieren technique.
17.	Effect of back pressure study of C-D nozzle using Open Jet Facility.
18.	MATLAB assignment related to Vortex Lattice Method (VLM).
	Total Lectures **15 Hours**

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	INTRODUCTION TO AEROSPACE MATERIALS	L	T	P	C
20AE2016		3	0	0	3

Course Objectives:

Impart knowledge on
1. Crystal structure and microstructures of metals and alloys.
2. Aerospace materials properties.
3. Material characterization.

Course Outcomes:

The student will be able to
1. Explain the influenced of microstructure on mechanical properties of metals and alloys.
2. Understand the material properties.
3. Classify different materials.
4. Identify the testing method of materials.
5. Select the right material for particular applications.
6. Develop new material combinations based on requirement.

Module: 1	INTRODUCTION TO AEROSPACE MATERIALS	8 Hours

Introduction, Nature of metallic bonding, Crystal structures of metals, structure of alloys, Imperfections in crystals, experimental study of structure. Phase Diagrams: The Phase rule, Binary phase diagrams, The Iron Carbon Equilibrium diagram, Nomenclature, Classification of Wrought Alloys, Corrosion, Alclad Aluminum Alloys

Module: 2	PROPERTIES ESTIMATION AND APPLICATIONS	8 Hours

Mechanical properties of the materials. Testing: Tension Testing, Hardness Testing Bending Tests, Reverse Bend Test, Flattening Test, Impact Tests: Crushing Tests, Hydrostatic Test, Torsion Test, Fatigue Testing: LCF, HCF, S-N curve, Life Estimation. ASTM Standards for testing materials. Metallic Materials Properties Development and Standardization. Specification of Materials

Module: 3	AERO THERMAL MATERIALS	8 Hours

High Temperature Materials: Historical Development of High Temperature Materials. Requirements of High Temperature Materials: Environmental Resistance, Erosion, Wear, Mechanical Behaviour. Increasing Temperature Capability.

Module: 4	COMPOSITE MATERIALS	7 Hours

Introduction. Classification: Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites. Types of fibers and matrix. Manufacturing glass and carbon fibers. Pre-preg Composites.

Module: 5	PROCESSING OF MATERIALS	7 Hours

Plain Carbon Steels and its alloy: Carbon Steels, Nickel Steels, Nickel-chromium Steels, Molybdenum Steels, Chrome-vanadium Steels, Special Steels: Silicon-chromium Steel; Nitriding Steel; Austenitic Manganese Steel. Heat Treatment of Steel. Aluminum Alloys, Extrusions, Forgings, Spot-welding Aluminum Alloys, HeatTreatment: Heat Treatment of Aluminum-Alloys, Aluminum-Alloy Castings: Sand Casting, Permanent-mold Castings, Die Casting.

Module: 6	MATERIALS USED IN LAUNCH VEHICLES AND SPACECRAFTS	7 Hours

Steels used in solid propellant and liquid propellant rocket motors (15CdV6 Steel, Maraging Steel) Materials used for non-cryogenic liquid propellants, Materials used for storage of cryogenic propellants and pumps, Materials used to make solid propellants and binders, High temperature insulation used for nose cone of launch vehicles and reentry vehicles, Graphene the wonder material and its applications

CONTENT BEYOND SYLLABUS

Shape Memory Alloys

Total Lectures	45 Hours

Text Books

1.	William D. Callister, Jr., David G. Rethwisch, Materials Science and Engineering An Introduction, John Wiley & Sons, Inc.,2018
2.	Raghavan, V. Physical Metallurgy: Principles and Practice‖. PHI Learning, 2015

Reference Books

1.	Cantor, B., Assender, H., and Grant, P. (Eds.), Aerospace Materials, CRC Press 2001.
2.	Reed, R. C., The Superalloys: Fundamentals and Applications, Cambridge Univ. Press 2006.
3.	ASM Speciality Handbook: Heat Resistant Materials, ASM International (1997).
4.	Campbell, F. C., Manufacturing Technology for Aerospace Structural Materials, Elsevier 2006.
5.	Kainer, K. U. (Ed.), Metal Matrix Composites, Wiley-VCH 2006.
6.	George E. Dieter, Mechanical Metallurgy, McGraw-Hili Book Company, 1988
7.	George F. Titterton, “Aircraft Materials and Processes” Himalayan Books, reprinted 2015.
8.	Autar K. Kaw, Mechanics of Composite Materials, Second Edition, CRC Press LLC, 2006.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**GAS DYNAMICS**	**L**	**T**	**P**	**C**
20AE2017		3	0	0	3

Course Objectives:

Impart knowledge on
1. The behavior of compressible fluid flow.
2. The difference between subsonic and supersonic flow.
3. Flow over flying vehicles at subsonic and supersonic speeds.

Course Outcomes:

The student will be able to
1. Understand the influence of compressibility to distinguish between the flow regimes.
2. Apply compressibility corrections for flow in converging-diverging passages and instruments like Pitot static tube.
3. Estimate the sudden changes in the flow field due to normal shocks.
4. Estimate the influence of friction and heat transfer in the flow field.
5. Understand oblique shocks and its effect on supersonic flow fields.
6. Choose proper flow visualization techniques for any given situation.

Module: 1	**INTRODUCTION TO COMPRESSIBLE FLOW**	**5 Hours**

Review of Thermodynamics,Compressibility, Velocity of sound, Speed of travel of a pressure disturbance, Mach Number and Concept of Mach Cone, Entropy Change in Ideal Gas, Basics of Wave propagation, Isentropic relations,

Module: 2	**STEADY ONE DIMENSIONAL FLOW**	**9 Hours**

Discharge from a reservoir, Flow through converging-diverging nozzle, Critical Conditions, Performance under various back pressures and occurrence of normal and oblique shocks, Dynamic head measurement and corrections of Pitot static tube for subsonic and supersonic Mach numbers, Pressure coefficient.

Module: 3	**NORMAL SHOCKS**	**9 Hours**

Equations of motion for normal shock, Prandtl Relation, Hugoniot equation, Propagating shock wave, Reflected shock wave, Centered Expansion Wave, Shock Tube,

Module: 4	**FANNO AND RAYLEIGH FLOW**	**9 Hours**

Influence of Friction on compressible flow, governing equations, relation between flow parameters and length, diameter and friction coefficient of pipe. Limiting Mach number and limiting length of pipe in Fanno Flow, Influence of Heat transfer on compressible flow, governing equations, relation between flow parameters and heat transfer and Limiting Mach number in Rayleigh flow, Maximum heat transfer.

Module: 5	**OBLIQUE SHOCKS AND EXPANSION WAVES**	**8 Hours**

Oblique shocks and corresponding equations, Hodograph and flow turning angle, shock polar, Flow past wedges, Strong, weak and detached shocks, Supersonic Compression and Expansion, Prandtl-MeyerExpansion, Detached shocks, Mach Reflection, Shock Expansion and Thin Airfoil theory

Module: 6	**HIGH SPEED FLOW OVER FINITE WING**	**5 Hours**

Measurement of pressure, temperature, velocity and density in compressible flow, Compressible flow visualization, High speed wind tunnels, Instrumentation and calibration of wind tunnels

CONTENT BEYOND SYLLABUS

Method of Characteristics,Introduction to Rarefied Gas Dynamics and High Temperature Gas Dynamics.		
	Total Lectures	**45 Hours**
Text Books		
1.	Rathakrishnan, E., “Gas Dynamics”, 7th Edition, Prentice Hall of India, 2020.	
2.	Michel Saad, Compressible Fluid Flow, 2nd Edition, Prentice Hall, 2020.	
Reference Books		
1.	Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, New Age International (p) Ltd., 6th Edition, 2018.	
2.	Anderson Jr., D., – “Modern Compressible flows”, McGraw-Hill Book Co., 4th edition, 2020	
3.	Robert D Zucker, Oscar Biblarz, Fundamental of Gas Dynamics, Second Edition, John Wiley &Sons, 2019.	
4.	Liepmann H W and Roshko A, “Elements of Gas Dynamics”, Dover Publications, 2002.	
5.	Shapiro, A.H., “Dynamics and Thermodynamics of Compressible Fluid Flow”, Vol 1 and 2, 1953.	
6.	Zucrow, M.J. and Joe D Hoffman, “Gas Dynamics”, John Wiley & Sons, 1976.	
7.	Compressible Flow: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-120-compressible-flow-spring-2003.	
8.	Gas Dynamics: http://www.nptel.ac.in/courses/101106044/.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**AIRCRAFT INSTRUMENTATION AND AVIONICS**	**L**	**T**	**P**	**C**
20AE2018		3	0	0	3

Course Objectives:

Impart knowledge on

1. Basic concepts of flight instruments, their significance and operation.
2. Concepts of measurements using air data sensor, gyroscope and engine data.
3. Basic concepts and functioning of the avionic system data buses.

Course Outcomes:

The student will be able to

1. Understand the basics of measurements and different parameters.
2. Identify the fundamental cockpit instruments and their working principles.
3. Differentiate various sensors and transducers used in aerospace vehicles.
4. Comprehend the principles behind temperature, pressure, fuel flow and engine measurements.
5. Analyze the functioning of military/civil aircraft data buses and communication process between them.
6. Identify display technologies and their working principles.

Module: 1	**GENERAL CONCEPTS OF MECHANICAL INSTRUMENTATION**	**8 Hours**

Generalized measurement system, Classification of instruments as indicators, recorders and integrators - their working principles, Precision and accuracy: measurement error and calibration, Functional elements of an instrument system and mechanisms.

Module: 2	**CLASSIFICATION OF AIRCRAFT INSTRUMENTS**	**8 Hours**

Classification of aircraft instruments - Air data instruments – pitot static systems and instruments, gyroscopic instruments - Gyroscope and its properties, Vacuum driven systems, Heading instruments.

Module: 3	**AIRCRAFT INSTRUMENTS & SENSORS**	**8 Hours**

Position and displacement transducers and accelerometer, Temperature measuring instruments, Pressure measuring instruments, Engine Instruments, Fuel Quantity measurement, Fuel flow measurement, Position and displacement transducers and accelerometers.

Module: 4	**DIGITAL AVIONICS**	**7 Hours**

Introduction to Avionics, Role for Avionics in Civil and Military Aircraft systems, Avionics sub-systems and design, defining avionics System/subsystem requirements-importance of ‘ilities’ of avionic sub-system, Avionics system architectures. Avionics Flight Deck instruments - CPCS, FMS, FCS, ECS, CMF/CMU, Flight Recorder, Fly-by-wire.

Module: 5	**AVIONICS DATA BUSES**	**7 Hours**

Military and Commercial Data Buses: MIL-STD-1553B, ARINC-429, ARINC-629, CSDB, AFDX and its Elements. AVIONICS DATA BUSES AND PLATFORMS overview, ARINC 653 APEX overview, ARINC 664 AFDX overview, ARINC 661 Display interface, MCDU, MFD, PFD.		
Module: 6	**COCKPIT DISPLAY SYSTEMS**	**7 Hours**
Trends in display technology, Alphanumeric displays, character displays etc., Civil and Military aircraft cockpits, MFDs, MFK, HUD, HDD, HMD, DVI, HOTAS, Synthetic and enhanced vision, situation awareness, Panoramic/big picture display, virtual cockpit. Power requirements.		
CONTENT BEYOND SYLLABUS		
Doppler navigational and inertial navigation, Global Positioning System (GPS), Traffic Alert and Collision Avoidance System (TCAS).		
	Total Lectures	**45 Hours**
Text Books		
1.	A.K. Sawhney, “A Course in Electrical and Electronic Measurement and Instrumentation”, Dhanpat Raj and Sons, New Delhi, 1999.	
2.	Pallet, E.H.J., “Aircraft Instruments & Integrated Systems”, Longman Scientific and Technical, McGraw-Hill, 1992.	
3.	Spitzer, C.R., “Digital Avionics Systems”, Prentice Hall, Englewood Cliffs, N.J., U.S.A., 1987.	
Reference Books		
1.	Cary R. Spitzer, “The Avionics Handbook”, CRC Press, 2000.	
2.	Collinson R.P.G., “Introduction to Avionics”, Chapman and Hall, 1996Middleton, D.H. “Avionics Systems”, Longman Scientific and Technical, Longman Group UK Ltd., England, 1989.	
3.	Jim Curren, “Trend in Advanced Avionics”, IOWA State University, 1992	
4.	Doeblin.E.O., “Measurement Systems Application and Design”, McGraw-Hill, New York, 1999.	
5.	Horowitz, P., and W. Hill. The Art of Electronics. 2nd ed. Cambridge, UK: Cambridge University Press, 1989.	
6.	Prototyping Avionics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-682-prototyping-avionics-spring-2006/.	
7.	Principles of Automatic Control: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-06-principles-of-automatic-control-fall-2012/.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**SPACE DYNAMICS**	**L**	**T**	**P**	**C**
20AE2019		3	0	0	3
Prerequisite: 20AE2001 Introduction to Aerospace Engineering					
Course Objectives:					
Impart knowledge on 1. Performance and stability of rockets. 2. Basics of orbital mechanics and its applications. 3. Various factors affecting satellite orbits.					
Course Outcomes:					
The student will be able to 1. Estimate performance and stability of rockets. 2. Attain a general knowledge of laws governing orbital motion. 3. Compute orbits of satellites. 4. Study the effects of perturbations on orbital motion. 5. Study orbital maneuvers useful for the study of inter-planetary trajectories. 6. Generate preliminary design of inter-planetary trajectories.					
Module: 1	**PERFORMANCE AND STABILITY OF ROCKETS**	**8 Hours**			
Rocket performance – Specific impulse; Derivation of rocket equation; Single and two stage rockets. Static and dynamic stability of rockets.					
Module: 2	**THE SOLAR SYSTEM**	**8 Hours**			

Solar system – planets, moons, asteroids, comets and meteoroids; Kepler's laws of motion; Reference frames – geocentric, geographic, topocentric, heliocentric; Time systems, Julian days; The ecliptic - motion of vernal equinox.		
Module: 3	**THE TWO-BODY PROBLEM**	**8 Hours**
Properties of conics; Angular momentum; Computation of position and velocity vectors from orbital elements and vice-versa; Solution of Kepler's equation – elliptic and hyperbolic orbits; Central force motion.		
Module: 4	**ORBIT PERTURBATIONS**	**7 Hours**
Orbit perturbations – Osculating ellipse, In-plane and out-of-plane perturbation components, Earth's oblateness, Sun-synchronous orbits, air drag; Introduction to general and special perturbation methods; Cowell's and Encke's methods.		
Module: 5	**ORBITAL MANEUVERS**	**7 Hours**
Single impulse maneuvers; Plane change maneuvers; Hohmann transfer from circular to circular orbits, Bi-elliptic Hohmann transfer, phasing maneuvers.		
Module: 6	**INTERPLANETARY TRAJECTORIES**	**7 Hours**
Interplanetary Hohmann transfers, Rendezvous opportunities, Sphere of influence; Synodic period, Method of patched conics; planetary departure.		
CONTENT BEYOND SYLLABUS		
Relative motion in orbit; Clohessy-Wiltshire equation. Satellite attitude dynamics.		
	Total Lectures	**45 Hours**

Text Books

1.	Vladimir A. Chobotov, "Orbital Mechanics", AIAA Education Series, AIAA Education Series, Published by AIAA, 2002.
2.	Howard D. Curtis, "Orbital Mechanics for Engineering Students", Elsevier Butterworth-Heinemann, Third Edition, 2010.

Reference Books

1.	Pini Gurfil, and P. Kenneth Seidelmann, "Celestial Mechanics and Astrodynamics: Theory and Practice", Springer, 2016.
2.	Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", Springer, 2015.
3.	J.W.Cornelisse, H.F.R. Schoyer, and K.F. Wakker, "Rocket Propulsion and Spaceflight Dynamics", Pitman, 2001.
4.	William E.Wiesel, "Spaceflight Dynamics", Aphelion Press, USA, Third Edition, 2010.
5.	David. A. Vallado, "Fundamentals of Astrodynamics and Applications", Microcosm and Kluwer, Second Edition, 2004.
6.	J. M. A. Danby, "Fundamentals of Celestial Mechanics", Willmann-Bell, Inc., USA, 1992.
7.	Battin, Richard. An Introduction to the Mathematics and Methods of Astrodynamics. Revised ed. Reston, VA: AIAA, 1999.
8.	Space Systems Engineering: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-83x-space-systems-engineering-spring-2002-spring-2003/.
9.	Space Flight Mechanics: http://nptel.ac.in/courses/101105029/.
10.	Space Technology: http://nptel.ac.in/courses/101106046/.
11.	Introduction to Aerospace Engineering: Astronautics and Human Spaceflight: https://www.edx.org/course/introduction-aerospace-engineering-mitx-16-00x-1.
12.	Human Spaceflight - An introduction: https://www.edx.org/course/human-spaceflight-introduction-kthx-sd2905-1x-0.
13.	Astrodynamics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-346-astrodynamics-fall-2008/.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	AEROSPACE STRUCTURES-II	L	T	P	C
20AE2020		3	0	0	3

Prerequisite: 20AE2011 Aerospace Structures-I

Course Objectives:

Impart knowledge on

1. Effect of load on structures of complex geometries.
2. Stresses and strains in beams of thin walled section.
3. Force distribution in different structures of an aircraft.

Course Outcomes:

The student will be able to

1. Describe the stresses due to unsymmetrical bending of beams.
2. Predict the shear flow and shear center in thin walled open section beams.
3. Calculate the shear stress in thin walled closed section beams.
4. Analyze the buckling characteristics of plates.
5. Assess the load and stress distribution of wing and fuselage sections.
6. Analyze the stresses in structural joints of aircraft components

Module: 1	UNSYMMETRICAL BENDING OF BEAMS	7 Hours

Stresses due to unsymmetrical bending – 'K' method, principal axis method, neutral axis method. Deflection in beams under unsymmetrical bending.

Module: 2	SHEAR FLOW IN OPEN SECTIONS	7 Hours

Shear flow in thin-walled open sections with and without booms due to bending. Structural idealization. Shear center of thin walled open sections.

Module: 3	SHEAR FLOW IN CLOSED SECTIONS	8 Hours

Shear flow in thin-walled single cell and multi cell closed sections with and without booms due to bending and torsion. Shear center of thin walled closed sections.

Module: 4	BUCKLING OF PLATES	8 Hours

Buckling of thin plates, Inelastic buckling of plates, local instability and instability of stiffened panels. Failure stress in plates and stiffened panels, Crippling stresses by Needham's and Gerard's methods. Buckling of thin walled beam of open and closed section.

Module: 5	WING & FUSELAGE ANALYSIS	7 Hours

Shear force, bending moment and torque distribution along the span of the Wing-Tension field beamand Semi tension field beam (Wagner Beam). Shear and bending moment distribution along the length of the fuselage. Structural and Aerodynamics Loads. Station diagram (layout)

Module: 6	DESIGN OF JOINTS	8 Hours

Type of Joints – Bolted Joints – Determination of Stresses & Design of a Bolted Joint for Axial, Shear, and Combined Loading – Different Types of Rivets and Riveted Joints – Loading on a Riveted Joint – Failure Modes – Strength and Efficiency of Joints. Spice Joints

CONTENT BEYOND SYLLABUS

Analysis of thick beams using first order shear deformation theory.

	Total Lectures	**45 Hours**

Text Books

1.	Donaldson B K., "Analysis of Aircraft Structures", Cambridge Aerospace Series, 2008.
2.	Megson, T.H.G., "Aircraft Structures for Engineering Students", Fourth edition, Elsevier Ltd, 2010.

Reference Books

1.	G Lakshmi Narasaiah, "Aircraft Structures", BS Publications, 2010.
2.	Sun C T, "Mechanics of Aircraft Structures", Wiley India, 2010.
3.	Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.
4.	Stephen P. Timoshenko & S.Woinovsky Krieger, "Theory of Plates and Shells", 2nd Edition, McGraw-Hill, Singapore, 1990.
5.	Rivello, R.M., "Theory and Analysis of Flight structures", McGraw-Hill, N.Y., 1993.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	AEROSPACE STRUCTURES AND COMPOSITE LABORATORY	L	T	P	C
20AE2021		0	0	4	2

Course Objectives:

Impart knowledge on

1. Testing equipment for various structural components.
2. Measuring equipments and sensors.
3. Practical exposure with composite material manufacturing.

Course Outcomes:

The student will be able to

1. Select test equipment for different types of static loading.
2. Conduct tests, analyses and compare with analytical/theoretical results.
3. Analyze the different types of structural failures.
4. Fabricate different Composite laminates.
5. Choose strain gauge for different application
6. Understand the stress distribution based on cross-section shape and loading condition.

List of Experiments

1.	Deflection of simply supported and cantilever beams - Verification of Castigliano's Theorem.
2.	Determine the stiffness factors of an Elastically Supported Beam.
3.	Determine the tensile strength of Flat plates, riveted joints and bolted joints using UTM.
4.	Compression test on columns, critical buckling loads – Southwell plot.
5.	Unsymmetrical bending of beams.
6.	Determination of the effective bending stiffness of a composite beam with the combination of Aluminium and steel.
7.	Determination of the natural frequency of vibrations of a cantilever beam.
8.	Shear center location for open sections.
9.	Torsion of a thin walled tube having closed cross section at the ends.
10.	Structural behaviour of a semi tension field beam (Wagner Beam).
11.	Using photo elastic techniques: Calibration of circular disc in compression to find the fringe value and Determination of stress concentration factor due to compression in circular ring.
12.	Composite material Manufacturing and Testing- Tensile and three point bending.
Total Lectures	**30 Hours**

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	PROPULSION-II	L	T	P	C
20AE2022		3	0	0	3

Prerequisite: 20AE2012 Propulsion-I

Course Objectives:

Impart knowledge on

1. Fundamentals of rocket propulsion.
2. Solid and liquid propulsion systems.
3. Advanced propulsion systems.

Course Outcomes:

The student will be able to

1. Understand and evaluate the performance of chemical propellant.
2. Select and design suitable air inlets and nozzles.
3. Select and design a suitable solid rocket motor.
4. Select and design a suitable liquid rocket engine.
5. Understand the working of sub-systems of the propulsion system.
6. Assess the performance of electric propulsion systems.

Module: 1	**INLETS FOR AIR-BREATHING ENGINES AND NOZZLES**	**8 Hours**

Internal flow and stall in subsonic inlets –major features of external flow near a subsonic inlet – external deceleration -relation between minimum area ratio and external deceleration ratio – Diffuser performance – Supersonic inlets- Modes of inlet operation. Theory of flow in isentropic nozzles – convergent / convergent –

divergent nozzles; nozzle efficiency – losses in nozzles – over expanded and under – expanded nozzles, types of nozzles conical nozzles, bell shaped nozzles, spike nozzles, expansion deflection nozzles, thrust reversal.		
Module: 2	**FUNDAMENTAL OF ROCKET PROPULSION**	**7 Hours**
Overview of rockets, thrust equation and specific impulse, performance parameters, mass flow rate, characteristic velocity, thrust coefficient, efficiencies vehicle acceleration, drag, gravity losses, multi-staging of rockets staging and clustering, classification of chemical rockets.		
Module: 3	**CHEMICAL PROPULSION**	**7 Hours**
Molecular mass, specific heat ratio, energy release during combustion, stoichiometric & mixture ratio, types and classifications, criteria for choice of propellant, solid propellants, requirement, composition and processing, liquid propellants, energy content, storability.		
Module: 4	**SOLID PROPULSION SYSTEMS**	**8 Hours**
Classifications, booster stage and upper stage rockets, hardware components and functions, propellant grain configuration and applications, burn rate, burn rate index for stable operation, mechanism of burning, ignition and ignitors types, relation between web shape and thrust, action time and burn time, factors influencing burn rates, thrust vector control, performance of solid rockets. Micro grain structure of solid rocket motor.		
Module: 5	**LIQUID PROPULSION SYSTEMS**	**8 Hours**
Liquid propellant engines, thrust chamber and its cooling, injectors and types, propellant feed systems, turbo pumps, bipropellant rockets, mono propellant thrusters, cryogenic propulsion system, special features of cryogenic systems and performance of liquid rockets.		
Module: 6	**ADVANCE PROPULSION SYSTEMS**	**7 Hours**
Hybrid propellants and gelled propellants, electrical rockets, types and working principle of nuclear rockets, solar sail, concepts of advance propulsion systems, introduction to scramjet – preliminary concepts in supersonic combustion, integral ram-rocket.		
CONTENT BEYOND SYLLABUS		
Concepts of microwave thrusters, water based thrusters etc.		
	Total Lectures	**45 Hours**

Text Books	
1.	Sutton, G.P., Oscar Biblarz "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9thEdn., 2016.
2.	Cohen, H., Rogers, G.F.C. and Saravanamutoo, H.I.H., "Gas Turbine Theory", 7th Edition, Longman Co., ELBS Ed., 2017
Reference Books	
1.	Gordon C. Oates., "Aero-thermodynamics of Gas Turbine and Rocket propulsion", AIAA Education series, New York, 1997.
2.	Mathur, M., and Sharma, R.P., "Gas Turbines and Jet and Rocket Propulsion", standard Publishers, New Delhi, 2014.
3.	Vigor Yang, "Liquid rocket thrust chamber: Aspect of modeling, analysis and design", American Institute of Aeronautics and Astronautics, 2004.
4.	Hill P.G. & Peterson, C.R., "Mechanics & Thermodynamics of Propulsion" Addison – Wesley publishing company INC, 1999.
5.	Rocket Propulsion: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/.
6.	Space Propulsion: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-522-space-propulsion-spring-2015/.
7.	Aerospace Propulsion: http://nptel.ac.in/courses/101106033/.
8.	Jet and Rocket Propulsion: http://nptel.ac.in/courses/101104019/.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
20AE2023		3	0	0	3

Prerequisite: 20AE2009 Aerodynamics

Course Objectives:

Impart knowledge on

1. Governing equations of fluid dynamics.
2. Solution methodologies of discretized equations.
3. Turbulence and combustion models and its behavior.

Course Outcomes:

The student will be able to

1. Understand the governing equations for fluid flow and its classification.
2. Choose proper turbulent models for given flow situations.
3. Apply proper solution methodologies for PDE.
4. Arrive at proper domain for the numerical simulation for given flow situations.
5. Define the boundary conditions and generate grids.
6. Solve real life fluid dynamic problems.

Module: 1	GOVERNING EQUATIONS	6 Hours

Governing equations of fluid flow and heat transfer, Navier-Stokes equations, Conservative, differential and integral form of transport equations; Classifications of PDEs.

Module: 2	INTRODUCTION TO CFD	8 Hours

Discretization and grids, Problem solving with CFD, Introduction to Finite difference method and finite volume method, explicit and implicit approaches, one dimensional steady state diffusion, one dimensional unsteady diffusion (heat conduction).

Module: 3	CONVECTION DIFFUSION PROBLEMS	8 Hours

Steady one dimensional convection diffusion. The central difference, upwind differencing and hybrid schemes. Properties of discretion schemes and convergence.

Module: 4	SOLUTION METHODOLOGY	8 Hours

Introduction, direct method- Tri-diagonal Matrix Algorithm (TDMA), application of TDMA point iterating method- Jacobi, Gauss Seidel, Relaxation Methods

Module: 5	BOUNDARY CONDITIONS AND CONTINUITY MOMENTUM COUPLING	8 Hours

Boundary Conditions – Inlet, outlet, Wall, constant pressure, symmetric and cyclic. Staggered grid and momentum equations, SIMPLE and SIMPLER algorithms

Module: 6	INTRODUCTION TO TURBULENCE	7 Hours

Turbulence, Transition from Laminar to turbulent flows, Time averaged Navier-Stokes equations. Turbulence Models – zero equation- One equation - two equation and Reynolds stress models, Usage of turbulence models.

CONTENT BEYOND SYLLABUS

Developing and executing 1D, 2D flow problem and 1D heat transfer problem using Matlab/ Python.

Total Lectures	**45 Hours**

Text Books

1.	Versteeg, H.K, and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Second Edition, Longman, 2007
2.	Dale A. Anderson, John C. Tannehill, Richard H. Pletcher, MunipalliRamakanth, VijayaShankar,"Computational Fluid Mechanics and Heat Transfer", 4th edition, CRC Press, https://doi.org/10.1201/9781351124027, eBook ISBN9781351124027, 2020

Reference Books

1.	John F. Wendt, "Computational Fluid Dynamics: An Introduction" third edition, Springer, 2008.
2.	Suhas V. Patankar, "Numerical Heat Transfer and Fluid Flow", McGraw-Hill, reprint 2017
3.	Anderson, J.D., "Computational Fluid Dynamics – the basics with applications", McGraw-Hill, 1995.
4.	Ghoshdastidar, P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw Hill Publishing Company Ltd., 1998.

5.	Muralidhar, K and Sundarajan .T, “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 1995.
6.	Bose, T.K, “Numerical Fluid Dynamics”, Narosa publishing House, 1997.
7.	Computational Fluid Dynamics: https://nptel.ac.in/courses/112/105/112105045/.
8.	Computational Fluid Dynamics: https://nptel.ac.in/courses/112/105/112105254/.
9.	https://ocw.mit.edu/courses/mechanical-engineering/2-29-numerical-fluid-mechanics-spring-2015/lecture-notes-and-references/
10.	https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	COMPUTATIONAL FLUID DYNAMICS LABORATORY	L	T	P	C
20AE2024		0	0	2	1

Course Objectives:

Impart knowledge on

1. Working of CFD codes, setting up of the problem and solution procedure.
2. Data, post process and data comparison.
3. Validation of numerically computed results.

Course Outcomes:

The student will be able to

1. Define the body shape in a CFD code, create the solution domain and generate a grid
2. Apply boundary conditions and generate the solution.
3. Perform convergence, grid independence and mesh improvement studies
4. Validate the aerodynamic quantities from computed data.
5. Perform CFD Analysis over 2D and 3D objects.
6. Solve problems using different turbulence models.

List of Experiments

1.	Laminar Pipe Flow.
2.	Turbulent Pipe Flow.
3.	Modeling a mixing Elbow (2-D).
4.	Flat Plate Boundary Layer.
5.	Forced Convection over a Flat Plate.
6.	Steady Flow past a Cylinder.
7.	Unsteady Flow past a Cylinder.
8.	Flow over an Airfoil.
9.	Flow simulation over an aircraft.
10.	Flow simulation over a rocket.
11.	Supersonic Flow over a Wedge.
12.	Compressible Flow in a Nozzle.
Total Lectures	**15 Hours**

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	AIRCRAFT STABILITY AND CONTROL	L	T	P	C
20AE2025		3	0	0	3

Course Objectives:

Impart knowledge on

1. The concept of stability and control of an aircraft.
2. Various Aircraft motions and related stability.
3. The concept of dynamic stability of an aircraft.

Course Outcomes:

The student will be able to

1. Understand the static stability behavior of an aircraft.
2. Analyze the effects of Elevator on static longitudinal stability.
3. Assess the motion of aircraft and related modes of directional stability.

4. Estimate the static lateral stability of aircraft.
5. Understand the dynamic longitudinal stability of aircraft.
6. Perform the dynamic analysis to determine stability of aircraft.

Module: 1	**STATIC LONGITUDINAL STABILITY-I**	**8 Hours**
Introduction- Degrees of Freedom of a system- conditions for stability. Basic equations of motion- Wing and tail contribution; Effects of Fuselage and nacelles- Static stick fixed neutral point- Power effects-Jet driven airplane and Propeller driven airplane, Elevator Requirements.		
Module: 2	**STATIC LONGITUDINAL STABILITY-II**	**7 Hours**
Basic equations of motion Elevator hinge moment, Estimation of hinge moment parameters, Stick Force gradients and Stick force per g load; Stick free Static Longitudinal Stability: Trim Tabs, Stick free Neutral Point.		
Module: 3	**STATIC DIRECTIONAL STABILITY**	**8 Hours**
Basic equations of motion- Stick fixed Directional Stability- Contribution of wing –Fuselage – Vertical tail-Propeller, Directional control- Adverse yaw, One engine In-operative Conditions, Cross wind Landing, Spin recovery- Rudder effectiveness- Rudder Lock –Dorsal Fins- Stick free Directional Stability.		
Module: 4	**STATIC LATERAL STABILITY**	**8 Hours**
Dihedral Effect- Criterion for stabilizing dihedral effect -Selection of dihedral angle-Contribution of wing – Fuselage –Vertical tail- Propeller and Flaps- Rolling moment and its convention; Lateral Control- Aileron effectiveness, Aileron control force requirements, Aerodynamic Balancing.		
Module: 5	**DYNAMIC STABILITY-I**	**7 Hours**
Equations of motion-stick fixed and stick free, stability derivatives, Phugoid and short period, Longitudinal Dynamic Stability.		
Module: 6	**DYNAMIC STABILITY-II**	**7 Hours**
Equation of motion- Lateral Dynamic Stability- Aileron fixed and free, Routh's discriminant, Dutchroll and Spiral instability, Auto rotation and Spin recovery.		
CONTENT BEYOND SYLLABUS		
Estimation of stability derivatives of Cessna 152 Airplane.		
	Total Lectures	**45 Hours**

Text Books

1.	Perkins, C D and Hage, R E; "Airplane Performance Stability and Control", Willey Toppan, 2010
2.	Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 2014.

Reference Books

1.	J D Anderson, "Aircraft Performance and Design", McGraw-Hill, New York, 2000.
2.	Etkin, Bernard, and Lloyd Duff Reid. "Dynamics of Flight Stability and Control", Third Edition, John Wiley, New York, 1995.
3.	Jan Roskam, J.Roskam, "Airplane Flight Dynamics and Automatic Flight Controls". Design, Analysis and Research Corporation. 2003.
4.	David G. Hull, "Fundamentals of Airplane Flight Mechanics" Springer-Verlag Berlin Heidelberg 2007.
5.	M.V.Cook, "Flight Dynamics Principles" Second Edition, Elsevier, 2007.
6.	Stevens, B., and F. Lewis. Aircraft Control and Simulation. 2nd ed. New York: Wiley-Interscience, 2003.
7.	Blakelock, John H. Automatic Control of Aircraft and Missiles. 2nd ed. New York: Wiley-Interscience, 1991.
8.	Franklin, Gene F., J. David Powell, and Abbas Emami-Naeini. Feedback Control of DynamicSystems. 4th ed. Upper Saddle River, NJ: Prentice Hall, 2002.
9.	McRuer, Duane, Irving Ashkenas, and Dunstan Graham. Aircraft Dynamics and Automatic Control. Princeton, NJ: Princeton University Press, 1973.
10.	Bryson, Arthur E. Control of Spacecraft and Aircraft. Princeton, NJ: Princeton University Press, 1994.
11.	Abzug, M., and E. Larrabee. Airplane Stability and Control. 2nd ed. New York: Cambridge

	University Press, 2002
12.	McCormick, B. Aerodynamics, Aeronautics, and Flight Mechanics. 2nd ed. New York:Wiley, 1994.
13.	Aircraft Stability and Control: https://nptel.ac.in/courses/101/104/101104062/.
14.	Flight dynamics II - Airplane stability and control: http://nptel.ac.in/courses/101106043/.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**FLIGHT STABILITY AND AERO MODELLING LABORATORY**	**L**	**T**	**P**	**C**
20AE2026		0	0	2	1

Course Objectives:

Impart knowledge on

1. The concept of stability and control of aircraft.
2. Various aircraft motions and related stability.
3. The concept of dynamic stability of aircraft.

Course Outcomes:

The student will be able to

1. Understand the degree of freedom of aircraft system.
2. Analyze the static stability behavior of aircraft.
3. Understand the dynamic longitudinal stability of aircraft.
4. Calculate the center of gravity of an aircraft.
5. Calibration of control surface movement of an aircraft.
6. Design the paper planes.

List of Experiments

1.	Modelling and Testing of Paper Planes.
2.	Aircraft “Jacking” procedure.
3.	Aircraft “Leveling” procedure.
4.	Calculation of CG of the Cessna 152 Aircraft.
5.	Parameters measurement of the Cessna 152 Aircraft.
6.	Study of Longitudinal Stability of the Cessna 152 Aircraft.
7.	Study of Directional Stability of the Cessna 152 Aircraft.
8.	Study of Lateral Stability of the Cessna 152 Aircraft.
9.	Aircraft Stability Check using Flight Simulator.
10.	Thrust measurement of brushless DC motor with different propellers.
11.	Estimation of thrust force in Muticopter drones.
Total Lectures	**15 Hours**

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**FINITE ELEMENT ANALYSIS**	**L**	**T**	**P**	**C**
20AE2027		3	0	0	3

Course Objectives:

Impart knowledge on

1. Finite element modeling in designing aerospace structural components.
2. Various finite element procedures and solution techniques.
3. Principle of mathematical modeling of engineering problems.

Course Outcomes:

The student will be able to

1. Understand the approximate methods applied to structural problems.
2. Understand the discretization of bar elements.
3. Develop mathematical models for truss problems.
4. Derive the finite element equations for beam elements.
5. Assemble finite element equation for 2D plane elements.
6. Solve filed problems for finding the unknowns in heat and fluid flow problems.

Module: 1	APPROXIMATE METHODS AND ITS SOLUTIONS	8 Hours
Review of various approximate methods – Weighted Residual Methods, Variational formulation of boundary value problems, Ritz technique, Governing equation and convergence criteria in finite element method. Degree of freedom for higher order elements and higher order approximations.		
Module: 2	**ANALYSIS OF BAR**	**7 Hours**
Basic finite element concepts – Basic ideas in a finite element solution, Derivation of shape functions, Stiffness matrix and force vectors, Assembly of elemental matrices, Solution to problems from solid mechanics.		
Module: 3	**ANALYSIS OF TRUSS**	**7 Hours**
Analysis of trusses-Two dimensional truss element, Three dimensional space truss element, and temperature changes.		
Module: 4	**ANALYSIS OF BEAM**	**7 Hours**
Beam bending-Governing differential equation for beam bending, Two node beam element, Calculation of stresses in beams, Thermal stresses in beams.		
Module: 5	**ISOPARAMETRIC ELEMENTS**	**8 Hours**
Definitions, Shape function for constant and linear strain triangular and quadrilateral elements, Stiffness matrix and consistent load vector, Plane stress, Plane strain and axisymmetric problems.		
Module: 6	**FIELD PROBLEM**	**8 Hours**
Heat transfer problems, Steady state fin problems, Derivation of element matrices for two dimensional problems, Fluid flow problems.		
CONTENT BEYOND SYLLABUS		
Optimization Techniques in FEA.		
	Total Lectures	**45 Hours**

Text Books

1.	Robert D. Cook, David S. Malkus, Michael E. Plesha, “Concepts and Applications of Finite Element Analysis”, John Wiley and Sons, 4th ed., 2007.
2.	Segerlind,L.J. “Applied Finite Element Analysis”, Second Edition, John Wiley and Sons Inc., New York, 1984.

Reference Books

1.	J.N. Reddy, “An Introduction to the Finite Element Method,”, McGraw-Hill International Editions, 3rd ed., 2009.
2.	Tirupathi R. Chandrupatla and Ashok D. Belegundu, “Introduction to Finite Elements in Engineering”, Prentice Hall, 2002.
3.	Rao S.S., “Finite Element Methods in Engineering”, Pergamon Press, 4th Ed., 2005.
4.	Daryl L. Logan, “A First Course in the Finite Element Method”, Chris Carson, 4th Ed., 2007.
5.	Ferreira A.J.M., “MATLAB Codes for Finite Element Analysis Solids and Structures”, Springer, 2009.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	FINITE ELEMENT ANALYSIS LABORATORY	L	T	P	C
20AE2028		0	0	2	1

Course Objectives:

Impart knowledge on

1. Various structural analysis software packages.
2. Stress analysis of different types of structural components.
3. Programming for various structural analysis.

Course Outcomes:

The student will be able to

1. Understand the various structural software packages.
2. Perform static structural analysis of one dimensional members.
3. Perform static structural analysis of two dimensional & three dimensional problem.

4. Analyze the Static Thermal analysis of various objects. 5. Understand open source software packages. 6. Create programs for various structures problem.	
List of Experiments	
1.	Static stress analysis of axial bar.
2.	Two dimensional (truss) frame with multiple materials and element types.
3.	Three dimensional truss- Airframe.
4.	Analysis of simply supported beam/ cantilever beam for SFD and BMD
5.	Simple two dimensional heat transfer problem.
6.	Modal analysis of Aircraft wing.
7.	Plate buckling analysis.
8.	Box beam- torsional and bending problem.
9.	Programming of one dimensional bar with single material and axial load using MATLAB.
Total Lectures	**15 Hours**
The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.	
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	AIRCRAFT DESIGN PROJECT	L	T	P	C
20AE2029		0	0	8	4

Course Objectives:

Impart knowledge on

1. Aerodynamic design of aircraft.
2. Performance analysis and stability aspects of different types of aircraft/spacecraft.
3. Structural design of the aircraft/spacecraft.

Course Outcomes:

The student will be able to

1. Choose type of aircraft/spacecraft for comparative studies.
2. Calculate aerodynamic parameters.
3. Design an aircraft and assess the performance of the design.
4. Analyze the stability of the designed vehicle.
5. Design the aircraft wings, tail, fuselage, landing gears.
6. Design and assess the strength of a structure.

List of Experiments

1.	Comparative studies of different types of airplanes and their specifications and performance details with reference to the design work under taken.
2.	Preliminary weight estimation– Mission Profiles, empty-weight estimation, fuel-fraction estimation, maximum takeoff-weight estimation.
3.	Preparation of layout drawing– Aircraft conceptual design, selection of design parameters, and three view diagrams of the airplane under consideration.
4.	Performance calculations– Wing loading and thrust loading, drag estimation, wing area and engine sizing.
5.	Preliminary design of an aircraft wing –Number of wings, vertical location,airfoil selection, Aerodynamic simulation on airfoil, High Lift devices, Aileron, Lifting-Line theory.
6.	Detailed design of an aircraft wing – Wing incidence, Aspect ratio, Taper ratio, Twist angle, sweep angle, Dihedral angle, Lift and Load distribution, Wing design steps.
7.	Aircraft tailDesign –Stability analysis, Tail configuration, canard or aft tail, Horizontal tail parameter and design, Vertical tail design, Tail design steps.
8.	Aircraft fuselage Design – Fuselage configuration design and internal arrangement. Cockpit Design, Passenger cabin design, Cargo selection design, Fuselage design steps, Optimum length to diameter ratio, Aera ruling, Fuselage rear selection.
9.	Propulsion system design– Functional analysis and design requirement, Engine type selection, Number of engines, Engine location, Engine installation, Propeller sizing, engine selection, propulsion system design steps.
10.	Design of control surfaces – Configuration selection of control surfaces, Aileron design, Elevator Design, Rudder design, Aerodynamic and mass balancing.

11.	Landing gear design– Landing gear configuration, landing gear geometry, landing gear and aircraft center of gravity. Landing gear mechanical subsystems, landing gear design steps.
12.	Preparation of a detailed design report with CAD drawings.
Total Lectures	**60 Hours**

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**TECHNICAL APTITUDE**	**L**	**T**	**P**	**C**
20AE2030		~~2~~1	0	0	1

Course Objectives:

Revise course material on

1. Incompressible and compressible flow.
2. Effects of forces and moments on aircraft and thrust required.
3. Behavior of structure under various loading conditions.

Course Outcomes:

The student will be able to

1. Show aptitude and skill in the basic aerospace topics of fluid mechanics, solid mechanics and propulsion.
2. Differentiate fluid flow in the inviscid and viscous regions with potential theory, boundary Layer theory, exact solutions of Navier Stokes equations and basic numerical simulation.
3. Display sound technical knowledge and confidence in propulsion, and aircraft systems and performance.
4. Develop simple performance maps of aircraft engines and rockets.
5. To choose the right materials for aircraft structural members.
6. Calculate loads and moments on aircraft structural members and design optimal structures to meet performance requirements.

Module: 1	**INCOMPRESSIBLE FLOW THEORY**	**2 Hours**

Conservation laws: Mass, momentum and energy; Dimensional analysis and dynamic similarity; Potential flow theory. Elementary ideas of viscous flows including boundary layers. Airfoil Characteristics. Prandtl lifting line theory.

Module: 2	**COMPRESSIBLE FLOW THEORY**	**2 Hours**

Basic concepts of compressibility, One-dimensional compressible flows, Isentropic flows, Fanno flow, Rayleigh flow; Normal and oblique shocks, Prandtl-Meyer flow; Flow through nozzles and diffusers.

Module: 3	**FLIGHT MECHANICS**	**3 Hours**

Aerodynamic forces and moments. Drag polar; takeoff and landing; steady climb & descent; absolute and service ceiling; range and endurance, load factor, turning flight, V-n diagram. Stability & control derivatives; Lateral, Longitudinal and Directional Static Stability.

Module: 4	**AIRCRAFT STRUCTURES**	**3 Hours**

Stress and strain: Three-dimensional transformations, Mohr's circle, principal stresses, Three-dimensional Hooke's law, Plane stress and strain. Failure theories: Maximum stress, Tresca and von Mises. Strain energy. Castigliano's principles. Statically determinate and indeterminate trusses and beams. Elastic flexural buckling of columns.Torsion, bending and shear of thin-walled sections. Loads on aircraft.

Module: 5	**FUNDAMENTALS OF VIBRATIONS**	**2 Hours**

Free and forced vibrations of undamped and damped SDOF systems. Free vibrations of undamped 2-DOF systems.

Module: 6	**AIRCRAFT AND ROCKET PROPULSION**	**3 Hours**

Thermodynamics, boundary layers, heat transfer, combustion and thermochemistry. Aircraft engines: Thrust, efficiency, range. Brayton cycle. Engine performance: ramjet, turbojet, turbofan, turboprop and turbo shaft engines. Afterburners. Axial compressors. Centrifugal compressor.

Total Lectures	**15 Hours**

Reference Books

1.	John D. Anderson, Jr., "Fundamentals of Aerodynamics", Sixth edition, McGraw-Hill publications, 2016.
2.	Rathakrishnan, E., "Gas Dynamics", 7th Edition, Prentice Hall of India, 2020.
3.	Anderson, J D, "Aircraft performance and Design", McGraw-Hill, New York, 2000.
4.	James M. Gere, Barry J. Goodno, "Mechanics of Materials", 8th edition, Cengage Learning India Pvt. Ltd, 2013.
5.	Singiresu.S.Rao., "Mechanical Vibrations", Addison Wesley Longman,2003.
6.	V. Ganesan, "Gas Turbines", Tata McGraw - Hill Publishing Company Ltd, 2010.
7.	Sutton, G.P., Oscar Biblarz "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9thEdn., 2016.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**HELICOPTER AERODYNAMICS**	**L**	**T**	**P**	**C**
20AE2031		3	0	0	3

Course Objectives:

Impart knowledge on

1. Basic layout of helicopter.
2. Aerodynamics of helicopter.
3. Design or rotor blade.

Course Outcomes:

The student will be able to

1. Understand the basic of helicopters.
2. Describe the aerodynamic performance of rotor blade.
3. Explain power units and flight performance of helicopter.
4. Understand the dynamic stability and control of helicopter.
5. Calculate rotor vibrations.
6. Design the rotor blade.

Module: 1	**INTRODUCTION TO HELICOPTER**	**9 Hours**

Helicopter as an aircraft, Basic features, Layout, Generation of lift, Main rotor, Gearbox, tail rotor, power plant, drive to main and tail rotor, considerations on blade, flapping and feathering, Rotor controls various types of rotor, Geometry of the rotor, Blade loading, Effect of solidity, profile drag, compressibility etc., Blade area required, number of Blades, Blade form, Power losses, Rotor efficiency.

Module: 2	**AERODYNAMICS OF ROTOR BLADE**	**8 Hours**

Aerofoil characteristics in forward flight, Hovering and Vortex ring state, Blade stall, maximum lift of the helicopter calculation of Induced Power, High speed limitations; parasite drag, power loading, ground effect. Blade element momentum theory

Module: 3	**POWER UNITS AND FLIGHT PERFORMANCE**	**7 Hours**

Piston engines, Gas turbines, Ramjet principle, Comparative performance, Horsepower required, Range and Endurance, Rate of Climb, Best Climbing speed, Ceiling in vertical climb, Autorotation.

Module: 4	**DYNAMIC STABILITY AND CONTROL**	**7 Hours**

Physical description of effects of disturbances, longitudinal dynamic stability, stick fixed dynamic stability, longitudinal stability characteristics, lateral dynamic stability, lateral stability characteristics, control response. Differences between stability and control of airplane and helicopter.

Module: 5	**ROTOR VIBRATIONS**	**7 Hours**

Dynamic model of the rotor, Motion of the rigid blades, flapping motion, lagging motion, feathering motion, Properties of vibrating system, phenomenon of vibration, fuselage response, vibration absorbers, Measurement of vibration in flight.

Module: 6	**ROTOR BLADE DESIGN**	**7 Hours**

Dynamic model of the rotor, Motion of the rigid blades, flapping motion, lagging motion, feathering motion, Properties of vibrating system, phenomenon of vibration, fuselage response, vibration absorbers, Measurement of vibration in flight.

CONTENT BEYOND SYLLABUS
Design the rotor blade to meet the desired conditions.

Total Lectures	**45 Hours**

Text Books	
1.	C. Venkatesan. Fundamentals of Helicopter Dynamics, CRC Press, 2014
2.	John Seddon, Simon Newman, "Basic Helicopter Aerodynamics", John Wiley & Sons, Ltd, 2011.
Reference Books	
1.	J Gordon Leishman, "Principles of Helicopter Aerodynamics", Cambridge University Press, 2006.
2.	Lalit Gupta, Helicopter Engineering; Himalayan Books New Delhi 1996
3.	Joseph Schafer, Basic Helicopter Maintenance, Jeppesen 1980.
4.	R W Prouty, Helicopter Aerodynamics, Phillips Pub Co 1985.
5.	John Fay, The Helicopter and How It Flies, Himalayan Books 1995.
6.	Helicopter Aerodynamics: https://nptel.ac.in/courses/101/104/101104017/.gn.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**THEORY OF ELASTICITY**	**L**	**T**	**P**	**C**
20AE2032		3	0	0	3

Course Objectives:

Impart knowledge on
1. 2D elasticity to solve beam problems.
2. Solving problems in cartesian coordinate systems.
3. Formulating and solving axisymmetric problems

Course Outcomes:

The student will be able to
1. Understand the elastic properties of solids.
2. Understand the use of compatibility equation.
3. Describe the plane stress and plane strain conditions.
4. Constitute elasticity equations in polar form to solve axisymmetric problems.
5. Predict stress distribution of various sections due to torsional load.
6. Analyze the states in 2D rotating discs.

Module: 1	**ASSUMPTIONS IN ELASTICITY**	**8 Hours**

Definitions- notations and sign conventions for stress and strain, Components of stress and strain, Hooke's law, Plane stress and Plane strain, Equations of equilibrium.

Module: 2	**BASIC EQUATIONS OF ELASTICITY**	**8 Hours**

Strain – displacement relations, Stress – strain relations, Lame's constant – cubical dilation, Compressibility of material, bulk modulus, Shear modulus, Compatibility equations for strains, Principal stresses and principal strains, Mohr's circle, Saint Venant's principle.

Module: 3	**PLANE STRESS AND PLANE STRAIN PROBLEMS**	**8 Hours**

Airy's stress function, Bi-harmonic equations, Polynomial solutions, Simple two-dimensional problems in Cartesian coordinates like bending of cantilever and simply supported beams, etc.

Module: 4	**AXI–SYMMETRIC PROBLEMS -POLAR COORDINATE**	**7 Hours**

Equations of equilibrium, Strain displacement relations, Stress – strain relations, Axi – symmetric problems, Kirsch, Michell's and Boussinesq problems.

Module: 5	**TORSION**	**7 Hours**

Navier's theory, St. Venant's theory, Prandtl's theory on torsion, semi- inverse method and applications to shafts of circular, elliptical, equilateral triangular and rectangular sections.

Module: 6	**STRESS DUE TO ROTATION**	**7 Hours**

Rotation stresses in thin cylinder or rotating ring, Expression for radial and circumferential stresses in a solid disc and disc with central hole, Disc of uniform strength.

CONTENT BEYOND SYLLABUS		
Elasticity problems of 2D functionally graded material.		
	Total Lectures	**45 Hours**
Text Books		
1.	Martin H. Sadd, “Elasticity Theory, Applications, and Numerics”, Academic Press, 2009.	
2.	J. R. Barber, “Elasticity”, Springer, 2010.	
Reference Books		
1.	Enrico Volterra & J.H. Caines, “Advanced Strength of Materials”, Prentice Hall New Jersey, 2001. Sun C T, “Mechanics of Aircraft Structures”, Wiley, India, 2010.	
2.	Timoshenko, S., and Goodier, T.N., “Theory of Elasticity”, Tata McGraw–Hill Education, 2001.	
3.	R.C. Ugural, S.K. Fenster . “Advanced strength and applied elasticity”, Elsevier, 2003.	
4.	P.N. Chandramouli, “Theory of Elasticity”, Yesdee Publisher, 2017.	
5.	Timoshenko.S.P, Goodier.J.N, “Theory of Elasticity”, Tata McGraw-Hill Education, Third Edition, 2010.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	DESIGN AND ANALYSIS OF COMPOSITE STRUCTURES	L	T	P	C
20AE2033		3	0	0	3

Course Objectives:

Impart knowledge on

1. Composite materials and design.
2. Behavior of composite structures and Failure criteria.
3. Manufacturing, testing, various applications of composite materials.

Course Outcomes:

The student will be able to

1. Describe the various types of composite materials.
2. Understand the structural behavior of lamina.
3. Compare the various failure theories of composite materials.
4. Assess various properties of lamina.
5. Analyze the stresses developed in a laminate.
6. Describe the manufacturing techniques of fibers.

Module: 1	**INTRODUCTION TO COMPOSITES**	**8 Hours**

Classifications - Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites and Carbon–Carbon Composites. Hooke’s Law for Different Types of Materials.

Module: 2	**TWO-DIMENSIONAL UNIDIRECTIONAL LAMINA**	**7 Hours**

Plane Stress Assumption, Reduction of Hooke’s Law in Three Dimensions to Two Dimensions. Relationship of Compliance and Stiffness Matrix to Engineering Elastic Constants of a Lamina.

Module: 3	**TWO-DIMENSIONAL ANGLE LAMINA**	**8 Hours**

Hooke’s Law for a Two-Dimensional Angle Lamina, Engineering Constants of an Angle Lamina, Strength Failure Theories of an Angle Lamina - Maximum Strain Failure Theory, Tsai–Hill Failure Theory, Tsai–Wu Failure Theory.

Module: 4	**MICROMECHANICAL ANALYSIS OF A LAMINA**	**8 Hours**

Volume Fractions, Mass Fractions, Density, Strength of materials approach for -Longitudinal Young’s Modulus, Transverse Young’s Modulus, Major Poisson’s Ratio, In-Plane Shear Modulus.

Module: 5	**MACRO-MECHANICAL ANALYSIS OF LAMINATES**	**7 Hours**

Laminate Code, Stress–Strain Relations for a Laminate, Force and Moment Resultants Related to Midplane Strains and Curvatures - ABD matrices.

Module: 6	**MANUFACTURING OF COMPOSITES FIBERS AND FORMS**	**7 Hours**

Design for Manufacturing. Manufacturing of Glass Fibers, Graphite Fibers and boron Fibers. Forms of Fibers – Unidirectional Fibers, Plain Weave Fibers, Chopped Fibers. Prepregs.

CONTENT BEYOND SYLLABUS		
Fatigue characteristic of Fiber Composites.		
	Total Lectures	**45 Hours**

Text Books	
1.	Autar K. Kaw, Mechanics of Composite Materials, Second Edition, CRC Press LLC, 2006.
2.	Robert M. Jones, "Mechanics of Composite Materials", Second Edition, Taylor & Francis, 1999.
Reference Books	
1.	M C Gupta, A P Gupta, "Polymer Composite" Second Edition, New Age International (P) Ltd, 2015.
2.	Christian Decolon., "Analysis of Composite Structures" Hermes Penton Ltd,2004.
3.	Valery V.Vasiliev, Evgeny V.Morozov, "Advanced Mechanics of Composite Materials and structural elements", Third Edition, Elsevier, 2013.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**INTRODUCTION TO NON-DESTRUCTIVE TESTING**	**L**	**T**	**P**	**C**
20AE2034		3	0	0	3

Course Objectives:

Impart knowledge on

1. Various processes involved in non-destructive testing.
2. Different types of defects and their inspection.
3. NDT application in Aerospace maintenance.

Course Outcomes:

The student will be able to

1. Understand various types of defects.
2. Acquire knowledge in non – destructive testing, its scope and purpose.
3. Understand different NDT processes.
4. Evaluate properties of materials without causing damage.
5. Learn dynamic behavior of defects with NDT tools.
6. Choose the best NDT method for specific applications.

Module: 1	**INTRODUCTION OF NON-DESTRUCTIVE TESTING**	**7 Hours**

Need for inspection, Different discontinuities/defects, Non-Destructive Testing (NDT), History of NDT, Non-destructive versus Destructive testing, Types of Non-destructive testing, Scope and features of NDT. NDT Benefits, Conditions for effective non-destructive testing

Module: 2	**VISUAL INSPECTION AND LIQUID PENETRANT TESTING**	**8 Hours**

Testing, Visual Inspection-Basic principle, Application, advantages and limitations, Optical aids used for Visual Inspection. Liquid Penetrant Testing- Principles, Procedures, Penetrant Testing Methods, Sensitivity, Applications and Limitations, Standards.

Module: 3	**MAGNETIC PARTICLE TESTING AND EDDY CURRENT TESTING**	**8 Hours**

Magnetizing techniques, Procedures, Equipment's for MPT, Sensitivity, and Limitations. Eddy Current Testing –Principles, Instrumentation, Techniques, Applications and limitations.

Module: 4	**RADIOGRAPHY**	**7 Hours**

Electromagnetic Radiation Sources, Radiation attenuation in the specimen, Effect of radiation on film, Radiographic Imaging, Inspection Techniques in Radiography, Applications and limitations.

Module: 5	**ACOUSTIC EMISSION TESTING AND ULTRASONIC TESTING**	**7 Hours**

Instrumentation of Acoustic Emission Technique, Sensitivity, Applications and limitations. Ultrasonic Testing-Basic properties of sound beam, Inspection methods, Techniques for Normal Beam Inspection and Angle Beam Inspection, Modes of display, applications and limitations.

Module: 6	**THERMOGRAPHY**	**8 Hours**

History and development, theory and basic principles, Detectors and Equipment, Techniques, Variables, Evaluation of test results and reports, Applications-electronics industry, aerospace applications and electrical applications, advantages and limitations, Standards, Recent Advances in Active Infrared Thermography for Non-Destructive Testing of Aerospace Components.

CONTENT BEYOND SYLLABUS		
Advanced Machine Learning for Non-Destructive testing.		
	Total Lectures	**45 Hours**

Text Books	
1.	Baldev Raj, T. Jayakumar, M. Thavasimuthu, "Practical Non-destructive Testing", Wood head Publishing, 2002.
2.	P. E. Mix, "Introduction to Non-destructive Testing", Wiley Interscience, John Wiley &Sons, Inc, Publ., 2005.
Reference Books	
1.	J. Prasad and C G Krishnadas Nair, "Non-Destructive Test and Evaluation of Materials" Tata McGraw-Hill Publishing, New Delhi, 2011.
2.	Lalith Gupta, "Aircraft General Engineering", Himalaya Book House, Delhi 2003.
3.	Ravi Prakash, "Non-Destructive Testing", New Age Sciences, New Delhi,2009.
4.	Louis Cartz, "Nondestructive Testing: Radiography, Ultrasonic, Liquid Penetrant, Magnetic Particle, Eddy Current", Asm International, 1995.
5.	C. Hellier, "Handbook of Nondestructive Evaluation", McGraw-Hill, 1994.
6.	https://nptel.ac.in/courses/113/106/113106070/

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**STRUCTURAL VIBRATION**	**L**	**T**	**P**	**C**
20AE2035		3	0	0	3

Course Objectives:

Impart knowledge on

1. Causes of vibration.
2. Vibration behavior of mechanical systems under different types of loading.
3. Vibration measuring equipment

Course Outcomes:

The student will be able to

1. Describe various types of vibration systems.
2. Understand multi degree freedom systems.
3. Calculate the frequency of free vibration of simple structures.
4. Compare the different methods of vibration analysis.
5. Understand the vibration of various components in aircraft.
6. Identify techniques used in vibration measurement.

Module: 1	**SINGLE DEGREE OF FREEDOM SYSTEMS**	**8 Hours**

Introduction to simple harmonic motion, D'Alembert's principle, Free vibrations, Damped vibrations, Forced vibrations with and without damping, Support excitation, Transmissibility.

Module: 2	**MULTI DEGREES OF FREEDOM SYSTEMS**	**7 Hours**

Two degrees of freedom systems, Static and dynamic couplings, Vibration absorber, Principal coordinates, Principal modes and orthogonal conditions, Eigen value problems Hamilton's principle, Lagrangian equations and applications.

Module: 3	**CONTINUOUS SYSTEMS**	**8 Hours**

Vibration of elastic bodies - Vibration of strings – Longitudinal, Lateral and Torsional vibrations.

Module: 4	**APPROXIMATE METHODS**	**8 Hours**

Approximate methods, Rayleigh's method, Dunkerley's method, Rayleigh-Ritz method, Matrix Iteration method.

Module: 5	**ELEMENTS OF AEROELASTICITY**	**7 Hours**

Coupled flexural - torsional oscillation of beam, Aeroelastic problems, Collars triangle, Wing Divergence, Aileron Control reversal, Flutter, Buffeting.

Module: 6	**VIBRATION MEASURING TECHNIQUES**	**7 Hours**

Basics of vibration measuring system:Vibration measuring instruments,Data acquisition, Fourier transformation, Filters.			
CONTENT BEYOND SYLLABUS			
Exact Treatment of Bending – Torsion Flutter of Uniform Wing.			
		Total Lectures	**45 Hours**
Text Books			
1.	Singiresu.S.Rao., "Mechanical Vibrations", Addison Wesley Longman,2003.		
2.	Benson H Tongue, "Principles of Vibration" 2nd edition, Oxford University Press, 2002.		
Reference Books			
1.	V.P. Singh "Mechanical Vibrations" Dhanpat Rai & Co, 2014.		
2.	Kelly, "Fundamentals of Mechanical Vibrations", Mc Graw Hill Publications, 2000.		
3.	Thomson, W.T.,--"Theory of Vibration with Applications" CBS Publishers and Distributers, NewDelhi,2002.		
4.	Rao V. Dukkipati, J. Srinivas., Vibrations: problem solving companion, Narosa Publishers, 2007.		
5.	William T. Thomson, Marie Dillon Dahleh, "Theory of Vibration with Applications" Prentice Hall Publishers, 1997		
Recommended by Board of Studies			
Approved by Academic Council	25th September 2021		

Course code	**AEROELASTICITY**	**L**	**T**	**P**	**C**
20AE2036		3	0	0	3

Course Objectives:

Impart knowledge on

1. Basic concepts of aero-elasticity.
2. Static aero-elastic phenomena.
3. Dynamic aero-elastic phenomena.

Course Outcomes:

The student will be able to

1. Remember the various structural vibration and solution techniques.
2. Understand the aero-elastic phenomena.
3. Identify various techniques to control aero-elastic instability of bodies.
4. Explain the static aero-elastic behavior of aircraft.
5. Clarify the dynamic aero-elastic behavior of aircraft.
6. Analyze the flutter and gust behavior of aircraft.

Module: 1	**REVIEW OF FOUNDATIONS OF MECHANICS**	**8 Hours**
Uniform Beam Torsional and Bending Dynamics-Principle of Virtual Work - Hamilton's Principle - Lagrange's Equations – Rayleigh-Ritz's Method-Galerkin's Method.		
Module: 2	**INTRODUCTION TO AEROELASTICITY**	**8 Hours**
History of Aeroelastic failures of Aircrafts and Tacoma Bridge. Aeroelasticity Triangle, divergence and aileron reversal.		
Module: 3	**STATIC AEROELASTICITY**	**8 Hours**
Introduction-Typical Section Model-an Airfoil-control surface-nonlinear effects; One Dimensional Aero-elastic Model of Airfoils-Eigenvalue and Eigen function approach – solution to the One Dimensional Aero-elastic Model- Two Dimensional Aero-elastic Model of Lifting Surfaces Aero-elastic equations of equilibrium and Matrix-lumped element solution method- Divergence and Control Reversal.		
Module: 4	**DYNAMIC AEROELASTICITY-FLUTTER**	**7 Hours**
Dynamics of the Typical Section Model of an Airfoil - Sinusoidal motion -Periodic motion- Arbitrary motion-Random motion; Flutter - an introduction to dynamic Aero-elastic instability - Quasi-steady, aerodynamic theory- Solutions to the Aero-elastic Equations of Motion-Time Domain and Frequency Domain.		
Module: 5	**DYNAMIC AEROELASTICITY-GUST**	**7 Hours**
Introduction to Gust - General form of equations in the time domain - Rigid aircraft in heave/pitch Motion-Frequency domain turbulence response – General form of equations in the frequency domain.		

Module: 6	**EXPERIMENTAL AEROELASTICITY**	**7 Hours**
Review of Structural Dynamics Experiments- Wind Tunnel Experiments- Sub-critical flutter testing- Approaching the flutter boundary- Safety devices- Research tests.		
CONTENT BEYOND SYLLABUS		
Exact Treatment of Bending – Torsion Flutter of Uniform Wing.		
	Total Lectures	**45 Hours**

Text Books	
1.	Jan R. Wright, Jonathan E. Cooper, "Introduction to Aircraft Aeroelasticity and Loads" John wiley & sons, Ltd, 2007.
2.	Earl H. Dowell, " A Modern Course in Aeroeleasticity", Springer, 2015.
Reference Books	
1.	Deway H. Hodges "Introduction to Structural Dynamics and Aero-Elasticity" Cambridge University Press,2002.
2.	R.L. Bisplinghoff, H. Ashley, and R.L. Halfman, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 1996.
3.	R.H. Scanlan and R.Rosenbaum, "Introduction to the Study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.
4.	E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Ltd., 1986.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	CRYOGENIC PROPULSION	L	T	P	C
20AE2037		3	0	0	3

Course Objectives:

Impart knowledge on
1. Concept of cryogenic propulsion.
2. Various applications of cryogenic fluids.
3. Various storage and transfer system.

Course Outcomes:

The student will be able to
1. Remember the thermal, physical and flow properties of cryogenic fluids.
2. Understand the liquefaction systems to produce cryogenic fluids.
3. Know various methods of cryogenic refrigeration systems.
4. Know the various cryogenic fluid storage and transfer lines.
5. Understand various insulations for cryogenic propellant tanks.
6. Know the various applications of cryogenics in propulsion systems.

Module: 1	**INTRODUCTION TO CRYOGENIC ENGINEERING**	**8 Hours**
Introduction to cryogenic systems, Historical background, Low temperature properties of materials Thermal properties, Electric and magnetic properties, properties of cryogenic fluids Hydrogen, Helium 3, Helium 4.		
Module: 2	**LIQUEFACTION SYSTEMS**	**8 Hours**
Thermodynamically ideal system – Joule-Thomson effect –Adiabatic expansion – Liquefaction systems-Simple Linde Hampson system-Pre cooled Linde Hampson system-Claude system – Kapitza system – Heylandt system – comparison of liquefaction systems.		
Module: 3	**CRYOGENIC REFRIGERATION SYSTEMS**	**8 Hours**
Concept of ideal refrigeration systems – Joule-Thompson refrigeration systems – Philips refrigerator – Vuilleumier refrigerator – Solvay refrigerator – Gifford-Mcmahon refrigerator-Magnetic cooling – Magnetic refrigeration systems – Dilution refrigerators.		
Module: 4	**CRYOGENIC FLUID STORAGE AND TRANSFER SYSTEMS**	**7 Hours**
Cryogenic fluid storage vessels- Basic storage vessels – Inner and outer vessel design – Piping- Draining the vessels –Safety devices– Cryogenic fluid transfer systems- Uninsulated and porous insulated lines –Vacuum insulated lines – Cryogenic valves.		

Module: 5	INSULATION REQUIREMENTS FOR CRYOGENIC PROPELLANT TANKS	7 Hours
Basic insulation types, selection of tanks insulation designs, Insulation requirements for cryogenic propellant tanks, challenges and problems associated with cryogenic propellant tanks.		
Module: 6	**APPLICATION OF CRYOGENIC FLUIDS IN PROPULSION**	**7 Hours**
Properties of liquid hydrogen, properties of liquid Oxygen, properties of liquid helium, properties of liquid Nitrogen, working principle of cryogenic engines, working of semi cryogenic engine, Advantages of cryogenic engines over solid and liquid engines.		
CONTENT BEYOND SYLLABUS		
Determine the heat transfer of various cryogenic fluids from an insulated and non –insulated container.		
	Total Lectures	**45 Hours**

Text Books	
1.	1. Thomas M. Flynn, “Cryogenic Engineering”, Second Edition, Revised and Expanded, CRC Press, 2009.
2.	R.Radebaugh, Klaus D.Timmerhaus, Richard P.Reed, “Cryogenic Engineering”, Springer Verlag New York, 2007.
Reference Books	
1.	A.R. Jha, “Cryogenic Technology and Applications”, Butterworth-Heinemann, 2005
2.	Wolfgang Kitshe, “Operation of a Cryogenic Rocket Engine: An Outline with Down-to-Earth and Up-to-Space Remarks”, Springer-Verlag Berlin Heidelberg, 2011.
3.	Ray Radebaugh, J.Patrick Kelley, “Application of Cryogenic Technology: Volume 10”, Springer US, 1991.
4.	R. Barron, “Cryogenic Systems”, Oxford University Press, 1985.
5.	H.S.Yang, H.Nagai,N.Takano, M.Murakami, Quan-Sheng Shu, “Advances in Cryogenic Engineering”, Springer US, 2000.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	ROCKET AND MISSILES	L	T	P	C
20AE2038		3	0	0	3

Course Objectives:

Impart knowledge on

1. Rocket and missile aerodynamics.
2. Rocket and missile in free space and gravitational field.
3. Staging & control of rockets

Course Outcomes:

The student will be able to

1. Discuss types of rockets and missiles with respect to Indian & International scenario.
2. Analyze the Aerodynamics of rockets & missiles.
3. Understand the performance of rocket and missiles within the atmosphere.
4. Estimate the rocket performance in free space and gravitational field.
5. Design the basic staging of rockets and missiles.
6. Identify the control methods of rockets and missiles.

Module: 1	CLASSIFICATION OF ROCKETS AND MISSILES	8 Hours
Various methods of classification of missiles and rockets, Basic aerodynamic characteristics of surface to surface, surface to air, air to surface and air to air missiles, Examples of various Indian space launch vehicles and missiles.		
Module: 2	**AERODYNAMICS OF ROCKETS AND MISSILES**	**7 Hours**
Airframe components of rockets and missiles – forces acting on a missile while passing through atmosphere – classification of missiles – slender body aerodynamics		
Module: 3	**AERODYNAMICS FORCES AND PERFORMANCE OF ROCKETS AND MISSILES**	**8 Hours**

Method of describing forces and moments, lift force and lateral moment, lateral aerodynamic damping moment, longitudinal moment, drag estimation, upwash and downwash in missile bodies – rocket dispersion.		
Module: 4	**ROCKET MOTION IN FREE SPACE AND GRAVITATIONAL FIELD**	**8 Hours**
One dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields – description of vertical, inclined and gravity turn trajectories – determination of range and altitude – simple approximations to determine burn out velocity and altitude – estimation of culmination time and altitude.		
Module: 5	**STAGING OF ROCKETS AND MISSILES**	**7 Hours**
Design philosophy behind multi-staging of launch vehicles and ballistic missiles – optimization of multi-stage vehicles – stage separation techniques in atmosphere and in space – stage separation dynamics and lateral separation characteristics.		
Module: 6	**CONTROL OF ROCKETS AND MISSILES**	**7 Hours**
Introduction to aerodynamic and jet control methods – various types of aerodynamic control methods for tactical and short range missiles- aerodynamic characteristics - various types of thrust vector control methods.		
CONTENT BEYOND SYLLABUS		
Determine the db level of a supersonic nozzle for various nozzle exit geometry.		
	Total Lectures	**45 Hours**

Text Books	
1.	George P.Sutton, and Oscar Biblarz, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 8th Edition, 2010.
2.	Ashish Tewari, “Atmospheric and Space Flight Dynamics”, Birkhauser, 2007.
Reference Books	
1.	E. Roy, “Orbital Motion”, Fourth Edition, IOP Publishing Ltd 2005.
2.	J. W. Cornelisse, H.F.R. Schoyer, and K.F. Wakker,. “Rocket Propulsion and Spaceflight Dynamics”, Pitman, 2001.
3.	William E.Wiesel, “Spaceflight Dynamics”, McGraw-Hill, 3rd Edition, 2010.
4.	Howard D. Curtis, “Orbital Mechanics for Engineering Students”, ELSEVIER, Butterworth, Heinemann, 3rd Edition, 2013.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	ADVANCED SPACE DYNAMICS	L	T	P	C
20AE2039		3	0	0	3

Pre-requisites: 20AE2019 Space Dynamics

Course Objectives:

Impart knowledge on

1. The basics of celestial mechanics,
2. Orbital transfers.
3. Orbits in restricted three-body problem.

Course Outcomes:

The student will be able to

1. Understand two-body orbital motion.
2. Gain knowledge of preliminary orbit determination and orbital transfer technique.
3. Understand the concept of dynamical systems.
4. Understand orbital motion in restricted three-body problem (RTBP).
5. Attain knowledge of equilibrium points and its uses in RTBP.
6. Gain knowledge of orbits in 3-dimensional RTBP.

Module: 1	**FUNDAMENTAL PRINCIPLES AND DEFINITIONS**	**7 Hours**
Two-body problem: Central orbits, Equations of motion in an inertial frame, Equations of relative motion.		
Module: 2	**PRELIMINARY ORBIT DETERMINATION**	**8 Hours**
Preliminary orbit determination techniques, Gibbs method of orbit determination from three position vectors, Lambert’s problem, Derivation of Lambert’s theorem.		

Module: 3	**RESTRICTED THREE-BODY PROBLEM (RTBP)**	**8 Hours**
Planar circular restricted three-body problem - Equations of motion in sidereal and synodic coordinate systems, Derivation of Jacobi integral, Tisserand's criterion for the identification of comets.		
Module: 4	**SOLUTIONS IN RTBP**	**7 Hours**
Totality of solutions; Concept of phase space; Manifold of the states of motion and their singularities; Computation of location of collinear and equilateral points.		
Module: 5	**ORBITAL MOTION IN RTBP**	**8 Hours**
Motion near the equilibrium points, derivation of variational equations, Characteristic equation, Motion around the collinear and equilateral points, Critical mass.		
Module: 6	**3-DIMENSIONAL RTBP**	**7 Hours**
Three-dimensional restricted three-body problem, Motion around the equilibrium points, Halo orbits, Lissajous orbits, Hill's problem.		
CONTENT BEYOND SYLLABUS		
Study of the perturbing forces, oblateness and radiation pressure, in RTBP; Elliptic restricted three-body problem.		
	Total Lectures	**45 Hours**

Text Books

1.	Howard D. Curtis, “Orbital Mechanics for Engineering Students”, Elsevier Butterworth-Heinemann, Third Edition, 2010
2.	Victor G. Szebehely, “Theory of Orbits - The Restricted Problem of Three Bodies”, Academic Press, New York and London,1967.

Reference Books

1.	Pini Gurfil, and P. Kenneth Seidelmann, “Celestial Mechanics and Astrodynamics: Theory and Practice”, Springer, 2016.
2.	Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", 1st edition, 2015.
3.	J.M.A.Danby, “Fundamental of Celestial Mechanics”, Inc., 2nd Edition, Willman-Bell,USA,1992.
4.	Carl D. Murray and Stanley F. Dermott, "Solar System Dynamics", Cambridge University Press, 1999.
5.	Vladimir A. Chobotov, “Orbital Mechanics”, AIAA Education Series, AIAA Education Series, Published by AIAA, 2002.
6.	Jan Vrbik, New Methods of Celestial Mechanics, Bentham Science Publishers,2018.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	AIR TRAFFIC CONTROL AND AERODROME DETAILS	L	T	P	C
20AE2040		3	0	0	3

Course Objectives:

Impart knowledge on

1. Air traffic services.
2. Aerodrome data.
3. Civil aviation requirements.

Course Outcomes:

The student will be able to

1. Recall the basic concepts of ATS and its services.
2. Recognize all information relevant to specific planned flight.
3. Exemplify the working routines of radar services.
4. Identify the Aerodrome layouts and the design.
5. Illustrate the runway restrictions, various approach systems and guidances.
6. Understand structural and practical insight in emergency management.

Module: 1	**AIR TRAFFIC CONTROL**	**5 Hours**
Objectives of ATS - Parts of ATC service – Scope and Provision of ATCs –VFR & IFR operations – Classification of ATS air spaces – Varies kinds of separation – Altimeter setting procedures – Establishment, designation and identification of units providing ATS – Division of responsibility of control.		

Module: 2	**AREA CONTROL SERVICE**	**8 Hours**
Area control service, assignment of cruising levels minimum flight altitude ATS routes and significant points – RNAV and RNP – Vertical, lateral and longitudinal separations based on time / distance –ATC clearances – Flight plans – position report.		
Module: 3	**RADAR SERVICES**	**8 Hours**
Radar service, Basic radar terminology – Identification procedures using primary / secondary radar – performance checks – use of radar in area and approach control services – assurance control and co-ordination between radar / non radar control – Flight information and advisory service – Alerting service– Rules of the air.		
Module: 4	**AERODROME DETAILS**	**7 Hours**
Aerodrome data - Basic terminology – Aerodrome reference code – Aerodrome reference point – Aerodrome elevation – Aerodrome reference temperature – Instrument runway, physical Characteristics; length of primary / secondary runway – Width of runways – Minimum distance between parallel runways etc. – obstacles restriction.		
Module: 5	**RUNWAY AIDS**	**9 Hours**
Visual aids for navigation Wind direction indicator – Landing direction indicator – Location and characteristics of signal area – Markings, general requirements – Various markings – Lights, general requirements – Aerodrome beacon, identification beacon – Simple approach lighting system and various lighting systems – VASI & PAPI - Visual aids for denoting obstacles; object to be marked and lighter – Emergency and other services.		
Module: 6	**EMERGENCY SERVICES**	**8 Hours**
Recognizing an Emergency situation, Emergency Triangle Procedure, Aircraft emergencies-General principles, Ballistic Recovery systems, Identification of Hijacks/ Unlawful Interference Situations, Introduction to Aerodrome Emergency Services, Aerodrome Fire Service.		
CONTENT BEYOND SYLLABUS		
Responsibilities of the airline regarding continuing airworthiness.		
	Total Lectures	**45 Hours**

Text Books

1.	Air Traffic Management, "PANS – RAC – ICAO DOC 4444", Sixteenth Edition, 2016.
2.	Airport Authority of India, "Manual of Air Traffic Services Part I", Fourth Edition, Amended 2017.

Reference Books

1.	Andrew Ford, "Aircraft Manual (India) Volume I", Shroff, Amended 2017.
2.	India (Republic). Aeronautical Information Service, "AIP: Aeronautical information publication, India", 2006.
3.	M.Mulder, "Air Traffic Control" Sciyo, 2010.
4.	Antonin Kazda, Robert E.Caves, "Airport Design and Operation", Second edition, Elsevier Science, 2007.
5.	Michael S.Nola, "Fundamentals of Air Traffic Control", Delmar Cengage Learing, 2010.
6.	Christopher D.Wickens, Anne S.Mavor, Raja Parasuraman, James P.McGee, "The future of Air Traffic Control: Human Operators and Automation", National Academies Press, 1998.
7.	Robert E.Caves, Geoffrey D.Gosling, "Strategic Airport Planning", Emerald Group Publishing Limited, 1999.
8.	Norman J.Ashford, Paul H. Wright, "Airport Engineering", Wiley-Interscience, 1992.
9.	Bouwman, Ronald, "Fundamentals of Ground Radar for Air Traffic Control Engineers and Technicians", SciTech Publishing, 2009.
10.	Lucio Bianco, Amedeo R. Odoni, "Large Scale Computation and Information Processing in Air Traffic Control", Springer-Verlag Berlin Heidelberg, Year: 1993.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	AIRCRAFT SYSTEMS	L	T	P	C
20AE2041		3	0	0	3

Course Objectives:

Impart knowledge on

1. Importance and operating principles of aircraft systems.
2. Aircraft environmental and flight conditions.
3. Importance and operating principles of aircraft protection systems.

Course Outcomes:

The student will be able to

1. Understand the principles aircraft Hydraulic systems.
2. Obtain knowledge on the landing gear systems.
3. Obtain knowledge on fuel systems and engine starting systems.
4. Diagnose aircraft engine starting systems performance.
5. Obtain knowledge on cabin atmosphere control systems.
6. Understand the basics of auxilliary systems in aircraft.

Module: 1	AIRCRAFT HYDRAULIC SYSTEMS	7 Hours

Hydraulic fluid – Types of Hydraulic Fluids – Phosphate Ester Base Fluids - Basic Hydraulic Systems – Contamination check and control – filters - Reservoirs – Pumps - Pressure Regulation Actuating cylinders – Relief valves - Selector valves – Aircraft Pneumatic systems – Pneumatic system components – typical Pneumatic power system.

Module: 2	LANDING GEAR SYSTEM	7 Hours

Main landing gear Alignment, support, Retraction – Emergency extension systems – Landing gear safety devices – Nose wheel steering systems – Brake Systems – Brake assemblies - inspection and maintenance of brakes – Aircraft landing wheels – Aircraft tires – Aircraft tire maintenance – Antiskid system – Landing gear system maintenance.

Module: 3	FUEL SYSTEMS	8 Hours

Characteristics and properties of Aviation Gasoline – Turbine engine fuels – fuel system contamination – fuel system components – indicators – multiengine fuel systems – fuel jettison systems – Reciprocating engine ignition systems – battery ignition system – magneto ignition system operating principles - auxiliary ignition units.

Module: 4	ENGINE STARTING SYSTEMS	8 Hours

Reciprocating engine starting systems – Gas Turbine engine starters – Air turbine starters – Lubrication systems – principles of engine lubrication – Requirements and characteristics – Reciprocating engine lubrication system – Turbine engine lubrication system – Engine cooling system – Turbine engine cooling.

Module: 5	CABIN ATMOSPHERE CONTROL SYSTEMS	8 Hours

Need for oxygen – air conditioning and pressurization systems – basic requirements – sources of cabin pressure – cabin pressure control systems – air distribution - air conditioning system – heating systems – cooling systems – electronic cabin temperature control system – oxygen systems – portable oxygen equipments – smoke protection equipments – oxygen cylinders – oxygen masks.

Module: 6	AUXILIARY SYSTEMS	7 Hours

Fire protection systems-Ice protection system –Rain-Removal systems –Water and Waste systems – Position and warning system – Auxiliary power units.

CONTENT BEYOND SYLLABUS

Modern flight control systems - control actuation digital fly by wire systems – Auto pilot System.

Total Lectures	**45 Hours**

Text Books

1.	Ion Moir and Allan Seabridge, Aircraft Systems, John Wiley & Sons Ltd, England, Third edition, 2008.
2.	Roy Langton, Chuck Clark, Martin Hewitt and Lonnie Richards, Aircraft Fuel Systems, Wiley & Sons Ltd, England, 2009.

Reference Books

1.	General Hand Books of Airframe and Power plant Mechanics", U.S. Dept. of Transportation, Federal Aviation Administration, The English Book Store, New Delhi1995.
2.	Mekinley, J.L. and Bent, R.D., "Aircraft Power Plants", McGraw-Hill, 1993.
3.	Pallet, E.H.J., "Aircraft Instruments & Principles", Pitman & Co., 1993.
4.	Treager, S., "Gas Turbine Technology", McGraw-Hill, 1997.
5.	McKinley, J.L., and Bent, R.D., "Aircraft Maintenance & Repair", McGraw-Hill, 1993.
6.	Michael Kroes, William Watkins, Frank Delp, Ronald Sterkenburg, "Aircraft Maintenance & Repair", Seventh Edition, The McGraw-Hill Education, 2013.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**BASICS OF ACOUSTICS**	**L**	**T**	**P**	**C**
20AE2042		3	0	0	3

Course Objectives:

Impart knowledge on
1. Fundamentals of sound.
2. Sound reflection, refraction, diffraction and diffusion.
3. Sound absorption and attenuation.

Course Outcomes:

The student will be able to
1. Understand the sound decibel levels comfortable for human.
2. Understand the behavior of sound propagation.
3. Solve the one dimensional wave equation.
4. Solve the three dimensional wave equation.
5. Gain knowledge on sound behavior in an enclosed room.
6. Understand the propagation of sound in different medium.

Module: 1	**INTRODUCTION TO ACOUSTICS**	**8 Hours**

Acoustic pressure. rms and mean square pressures. Definition and use of the decibel, and the reasons for its use. Addition of quantities (coherent and incoherent) in decibels. Third-octave bands. Human hearing. A-weighting. Sound level meters. Other acoustic metrics.

Module: 2	**INTRODUCTION TO THE PROPAGATION OF ACOUSTIC DISTURBANCES**	**8 Hours**

Longitudinal wave motion, introduction to plane acoustic waves. Speed of sound, frequency, wavelength, wavenumber, particle velocity, characteristic acoustic impedance. Thermodynamics of acoustic compressions. Linear relationships between basic acoustic quantities. Variation of speed of sound with temperature and pressure.

Module: 3	**ONE-DIMENSIONAL ACOUSTIC WAVE MOTION**	**8 Hours**

Conservation equations in one dimension; linearization of governing equations; derivation of one-dimensional wave equation. Solutions to the one-dimensional wave equation. Complex exponential representation of wave motion. Helmholtz equation. Linearity and the superposition principle. Specific acoustic impedance. Acoustic energy density and intensity. Standing waves. Application to impedance tube measurements. Concepts of nonlinear propagation.

Module: 4	**WAVES IN THREE DIMENSIONS**	**7 Hours**

Conservation equations in three dimensions; derivation of the three-dimensional wave equation. Solutions to the three-dimensional wave equation. Spherical waves. Impedance of spherical waves. Sound radiation from a pulsating sphere. The point monopole source. Sound intensity due to a spherical wave. Sound power output of a pulsating sphere and its radiation efficiency. Sound Intensity measurement. International standards for sound power measurement.

Module: 5	**SOUND IN ENCLOSURES**	**7 Hours**

Solution to the three-dimensional wave equation in a room with rigid walled boundaries. Room modes and their natural frequencies. Modal statistics; modal density, modal overlap and the Schroeder frequency. The concepts of a diffuse field and average absorption coefficient; the energy balance equation and reverberation time. Basic auditorium requirements.

Module: 6	**SOUND REFLECTION, TRANSMISSION, REFRACTION AND ATTENUATION**	**7 Hours**
Reflection and transmission at a fluid-fluid interface. The transmission and reflection coefficients. Normal and oblique incidence. Refraction in the atmosphere and underwater: Snell's law. Sound attenuation.		
CONTENT BEYOND SYLLABUS		
Sound radiation and Multipole sources		
	Total Lectures	**45 Hours**

Text Books	
1.	Jerry H. Ginsberg, "Acoustics-A Textbook for Engineers and Physicists, Volume I-Fundamentals", ASA Press, Springer 2018.
2.	Jerry H. Ginsberg, "Acoustics-A Textbook for Engineers and Physicists, Volume II – Applications", ASA Press, Springer 2018.
Reference Books	
1.	Lawrence E. Kinsler, Austin R. Frey, Alan B. Coppens, James V. Sanders, Fundamentals of Acoustics, Fourth Edition, John Wiley 6 Sons, Inc, 2000.
2.	Carl Q Howard_ Benjamin S Cazzolato, "Acoustic analyses using Matlab and Ansys" - CRC, Taylor and Francis, 2014.
3.	Leo L. Beranek, "Acoustics" Amer Inst of Physics, 1986.
4.	Michel Bruneau , "Fundamentals of acoustics", ISTE Ltd, 2006.
5.	Alton F. Everest, "The Master Handbook of Acoustics", McGraw-Hill Companies publisher, 2002.
6.	Glen M Ballou, "Handbook for Sound Engineers", Elsevier, Focal Press, 2008.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**EXPERIMENTAL STRESS ANALYSIS**	**L**	**T**	**P**	**C**
20AE2043		3	0	0	3

Course Objectives:

Impart knowledge on
1. Strain measurement techniques.
2. Electrical-resistance strain gauges and its applications.
3. Photo-elasticity and holography techniques.

Course Outcomes:

The student will be able to
1. Explain the measurement of strain under static and dynamic loads.
2. Describe the electrical strain gauges for strain measurement.
3. Understand the optical techniques in measuring strain.
4. Describe the use of 3D photo elasticity.
5. Identify the suitable stress coating methods.
6. Understand the role of holography in strain measurement.

Module: 1	**BASICS OF EXPERIMENTAL STRESS ANALYSIS**	**8 Hours**
Principle of measurements-Accuracy, Precision, Sensitivity and Range- Definition of strain and its relation to experimental determinations, Properties of strain gauge systems, Types of strain gauge systems- Mechanical, Optical, Acoustical and Electrical extensometers.		
Module: 2	**ELECTRICAL-RESISTANCE STRAIN GAUGES**	**8 Hours**
Electrical-Resistance strain gauges and circuits, Principle of operation and requirements - Types and their uses- Materials for strain gauge-Calibration and temperature compensation-Cross sensitivity- Rosette analysis - Wheatstone bridge-Potentiometer circuits for static and dynamic strain measurements.		
Module: 3	**OPTICAL METHOD OF STRESS ANALYSIS**	**8 Hours**
Polariscope – Concepts of photoelastic effects, Photoelastic materials-Stress optic law- Plane Polariscope – Circular Polariscope -Transmission and Reflection type, Effect of stressed model in Plane and Circular Polariscope, Interpretation of fringe pattern- Isoclinics and Isochromatics. Interferometer, Moiré Method.		
Module: 4	**CONTACT AND NON-CONTACT MEASUREMENTS**	**6 Hours**

Digital Image Correlation, Accelerometer, Force transducer, Linear Differential variable Transformer.		
Module: 5	**BIREFRINGENT COATINGS**	**7 Hours**
Coating stresses and strain- Coating sensitivity – Coating materials- Application of coatings- Effect of coating thickness-Fringe-Order Determinations in coatings- Stress separation methods.		
Module: 6	**INTRODUCTION TO HOLOGRAPHIC INTERFEROMETRY**	**8 Hours**
Hologtaphy: The Laser Light, Hologram, Reconstruction. Holographic Interferometry: Interference Fringes in a double exposure hologram, Interference Fringes in a real time hologram. Description by means of Ellipses, Displacement Vector lying on plane, Displacement Vector lying not on plane, order determination when no zero fringe is present. Strains from displacement.		
CONTENT BEYOND SYLLABUS		
Measurement of stresses using strain gauge as stress gauge.		
	Total Lectures	**45 Hours**

Text Books	
1.	James W Dally & William F Riley, “Experimental Stress Analysis”, McGraw–Hill Inc, 3rd Edition, 2009.
2.	Alessandro Freddi, Giorgio Olmi, Luca Cristofolini, “Experimental Stress for Materials and Structures”, Springer, 2015.
Reference Books	
1.	James F. Doyle, “Modern Experimental Stress Analysis: Completing the Solution of Partially Specified Problems”, John Wiley & Sons Ltd, 2004.
2.	U. C. Jindal, Experimental Stress Analysis, Pearson Ltd, 2012.
3.	Sadhu Singh, “Experimental Stress Analysis”, Khanna Publishers, 2009.
4.	A.J. Durelli and V.J. Parks, “Moire Analysis of Strain”, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1980.
5.	Gregory R. Toker, “Holographic Interferometry” CRC Press, Taylor & Francis Inc, 2017.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**BOUNDARY LAYER THEORY**	**L**	**T**	**P**	**C**
20AE2044		3	0	0	3

Course Objectives:

Impart knowledge on

1. Boundary layers and its applications.
2. Viscous flow phenomena.
3. Laminar and thermal boundary layer equations.

Course Outcomes:

The student will be able to

1. Define the fundamentals of boundary layer theory.
2. Solve the equations involved in boundary layer theory.
3. Analyze the different kinds of boundary layer control.
4. Differentiate turbulent and laminar boundary layers.
5. Estimate the boundary layer thickness for flow over a different bodies.
6. Attain knowledge of boundary layer effects in hypersonic flows.

Module: 1	**FUNDAMENTALS OF BOUNDARY LAYER THEORY**	**6 Hours**
Boundary layer concept- boundary layer on a flat plate, Description of Flow fields, continuity, Momentum and Navier-Stokes equations, Stress-Strain rate relationship, Stokes Hypothesis, Energy equation.		
Module: 2	**EXACT SOLUTIONS OF NAVIER-STOKES EQUATIONS**	**8 Hours**
Steady Plane Flows-Couette Flow, Poiseuille Flow, Flow of Immiscible fluids in a Channel, Steady Axisymmetric Flows-Flow at a rotating disk and axisymmetric free jet. Unsteady Axisymmetric Flows-Vortex Decay.		
Module: 3	**LAMINAR BOUNDARY LAYER EQUATIONS**	**10 Hours**

Boundary Layer equations, Derivation of boundary layer equations, Wall friction, separation and displacement, friction drag, Plate boundary layer. Integral relations of boundary layer-Momentum Integral equation, Energy Integral equation.		
Module: 4	**BOUNDARY LAYER OVER AXISYMMETRIC BODIES**	**7 Hours**
Governing Equations for Axisymmetric Flow, Mangler transformation, Relation between flow over plate and Sharp Cone.		
Module: 5	**THERMAL BOUNDARY LAYER**	**7 Hours**
Thermal boundary layers with coupling of the velocity field of the temperature field-Boundary layer equations. Compressible Boundary layers- Simple solutions of energy equation, Integral methods, Boundary layers in hypersonic flows.		
Module: 6	**BOUNDARY LAYER CONTROL**	**7 Hours**
Different Kinds of Boundary Layer control, Continuous suction and blowing-Massive suction, Massive Blowing, Plate flow with uniform suction or blowing, Airfoil. Three –Dimensional boundary layers boundary layer at cylinder, Boundary layer at a yawing cylinder.		
CONTENT BEYOND SYLLABUS		
Develop and execute C++/ Python programming to solve boundary value problems.		
	Total Lectures	**45 Hours**

Text Books	
1.	Schlichting, Herrmann, Gersten, Klaus Translated by Mayes-“Boundary Layer Theory” 8th rev. and enlarged ed. 2000.
2.	Frank White, “Viscous Fluid flow” – 3rd edition, McGraw Hill, 2005.
Reference Books	
1.	Ian. J. Sobey, “Introduction to Interactive Boundary Layer Theory”, Oxford University Press, USA, 2001.
2.	Ronald L., Panton, “Incompressible Fluid Flow”, John Wiley & Sons, 2005.
3.	J. Reynolds, “Turbulent flows in Engineering”, John Wiley & Sons, 1992.
4.	Tuncer Cebeci and Peter Bradshaw, “Momentum transfer in boundary layers”, Hemisphere Publishing Corporation, 1977.
5.	Holger Babinsky, John K. Harvey, “Shock Wave-Boundary-Layer Interactions (Cambridge Aerospace Series)”,Cambridge, 2014.
6.	Schlichting, “Boundary Layer Theory” Seventh Edition, Mc Graw Hill Education, Indian Edition,2014.
7.	Introduction to Boundary Layers: https://nptel.ac.in/courses/112/106/112106190/.
8.	Boundary layers, separation and drag: https://ocw.mit.edu/courses/mechanical-engineering/2-25-advanced-fluid-mechanics-fall-2013/boundary-layers-separation-and-drag/.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**INTRODUCTION TO HYPERSONIC FLOWS**	**L**	**T**	**P**	**C**
20AE2045		3	0	0	3

Course Objectives:

Impart knowledge on

1. Features of in-viscid hypersonic flows, viscous hypersonic flows and high temperature effects
2. Estimation of flow over bodies under hypersonic conditions
3. High temperature issues of hypersonic wings.

Course Outcomes:

The student will be able to

1. Solve the problems involving in-viscid and viscous hypersonic flows
2. Estimate the high temperature effects in hypersonic aerodynamics
3. Asses the design issues for hypersonic wings
4. Apply the computational tools to evaluate hypersonic flows
5. Distinguish the high Mach number flow from supersonic flows
6. Estimate flow parameters over a vehicles under hypersonic conditions.

Module: 1	INTRODUCTION TO HYPERSONIC FLOWS	5 Hours
Features of hypersonic flows, thin shock layers, Entropy layer, Viscous- Inviscid Interaction, High Temperature effects, Low Density Effects.		
Module: 2	**HYPERSONIC SHOCK AND EXPANSION WAVE RELATIONS**	**6 Hours**
Oblique shock relations for high Mach numbers, Expansion wave relations for high Mach numbers. Theoretical basis of Mach number independence principle- corroboration by experimental results. Importance of experiments.		
Module: 3	**INVISCID HYPERSONIC FLOWS**	**10 Hours**
Hypersonic Shock relations, Hypersonic Shock relations, Hypersonic Expansion Wave relation, Methods of calculating surface pressures- Newtonian Flows, Modified Newtonian Laws, Centrifugal Force Correction, Tangent wedge Method, Tangent Cone Method, Shock Expansion Method.		
Module: 4	**HYPERSONIC INVISCID FLOW FIELD**	**8 Hours**
Approximate Methods for inviscid hypersonic flows, Mach number independence Principle, Hypersonic slender body theory for all angle of attack, hypersonic similarity laws, thin shock layer theory.		
Module: 5	**INTRODUCTION TO VISCOUS HYPERSONIC FLOWS**	**8 Hours**
Viscous hypersonic flows-Boundary layer Equations, Navier-Stokes equations, Similarity Parameters, Boundary Conditions, Hypersonic Boundary Layer Theory, Self-similar Solution – Flat Plate and Stagnation Point, Non-similar Boundary Layer, Local similarity Method, Hypersonic Transition, Turbulent Boundary layer.		
Module: 6	**AERODYNAMIC HEATING AND VISCOUS-INVISCID INTERACTION**	**8 Hours**
Hypersonic Aerodynamic Heating, axi-symmetric analogue for three dimensional bodies, hypersonic viscous Interactions.		
CONTENT BEYOND SYLLABUS		
Hypersonic wind tunnel and its calibration.		
	Total Lectures	**45 Hours**

Text Books

1.	John D.Anderson Jr., "Hypersonic and High Temperature Gas dynamics", AIAA, 2nd Edition 2006.
2.	John J Bertin., "Hypersonic Aerothermodynamics", AIAA Education Series., Washington DC, 1994.

Reference Books

1.	Hayes, Wallace.D and Probstein R F., "Hypersonic Inviscid Flow", Dover Publications, 2004.
2.	Ernst Heinrich Hirschel., "Basics of Aerothermodynamics", Springer Verlag Berlin, 2005.
3.	Vladimir V. Lunev, "Real Gas Flows with High Velocities", CRC Press, 2009.
4.	Maurice Rasmussen, Hypersonic Flow, John Wiley & Sons, 1994.
5.	Harry J Davies, H.J. and Churchack, H.D., "Shock Tube Techniques & Instrumentation", 1969, US Army Material Command, Harry Diamond Lab, Washington DC.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	FATIGUE AND FRACTURE MECHANICS	L	T	P	C
20AE2046		3	0	0	3

Course Objectives:

Impart knowledge on

1. Structural fatigue and its behavior.
2. Physical aspects of fatigue and the failure mechanism of components
3. Failure mechanisms in composite materials.

Course Outcomes:

The student will be able to

1. Understand the concepts of fatigue behavior of structures.
2. Understand the phases in metal fatigue.
3. Describe the fatigue life of structures.

4. Distinguish between low and high cycle fatigue. 5. Understand the importance of stress intensity factor. 6. Describe the failure mechanisms in fiber composites.		
Module: 1	**INTRODUCTION TO FATIGUE**	**7 Hours**
Fatigue – maximum stress, minimum stress, mean stress, stress amplitude, stress ratio. Constant amplitude fatigue, variable amplitude fatigue.		
Module: 2	**PHYSICAL ASPECTS OF FATIGUE**	**8 Hours**
Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations - fatigue fracture surfaces.		
Module: 3	**FATIGUE OF STRUCTURES**	**8 Hours**
S.N. curves - Endurance limits - Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams - Notches and stress concentrations - Neuber's stress concentration factors - Plastic stress concentration factors - Notched S.N. curves.		
Module: 4	**STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR**	**7 Hours**
Low cycle and high cycle fatigue - Coffin - Manson's relation - Transition life - cyclic strain hardening and softening - Analysis of load histories - Cycle counting techniques -Cumulative damage - Miner's theory.		
Module: 5	**LINEAR ELASTIC FRACTURE MECHANICS**	**7 Hours**
Stress intensity factors for typical geometries. – Center-cracked test specimen, Edge-cracked strip, Tension specimen with two symmetric edge cracks. Three modes of crack opening, Paris law.		
Module: 6	**FRACTURE MECHANICS**	**8 Hours**
Potential energy and surface energy - Griffith's theory - Irwin - Orwin extension of Griffith's theory to ductile materials - stress analysis of cracked bodies - Effect of thickness on fracture toughness.		
CONTENT BEYOND SYLLABUS		
Estimation of crack tip plastic zone size using various approaches.		
	Total Lectures	**45 Hours**

Text Books	
1.	Alten F. Grant, "Fundamentals of Structural Integrity Damage Tolerant Design and Nondestructive Testing", John Wiley & Sons, 2004.
2.	J Prasanth Kumar – "Elements of Fracture Mechanics" – Wheeter publication, 1999.
Reference Books	
1.	S. Suresh, "Fatigue of Materials", Second Edition, Cambridge University Press, 2001.
2.	J.Schijive, "Fatigue of Structures and Materials",Second Edition, Springer, 2009.
3.	Knott, J.F., "Fundamentals of Fracture Mechanics", Buterworth & Co., Ltd., London, 1983.
4.	T. S. Srivatsan, M. Ashraf Imam, Raghavan Srinivasan, "Fatigue of Materials: Advances and Emergences in Understanding", John Wiley & Sons, 2010.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**FUNDAMENTALS OF COMBUSTION**	**L**	**T**	**P**	**C**
20AE2047		3	0	0	3

Course Objectives:

Impart knowledge on

1. Importance and basics of combustion and various types of flames.
2. Combustion in various engines.
3. Deflagration, detonation and supersonic combustion.

Course Outcomes:

The student will be able to

1. Analyze a given system by applying laws of combustion.
2. Evaluate the premixed and non-premixed combustion.
3. Measure burning velocity and their effects on combustion.
4. Design combustor for engines.
5. Analyze the reaction and mixing processes.

6. Evaluate performance of rocket fuels.		
Module: 1	**FUNDAMENTAL CONCEPTS IN COMBUSTION**	**7 Hours**
Thermo - chemical equations - Heat of reaction, Law of Mass action, Order of reaction- first order, second order and third order reactions - reacting flows - modelling of reacting flows - premixed flames – detonation and explosion.		
Module: 2	**INTRODUCTION TO TURBULENCE**	**7 Hours**
Introduction to turbulence- Influence of turbulence in combustion - turbulent premixed combustion - non-premixed combustion- turbulent non premixed combustion - spray combustion - combustion instability.		
Module: 3	**CHEMICAL KINETICS AND FLAMES**	**8 Hours**
Measurement of burning velocity - Various methods - Effect of various parameters on burning velocity - Flame stability - Detonation - Deflagration - Rankine - Hugoniot curve - Radiation by flames.		
Module: 4	**COMBUSTION IN GAS TURBINE ENGINES**	**8 Hours**
Combustion in gas turbine combustion chambers - Re-circulation - Combustion efficiency - Factors affecting combustion efficiency - Fuels used for gas turbine combustion chambers - Combustion stability - Flame holder types.		
Module: 5	**COMBUSTION IN ROCKETS**	**7 Hours**
Solid propellant combustion - Double base and composite propellant combustion- Various combustion models, thrust time curve, Combustion in liquid rocket engines - Single fuel droplet combustion model - Combustion in hybrid rockets.		
Module: 6	**SUPERSONIC COMBUSTION**	**8 Hours**
Introduction - Supersonic combustion controlled by mixing, diffusion and heat convection - Analysis of reaction and mixing processes - Supersonic burning with detonation shocks.		
CONTENT BEYOND SYLLABUS		
Study the Flame structure of Bunsen burner and a kerosene lamp		
	Total Lectures	**45 Hours**

Text Books	
1.	H. Lefebvre, Dilip R. Ballal, “Gas Turbine Combustion”, Taylor & Francis Group, 2012.
2.	Law, C. K., “Combustion Physics”, Cambridge Univ. Press, 2006.
Reference Books	
1.	Sutton, G.P., and Biblarz, “Rocket Propulsion Elements”, 7 th Edition John Wiley and Sons, Inc., New York, 2017.
2.	Turns, S.R., “An Introduction to Combustion Concepts and Applications”, 2nd Edition. McGraw Hill International Editions, New Delhi, 2000.
3.	Glassman, I. and Yetter, R. A., “Combustion”, 4th ed., Academic Press, 2008.
4.	Kuo, K. K., “Principles of Combustion”, 2nd ed., John Wiley, 2005.
5.	Warnatz, J., Maas, U., and Dibble, R. W., “Combustion”, 4th ed., Springer, 2006.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**UNMANNED AIRCRAFT SYSTEMS**	**L**	**T**	**P**	**C**
20AE2048		3	0	0	3

Course Objectives:

Impart knowledge on
1. Basic terminologies, models and prototypes of UAV system.
2. Design considerations of UAV systems.
3. Designing UAV system for specific requirements.

Course Outcomes:

The student will be able to
1. Understand the basic terminologies and classification of UAS.
2. Relate the design parameters of UAV systems.
3. Obtain knowledge on the application of aerodynamic principles to design UAS.

4. Obtain knowledge on payloads and launch systems for UAS. 5. Understand the basic principles of UAV Testing. 6. Apply the principles to design UAS for specific applications.		
Module: 1	**INTRODUCTION TO UAS**	**8 Hours**
Introduction to Unmanned Aircraft Systems (UAS) – Systematic basis of UAS – System composition - Categories and Roles – Elements of UAS – Unmanned Aircraft system operations.		
Module: 2	**DESIGN OF UAV SYSTEMS**	**8 Hours**
Design and selection of UAS – Aerodynamics and airframe configurations – Aspects of airframe design - Unmanned Aircraft characteristics – Long range, Medium and Close range UAVs – Mini, Micro and Nano UAVs – Novel hybrid combinations.		
Module: 3	**UAV STANDARDS**	**7 Hours**
Unmanned Design standards and Regulatory aspects – Airframe design – Ancillary equipment – Design of Stealth.		
Module: 4	**UAV PAYLOADS**	**7 Hours**
Sensors and payloads – payload types – Communications, Control and stability, Navigation – Launch and recovery.		
Module: 5	**UAV TESTING**	**7 Hours**
Certification and ground testing – inflight testing - Human factors in UAS – Future of UAS and challenges.		
Module: 6	**ROLE OF UAV**	**8 Hours**
Launch of HTOL & VTOL systems – recovery of HTOL & VTOL systems - Naval roles – Army roles – Civilian roles – paramedical and commercial roles – commercial applications		
CONTENT BEYOND SYLLABUS		
Materials used in UAV		
	Total Lectures	**45 Hours**

Text Books	
1.	Reg Austin, "Unmanned Aircraft Systems: UAVS Design Development and Deployment", First edition, John Wiley and Sons, 2010.
2.	Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, "Introduction to Unmanned Aircraft systems", CRC press, Taylor and Francis, New York, 2012. Richard Microcontroller Systems for a UAV, A. Skafidas, 2002.
Reference Books	
1.	Paul.G.Fahlstrom, Thomas.J.Gleason Introduction to UAV systems, UAV SYSTEMS, Ins.. 2013.
2.	Armand.J. Chaput, "Design of UAV Systems" , Lockheed Martin Aeronautics Company, 2001.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**INDUSTRIAL AERODYNAMICS**	**L**	**T**	**P**	**C**
20AE2049		3	0	0	3
Course Objectives:					
Impart knowledge on 1. Non-aeronautical applications of aerodynamics, such as road vehicles, building etc. 2. The concept of wind energy system and its applications. 3. Solution to problems in flow induced vibrations.					
Course Outcomes:					
The student will be able to 1. Understand the airflow over a surface. 2. Apply the principles of aerodynamics to different ground vehicles. 3. Asses various wind energy system. 4. Predict the behavior of airflow over civil structures. 5. Analyze the flow field over trains. 6. Estimate the flow induced vibrations in cables and bridges.					
Module: 1	**ATMOSPHERIC BOUNDARY LAYER**	**7 Hours**			

Atmospheric circulation-local winds – terrain types – mean velocity profiles- power law and logarithmic law, wind speeds, turbulence profiles, Roughness parameters – simulation techniques in wind tunnels.		
Module: 2	**BLUFF BODY AERODYNAMICS**	**7 Hours**
Boundary layers and separation, 2-D wake and vortex formation, Strouhal and Reynolds numbers, separation and reattachments, power requirements and drag coefficients of automobiles, effect of cut back angle, and aerodynamics of trains.		
Module: 3	**WIND ENERGY COLLECTORS**	**7 Hours**
Horizontal and vertical axis machines, energy density of different rotors, power coefficient, Betz coefficient by momentum theory.		
Module: 4	**BUILDING AERODYNAMICS**	**8 Hours**
Pressure distribution on low rise buildings, wind forces on buildings, environmental winds in city blocks, and special problems of tall buildings, building codes, ventilation and architectural aerodynamics.		
Module: 5	**FLOW INDUCED VIBRATION**	**8 Hours**
Vortex shedding, effect of Reynolds number on wake formation in turbulent flows, across wind galloping, wake galloping, along wind galloping of circular cables, oscillation of tall structures and launch vehicles under wind loads, stall flutter.		
Module: 6	**WINDTUNNEL TESTING**	**8 Hours**
Simulation of the Natural wind at small scale, Test Methods to Determine wind loads on the structural systems, Aeroelastic Model Testing, Test Methods to Determine Cladding loads, Other types of wind related study.		
CONTENT BEYOND SYLLABUS		
Performance evaluation of road vehicles and estimation of fuel consumption		
	Total Lectures	**45 Hours**

Text Books

1. Gino Sovran, "Aerodynamic Drag Mechanisms of Bluff Bodies and Road Vehicles" Springer 2012.
2. Tom Lawson, Building Aerodynamics", Imperial College Press; first edition, 2001.

Reference Books

1. John D. Holmes, "Wind Loading of Structures", CRC Press, second Edition, 2007.
2. Steven R.H, Rex E.B., "Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites", John Wiley& Sons, 2003.
3. Blevins R.D., "Flow Induced Vibrations", Van Nostrand, 1990
4. Wolf-Heinrich Hucho, "Aerodynamics of Road Vehicles. From Fluid Mechanics to Vehicle Engineering" Butterworth-Heinemann Ltd, Year: 1987.
5. Antony Wood, "Wind Tunnel Testing of High-Rise Buildings" Routledge Publisher, 2013.
6. Wind tunnel testing for buildings and other structures: ASCE/SEI 49-12, American Society of Civil Engineers, Year: 2012.
7. Sachs P, "Wind Forces in Engineering:, Pergamon Press, 1988.
8. J. B. Barlow, W. H. Rae, A. Pope, "Low Speed Wind Tunnel Testing", John Wiley & Sons Publisher, 1999.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**NAVIGATION, GUIDANCE AND CONTROL OF AEROSPACE VEHICLES**	**L**	**T**	**P**	**C**
20AE2050		3	0	0	3

Course Objectives:

Impart knowledge on

1. Various navigation methodologies.
2. Guidance laws.
3. Control systems and their stability.

Course Outcomes:

The student will be able to

1. Recall the radar concepts and their operation. 2. Identify fundamental navigation concepts and their working. 3. Exemplify various inertial sensors and their applications in IMU. 4. Compute guidance commands with the knowledge of the guidance laws. 5. Illustrate control system concepts. 6. Integrate and validate control systems in aerospace applications.		
Module: 1	**INTRODUCTION TO RADARS**	**6 Hours**
Introduction to radars, Radar equation, Block Diagram and Operation; Radar Frequencies. Application of Radars, Range performance of radars. Minimum detectable signal, Noise effects. Multiplexing (TDMA, FDMA, CDMA).		
Module: 2	**INTRODUCTION TO NAVIGATION SYSTEMS**	**8 Hours**
Introduction to navigation systems- Navigation by VFR, Navigation by IFR – Radio & Radar Navigation, Hyperbolic Navigation, Satellite Navigation - Introduction to GPS - system description - basic principles - position and velocity determination, ILS, MLS. VOR/DME Doppler/LORAN/Omega, Radio Altimeter, GLS.		
Module: 3	**INERTIAL NAVIGATION**	**8 Hours**
Geometric concepts of Navigation, Reference frames, coordinate transformation, comparison of transformation methods. Inertial sensors, Inertial navigation systems-mechanization, Externally aided navigation, Integrated navigation. GYRO - Fiber Optic, Ring Laser		
Module: 4	**INTRODUCTION TO GUIDANCE**	**7 Hours**
Missile Guidance laws; Classification of guidance laws; Classical guidance laws; Modern guidance laws, Autopilots – Longitudinal, Lateral & Missile.		
Module: 5	**INTRODUCTION TO CONTROL**	**8 Hours**
Introduction to Control System open loop and closed loop control system-Transfer function poles and zeroes - block diagram reduction- signal flow graph - Mason's gain formula. High MACH Number difficulties, Flight Control Laws.		
Module: 6	**SYSTEM STABILITY**	**8 Hours**
Characteristics equation-concept of stability - Routh's stability Criteria Root Locus. Classical linear time invariant control systems. Stability; time domain characteristics. PID controller design for aerospace systems. Frequency domain characteristics, Nyquist and Bode plots and their application to controller design for aerospace systems.		
CONTENT BEYOND SYLLABUS		
Selection and trade-of between various navigation components such as the IMU, GPS and other navigation components.		
	Total Lectures	**45 Hours**

Text Books	
1.	Nagaraja, N.S. "Elements of Electronic Navigation", Tata McGraw-Hill Pub. Co., 15th reprint, 2006.
2.	Blake Lock, J.H, "Automatic control of Aircraft and missiles", John Wiley Sons, Second Edition, 1991.
Reference Books	
1.	M .I. Skolnik, "Introduction to Radar Systems", Tata McGraw-Hill, 2007
2.	M. Kayton and W. Fried, "Avionics Navigation System", Wiley Interscience, 1997.
3.	P. Zarchan, "Tactical and Strategic Missile Guidance", AIAA, 2007.
4.	N.S. Nise, "Control Systems Engineering", Wiley-India, 2004.
5.	B. Friedland, "Control System Design", Dover, 2005.
6.	Debasish Ghose, "Navigation, Guidance, And Control", NPTEL: Courses - Aerospace Engineering: https://nptel.ac.in/syllabus/101108056/.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	AIRCRAFT INSTRUMENTATION & CONTROL LABORATORY	L	T	P	C
20AE2051		0	0	2	1

Course Objectives:

Impart knowledge on

1. Aircraft instrumentation.
2. Training to measure aircraft parameters.
3. Sensors and transducers in aerospace application.

Course Outcomes:

The student will be able to

1. Measure three axis acceleration.
2. Measure velocity using hot wire anemometer.
3. Measure temperature using RTD & Thermocouple.
4. Design a control system for autopilots.
5. Estimate the data transferred in a MIL-STD-1553B data bus.
6. Determine position in GPS using my RIO.

List of Experiments

1.	ARM processor based Programming.
2.	Transmission and reception of data via ARINC 429.
3.	Determination of temperature using RTD.
4.	Determination of temperature using thermocouple.
5.	Determination of Angular Position using mems gyro.
6.	Determination of velocity using hot wire anemometer.
7.	Designing a control system for longitudinal autopilot.
8.	Designing a control system for lateral autopilot.
9.	Designing a control system for missile autopilot.
10.	Position fixing using GPS.
11.	Transmission of data in Mil-Std-1553B.

Total Lectures | **15 Hours**

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	WIND TUNNEL TECHNIQUES	L	T	P	C
20AE2052		3	0	0	3

Course Objectives:

Impart knowledge on

1. Various types of wind tunnels and test techniques.
2. The basic concepts of measurement of pressure, velocity, forces and moments on models.
3. Various flow visualization techniques.

Course Outcomes:

The student will be able to

1. Understand the various types of wind tunnels and test techniques.
2. Choose proper high speed wind tunnel for required test.
3. Choose correct model for wind tunnel testing.
4. Estimate the forces and moments for given model.
5. Estimate pressure, velocity and temperature using measurement techniques.
6. Choose the proper flow visualization techniques.

Module: 1	**LOW SPEED WIND TUNNELS**	**8 Hours**

Wind tunnel and its components, Similarity and flow parameters, Types of Wind Tunnel- subsonic, supersonic, transonic and hypersonic, Low Speed: layouts and nomenclature, types - closed circuit and open circuit, closed jet and open jet test section, Energy losses in wind tunnel, application, Special purpose tunnels - Smoke Tunnels – Water Tunnels – Spin tunnel etc.,

Module: 2	**SUPERSONIC WIND TUNNEL**	**8 Hours**

Classification, Blow down, Continuous and intermittent tunnel, Compressible flow theory and isentropic relations,Runtime mass flow rate, Size of pressure vessel, Starting and stopping Loads, Model Sizing, Calibration.		
Module: 3	**HYPERSONIC WIND TUNNEL**	**8 Hours**
Classification; Runtime Calculation; Shock Tube: Driver – driven section – Diaphragm – Type of operation – Shock Speed and Initial Diaphragm Pressure Ratio. Model sizing; Starting and stopping Loads - Calibration of test section for various Tunnels.		
Module: 4	**MEASUREMENTS OF FORCES AND MOMENTS**	**8 Hours**
Forces, moments and Reference Frames, Wind tunnel balance-Wire type balance, Strut type balance, Strain gauge balance-Internal and External, Requirements and Specifications, Fundamentals of Model Installations.		
Module: 5	**WIND TUNNEL MEASUREMENTS**	**7 Hours**
Pressure measurements – Barometers, Manometers, Pressure Transducer, Pressure sensitive Paints, Pitot-static tube, Velocity Measurements -Laser Doppler Anemometer, Hot-wire Anemometer, PIV – PLIF - LDV, Temperature Measurements–Thermocouples, Temperature sensitive Paints, Heat flux measurements.		
Module: 6	**FLOW VISUALIZATION TECHNIQUES**	**6 Hours**
Path – Streak – Stream and Timelines; Techniques: Smoke, Tuft, Streaks, Surface oil flow, Interferometer, Schlieren and Shadowgraph technique.		
CONTENT BEYOND SYLLABUS		
Optical methods of flow visualization – Particle image velocimetry.		
	Total Lectures	**45 Hours**

Text Books

1. Rae, W.H. and Pope, A. “Low Speed Wind Tunnel Testing”, John Wiley Publication, 1999.
2. Pope, A., and Goin, L., “High Speed wind Tunnel Testing”, John Wiley Publication, 1999.
3. Rathakrishnan E, Instrumentation, Measurements and Experiments in fluids. CRC Press, London, 2007.

Reference Books

1. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010.
2. J Lukosiewitz, M Dekkar, “Experimental Methods of Hypersonic”, 1973.
3. Rathakrishnan E, “Gas Dynamics”, PHI Learning Pvt Ltd, 2013.
4. Justin D. Pereira, “Wind tunnels: aerodynamics, models and experiments”, Nova Science Publishers, 2011.
5. https://nptel.ac.in/courses/101/106/101106040/.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**BASICS OF AEROSPACE ENGINEERING**	**L**	**T**	**P**	**C**
20AE2056		3	0	0	3

Course Objectives:

Impart knowledge on

1. Basic concepts of aircrafts, rockets, satellites and their development
2. Basic parts of aircrafts and UAVs and their function
3. Basics of propulsion and application of rockets

Course Outcomes:

The student will be able to

1. Understand the evolution of aircrafts and flying vehicles
2. Understand the parts and functions of aircrafts
3. Obtain knowledge on principles of flight
4. Understand the fundamentals of structures and materials used in Aerospace applications
5. Understand the principles of aircraft and rocket propulsion
6. Obtain knowledge on the components and function of Multicopter drones

Module: 1	**INTRODUCTION TO AEROSPACE ENGINEERING**	**8 Hours**

Historical evolution - Developments in aerodynamics, materials, structures and propulsion over the years – Components of an airplane and their functions; Different types of flight vehicles, classifications; Basic instruments for flying.		
Module: 2	**PRINCIPLES OF FLIGHT**	**7 Hours**
Principles of flight- Evolution of lift, drag and moment; altitude and standard atmosphere - Airfoil and nomenclature-Basic aerodynamics - Fuselage and Wing Structure.		
Module: 3	**: AIRCRAFT MATERIALS AND STRUCTURES**	**8 Hours**
General types of Aircraft construction, Aerospace materials, metallic and non-metallic materials, Introduction to composites – Types - Composites in Aerospace applications.		
Module: 4	**AIRCRAFT PROPULSION**	**8 Hours**
Basic ideas about piston, turboprop and jet engines, Basic Propeller theory; Principles of operation of rocket, types of rockets and typical applications – Satellites and applications.		
Module: 5	**EXPLORATION INTO SPACE**	**6 Hours**
Sun and the solar system – Apollo mission, India's achievement in space – Launch vehicles – Mars Mission – Lunar missions.		
Module: 6	**UNMANNED AIRCRAFT SYSTEMS**	**8 Hours**
History of UAV – Nomenclature – Types – Components of Multicopter drones – Airframe, Flight controller, Battery, GPS, Transmitter, Telemetry , Payload, Autopilot – Societal applications of drones.		
	Total Lectures	**45 Hours**

Text Books	
1.	John D. Anderson Jr, Introduction to Flight, Tata McGraw Hill Education Private Limited, New Delhi, 5th Edition, 2009.
2.	Terry Kilby & Belinda Kilby, "Getting started with Drones", Maker Media, San Francisco, 2015.
3.	A. C. Kermode, Mechanics of Flight, Pearson Education, 11th Edition, 2006.
Reference Books	
1.	Dave Doody, "Basics of Space Flight", National Aeronautics and Space Administration, 2011.
2.	John Baichtal, "Building your own Drones", Que Publishing, 2016.

Recommended by Board of Studies	
Approved by Academic Council	25^{th} September 2021

Course code	**ROAD VEHICLE AERODYNAMICS**	**L**	**T**	**P**	**C**
20AE2057		3	0	0	3

Course Objectives:

Impart knowledge on

1. Aerodynamics in road vehicles.
2. Aerodynamic force influences in road vehicle design.
3. Wind tunnel testing for road vehicles.

Course Outcomes:

The student will be able to

1. Understand the fundamentals of fluid mechanics.
2. Apply the principles of aerodynamics to different ground vehicles.
3. Discuss the behavior of airflow over bluff body.
4. Explain the flow field over high-performance vehicles.
5. Infer the flow field over commercial vehicles.
6. Select the wind tunnel testing method and measuring techniques for road vehicles.

Module: 1	**INTRODUCTION & FUNDAMENTALS OF FLUID MECHANICS**	**8 Hours**
Introduction: Basic principle, Historical development, Basic shapes, streamlined shapes. Fluid Mechanics-Properties of incompressible fluids: density, viscosity, thermal conductivity, Flow phenomena related to vehicles: External flow, Internal flow. External flow problem: Basic equations for inviscid incompressible flow, Applications: The two-dimensional flow around a vehicle-shaped body. Effects of viscosity: Laminar and turbulent boundary-layer development, Separation, Friction drag, Pressure drag,		

Overall forces and moments, Thermal boundary layers, Special Problem: Aerodynamic noise, Aeroelastic effects.		
Module: 2	**AERODYNAMIC PERFORMANCE OF CARS AND LIGHT VANS**	**8 Hours**
Introduction- Resistance to vehicle motion: Equation of resistance to motion, Analysis of the resistances to motion: Aerodynamic drag - Rolling resistance - Climbing resistance - Acceleration resistance. Performance: Motive force diagram- Acceleration time and elasticity- Top speed, Impact of aerodynamic drag and weight		
Module: 3	**AERODYNAMIC DRAG OF PASSENGER CARS**	**8 Hours**
The passenger car as a bluff body - Flow field around a passenger car , Analysis of aerodynamic drag, Global considerations, Components of drag- Procedure- Forebody- Windshield, A-pillar- Vehicle rear ends, Sides, Underside, Wheels and wheel wells, Front spoiler, Rear spoiler Attachments, Drag from flow through the car, Trailers and roof luggage racks, Strategies for aerodynamic development of passenger cars- Detail optimization- Shape optimization- Drag reduction in the course of model improvement measures.		
Module: 4	**HIGH-PERFORMANCE VEHICLES**	**7 Hours**
Introduction- Some historical milestones- The influence of aerodynamics on high-performance vehicles- Drag and lift, Handling- Driving tests- Angle of attack and yawed air flow – Draughting - Theoretical investigation - Cooling and ventilation- Design alternatives - Drag and lift.		
Module: 5	**COMMERCIALVEHICLES**	**7 Hours**
Introduction- Tractive resistance and fuel consumption - Drag reduction and fuel consumption, Aerodynamic drag coefficients of different commercial vehicles- Wind influence—definition of yaw angle- Characterization of air resistance in actual operating conditions. Reducing aerodynamic drag. Drag minimization on trucks, Minimizing drag of buses and delivery vans.		
Module: 6	**WIND TUNNELS FOR AUTOMOBILE AERODYNAMICS**	**7 Hours**
Requirements for a vehicle wind tunnel- Simulation of road driving, Principles of wind tunnel technology, Limitations of simulation, Tests with scale models- Influence of the Reynolds number. Existing automobile wind tunnels. Measuring equipment and transducers, Pressure measurements, Air flow velocity measurements, Temperature measurement, Measurement of aerodynamic coefficients.		
CONTENT BEYOND SYLLABUS		
Performance evaluation of road vehicles and estimation of fuel consumption		
	Total Lectures	**45 Hours**

Text Books	
1.	Aerodynamics of Road Vehicles: From Fluid Mechanics to Vehicle Engineering 1998 by Wolf-Heinrich Hucho (Editor).
2.	Aerodynamics of Road Vehicles, Fifth Edition R-430 by Thomas Christian Schuetz, SAE International.
Reference Books	
1.	E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012.
2.	Wolf-Heinrich Hucho, “Aerodynamics of Road Vehicles. From Fluid Mechanics to Vehicle Engineering” Butterworth-Heinemann Ltd, Year: 1987.
3.	Blevins R.D., “Flow Induced Vibrations”, Van Nostrand, 1990.
4.	J. B. Barlow, W. H. Rae, A. Pope, “Low Speed Wind Tunnel Testing”, John Wiley & Sons Publisher, 1999.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	WIND TURBINE DESIGN	L	T	P	C
20AE2058		3	0	0	3

Course Objectives:

Impart knowledge on

1. Aerodynamics in wind turbine design.
2. The concept of wind energy system and its applications.
3. Wind tunnel testing.

Course Outcomes:		
The student will be able to 1. Understand the atmospheric impact on wind energy. 2. Understand the basic fluid mechanics of wind turbines. 3. Apply the principles of aerodynamics to different aerofoil and blade shape. 4. Asses various wind energy systems. 5. Analyze the performance of wind turbine. 6. Design wind turbine blades.		
Module: 1	**INTRODUCTION & FUNDAMENTALS OF FLUID MECHANICS**	**8 Hours**
Introduction: Basic principle, Historical development, Basic shapes, streamlined shapes. Fluid Mechanics: Properties of incompressible fluids: density, viscosity, thermal conductivity, Flow phenomena related to vehicles: External flow, Internal flow. External flow problem: Basic equations for inviscid incompressible flow, Applications: The two-dimensional flow around a vehicle-shaped body. Effects of viscosity: Laminar and turbulent boundary-layer development, Separation, Friction drag, Pressure drag, Overall forces and moments, Thermal boundary layers, Special Problem: Aerodynamic noise, Aeroelastic effects. .		
Module: 2	**WIND ENERGY COLLECTORS**	**7 Hours**
Horizontal and vertical axis machines, energy density of different rotors, power coefficient, Betz coefficient by momentum theory.		
Module: 3	**SELECTION OF AEROFOIL**	**8 Hours**
Physical description of effects of disturbances, longitudinal dynamic stability, stick fixed dynamic stability, longitudinal stability characteristics, lateral dynamic stability, lateral stability characteristics, control response. Differences between stability and control of airplane and helicopter.		
Module: 4	**DESIGN OF WIND TURBINE BLADE**	**8 Hours**
Rotor Aerodynamic Design- Optimum Rotors and Solidity-Rotor Solidity and Ideal Variable Speed Operation-Solidity and Loads-Aerofoil Design Development - Sensitivity of Aerodynamic Performance to Planform Shape-Aerofoil Design Specification-Aerofoil Design for Large Rotors, Rotor Structural Interactions -Blade Design in General-Basics of Blade Structure -Simplified Cap Spar Analyses-The Effective t/c Ratio of Aerofoil Sections-Blade Design Studies-Example of a Parametric Analysis - Industrial Blade Technology.		
Module: 5	**WIND TURBINE PERFORMANCE**	**7 Hours**
Wind-turbine Performance, The Performance Curves, Constant Rotational Speed Operation, Comparison of Measured with Theoretical Performance, Variable-speed Operation, Estimation of Energy Capture, Wind-turbine Performance Measurement, Aerodynamic Performance Assessment.		
Module: 6	**WIND TUNNEL TESTING**	**7 Hours**
Simulation of the Natural wind at small scale, Test Methods to determine wind loads on the wind turbine blade, structural systems, Aeroelastic Model Testing, Test methods to determine force, Moment on each blade, power produced by wind turbine.		
CONTENT BEYOND SYLLABUS		
Design the rotor blade to meet the desired conditions.		
	Total Lectures	**45 Hours**

Text Books

1.	Wind Turbine Technology Principles and Design; 1st Edition; Edited By Muyiwa Adaramola Copyright Year 2014.
2.	Wind Energy Explained: Theory, Design and Application 2nd Edition by James F. Manwell, Jon G. McGowan, Anthony L. Rogers.

Reference Books

1.	Muyiwa Adaramola, “Wind Turbine Technology: Principles and Design”, Taylor and Francis, CRC Press, 2014.
2.	Jamieson, Peter, “Innovation In Wind Turbine Design”, John Wiley, 2018.
3.	John D.Holmes, “Wind Loading of Structures”, CRC Press, second Edition, 2007
4.	Steven R.H, Rex E.B., “Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites”, John Wiley& Sons, 2003.
5.	Blevins R.D., “Flow Induced Vibrations”, Van Nostrand, 1990

6.	P. Brøndsted and R. Nijssen , "Advances in Wind Turbine Blade Design and Materials", Woodhead Publishing, 2013.
7.	Sachs P, "Wind Forces in Engineering:, Pergamon Press, 1988.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	BUILDING AERODYNAMICS	L	T	P	C
20AE2059		3	0	0	3

Course Objectives:

Impart knowledge on

1. Non-aeronautical applications of aerodynamics.
2. The concept of influences of aerodynamic forces over building structures.
3. Solution of problems in tall building structures.

Course Outcomes:

The student will be able to

1. Understand the airflow over a building surface.
2. Apply the principles of aerodynamics to different building.
3. Predict the behavior of airflow over civil structures.
4. Analyze the flow field over building and other high structures.
5. Estimate the flow induced vibrations on cables and bridges.
6. Select the proper wind tunnel testing method for building structures.

Module: 1	**INTRODUCTION &FUNDAMENTALS OF FLUID MECHANICS**	**7 Hours**

Introduction: Basic principle, Historical development, Basic shapes, streamlined shapes. Fluid Mechanics: Properties of incompressible fluids: density, viscosity, thermal conductivity, Flow phenomena related to vehicles: External flow, Internal flow. External flow problem: Basic equations for inviscid incompressible flow.

Module: 2	**AERODYNAMICS**	**8 Hours**

Aerodynamic forces, effects of viscosity: Laminar and turbulent boundary-layer development, Separation, Friction drag, Pressure drag, overall forces and moments, Thermal boundary layers, Special Problem: Aerodynamic noise, Aeroelastic effects.

Module: 3	**ATMOSPHERIC BOUNDARY LAYER**	**8 Hours**

Atmospheric circulation-local winds – terrain types – mean velocity profiles- power law and logarithmic law, wind speeds, turbulence profiles, Roughness parameters – simulation techniques in wind tunnels.

Module: 4	**BUILDING AERODYNAMICS**	**7 Hours**

Pressure distribution on low rise buildings, wind forces on buildings, environmental winds in city blocks, and special problems of tall buildings, building codes, ventilation and architectural aerodynamics.

Module: 5	**FLOW INDUCED VIBRATION**	**8 Hours**

Vortex shedding, effect of Reynolds number on wake formation in turbulent flows, across wind galloping, wake galloping, along wind galloping of circular cables, oscillation of tall structures and launch vehicles under wind loads, stall flutter.

Module: 6	**WIND TUNNEL TESTING**	**7 Hours**

Simulation of the Natural wind at small scale, Test methods to determine wind loads on the structural systems, Aeroelastic model testing, Test methods to determine cladding loads, other types of wind related study.

CONTENT BEYOND SYLLABUS

Structural design for varying wind loads

Total Lectures	**45 Hours**

Text Books

1.	Emil Simiu & Robert H Scanlan, Wind effects on structures - fundamentals and applications to design, John Wiley & Sons Inc New York, 1996.
2.	Tom Lawson, Building Aerodynamics; https://doi.org/10.1142/p161, April 2001.

Reference Books

1.	Gino Sovran, “Aerodynamics Drag Mechanisms of Bluff Bodies and Road Vehicles” Springer 2012.
2.	Tom Lawson, Building Aerodynamics”, Imperial College Press; first edition, 2001.
3.	John D. Holmes, “Wind Loading of Structures”, CRC Press, second Edition, 2007.
4.	Steven R.H, Rex E.B., “Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites”, John Wiley& Sons, 2003.
5.	Blevins R.D., “Flow Induced Vibrations”, Van Nostrand, 1990
6.	Wolf-Heinrich Hucho, “Aerodynamics of Road Vehicles. From Fluid Mechanics to Vehicle Engineering” Butterworth-Heinemann Ltd, Year: 1987.
7.	Antony Wood, “Wind Tunnel Testing of High-Rise Buildings” Routledge Publisher, 2013.
8.	Wind tunnel testing for buildings and other structures : ASCE/SEI 49-12, American Society of Civil Engineers, Year: 2012.
9.	Sachs P, “Wind Forces in Engineering:, Pergamon Press, 1988.
10.	J. B. Barlow, W. H. Rae, A. Pope, “Low Speed Wind Tunnel Testing”, John Wiley & Sons Publisher, 1999.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS**	**L**	**T**	**P**	**C**
20AE2060		3	0	0	3

Course Objectives:

Impart knowledge on

1. Basic terminologies, models and prototypes of UAV system.
2. Design considerations of UAV systems.
3. Designing UAV system for specific requirements.

Course Outcomes:

The student will be able to

1. Understand the basic terminologies and classification of UAS.
2. Relate the design parameters of UAV systems.
3. Obtain knowledge on the application of aerodynamic principles to design UAS.
4. Understand the principles of communication systems used in UAVs.
5. Obtain knowledge on payloads and launch systems for UAS.
6. Apply the principles to design UAS for specific applications

Module: 1	**INTRODUCTION TO UAS**	**8 Hours**

Introduction to Unmanned Aircraft Systems (UAS) – Systematic basis of UAS – System composition - Categories and Roles – Elements of UAS – Unmanned Aircraft system operations.

Module: 2	**DESIGN OF UAV SYSTEMS**	**8 Hours**

Design and selection of UAS – Aerodynamics and airframe configurations – Aspects of airframe design - Unmanned Aircraft characteristics – Long range, Medium and Close range UAVs – Mini, Micro and Nano UAVs – Novel hybrid combinations.

Module: 3	**UAV STANDARDS**	**7 Hours**

Unmanned Design standards and Regulatory aspects – Airframe design – Ancillary equipment – Design of Stealth.

Module: 4	**UAV PAYLOADS**	**7 Hours**

Sensors and payloads – payload types – Communications, Control and stability, Navigation – Launch and recovery.

Module: 5	**UAV TESTING**	**7 Hours**

Certification and ground testing – inflight testing - Human factors in UAS – Future of UAS and challenges.

Module: 6	**ROLE OF UAV**	**8 Hours**

Launch of HTOL & VTOL systems – recovery of HTOL & VTOL systems - Naval roles – Army roles – Civilian roles – paramedical and commercial roles – commercial applications

CONTENT BEYOND SYLLABUS

Materials used in UAV	
Total Lectures	**45 Hours**

Text Books	
1.	Reg Austin, "Unmanned Aircraft Systems: UAVS Design Development and Deployment", First edition, John Wiley and Sons, 2010.
2.	Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, "Introduction to Unmanned Aircraft systems", CRC press, Taylor and Francis, New York, 2012. Richard Microcontroller Systems for a UAV, A. Skafidas, 2002.
Reference Books	
1.	Paul.G.Fahlstrom, Thomas.J.Gleason Introduction to UAV systems, UAV SYSTEMS, Ins.. 2013.
2.	Armand.J. Chaput, "Design of UAV Systems" , Lockheed Martin Aeronautics Company, 2001.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**FOUNDATIONS OF SPACE ENGINEERING**	**L**	**T**	**P**	**C**
20AE2061		3	0	0	3

Course Objectives:

Impart knowledge on

1. Coordinate systems used in astronautics.
2. Rocket and spacecraft trajectories.
3. Basic knowledge of space environment.

Course Outcomes:

The student will be able to

1. Understand the most common coordinate system used in astronautics.
2. Transform between coordinate systems using rotational matrices.
3. Understand the fundamental principles of orbital motion.
4. Perceive the design of trajectories in the atmosphere and space.
5. Attain a general knowledge on the composition of space environment.
6. Attain knowledge of space debris.

Module: 1	**MATHEMATICAL FUNDAMENTALS**	**8 Hours**

Vectors and scalars, Dot and cross product of vectors, Derivative of a vector function, Gradient, Integral of a vector function, Plane motion – radial and transverse components, tangential and normal components, Spherical trigonometry laws and applications.

Module: 2	**PHYSICAL PRINCIPLES AND TIME MEASURES**	**8 Hours**

Kepler's laws, Newton's laws, Work and energy, Force and momentum, Impulse and momentum, Law of conservation of total energy, Angular momentum, Universal time, Dynamical time, Julian date, Solar and sidereal days.

Module: 3	**COORDINATE SYSTEMS AND TRANSFORMATION**	**8 Hours**

Two and three dimensional coordinate systems, Polar and Cartesian coordinates, Spherical polar coordinates, Inertial and body-fixed coordinate systems, Rotation and rotation matrices, Two and three dimensional rotation, Three-angle sets for specifying orientation: Roll-pitch-yaw, Euler angles, Euler parameters.

Module: 4	**INTRODUCTION TO ATMOSPHERIC AND SPACECRAFT TRAJECTORY**	**8 Hours**

Rocket equation, Staging, Central force motion, Newtonian gravitation, Properties of conic sections, Escape velocity, Two-body motion: energy and velocity on orbit, Classical orbital elements, Velocity azimuth and flight path angle.

Module: 5	**INTRODUCTION TO SPACE ENVIRONMENT**	**6 Hours**

Sun and solar wind, Earth's atmosphere, Ionosphere and communications, Geomagnetic field, Micro-meteoroids.

Module: 6	**SPACE DEBRIS**	**7 Hours**

Introduction to space debris, Space debris environment in low earth orbit, Debris measurements, Space debris environment in geosynchronous equatorial orbit, Spatial density, Collision hazards associated with orbit operations. Space Debris.
CONTENT BEYOND SYLLABUS
Recent studies on the effect of space debris on near-Earth satellites.

	Total Lectures	**45 Hours**
Text Books		
1.	Gerald R. Hintz, "Orbital Mechanics and Astrodynamics – Techniques and tools for space missions", Springer, First edition, 2015.	
2.	William T. Thomson, "Introduction to Space Dynamics", Dover Publications, 2000.	
Reference Books		
1.	William E. Wiesel, "Spaceflight Dynamics", Aphelion Press, USA, Third Edition, 2010.	
2.	David A. Vallado,"Fundamentals of Astrodynamics and Applications", Microcosm and Kluwer, Second Edition, 2004.	
3.	Jerry Jon Sellers, Understanding Space: An Introduction to Astronautics, 3rd ed. McGraw-Hill, 2005.	
4.	John E. Prussing, Bruce A. Conway, Orbital Mechanics, 2nd ed. Oxford University Press, 2012.	
5.	J.W.Cornelisse, H.F.R. Schoyer, and K.F. Wakker, "Rocket Propulsion and Spaceflight Dynamics", Pitman, 2001.	
6.	Alan C. Tribble, "The Space Environment: Implications for Spacecraft Design", Princeton University Press, 2003.	
7.	J.R.Wertz, D.F.Everett, and J J. Puschell, "Space Mission Engineering: The New SMAD", Microcosm Press, 2011.	
8.	V. A. Chobotarev, "Orbital Mechanics, Third Edition, AIAA Educational Series, Reston, Virginia, 2002.	

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	HEAT AND MASS TRANSFER	L	T	P	C
20AE2062		3	0	0	3

Course Objectives:

Impart knowledge on

4. The various modes of heat transfer and its applications in solving practical engineering problems.
5. Capabilities to model and analyze thermal systems with appropriate analytical, numerical and graphical methods.
6. The ability to select or design practical heat transfer equipment.

Course Outcomes:

The student will be able to

1. Understand the various modes of heat transfer and the factors affecting it.
2. Solve steady state and transient heat conduction problems.
3. Understand the physical phenomena associated with convective transport processes.
4. Understand the role of non dimensional parameters and use then to solve practical convective heat transfer problems.
5. Understand the physical mechanisms involved in radiation heat transfer.
6. Select and design heat exchangers for a given application and heat load.

Module: 1	MODES OF HEAT AND MASS TRANSFER	2 Hours
Introduction to conduction, diffusion, convection, radiation, basic rate equations for all modes of heat transfer, differentiation between heat transfer and thermodynamics, thermal conductivity, heat transfer coefficient, Stefan-Boltzmann constant.		
Module: 2	**CONDUCTION HEAT TRANSFER**	**13 Hours**
Three-dimensional heat conduction equations in various co-ordinate systems, steady state one dimensional heat conduction equation for plane, cylindrical and spherical shapes, Critical radius of insulation, single layer and multi layer-film co-efficient, Variable thermal conductivity, heat transfer with heat generation in different shapes. Extended surfaces (fins) – with different end conditions, calculation of fin efficiency and overall surface		

efficiency, Transient Heat Transfer - Lumped parameter systems, infinite solids, and semi-infinite solids, numerical and graphical methods.		
Module: 3	**FORCED CONVECTION HEAT TRANSFER**	**13 Hours**
Derivation of Energy Equation, Boundary Layer Concepts**,** Similarity of hydrodynamic, thermal and concentration boundary layers, Differential and integral equations for hydrodynamic and thermal boundary layer, Non-dimensional analysis, Heat and mass transfer analogy Forced Heat transfer from flat plate – Exact Solution, Convection from cylinders and spheres, Forced convection through tubes. Constant heat flux and Constant Temperature Boundary Conditions.		
Module: 4	**NATURAL CONVECTION HEAT TRANSFER**	**5 Hours**
Free convection, heat transfer from vertical and horizontal surfaces. Use of Empirical Correlations for forced and free convection		
Module: 5	**RADIATION HEAT TRANSFER**	**9 Hours**
Basic definitions - Black Body Radiation, Radiosity, Grey Surface, Radiation between black surfaces, Radiation between grey surfaces, Grey body radiation - Shape Factor – Electrical Analogy – Radiation Shields		
Module: 6	**HEAT EXCHANGERS**	**3 Hours**
Types, tube and shell arrangements, single and multi-pass types, parallel, counter and cross flow, compact heat exchangers, LMTD and Effectiveness method (NTU)		
CONTENT BEYOND SYLLABUS		
PHASE CHANGE HEAT TRANSFER: Boiling heat transfer - bubble growth, freezing and melting; Condensation - film wise condensation and drop wise condensation.		
	Total Lectures	**45 Hours**

Text Books	
1.	Frank P. Incropera, David P. Dewitt, Theodore L. Bergman, Adrienne S. Lavine, Principles of Heat and Mass Transfer, Wiley India (2018)
2.	Yunus A. Cengel, Afshin J. Ghajar, Heat and Mass Transfer -Fundamentals and Applications, McGraw Hill Education (India); Sixth edition (2020)
Reference Books	
1.	J Holman, Souvik Bhattacharyya, Heat Transfer, McGraw Hill Education (India), 10th Edition, 2017
2.	C. Balaji Srinivasan, Sateesh Gedupudi, Heat Transfer Engineering - Fundamentals and Techniques, Academic Press, 1st Edition, 2020
3.	P K Nag, Heat and Mass Transfer, McGraw Hill Education (India), 3rd edition, 2011
4.	https://nptel.ac.in/courses/112/108/112108149/

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**HIGH SPEED JET FLOWS**	**L**	**T**	**P**	**C**
20AE3001		**3**	**0**	**0**	**3**

Course Objectives:

Impart knowledge on

1. To introduce the basic concepts of nozzles, shockwaves and boundary layer.
2. To give an introduction high speed flow, and acoustic.
3. To provide knowledge about the compressible flow, velocity distribution and Shock-boundary layer interactions.

Course Outcomes:

The student will be able to

1. Understand the nature of high-speed flow characteristics.
2. Identify the different types of nozzles and diffusers.
3. Learn about various jet control methods.
4. Understand the performance jet acoustics aspects and free shear layer.
5. Apply the knowledge flow theory pertaining to turbulent jets with high speed

Module: 1	**INTRODUCTION**	**8 Hours**
Types of nozzles – over expanded and under expanded flows - Isentropic flow through nozzles– Interaction of nozzle flows over adjacent surfaces – Mach disk - Jet flow – types- Numerical problems.		

Module: 2	**COMPRESSIBLE FLOW THEORY**	**8 Hours**
One-dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers – normal and oblique shock waves and calculation of flow and fluid properties across the shocks and expansion fans. Interaction of shocks with solid and fluid surface.		
Module: 3	**TYPES OF JETS**	**6 Hours**
Types of jet control - single jet, multi jet, co-flow jet, parallel flow jet. Subsonic jets- Mathematical treatment of jet profiles -Theory of Turbulent jets- Mean velocity and mean temperature- Turbulence characteristics of free jets- Mixing length-		
Module: 4	**JET CONTROL**	**6 Hours**
Experimental methods for studying jets and the Techniques used for analysis- Expansion levels of jets- Over-expanded, correctly expanded, Under-expanded jets - Control of jets. Centre line decay, Mach number Profile, Iso-Mach (or iso-baric) contours, Shock cell structure in under-expanded and over-expanded jets, Mach discs.		
Module: 5	**BOUNDARY LAYER CONCEPT**	**8 Hours**
Boundary Layer – displacement and momentum thickness- laminar and turbulent boundary layers over flat plates – velocity distribution in turbulent flows over smooth and rough boundaries- laminar sublayer.		
Module: 6	**JET ACOUSTICS**	**9 Hours**
Introduction to Acoustic – Types of noise – Source of generation- Traveling wave solution- standing wave solution – multi-dimensional acoustics -Noise suppression techniques– applications to problems.		
	Total Lectures	**45 Hours**
Text Books		
1.	Rathakrishnan E., "Applied Gas Dynamics", John Wiley, NY, 2010.	
2.	Liepmann and Roshko, "Elements of Gas Dynamics", John Wiley, NY, 1963.	
Reference Books		
1.	Rathakrishnan E., "Gas Dynamics", Prentice Hall of India, New Delhi, 2008.	
2.	Shapiro, AH, "Dynamics and Thermodynamics of Compressible Fluid Flow", Vols. I & II, Ronald Press, New York, 1953	
Recommended by Board of Studies		
Approved by Academic Council		

Course code	**ADVANCED AERODYNAMICS**	**L**	**T**	**P**	**C**
21AE3001		3	0	0	3

Course Objectives:

Impart knowledge on

1. Airfoils and wings and the flow over them.
2. Compressibility effects over an aerofoil and finite wings.
3. High temperature effects over a hypersonic wing.

Course Outcomes:

The student will be able to

1. Assess the forces and moments due to flow.
2. Understand the flow behavior over various body shapes.
3. Apply compressibility corrections for flow in C-D passages and instruments like Pitot static tube
4. Assess the nature of compressible flow over airfoils and finite wings.
5. Use the computational tools to evaluate hypersonic flows.
6. Understand the basic principles of expansion waves

Module: 1	**REVIEW OF GOVERNING EQUATIONS**	**6 Hours**
Description of Flow fields, Continuity, Stress-Strain rate relationship, Law of conservation of momentum Stokes Hypothesis, Navier-Stokes equations		
Module: 2	**EXACT SOLUTIONS OF NAVIER-STOKES EQUATIONS**	**8 Hours**
Concept of Fully Developed Flow, Entrance Length, Plane Poiseuille Flow, Couette Flow, Poiseuille Flow, Flow of Immiscible fluids in a Channel		
Module: 3	**LAMINAR BOUNDARY LAYER EQUATIONS**	**8 Hours**
Boundary Layer Concept, Order of Magnitude Analysis, Boundary Layer equations, Wall friction, separation and displacement, friction drag, Plate boundary layer. Blasius Similarity Solution by Runge Kutta and Semi Analytical Method, Integral solution of momentum equation		

Module: 4	INTRODUCTION TO COMPRESSIBLE FLOW AND ISENTROPIC FLOW	9 Hours
Review of Thermodynamics, Compressibility, Velocity of sound, Speed of travel of a pressure disturbance, Mach Number and Concept of Mach Cone, Entropy Change in Ideal Gas, Basics of Wave propagation, Isentropic relations, Discharge from a reservoir, Flow through converging-diverging nozzle, Critical Conditions, Performance under various back pressures and occurrence of normal and oblique shocks, Dynamic head measurement and corrections of Pitot static tube for subsonic and supersonic Mach numbers, Pressure coefficient		
Module: 5	**NORMAL SHOCKS**	**7 Hours**
Equations of motion for normal shock, Prandtl Relation, Hugoniot equation, Propagating shock wave, Reflected shock wave, Centered Expansion Wave, Shock Tube		
Module: 6	**FANNO AND RAYLEIGH FLOW**	**7 Hours**
Influence of Friction on compressible flow, governing equations, relation between flow parameters and length, diameter and friction coefficient of pipe. Limiting Mach number and limiting length of pipe in Fanno Flow, Influence of Heat transfer on compressible flow, governing equations, relation between flow parameters and heat transfer and Limiting Mach number in Rayleigh flow, Maximum heat transfer.		
	Total Lectures	**45 Hours**

Text Books	
1.	Schlichting, Herrmann, Gersten, Klaus -"Boundary Layer Theory", 9th edition, Springer-Verlag, 2017
2.	Michel Saad, Compressible Fluid Flow, 2nd Edition, Prentice Hall, 2020
Reference Books	
1.	Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, New Age International (p) Ltd., 6th Edition, 2018
2.	Anderson Jr., D., – "Modern compressible flows", McGraw-Hill Book Co., 4th edition, 2020
3.	Robert D Zucker, Oscar Biblarz, Fundamental of Gas Dynamics, Second Edition, John Wiley &Sons, 2019
4.	Liepmann H W and Roshko A, "Elements of Gas Dynamics", Dover Publications, 2002
5.	Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Vol 1 and 2, 1953
6.	Zucrow, M.J. and Joe D Hoffman, "Gas Dynamics", John Wiley & Sons, 1976
7.	Compressible Flow: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-120-compressible-flow-spring-2003
8.	Gas Dynamics: http://www.nptel.ac.in/courses/101106044/
9.	Introduction to Boundary Layers: https://nptel.ac.in/courses/112/106/112106190/
10.	Boundary layers, Separation and Drag :https://ocw.mit.edu/courses/mechanical-engineering/2-25-advanced-fluid-mechanics-fall-2013/boundary-layers-separation-and-drag/Rathakrishnan, E., "Gas Dynamics", 7th Edition, Prentice Hall of India, 2020
11.	Frank White, "Viscous Fluid flow" – 4th edition, McGraw Hill, 2021

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	ADVANCED STRUCTURAL ANALYSIS	L	T	P	C
21AE3002		3	0	0	3

Course Objectives:

Impart knowledge on

1. Elastic behavior of aircraft structures under different loading conditions.
2. Stresses and strains in thin walled structure.
3. Distribution of stresses in wing and fuselage structures.

Course Outcomes:

The student will be able to

1. Understand stress and strain compatibility conditions.
2. Derive stress-strain relationship of a lamina.
3. Differentiate the symmetrical and unsymmetrical bending.
4. Determine the shear center in various open and closed section of aircraft structures.
5. Analyze the buckling of plates to predict the critical stress.

6. Design aircraft composite panel for aerospace applications.		
Module: 1	**BASICS TO ELASTICITY**	**8 Hours**
General Deformations, Geometric Construction of Small Deformation Theory, Body and Surface Forces, Traction Vector and Stress Tensor, Stress and Strain Transformation, Principal Stresses and Strains, Spherical and Deviatoric Stresses and strains, Equilibrium Equations, Strain Compatibility		
Module: 2	**INTRODUCTION TO COMPOSITE LAMINA**	**8 Hours**
Hooke's Law for Different Types of Materials, Hooke's Law for a Two-Dimensional Unidirectional Lamina, Relationship of Compliance and Stiffness Matrix to Engineering Elastic Constants of a Lamina, Two-Dimensional Angle Lamina.		
Module: 3	**BENDING OF AEROSPACE STRUCTURES AND IDEALIZATION**	**8 Hours**
Deflection of open and closed section beams. Bending of open and closed thin-walled beams - Symmetrical bending - Unsymmetrical bending. Structural idealization-Principle of Idealization of a panel- Effect of idealization on the analysis of open and closed section beams		
Module: 4	**SHEAR FLOW OF AEROSPACE STRUCTURES DUE TO TORQUE**	**7 Hours**
General stress, strain and displacement relationships for open and single cell closed section thin-walled beams - Shear of open section and closed section beams. Torsion of closed and open section beams - Bending-Shear-Torsion of combined open and closed section beams.		
Module: 5	**BUCKLING OF THIN PLATES**	**7 Hours**
Buckling of thin plates- Inelastic buckling of plates- Experimental determination of critical load for a flat plate - Local instability -Instability of stiffened panels - Failure stress in plates and stiffened panels - Tension field beams.		
Module: 6	**WING AND FUSELAGE ANALYSIS**	**7 Hours**
Shear force, bending moment and torque distribution along the span of the Wing-Tension field beam and Semi tension field beam (Wagner Bam). Fuselage Analysis - Shear and bending moment distribution along the length of the fuselage.		
	Total Lectures	**45 Hours**

Text Books	
1.	Donaldson B K., "Analysis of Aircraft Structures", Cambridge Aerospace Series, 2008.
2.	Megson, T.H.G., "Aircraft Structures for Engineering Students", Fourth edition, Elsevier Ltd, 2010.
Reference Books	
1.	G Lakshmi Narasaiah, "Aircraft Structures", BS Publications, 2010.
2.	Sun C T, "Mechanics of Aircraft Structures", Wiley India, 2010.
3.	Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.
4.	Stephen P. Timoshenko & S.Woinovsky Krieger, "Theory of Plates and Shells", 2nd Edition, McGraw-Hill, Singapore, 1990.
5.	Rivello, R.M., "Theory and Analysis of Flight structures", McGraw-Hill, N.Y., 1993.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**ADVANCED AERODYNAMICS LABORATORY**	**L**	**T**	**P**	**C**
21AE3003		0	0	2	1

Course Objectives:

Impart knowledge on

1. To impart knowledge of basics of subsonic and supersonic flow over a model.
2. To impart knowledge of forces and moments over an aerofoil.
3. To impart knowledge of shock wave over various model.

Course Outcomes:

The student will be able to

1. Understand the aerodynamic variable connected with airflow.
2. Estimate lift and drag of various stream line and bluff bodies

	3. Visualize subsonic flow over various model. 4. Perform calibration of supersonic wind tunnel. 5. Visualize shock wave and estimate shock angle over various model. 6. Understand the effect of back pressure in C-D nozzle.
List of Experiments	
1.	Calibration of subsonic wind tunnel for different velocities.
2.	The pressure distribution over a symmetric and cambered aerofoil.
3.	Smoke and tuft flow visualization of symmetric and cambered aerofoil.
4.	Estimation of the lift and drag of symmetric and cambered aerofoil.
5.	Identify the trailing vortices over a rectangular wing using smoke and tuft flow visualization technique
6.	Boundary layer calculation in the test section of subsonic wind tunnel.
7.	Calibration and runtime calculation of supersonic wind tunnel for different Mach.
8.	Flow visualisation over a sharp and blunt cone model using Schlieren technique.
9.	Flow visualisation over a sharp and blunt cone model using shadowgraph technique.
10.	Flow visualisation over a double wedge model using shadowgraph technique.
11.	Flow visualisation over a sharp and blunt edge delta wing model using shadowgraph and Schlieren technique
12.	Effect of back pressure study of C-D nozzle using Open Jet Facility.
13.	Calibration of six component strain gauge balancing.
14.	Force measurement of aircraft model using six component strain gauge balancing.
	Total Lectures **15 Hours**
The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.	
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**STRUCTURAL ANALYSIS LABORATORY**	**L**	**T**	**P**	**C**
21AE3004		0	0	2	1

Course Objectives:

Impart knowledge on

1. The testing equipment for various structural components.
2. The practical exposure of measuring equipment and sensors.
3. The practical exposure of composite material manufacturing and testing.

Course Outcomes:

The student will be able to

1. Select test equipment for different types of static loading.
2. Conduct tests, analyse results, document and compare with analytical/theoretical results.
3. Assess different types of structural failures.
4. Make composite material and laminate.
5. Choose strain gauge for different application and get knowledge in strain gauge installation.
6. Understand the stress distribution with respect to different cross-section shape and loading condition.

List of Experiments	
1.	Compression test on columns, critical buckling loads – South well plot.
2.	Unsymmetrical bending of beams-Z section.
3.	Determination of the natural frequency of vibrations of a cantilever beam.
4.	Shear center location for open sections.
5.	Torsion of a thin walled tube having various closed cross section at the ends.
6.	Structural behaviour of a semi tension field beam (Wagner Beam).
7.	Using photo elastic techniques: Calibration of circular disc in compression to find the fringe value and Determination of stress concentration factor due to compression in circular ring.
8.	Composite material Manufacturing and Testing- Tensile and Three point bending.
9.	Strain Gauge Calibration.
10.	Tensile Test-Single lab bonded joint & riveted joint.
	Total Lectures **15 Hours**

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**ELEMENTS OF DATA ANALYTICS**	**L**	**T**	**P**	**C**
21AE3005		2	0	0	2

Course Objectives:

Impart knowledge on

1. Statistical methods to solve practical problems.
2. Perform statistical analysis on variety of data.
3. Various regression techniques.

Course Outcomes:

The student will be able to

1. Find a meaningful pattern in data.
2. Graphically interpret data.
3. Implement the analytic algorithms.
4. Handle large scale analytics projects from various domains.
5. Develop intelligent decision support systems.
6. Understand the various techniques in handling data.

Module: 1	**DATA DEFINITIONS AND ANALYSIS TECHNIQUES**	**6 Hours**

Elements, Variables, and Data categorization, Levels of Measurement, Data management and indexing, Introduction to statistical learning and R-Programming.

Module: 2	**DESCRIPTIVE STATISTICS**	**4 Hours**

Introduction to the course, Descriptive Statistics: Measures of central tendency, Measures of location of dispersions. Probability Distributions.

Module: 3	**INFERENTIAL STATISTICS**	**5 Hours**

Inferential Statistics through hypothesis tests, Permutation & Randomization Test.

Module: 4	**BASIC ANALYSIS TECHNIQUES**	**5 Hours**

Basic analysis techniques, Statistical hypothesis generation and testing, Chi-Square test, t-Test, Analysis of variance, Correlation analysis, Maximum likelihood test.

Module: 5	**DATA ANALYSIS TECHNIQUES**	**5 Hours**

Regression analysis, Classification techniques, Clustering Association rules analysis.

Module: 6	**CORRELATION AND REGRESSION**	**5 Hours**

Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification. ANOVA.

Total Lectures	**30 Hours**

Text Books

1.	Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability & Statistics for Engineers & Scientists (9th Edn.), Prentice Hall Inc., 2016,
2.	The Elements of Statistical Learning, Data Mining, Inference, and Prediction (2nd Edn.), Trevor Hastie Robert Tibshirani Jerome Friedman, Springer, 2014

Reference Books

1.	G James, D. Witten, T Hastie, and R. Tibshirani, An Introduction to Statistical Learning: with Applications in R, Springer, 2013
2.	Dr. Joshua F. Wiley, Larry A. Pace, Beginning RAn Introduction to Statistical Programming, A press, 2015.
3.	Hastie, Trevor, et al. The elements of statistical learning. Vol. 2. No. 1. New York: springer, 2009.
4.	Montgomery, Douglas C., and George C. Runger, Applied statistics and probability for engineers. John Wiley &Sons, 2010

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	SIMULATION AND MODEL BASED SYSTEMS ENGINEERING	L	T	P	C
21AE3011		3	0	0	3

Course Objectives:

Impart knowledge on

1. The impact of system engineering in development of systems.
2. The development of different model based engineering systems.
3. Modelling patterns.

Course Outcomes:

The student will be able to

1. Understand system engineering and its usage.
2. Understand how model based engineering used in development of systems.
3. Understand the concepts of Modelling Patterns.
4. Articulate the usage of modelling patterns.
5. Illustrate the concepts of MBSE.
6. Examine applications and case studies of modelling patterns.

Module: 1	SYSTEM AND SYSTEMS ENGINEERING	8 Hours

Origins and SE Standards, Hierarchy, Systems of Systems, Use of SE, Life-Cycle Stages, Technical Process of SE, Lean Systems Thinking – Applying systems Engineering to systems design – Multidisciplinary approach – Design space: systems and Boundary – Process –Domains – Communication.

Module: 2	MODEL BASED ENGINEERING	8 Hours

Elements of a model – Characteristics – Language – Managing complexities – Structure – Argument – Presentations. Requirements for a systems engineering process – MBSE Model and system definition module – Developing layers – Architectural design – Verification and validation.

Module: 3	FUNDAMENTAL MODELING PATTERNS	7 Hours

System Architecture Model Vs Analytical Model, System Decomposition, SysML, Pattern-Based Systems Engineering, Modeling Patterns – Definition – Enabling patterns – Interface definition pattern – Traceability pattern – Test Pattern – Epoch Pattern – Life cycle pattern.

Module: 4	MODELING PATTERNS	7 Hours

Evidence pattern – Description pattern – context pattern – Analysis pattern – Model maturity pattern.

Module: 5	MBSE PATTERNS FOR MODEL ASSESSMENT	8 Hours

Defining a pattern – Using patterns for model assessment, model definition and model retro-fitting - MBSE in Aerospace industries.

Module: 6	APPLICATIONS OF MODELING PATTERNS	7 Hours

Requirements modeling – Expanded requirements modeling – Process modeling – Competence modeling – Life cycle modeling.

Total Lectures: 45 Hours

Text Books

1.	David Long, Zane Scott, “A Primer for Model -based Systems Engineering” Vitech Publications, second edition, 2011.
2.	John Holt, Simon Perry and Mike Brownsword, “Foundations for Model-based Systems Engineering – From patterns to models”, Institution of Engineering and Technology, London, United Kingdom, 2016.

Reference Books

1.	Sastry Veluri, Vishal Agarwal, “Model-Based systems Engineering: Digitized requirements Management for Aerospace and Defense Products”, White paper: Infosys Limited, Bangalore, 2019.
2.	Patrice Micouin, “Model-Based Systems Engineering: Fundamentals and Methods”, John Wiley & Sons, Inc., 2014.
3.	Borky, John M., Bradley, Thomas H, “Effective Model-Based Systems Engineering”, Springer Publications, 2019.
4.	Leon McGinnis, Georgia Tech, George Thiers, ModGeno, “Model-Based Systems Engineering for Aerospace Manufacturing”, Global product data Interoperability Summit 2017.

5.	Burak Bagdatli, Fatma Karagoz, Kevin A. Reilley and Dimitri N. Mavris, "MBSE-enabled Interactive Environment for Aircraft Conceptual Sizing & Synthesis", AIAA 2019-0497 Session : Systems Engineering II, 2019. https://doi.org/10.2514/6.2019-0497.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**AVIATION 4.0**	**L**	**T**	**P**	**C**
21AE3012		3	0	0	3

Course Objectives:

Impart knowledge on

1. Aviation 4.0 and its technologies.
2. The recent trends in Digital Manufacturing.
3. Cyber Physical Systems and Fly-By-Wire.

Course Outcomes:

The student will be able to

1. Understand the concepts of Aviation 4.0
2. Articulate the usage of Digital Twin in aviation.
3. Understand use of digital technologies in smart manufacturing.
4. Articulate the usage of the CPS, IOT and Big data in Avionics.
5. Illustrate the concepts of Digital Fly-By-Wire.
6. Examine applications and case studies of AR, VR & MR in Manufacturing.

Module: 1	**AVIATION 4.0 INTRODUCTION**	**8 Hours**

Introduction – Concept of Aviation 4.0 – Autonomous flying – Predictive aircraft maintenance - Cockpit safety cognitive computing aid systems - Search and rescue services - Real-time human performance monitoring, Digital Supply Chain Management and synchronized planning.

Module: 2	**DIGITAL TWIN**	**8 Hours**

Introduction – Characteristics – Digital twin models – Product digital twin model – Basic features - Relationship between digital twin and digital thread - Implementation stages of digital twin technology - Traditional three-dimensional digital twin – Extended five-dimensional digital twin- application of digital twin technology.

Module: 3	**SMART MANUFACTURING AND DESIGN**	**8 Hours**

Digital twin in PLC, Industrial applications – Rules for digital twin modeling – Digital twin shop floor – Cyber physical fusion – Pragmatics and health management. Smart Design/Fabrication: COBOTS, Digital Tools, Product Representation and Exchange Technologies and Standards, Agile (Additive) Manufacturing Systems and Standards. Mass Customization, Smart Machine Tools, Robotics and Automation (perception, manipulation, mobility, autonomy), Smart Perception – Sensor networks and Devices.

Module: 4	**CYBER-PHYSICAL SYSTEMS, IOT AND BIG DATA**	**7 Hours**

Big data – Life cycle of big data in manufacturing, 360' comparison – Fusion of digital twin and big data – CPS In manufacturing – IoT in manufacturing, IIOT – Digital twin and CPS – IoT in digital twin-based CPS.

Module: 5	**DIGITAL FLY-BY-WIRE**	**7 Hours**

Need for FBW systems - Historical perspectives in design Programs - Description of various elements of DFBW systems - Need for redundant architecture, discussion on triplex vs. quadruplex architecture for DFBW system - Concept of cross-strapping, Actuator command voting and servo force voting.

Module: 6	**APPLICATION OF AR, VR AND MIXED REALITY IN MANU.**	**7 Hours**

Applications of VR in design, Manufacturing and service, AR in design, Manufacturing and service, Comparison – Digital twin and AR & VR, Combining VR & AR.

Total Lectures	**45 Hours**

Text Books

1.	https://www.incose.org/docs/default-source/enchantment/140514schindel-intro-to-pbse1f58e68472db67488e78ff000036190a.pdf?sfvrsn=928381c6_2
2.	https://www.incose.org/docs/default-source/delaware-valley/mbse-overview-incose-30-july-2015.pdf
3.	Melih Kushan, "Aircraft Technology", Intech Open Publications, 2018.

4.	Tamás Bányai, "Industry 4.0 Impact on Intelligent Logistics and Manufacturing", Intech Open Publications, 2020.
5.	Fei Tao, Meng Zhang, A Y C Nee, "Digital twin driven smart manufacturing", Academic press, 2019.
6.	Fuh-Gwo Yuan, "Structural Health Monitoring (SHM) in Aerospace Structures", Woodhead Publishing Series, 2016.
7.	Vernon R Schmitt, James W Morris and Gavin D Jenny, "Fly By Wire-A Historical Perspective", SAE International, 1998.
Reference Books	
1.	Digital transformation in the Aviation sector, DLA Piper, Ref: 25632687.1, 2017.
2.	Embracing Airline digital transformation, Amadeus IT Group SA, 2017.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**GAS TURBINE TECHNOLOGY**	**L**	**T**	**P**	**C**
21AE3019		**3**	**0**	**0**	**3**

Course Objectives:

Impart knowledge on

1. The types of engines and its applications.
2. Materials required for engine manufacturing.
3. Engine performance and testing.

Course Outcomes:

The student will be able to

1. Understand the subsystems and working of turbine engines
2. Select the suitable materials for engine manufacturing.
3. Evaluate the performance of the engine.
4. Test the engine using several types of engine testing methods
5. Understand compressor and turbine maps
6. Analyze the performance of gas turbine Engines

Module: 1	**TYPES OF ENGINES AND OPERATIONS**	**8 Hours**

Types of engines showing arrangement of parts. Operating parameters. Energy distribution of turbojet, turboprop and turbofan engines, Comparison of thrust and specific fuel consumption, Thrust, pressure and velocity diagrams. Engine Parts: Compressor assembly, types of burners: advantages and disadvantages. Influence of design factors on burner performance, Performance requirements of combustion chambers. Construction of nozzles, Impulse turbine and reaction turbine, Exhaust system, sound suppression.

Module: 2	**MATERIAL SELECTION, SUBSYSTEMS**	**7 Hours**

Criteria for selection of materials. Heat ranges of metals, high temperature strength. Surface finishing. Powder metallurgy. Use of composites and Ceramics, Super alloys for Turbines.

Subsystems: Fuel systems and components. Sensors and Controls, FADEC interface with engine, Typical fuel system, Oil system components, Typical oil system. Starting systems, Typical starting characteristics, Various gas turbine starters.

Module: 3	**ENGINE PERFORMANCE ANALYSIS**	**8 Hours**

Design & off - design Performance. Surge margin requirements, surge margin stack up. Transient performance. Qualitative characteristics quantities, Transient working lines. Starting process & Wind milling of Engines. Thrust engine start envelope. Starting torque and speed requirements Calculations for design and off-design performance from given test data– Engine performance monitoring.

Module: 4	**COMPRESSOR AND TURBINE PERFORMANCES**	**9 Hours**

Compressor MAP. Surge margin, Inlet distortions. Testing and Performance Evaluation. Combustor: Combustor MAP, Pressure loss, combustion light up test. Testing and Performance Evaluation. Turbines: Turbine MAP. Turbine Testing and Performance Evaluation. Inlet duct & nozzles: Ram pressure recovery of inlet duct. Propelling nozzles, after burner, maximum mass flow conditions. Testing and Performance Evaluation

Module: 5	**PERFORMANCE EVALUATION OF GAS TURBINE ENGINES**	**7 Hours**

Proof of Concepts: Design Evaluation tests. Structural Integrity, Environmental Ingestion Capability, Preliminary Flight Rating Test, Qualification Test, Acceptance Test, Reliability figure of merit, Durability and Life Assessment Tests, Reliability Tests. Engine testing with simulated inlet distortions and, surge test. Estimating engine operating limits. Methods of displacing equilibrium lines

Module: 6	**TESTING OF GAS TURBINE ENGINES**	**6 Hours**

Normally Aspirated Testing, Open Air Test Bed, Ram Air Testing, Altitude Testing, Altitude test facility, Flying Test Bed, Ground Testing of Engine Installed in Aircraft, Flight testing. Jet thrust measurements in flight. Measurements and Instrumentation, Data Acquisition system, Measurement of Shaft speed, Torque, Thrust, Pressure, Temperature, Vibration, Stress, Temperature of turbine blading etc. Engine performance trends: Mass and CUSUM plots. Accuracy and Uncertainty in Measurements, Uncertainty analysis. Performance Reduction Methodology		
	Total Lectures	**45 Hours**
Text Books		
1.	Irwin E. Treager, 'Gas Turbine Engine Technology ', McGraw Hill Education,3rd edition, 2013, ISBN-13: 978-1259064876.	
2.	P.P Walsh and P. Fletcher, 'Gas Turbine Performance' Blackwell Science, 1998, ISBN0632047843	
Reference Books		
1.	J P Holman, 'Experimental Methods for Engineers ', Tata McGraw Hill, 7th edition,2007, ISBN13: 978-0070647763	
2.	A S Rangwala, Turbomachinery Dynamics-Design and operations, McGraw–Hill, 2005, ISBN13: 978-0071453691.	
3	Michael J.Kroes, and Thomas W. Wild,' Aircraft Power Plant', GLENCOE Aviation Technology Series, 7th Edition, Tata McGraw Hill Publishing Co. Ltd., 2002	
4	Advanced Aero-Engine Testing, AGARD-59, Publication.	
5	MIL–5007E, 'Military Specifications: Engine, Aircraft, Turbo Jet & Turbofan; General Specification for Advance Aero Engine testing ', 15th Oct 1973.	
Recommended by Board of Studies		
Approved by Academic Council		

Course code	ROTOR DYNAMICS	L	T	P	C
21AE3020		**3**	**0**	**0**	**3**

Course Objectives:

Impart knowledge on

1. Importance of vibrations of rotating systems.
2. Torsional vibrations of rotating machinery.
3. Support and support systems and configurations of journal bearings.

Course Outcomes:

The student will be able to

1. Understand the importance of Rotor Dynamics and balancing rotors
2. Describe the importance of vibrations of rotating systems under various conditions in maintenance engineering applications.
3. Determine the natural frequency and mode shapes of various types of rotor systems.
4. Plot a Campbell diagram and determine critical speeds and estimate or mitigate severity by damping
5. Carry out orbital analysis and draw cascade plots and describe the importance of support systems and develop design configurations of journal bearings.
6. Develop equations for balancing of rotating systems and generate graphical analysis.

Module: 1	**INTRODUCTION TO VIBRATION**	**10 Hours**

Vibration of dynamic systems, rotor systems of mechanical and electrical devices, Co-ordinate systems, Steady state rotor motion, Elliptical motion, Single degree of freedom systems, Free and forced vibrations. Two degrees of freedom rotor system, Geared systems, Translational motion, importance of Natural frequencies and Natural modes, Steady state response to unbalance, importance of supports in dynamic systems, types of supports, effect of flexible support.

Module: 2	**TORSIONAL VIBRATIONS OF ROTATING MACHINERY**	**7 Hours**

Introduction to torsional vibrations, modelling of rotating machinery shafting, Multi degree of freedom, Systems, Determination of natural frequencies and mode shapes, Branched systems, geared systems, Numerical methods for fundamental frequency, Vibration measurement on rotating machinery, diagrammatic approach in rotating systems, Measurement of torsional vibration.

Module: 3	**RIGID ROTOR DYNAMICS AND CRITICAL SPEED**	**7 Hours**

Critical Speed in dynamic systems, applications in low and high speed systems, Rigid disk equation - Rigid rotor dynamics, Rigid rotor and flexible rotor.

Module: 4	**GYROSCOPIC EFFECT ON ROTOR DYNAMICS**	**7 Hours**

Whirling of an unbalanced simple elastic rotor, Unbalance response, Orbital Analysis and Cascade Plots, Simple shafts with several disks, Effect of axial stiffness, Determination of bending critical speeds, Campbell diagram.		
Module: 5	**INFLUENCE OF BEARINGS ON ROTOR VIBRATIONS**	**7 Hours**
Influence of Support stiffness for rotating systems, Importance of supports on critical speeds, Stiffness and damping for low speed and high speed applications in coefficients of journal bearings, Computation and measurements of journal 33 bearing coefficients, Mechanics of Hydro dynamic Instability, Half frequency whirl and Resonance whip, Design configurations of stable journal bearings.		
Module: 6	**BALANCING OF ROTORS**	**7 Hours**
Introduction to Balancing, balancing of rotating and reciprocating masses, Importance of balancing in dynamic systems, Single plane balancing, Multi-plane balancing, Balancing of rigid rotors, Balancing of flexible rotors, Influence coefficient and modal balancing techniques for flexible rotors, graphical analysis, applications in automotive systems balancing.		
	Total Lectures	**45 Hours**

Text Book	
1.	J. S. Rao, “Rotor Dynamics”, New Age International Publishers, New Delhi.
Reference Books	
1.	S. Timoshenko, D H. Young and W. Weaver, “Vibration Problems in Engineering”, John Wiley.
2.	W J Chen and J E Gunter, “Introduction to Dynamics of Rotor – Bearing Systems”, Trafford Publishing Ltd.

Recommended by Board of Studies	
Approved by Academic Council	

DEPAPARTMENT OF AEROSPACE ENGINEERING

LIST OF NEW COURSES (2020)

S.No	Code No.	Name of the Course	L	T	P	Credits
1	19AE2002	Digital Manufacturing in Aerospace Industries	3	0	0	3
2	19AE2003	Aircraft Materials and Processes	3	0	0	3
3	19AE2004	Engineering Design and Cost Engineering	3	0	0	3
4	19AE2005	Elements of Small Satellite Design	2	1	2	4
5	20AE2001	Introduction to Aerospace Engineering	3	0	0	3
6	20AE2002	Basics of Fluid Mechanics	3	0	0	3
7	20AE2003	Fluid Mechanics Laboratory	0	0	2	1
8	20AE2053	Machine Learning and Artificial Intelligence in Aerospace Applications	3	0	0	3
9	20AE2054	Internet of Things in Aerospace Applications	3	0	0	3
10	20AE2055	Space Systems Engineering	3	0	0	3

19AE2002	DIGITAL MANUFACTURING IN AEROSPACE INDUSTRIES	L	T	P	C
		3	0	0	3

Course Objective:

1. To impart the importance of additive manufacturing and its applications.
2. To acquire knowledge about the various techniques involved in additive manufacturing.
3. To be aware of the additive manufacturing techniques in Aerospace industries

Course Outcome:

The Student will able to

1. Understand the principles, merits and demerits of additive manufacturing
2. Understand the convergence of different technologies and integrated into additive manufacturing
3. Understand the diverse range of additive manufacturing techniques
4. Understand the application of additive manufacturing in Aerospace industries
5. Select suitable process and materials used in additive manufacturing
6. Apply 3D printing technology for producing aircraft parts

Module 1: Introduction (7 hrs)

Additive manufacturing principle, Advantages of additive manufacturing, General limitation of additive manufacturing. Procedure for product development in additive manufacturing, Classification of additive manufacturing processes, Materials used in additive manufacturing, Challenges in Additive Manufacturing.

Module 2: Development of Additive Manufacturing Technology (7 hrs)

Distinction between additive manufacturing and CNC Machining. Computer-Aided design technology and other associated technologies; Lasers, Printing Technologies, Programmable Logic Controllers, Materials, Computer Numerically Controlled Machining. Classification of additive manufacturing processes; Liquid polymer systems, Discrete particle systems, Molten material systems, Solid sheet systems, New additive manufacturing classification schemes.

Module 3: Solid Based Additive Manufacturing Systems (8 hrs)

Fused deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications.

Module 4: Liquid Based Additive Manufacturing Systems (8 hrs)

Stereolithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo-polymerization of SL resins, part quality and process planning,

Module 5: Powder Based Additive Manufacturing Systems (8 hrs)

SLS process description, Powder fusion mechanisms; Solid-state sintering, Chemically-induced sintering, Liquid-phase sintering and partial melting, Full melting. Powder handling; Powder handling challenges, Powder handling systems, Powder recycling.

Module 6: 3D Printing in Aerospace Industry (7 hrs)
Commercial Aircrafts Components: Fuel Nozzle, Cooling Fan, Cabin Interior Components, Engine and Turbine Parts, etc. Industrial Spacecrafts: Flame Retardant Vents, Camera Mounts and Housings, Engine Combustion Chamber, Integral Propellant Tank, etc. Sustainability of 3D Printing in Aerospace Industry.

Content Beyond Curriculum
Case studies - Production of Satellite Parts, Honeycomb pattern on thin wall object with grain-based 3d printing, 3D printing a jet engine: an undergraduate project to exploit additive manufacturing now and in the future, etc.

Text Books:

1. Gibson l D. W. Rosen l B. Stucker, Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.
2. Chua C.K., Leong K.F., and Lim C.S., “Rapid Prototyping; Principles and Applications”, Third Edition, World Scientific Publishers, 2010

References:

1. Andreas Gebhardt, Understanding Additive Manufacturing Rapid Prototyping · Rapid Tooling · Rapid Manufacturing, Hanser Publishers, 2011.
2. Frank W. Liou, Rapid Prototyping and Engineering Applications A Toolbox for Prototype Development, CRC Press, 2008.
3. Peter D. Hilton, Paul F. Jacobs, Rapid Tooling Technologies and Industrial Applications, Marcel Dekker, Inc., 2000.
4. Kamrani, Ali K. , Nasr, Emad Abouel, Rapid Prototyping: Theory and Practice, Springer, 2006.

19AE2003	AIRCRAFT MATERIALS AND PROCESSES	L	T	P	C
		3	0	0	3

Course Objectives :

1. To be able to apply the properties of various materials and examine their suitability in making different aircraft components
2. To be aware of various methods of producing materials suitable for aircraft components
3. To know the metal joining processes and other manufacturing processes in Aircraft manufacturing

Outcomes :

The student will be able to

1. Understand the importance of material selection in Aircraft design
2. Describe and identify materials for development of aircraft and its components
3. Analyze Properties of Aircraft Light Alloys, Aircraft Steels & Composites
4. Review standardization of Aircraft materials viz-a-viz, Crystalline / material micro-structures
5. Describe standard engineering processes associated with aircraft manufacture
6. Evaluate modern aerospace component fabrication Techniques

Module 1 : Introduction (5 hrs)
General classification of materials - Importance & selection of materials for Aircraft & aerospace vehicle designs. Structures & Importance of temperature variations, for different parts of airplane.

Module 2 : Light-weight Metal Alloys & Titanium Alloys (9 hrs)
Aluminum alloys, Heat treatment, High strength and high corrosion resistant alloys, Magnesium alloys and their properties. Titanium and its alloys. Application to Aerospace Vehicle of these alloys.

Module 3 : Aircraft Steels (5 hrs)
Classification of alloy steels, Effect of alloying elements, corrosion resistant steels, Heat treatment of steel alloys , Corrosion prevention methods.

Module 4 : High Strength , Heat Resistant Alloys and Composites (10 hrs)
Nickel and cobalt base alloys, properties of Inconel, Monal and K-Monal, Nimonic and super alloys; Refractory materials; Composites their types, structure, multi-layering & hybrid materials, Stealth materials & Ceramics, Application to Aerospace vehicles.

Module 5 : Metal Joining Processes (6 hrs)
Standard aircraft welding practices, Inert-gas, arc welding, resistance welding. Welding of light alloys. Electron-beam & Plasma Welding. Basics of aircraft & aerospace vehicle Riveting, types of rivet heads & tools. Stress calculations – Advantages and limitations – Selection of welding process
Module 6 : Aircraft Manufacturing Processes (10 hrs)
Profiling, Hydro forming, forming bending rolls, Spar milling, Spark erosion and Powdered metal parts, integral machining, Contour etching, High energy rate forming, Manufacturing of honeycomb structures, General methods of construction of aircraft and aero engine parts.
Content Beyond Curriculum
1. Videos on Aircraft Manufacturing Process
2. Study of aircraft Materials in modern aircrafts
3. Case studies on material choices for a) blades b) Pressure vessels

Text Books :

1. G.F. Titterton, "Aircraft Materials and Processes", Himalayan Books, New Delhi, 2015
2. G.B. Ashmead, "Aircraft Production Methods" Chilton Company, 1956.

References :

1. Steven M. Arnold & David Cebon and Mike Ashby, "Materials Selection for Aerospace Systems", National Aeronautics and Space Administration Glenn Research Center Cleveland, Ohio 44135, January, 2012.
2. Chapman WAJ, "Workshop Technology", Vol. I, II, III, CBS Publishers & Distributors, 2001.
3. Lalit Gupta, "Advanced Composite Materials", Himalayan Books, New Delhi,1998
4. MIT Lecture notes on Aircraft Materials

19AE2004	ENGINEERING DESIGN AND COST ENGINEERING	L T P C 3 0 0 3

Course Objectives:
1. To give an insight into product life cycle
2. To understand various steps in product development
3. To get an overall view of Cost Engineering and its importance in different stages of product life cycle.

Course Outcomes:
The student will be able to
1. Appreciate of the concept of Product Life Cycle
2. Conduct requirement analysis
3. Generate ideas, evaluate and select engineering techniques
4. Carryout FMEA, Fault Tree Analysis etc.
5. Carry out functional analysis
6. Apply the basics of Value Engineering

Module 1 : Product Life Cycle & Requirement Engineering (7 hrs)
Stages of Product Life Cycle, Product Life Cycle Management, PESTEL Analysis, Requirement Analysis, Voice of Customer, Quality Function Deployment.
Module 2: Product Development (8 hrs)
Idea Generation, TRIZ, Idea Evaluation, Idea Selection, Risk Analysis, Industrial Design
Module 3: Value Engineering Techniques I (8 hrs)
Selectingproductsandoperationforvalueengineeringaction,value engineering programmes, determining and evaluating function(s) assigning rupee equivalents, developing alternate means to required functions.
Module 4: Value engineering techniques I (8 hrs)
Decision making for optimum alternative, use of decision matrix, queuing theory and Monte Carlo method make or buy, measuring profits, reporting results, Follow up, Use of advanced technique like Function Analysis system.

Module 5: Value engineering level of effort (7 hrs)
Value engineering team, co-coordinator, designer, different services, definitions, construction management contracts, value engineering case studies.
Module 6: Recent Advances in Engineering Design (7 hrs)
Design for Manufacturing, Concurrent Engineering, Lean Design, Rapid Prototyping, Model Based Definition
Content Beyond Curriculum
Case studies on costing & Value engineering pertaining to Aerospace industries
Text Book:

1. Anil Kumar Mukhopadhyaya, "Value Engineering: Concepts Techniques and applications", SAGE Publications 2010.
2. John M Nicholas, "Project Management for Business and Technology", Prentice Hall India Pvt. Ltd., New Delhi, 2002.

References:

1. Alphonse Dell'Isola, "Value Engineering: Practical Applications for Design, Construction, Maintenance &Operations", R S Means Co.,1997.
2. Richard Park, "Value Engineering: A Plan for Invention", St. Lucie Press,1999.
3. James L Riggs, David D Bedworth and Sabah U Randhawa, "Engineering Economics", McGraw Hill Book Company, New Delhi, 2004.

19AE2005	ELEMENTS OF SMALL SATELLITE DESIGN	L T P C 2 1 2 4

Course Objectives :
1. To sensitize students in developing, launching and utilizing the benefits of small satellites
2. To disseminate knowledge required for small satellites technology
3. Exposure to infrastructure required for small satellite development

Outcomes :
The student will be able to
1. Understand the elements of each satellite subsystem
2. Understand the interconnections of satellite subsystems
3. Perform trade-offs and conduct basic design steps for each satellite subsystem
4. Understand and apply the space mission design process
5. Reason and to solve problems related to space systems analytically
6. Design and implement a small satellite mission in an interdisciplinary team

Phases
- E-Learning phase with weekly online lectures and Tutorial Assignment
- Project phase with a concurrent design approach

E-Learning phase
Module 0 : Course Introduction (2 hrs)
Module 1 : Introduction (4 hrs)
Space applications - Earth observation, communication, navigation, space exploration, other use-cases, mission examples - Space environment -Vacuum, micro-gravity, heat sources and sinks, particles in space, radiation, verification and testing - Satellite orbits (LEO, MEO, GEO, HEO, Keplerian elements, orbit transfer)
Module 2 : Space Mission design process & Satellite structure (8 hrs)
Phases 0 to F according to the ECSS standards, review milestones, mission planning - Space systems engineering - Definition, role and functions of a systems engineer, requirements engineering - Space standards - Overview of standards worldwide, Introduction to the ECSS standards, application of standards
Satellite structure and mechanisms - Role, load sources, primary/secondary/tertiary structures, satellite configurations, structural elements, materials, deployment mechanisms, release mechanisms, structure verification and test
Tutorial 1 (10 hrs)
Task: Designing a deployment mechanism according to pre-defined requirements and constraints

Sub-tasks: materials selection, mass estimation, mechanism definition, test campaign definition, risk assessment, drawings

Module 3 : Thermal Control Subsystem (6 hrs)

Role, temperature requirements, hot/cold case, Thermal modeling and analysis, heat conduction, thermal radiation, thermal sources and sinks, thermal balance, aborptivity/emissivity, thermal surfaces, passive thermal control elements, active thermal control elements, thermal verification and test, design process

Tutorial 2 (10 hrs)

Task: Thermal analysis of a six-node satellite in GEO

Sub-tasks: sun/eclipse time calculation, software implementation of a six-node thermal model, use of a numerical solver in MATLAB/Octave/Scilab, visualization of satellite temperatures

Module 4 : Onboard Data handling (6 hrs)

Role, data handling requirements of subsystems, data acquisition and processing, design challenges, design process, computer architectures, computer hardware, radiation effects and mitigation, bus architectures, standard busses in space flight, failure-tolerant design, source coding, channel coding, line coding, software design and verification

Tutorial 3 (10 hrs)

Task: Implementation of a data verification algorithm (e.g. CRC, parity check)

Sub-tasks: Implementation of code using MATLAB/Octave/Scilab

Module 5 : Electrical Power subsystem (4 hrs)

Role, requirements, power budget, functional groups, energy sources, energy storage, regulation and control, distribution and safety, solar cells, EPS design process, solar array sizing, battery sizing, fault tolerance

Tutorial 4 (10 hrs)

Task: Conceptual design of a satellite electrical power subsystem

Sub-tasks: Drawing a block diagram with all components, creating the power budget, sizing the solar array and batteries

Module 6 : Attitude Control subsystem (4 hrs)

Role, Functions, coordinate systems, general terms, torque and angular momentum, control system, passive satellite stabilization methods, active satellite stabilization methods, ACS sensors, ACS actuators, ACS design process

Tutorial 5 (10 hrs)

Task: Dimensioning of ACS actuators

Sub-tasks: ACS thrust force calculation, reaction wheel speed/torque/momentum calculation, magnetorquer dimensioning

Module 7 : Telemetry, Tracking and Command (6 hrs)

Role, satellite communication architectures, frequency bands, modulation techniques, encoding techniques, RF link design, antennas, noise, link budget

Tutorial 6 (10 hrs)

Task: Link budget calculation for a defined satellite

Sub-tasks: Calculation of uplink and downlink budgets

Module 8 : Satellite Propulsion (6 hrs)

Role, applications, basic physics, classification, liquid propulsion systems, solid propulsion systems, electric propulsion systems, electro-thermal propulsion systems, electro-static propulsion systems, electro-magnetic propulsion systems

Tutorial 7 (10 hrs)

Task: Design of a satellite propulsion system

Sub-tasks: Delta-V calculation, propellant mass calculation, volume/pressure calculations, propulsion system architecture design

Project Phase (25 hrs)

- The students form two teams with 10 to 15 members each
- Each team designs a whole satellite mission including satellite subsystems, mission parameters, project costs, AIT approach, etc.
- The teams present their design status on defined milestones

- The teams are supervised by a coach with satellite design experience

Team building, mission definition, requirements definition, work package definitions
Definition of the mission architecture, start of the first design iteration, mission design
Mission design, presentation of the first design iteration
Start of the second design iteration
Finalization of the design, final review

Teaching & assessment methods

- Tailored e-Learning lectures
- Graded homework
- Written exam
- Small satellite design project including graded presentations
- Online forum for questions related to the content and the homework

Text Books :

1. George Sebestyen , Steve Fujikawa, Nicholas Galassi & Alex Chuchra, "Low Earth Orbit Satellite Design", Springer; 1st ed. 2018 edition.
2. Madry, Scott, Martinez, Peter**,** Laufer, Rene, "Innovative Design, Manufacturing and Testing of Small Satellites", Springer International Publishing, 2018.

Reference :

1. Lecture Videos by Technical University, Berlin

Course code	**INTRODUCTION TO AEROSPACE ENGINEERING**	**L**	**T**	**P**	**C**
20AE2001		**3**	**0**	**0**	**3**

Course Objectives:

Impart knowledge on

1. Basic concepts of aircrafts, rockets and their functions.
2. Aerodynamics, aircraft structure and aircraft propulsion.
3. Basic parts, function and construction of aerospace vehicles.

Course Outcomes:

The student will be able to

1. Understand the nature of aerospace technologies.
2. Identify the different types of Aircraft components and their functions.
3. Assess the forces and moments due to flow over the aircraft components.
4. Apply the principles of aerodynamics to different parts of an aeroplane.
5. Understand the performance of propulsion systems.
6. Apply the knowledge of gravitational law, Kepler's law and Newton's law to space vehicles.

Module: 1	**HISTORICAL EVOLUTION AND STANDARD ATMOSPHERE**	**8 Hours**

History of aviation, History and Mission of Indian Space Research Organization, National Aerospace Laboratories(NAL), Gas Turbine Research Establishment (GTRE), Hindustan Aeronautics Limited (HAL), Defence Research and Development Organisation. Different types of flight vehicles and Classifications, Components of an airplane and their functions, Standard atmosphere-Isothermal layer and gradient layer.

Module: 2	**PRINCIPLES OF FLIGHT**	**8 Hours**

Basic aerodynamics, Aerofoils, wings and their nomenclature; lift, drag and pitching moment coefficients, centre of pressure and aerodynamic centre, NACA airfoil nomenclature.

Module: 3	**AEROSPACE STRUCTURES**	**8 Hours**

General types of construction, Types of structure, typical wing and fuselage structure-monocoque-Semi-monocoque, Honeycomb and Sandwich structure, Aircraft materials.

Module: 4	PROPULSION SYSTEMS	7 Hours
Principles of Thrust generation, Reciprocating engine, propeller, turboprop engine, Basic ideas about jet propulsion, Types of jet engines - turbofan and turbojet engines.		
Module: 5	**ROCKETS & MISSILES**	**7 Hours**
Principles of operation of rocket, Rocket engine-specific impulse, Rocket equation, Single and Multi-stage rockets, Types of Rockets, Types of Missiles. Rocket and Missile developed by India.		
Module: 6	**SPACE FLIGHT**	**7 Hours**
Newton's laws, Kepler's laws of motion, Kepler's equation, Two-body problem, Orbital elements, Angular momentum, Vis-viva equation, Hohmann transfer, Introduction to space debris.		
CONTENT BEYOND SYLLABUS		
Understanding of lift generation using paper planes.		
	Total Lectures	**45 Hours**

Text Books

1.	Anderson, J.D., "Introduction to Flight", Tata McGraw-Hill, sixth Edition, 2013
2.	Kermode A C., "Mechanics of Flight", Pearson Education Low Price Edition, 2005.

Reference Books

1.	Kermode, A.C., "Flight without Formulae", McGraw-Hill, 1997.
2.	Sutton, G.P. "Rocket Propulsion Elements", John Wiley.
3.	E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012.
4.	Megson, T.M.G., "Aircraft Structures for Engineering Students", 2007.
5.	Howard D. Curtis, "Orbital Mechanics for Engineering Students", Elsevier Butterworth-Heinemann, Third Edition, 2010.
6.	https://www.hal-india.co.in, https://www.isro.gov.in, https://www.nal.res.in, https://www.ada.gov.in , https://www.drdo.gov.in.
7.	https://www.grc.nasa.gov/WWW/K-12/UEET/StudentSite/aeronautics.html.
8.	https://en.wikipedia.org/wiki/History_of_aviation.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	BASICS OF FLUID MECHANICS	L	T	P	C
20AE2002		3	0	0	3

Course Objectives:

Impart knowledge on

1. Basic concepts of fluid statics.
2. Basic laws governing fluid motion and its application.
3. Concept of basic airflow.

Course Outcomes:

The student will be able to

1. Know the properties of different fluids and pressure measurements.
2. Apply mathematical knowledge to predict the properties and characteristics of a fluid.
3. Understand the nature of buoyancy of submerged and floating bodies.
4. Attain the Knowledge of flow measurement systems.
5. Estimate the friction factor of pipe flow and losses associated with it.
6. Understand the non-dimensional parameters used in airflow.

Module: 1	BASICS OF FLUID FLOW	8 Hours

Definition of a fluid – Continuum hypothesis – Fluid properties - Pressure, Temperature, Density, Viscosity - stress-strain rate relationship, Measurement of pressure –Fluid statics – Total and Centre of pressure of submerged surfaces-Stability of submerged and floating bodies.		
Module: 2	**BASIC EQUATIONS**	**8 Hours**
Motion of a fluid particle – Types of flow-Continuity equation-Velocity and acceleration-velocity potential and stream function- Path lines, Stream lines and Streak lines,-Fluid deformation–RotationVorticity, Elementary flows- Uniform flow, Source flow, Sink flow, Doublet flow, Vortex flow, Super imposed flows- Semi-Infinite Body, Rankine Body.		
Module: 3	**INCOMPRESSIBLE INVISCID FLOW**	**8 Hours**
Equations of motion-Euler's equation of motion- Energy equation-Momentum equation – Bernoulli's equation and its Applications — Flow measurement – Orifice meter – Venturimeter- Pitot tube.		
Module: 4	**INCOMPRESSIBLE VISCOUS FLOW**	**7 Hours**
D' Alembert's Paradox, Viscous stress-strain rate relationship, Flow of viscous fluid through circular pipes – Velocity profiles – Frictional loss in pipe flow-Calculation of minor and major energy losses in pipes.		
Module: 5	**DIMENSIONAL ANALYSIS**	**7 Hours**
Dimensional analysis – The Buckingham-Pi theorem – Non dimensional numbers-Mach Number, Reynolds Number, Strouhal Number, Knudsen Number, etc.,		
Module: 6	**IMPACT OF JETS**	**7 Hours**
Impact of jets –Force exerted by a jet on stationary and moving vertical, horizontal and inclined plates.		
CONTENT BEYOND SYLLABUS		
Numerical methods to solve incompressible flow problems.		
	Total Lectures	**45 Hours**

Text Books

1.	Rathakrishnan.E, "Fundamentals of Fluid Mechanics", Prentice-Hall, 2012.
2.	White F.M., "Fluid Mechanics", 7th Edition, Tata McGraw-Hill Education, 2011.

Reference Books

1.	Robert W Fox & Alan T Mc.Donald, "Introduction to fluid Mechanics", John Wiley and Sons,1995.
2.	Kuethe, A.M. and Chow, C.Y., "Foundations of Aerodynamics", First Indian Reprint, John Wiley & Sons, 2010.
3.	Yuan S W, "Foundations of fluid Mechanics", Prentice-Hall, 1987.
4.	Graebel, W.P. "Engineering Fluid Mechanics" Taylor and Francis, 2001.
5.	S K Som, G Biswas, Suman Chakraborty, "Introduction to Fluid Mechanics and Fluid machines", Tata McGraw Hill Education, 2012.
6.	Fluid Mechanics: http://nptel.ac.in/courses/112105171/.
7.	Fluid Mechanics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-01-unifiedengineering-i-ii-iii-iv-fall-2005-spring-2006/fluid-mechanics/.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	FLUID MECHANICS LABORATORY	L	T	P	C
20AE2003		0	0	2	1

Course Objective:

Impart knowledge on

1. Principle and working of different flow measuring instruments.
2. Working of different types of turbines.
3. Energy losses in pipe connections.

Course Outcome:

The student will be able to

1. Recall the principles of instruments used in flow related measurements.
2. Describe the flow measurement methods.
3. Demonstrate energy losses in pipe connections.
4. Appraise the flow measurement techniques.
5. Select flow measuring techniques.
6. Investigate the operation of flow measuring instruments.

List of Experiments

1.	Determination of Darcy's Friction Factor.
2.	Calibration of Flow Meters.
3.	Flow over weirs / Notches.
4.	Flow through Mouth piece / orifice.
5.	Determination of Minor Losses in pipes.
6.	Determination of Manning's Co-efficient of Roughness.
7.	Calibration of pressure Gauges.
8.	Impact of jet on vanes.
9.	Reynolds' Experiment.

Total Lectures	**14 Hours**

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE IN AEROSPACE APPLICATIONS	L	T	P	C
20AE2053		3	0	0	3

Course Objectives:

Impart knowledge on

1. Fundamental concepts of Artificial Intelligence (AI).
2. Application of AI in aircraft industry.
3. AI in the real time application.

Course Outcomes:

The student will be able to

1. Define the fundamental concepts of Artificial Intelligence (AI).
2. Design and implement intelligent agents to solve real-world AI problems.
3. Solve problems using search, games, machine learning, logic and constraint satisfaction.
4. Explain the natural language processing.
5. Understand the machine learning concepts.
6. Understand the basic applications of AI in aerospace.

Module: 1	**INTRODUCTION TO AI AND INTELLIGENT AGENTS**	**8 Hours**

Introduction to AI, history of AI, Intelligent agents, search agents, uniformed search.

Module: 2	**HEURISTIC SEARCH AND GAME PLAYING**	**7 Hours**

Greedy search, A* algorithm, stochastic search, local search, Minimax algorithm, alpha beta pruning, stochastic games.		
Module: 3	**MACHINE LEARNING**	**9 Hours**
Basic concepts, linear models, K nearest neighbors, overfitting perceptron's, neural networks, naive Bayes, Decision trees, ensemble, logistic regression, and unsupervised learning.		
Module: 4	**REINFORCEMENT LEARNING**	**7 Hours**
Reinforcement learning overview, Markov decision processes, reinforcement learning algorithms.		
Module: 5	**AI APPLICATIONS TO NATURAL LANGUAGE PROCESSING (NLP)**	**7 Hours**
AI application with NLP, Text classification, Language models, progress in NLP.		
Module: 6	**AI APPLICATIONS IN AEROSPACE**	**7 Hours**
Introduction to aerospace, Preventive Maintenance and Operational Efficiency, Spark Cognition, Slingshot Aerospace, Neurala.		
CONTENT BEYOND SYLLABUS		
Recurrent neural network.		
	Total Lectures	**45 Hours**

Text Books	
1.	Stuart Russell and Peter Norvig, Artificial Intelligence: A modern Approach (3rd edition).
2.	Deepak Khemani.A First Course in Artificial Intelligence, McGraw Hill Education (India), 2013.
3.	Stefan Edelkamp and Stefan Schroedl. Heuristic Search: Theory and Applications, Morgan Kaufmann, 2011.
Reference Books	
1.	Peter Jackson, "Introduction to Expert Systems", 3rd Edition, Pearson Education, 2007.
2.	Stuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, Pearson Education 2007.
3.	Deepak Khemani "Artificial Intelligence", Tata Mc Graw Hill Education 2013.
4.	http://nptel.ac.in
5.	MOOCs (Online courses): Refer to edX, Coursera, Analyticsvidhya, Simplilearn, Udemy, Udacity, Lynda, Pluralsight, Safari.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**INTERNET OF THINGS IN AEROSPACE APPLICATIONS**	**L**	**T**	**P**	**C**
20AE2054		3	0	0	3

Course Objectives:

Impart knowledge on

1. Fundamentals of Internet of Things.
2. IoT Architecture.
3. Enablers of IoT: Cloud Computing and Analytics.

Course Outcomes:		
The student will be able to 1. Understand the concept of IoT technologies. 2. Explain IoT architecture. 3. Understand the wired and wireless communication protocols. 4. Learn the concepts of cloud systems, parallel processing in the cloud. 5. Understand patterns and behaviours of data obtained from different data streams. 6. Apply concepts of IoT in Aerospace applications		
Module: 1	**INTRODUCTION- CONCEPTS AND TECHNOLOGIES BEHIND INTERNET OF THINGS**	**7 Hours**
Concepts & Definitions –Identification, localization, wireless protocols, data storage and security; Collecting, communicating, coordinating, and leveraging the data from connected devices; understand how to develop and implement IoT technologies, solutions, and applications. Machine Learning, Distributed Computing, Artificial Intelligence.		
Module: 2	**IOT ARCHITECTURE**	**7 Hours**
IoT Network Architecture - IoT Device Architecture - IoT Application Architecture - Client Server vs Publish Subscribe Architecture.		
Module: 3	**COMMUNICATION PROTOCOLS**	**8 Hours**
Wired Communication Protocols – UART, USART, SPI, I2C, ModBUS, CAN - Wireless Communication Protocols – Bluetooth, Beacons, WiFi, Overview of Zigbee, 6lowPAN, LPWAN and other IoT communication technologies and protocols (coverage area, frequency range, power usage, interference aspects and legalities) - Networking Protocols – OSI Reference Model, TCP/IP, Ethernet - Application Protocols – HTTP, Web sockets, MQTT, Overview of CoAP, XMPP, AMQP - Device management, discovery, addressing - Device to Device or Machine to Machine communication (M2M).		
Module: 4	**ROLE OF CLOUD COMPUTING IN IOT**	**7 Hours**
Concept & Architecture of Cloud - Tools, API and Platform for integration of IoT devices with Cloud - IoT cloud platform and integration with Gateway (Thingspeak, AWS IoT and Pubnub) – Web services and APIs.		
Module: 5	**DATA VISUALIZATION**	**8 Hours**
Introduction to Data Visualization, Importance of Data Visualization, Introduction to Microsoft Power BI, Connecting to various backend sources for data, Creating Charts using Power BI, Data Cleansing, Data Refresh.		
Module: 6	**IoT IN AEROSPACE**	**8 Hours**
Introduction, IoT applications for industry: Future Factory Concepts, Smart Applications, New manufacturing tools, Coonnected systems, Connected factory, connected aircrafts, Precision manufacturing, Location tracking, Preventive Maintenance, benefits of IoT in Aviation, Challenges		
CONTENT BEYOND SYLLABUS		
IoT – privacy and security issues.		
	Total Lectures	**45 Hours**

Text Books	
1.	Arshdeep Bahga and Vijay Madisetti, "Internet of things – A hands on Approach", First edition, Orient Blackswan Publishers, 2014.
2.	Jeeva Jose, "Internet of Things" Khanna Book Publishing Co (P) Ltd, New Delhi, 2018.

Reference Books	
1.	Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013.
2.	Cuno Pfister, Getting Started with the Internet of Things, O"Reilly Media, 2011, ISBN: 978-1-4493-9357-1.
3.	Honbo Zhou, "The Internet of Things in the Cloud: A Middleware Perspective", CRC Press, 2012.
4.	Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), "Architecting the Internet of Things", Springer, 2011.
5.	David Easley and Jon Kleinberg, "Networks, Crowds, and Markets: Reasoning About a Highly Connected World", Cambridge University Press, 2010.
6.	Olivier Hersent, David Boswarthick, Omar Elloumi, "The Internet of Things – Key applications and Protocols", Wiley, 2012.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	SPACE SYSTEMS ENGINEERING	L	T	P	C
20AE2055		3	0	0	3

Course Objectives:

Impart knowledge on

1. Small satellites technology.
2. Phases in developing, launching and utilizing small satellites.
3. Design aspects of sub systems..

Course Outcomes:

The student will be able to

1. Understand the elements of satellite subsystem
2. Understand the interconnections of satellite subsystems
3. Conduct basic design calculations for the different satellite subsystems
4. Understand and apply the space mission design process
5. Reason and to solve problems related to space systems analytically
6. Design and implement a small satellite mission in an interdisciplinary team

Module: 1	INTRODUCTION- SPACECRAFT SYSTEMS	7 Hours

Introduction – Payload and Missions – A system view of Spacecraft – Pre operational space environment – Operational Spacecraft Environments – Environmental Effects of design

Module: 2	DYNAMICS OF SPACE & MISSION ANALYSIS`	7 Hours

Trajectory Dynamics – General Attitude Dynamics - .Orbit Perbutations – Keplerian Orbit transfers – Mission analysis - Polar LEO/Remote-Sensing Satellites - Satellite Constellations - Geostationary Earth Orbits - Highly Elliptic Orbits - Interplanetary Missions.

Module: 3	PROPULSION SYSTEMS & LAUNCH VEHICLES	7 Hours

Systems Classification - Chemical Rockets - Spacecraft Propulsion - Electric Propulsion
Basic Launch Vehicle Performance and Operation - Spacecraft Launch Phases and Mission Planning - Small Launchers and Reusable Sub-Orbital Vehicles - Re-Entry into Earth's Atmosphere.

Module: 4	SPACECRAFT STRUCTURES & ATTITUDE CONTROL	7 Hours

Design Requirements of spacecraft structures - Material Selection - Analysis - Design Verification - Impact Protection

ACS Overview - The Spacecraft Attitude Response - Torques and Torquers - Attitude Measurement - ACS Computation.		
Module: 5	**SPACECRAFT SUBSYSTEMS**	**10 Hours**
Electrical Power systems – Thermal Control Systems – Telecommunications – Telemetry, command, data handling and Processing – Ground segment.		
Module: 6	**ASSEMBLY, INTEGRATION AND VERIFICATION**	**7 Hours**
The Verification Plan - Relationship between Analysis and Test - The AIV Plan - Testing: General - Test Types - Model Philosophy - Build Standards and Applications - Ground Support Equipment - Checkpoints in the AIV Programme - Verification Closeout - Launch Preparation.		
CONTENT BEYOND SYLLABUS		
Launch Vehicles – Satellite constellation.		
	Total Lectures	**45 Hours**

Text Books

1.	Spacecraft Systems Engineering, Fourth Edition by Peter Fortescue, Graham Swinerd and John Stark, Editors, John Wiley & Sons, N.Y., Applied Thermosciences Series, 2011.

Reference Books

1.	Space Mission Analysis and Design, Third Edition, Wiley J. Larson and James R. Wertz, Editors, Microcosm Press and Kluwer Academic Publishers, 1999 (if Space Systems Engineering is your passion).
2.	Fundamentals of Space Systems, Second Edition, by Vincent L. Pisacane, Oxford University Press, 2005 (if this were a graduate or 600 level course).
3.	Aircraft Design: http://nptel.ac.in/courses/101104069/.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

DEPT. OF AEROSPACE ENGINEERING

LIST OF NEW COURSES

S.No	Code No.	Name of the Course	L	T	P	Credits
1	18AE2025	Navigation, Guidance and Control of Aerospace Vehicles	3	0	0	3
2	18AE2026	Aircraft Instrumentation and Control Laboratory	0	0	3	1.5
3	18AE2027	Heat and Mass Transfer	3	0	0	3
4	18AE2028	Computational Fluid Dynamics	3	0	0	3
5	18AE2029	Computational Fluid Dynamics Laboratory	0	0	2	1
6	18AE2030	Wind tunnel Techniques	3	0	0	3
7	18AE2031	Helicopter Aerodynamics	3	0	0	3
8	18AE2032	Finite Element Analysis	3	0	0	3
9	18AE2033	Finite Element Analysis Laboratory	0	0	2	1
10	18AE2034	Theory of Elasticity	3	0	0	3
11	18AE2035	Design and Analysis of Composite Structures	3	0	0	3
12	18AE2036	Introduction to Non Destructive Testing	3	0	0	3
13	18AE2037	Structural Vibration	3	0	0	3
14	18AE2038	Aeroelasticity	3	0	0	3
15	18AE2039	Cryogenic Propulsion	3	0	0	3
16	18AE2040	Rocket and Missiles	3	0	0	3
17	18AE2041	Advanced Space Dynamics	3	0	0	3
18	18AE2042	Air Traffic Control and Aerodrome Details	3	0	0	3
19	18AE2043	Aircraft Systems	3	0	0	3
20	18AE2044	Basics of Acoustics	3	0	0	3
21	18AE2045	Basics of Aerospace Engineering	3	0	0	3
22	18AE3001	Advanced Aerodynamics	3	0	0	3
23	18AE3002	Advanced Aerodynamics Laboratory	0	0	2	1
24	18AE3003	Aerospace Propulsion	3	0	0	3
25	18AE3004	Aero Propulsion Laboratory	0	0	2	1
26	18AE3005	Orbital Space Dynamics	3	0	0	3
27	18AE3006	Flight Mechanics	3	1	0	4
28	18AE3007	Aerospace Structural Analysis	3	0	0	3
29	18AE3008	Aerospace Structural Analysis Laboratory	0	0	2	1
30	18AE3009	Flight Control Systems	3	0	0	3
31	18AE3010	Flight Control System Laboratory	0	0	2	1
32	18AE3011	Computer Aided Design Laboratory	0	0	2	1
33	18AE3012	Advanced Computational Fluid Dynamics	3	0	0	3
34	18AE3013	Advanced Computational Fluid Dynamics Laboratory	0	0	2	1
35	18AE3014	Computational Heat Transfer	3	0	0	3
36	18AE3015	Cryogenic Engineering	3	0	0	3
37	18AE3016	Advanced Finite Element Analysis	3	0	0	3
38	18AE3017	Advanced Finite Element Analysis Laboratory	0	0	2	1
39	18AE3018	Aerospace Materials	3	0	0	3
40	18AE3019	Composite Materials and Structural Analysis	3	0	0	3
41	18AE3020	Aeroelasticity	3	0	0	3
42	18AE3021	Aircraft Design	3	0	0	3
43	18AE3022	Experimental Stress Analysis	3	0	0	3
44	18AE3023	Boundary Layers Theory	3	0	0	3
45	18AE3024	Introduction to Hypersonic Flows	3	0	0	3
46	18AE3025	Fatigue and Fracture Mechanics	3	0	0	3
47	18AE3026	Fundamental of Combustion	3	0	0	3
48	18AE3027	Unmanned Aircraft Systems	3	0	0	3

49	18AE3028	Industrial Aerodynamics	3	0	0	3
50	18AE3029	Composite Structures and Acoustics	3	0	0	3
51	18AE3030	Elements of Aerospace Engineering	3	0	0	3
52	18AE3031	Road Vehicle Aerodynamics	3	0	0	3
53	18AE3032	Wind Turbine Design	3	0	0	3
54	18AE3033	Building Aerodynamics	3	0	0	3
55	18AE3034	Introduction to Unmanned Aircraft System	3	0	0	3
56	18AE3035	Foundations of Space Engineering	3	0	0	3
57	19AE1001	Fundamentals of Space Science	3	0	0	3
58	19AE2001	Flight Stability and Aeromodelling Laboratory	0	0	2	1

18AE2025	**NAVIGATION, GUIDANCE AND CONTROL OF AEROSPACE VEHICLES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Co-requisite: 18AE2026 Aircraft Instrumentation and Control Laboratory

Course Objectives:

1. To impart the knowledge of various navigation methodologies.
2. To impart the knowledge of the guidance laws.
3. To impart the knowledge of control systems and their stability.

Course Outcomes:

After completing the course the student will be able to

1. Recall the radar concepts and their operation.
2. Identify fundamental navigation concepts and their working.
3. Exemplify various inertial sensors and their applications in IMU.
4. Compute guidance commands with the knowledge of the guidance laws.
5. Illustrate control system concepts.
6. Integrate and validate control systems in aerospace applications.

MODULE 1: INTRODUCTION TO RADARS (5 LECTURE HOURS)

Introduction to radars, Radar equation, Block Diagram and Operation; Radar Frequencies. Application of Radars, Range performance of radars. Minimum detectable signal, Noise effects.

MODULE 2: INTRODUCTION TO NAVIGATION SYSTEMS (8 LECTURES HOURS)

Introduction to navigation systems- Navigation by VFR, Navigation by IFR – Radio & Radar Navigation, Hyperbolic Navigation, Satellite Navigation - Introduction to GPS - system description - basic principles - position and velocity determination, ILS, MLS.

MODULE 3: INERTIAL NAVIGATION (8 LECTURE HOURS)

Geometric concepts of Navigation, Reference frames, coordinate transformation, comparison of transformation methods. Inertial sensors, Inertial navigation systems-mechanization, Externally aided navigation, Integrated navigation.

MODULE 4: INTRODUCTION TO GUIDANCE (7 LECTURE HOURS)

Missile Guidance laws; Classification of guidance laws; Classical guidance laws; Modern guidance laws, Autopilots – Longitudinal, Lateral & Missile.

MODULE 5: INTRODUCTION TO CONTROL (8 LECTURE HOURS)

Introduction to Control System open loop and closed loop control system-Transfer function poles and zeroes - block diagram reduction- signal flow graph - Mason’s gain formula

MODULE 6: SYSTEM STABILITY (9 LECTURE HOURS)

Characteristics equation-concept of stability - Routh’s stability Criteria Root Locus. Classical linear time invariant control systems. Stability; time domain characteristics. PID controller design for aerospace systems. Frequency domain characteristics, Nyquist and Bode plots and their application to controller design for aerospace systems.

Text Books:

1. Nagaraja, N.S. “Elements of Electronic Navigation”, Tata McGraw-Hill Pub. Co., 15th reprint, 2006.

2. Blake Lock, J.H, “Automatic control of Aircraft and missiles”, John Wiley Sons, Second Edition, 1991.

References:

1. M .I. Skolnik, “Introduction to Radar Systems”, Tata McGraw-Hill, 2007
2. M. Kayton and W. Fried, “Avionics Navigation System”, Wiley Interscience, 1997.
3. P. Zarchan, “Tactical and Strategic Missile Guidance”, AIAA, 2007.
4. N.S. Nise, “Control Systems Engineering”, Wiley-India, 2004.
5. B. Friedland, “Control System Design”, Dover, 2005.
6. Debasish Ghose, “Navigation, Guidance, And Control”, NPTEL: Courses - Aerospace Engineering: https://nptel.ac.in/syllabus/101108056/.

18AE2026	AIRCRAFT INSTRUMENTATION AND CONTROL LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1. To impart the knowledge of aircraft instrumentation.
2. To give hands on training to measure aircraft parameters.
3. To impart knowledge on sensors and transducers in aerospace application.

Course Outcomes:

After completing the course the student will be able to

1. Measure three axis acceleration.
2. Measure velocity using hot wire anemometer.
3. Measure temperature using RTD & Thermocouple.
4. Design a control system for autopilots.
5. Estimate the data transferred in a Mil-STD-1553B data bus.
6. Determine position in GPS using my RIO.

List of Experiment:

1. Programming of 8085.
2. Programming of 8086.
3. Determination of temperature using RTD.
4. Determination of temperature using thermocouple.
5. Determination of Angular Position using mems gyro.
6. Determination of velocity using hot wire anemometer.
7. Designing a control system for longitudinal autopilot.
8. Designing a control system for lateral autopilot.
9. Designing a control system for missile autopilot.
10. Position fixing using GPS.
11. Transmission of data in Mil-Std-1553B.

Reference:

Lab - LabVIEW, Getting Started with LabVIEW, by National Instruments, June 2013

18AE2027	HEAT AND MASS TRANSFER	L	T	P	C
		3	0	0	3

Pre-requisites: 18AE2007 Thermodynamics

Course Objective

1. To understand the mechanisms of heat transfer under steady and transient conditions.
2. To understand the concepts of heat transfer through extended surfaces.
3. To learn the thermal analysis and sizing of heat exchangers and to understand the basic concepts of mass transfer.

Course Outcome

After completing the course the student will be able to

1. Understand the fundamental modes of heat transfer.
2. Understand the phase change heat transfer .
3. Use the heat transfer correlation for different heat transfer applications.

4. Understand the concept of hydrodynamic and thermal boundary layers.
5. Analyse and design the different types of heat exchangers.
6. Apply heat transfer principles of different applications.

(Use of standard HMT data book permitted)

MODULE 1: CONDUCTION (8 LECTURES HOURS)
General Differential equation of Heat Conduction– Cartesian and Polar Coordinates – One Dimensional Steady State Heat Conduction — plane and Composite Systems – Critical thickness of insulation - Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis –Semi Infinite and Infinite Solids –Use of Heisler's charts.
MODULE 2: CONVECTION (9 LECTURES HOURS)
Convection: Dimensional analysis – forced and free convection- Significance of dimensionless number - Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection during external flow over Plates and Cylinders and Internal flow through tubes.
MODULE 3: PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS (9 LECTURES HOURS)
Nusselt's theory of condensation - Regimes of Pool boiling and Film boiling. Correlations in boiling and condensation. Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factors - Analysis – LMTD method – effectiveness, NTU method.
MODULE 4: RADIATION (7 LECTURES HOURS)
Basic definitions - Black Body Radiation – Grey body radiation - Shape Factor – Electrical Analogy – Radiation between black surfaces - Radiation Shields - Radiation through gases.
MODULE 5: NUMERICAL METHODS IN HEAT TRANSFER AND APPLICATIONS (7 LECTURES HOURS)
Numerical analysis of heat conduction – finite difference formulation of differential equations – one-dimensional and two-dimensional steady heat conduction – Transient heat conduction in a plane wall-Application of heat transfer – Gas turbines-Rocket Thrust Chambers - Aerodynamic Heating -Ablative Heat Transfer.
MODULE 6: MASS TRANSFER (5 LECTURES HOURS)
Fick's law of diffusion, equimolar counter diffusion, Convective mass transfer coefficient, non–dimensional number in mass transfer, evaporation process in the atmosphere.

Text Books:

1. Yunus A. Cengel, "Heat Transfer A Practical Approach", Tata McGraw Hill, 2010 .
2. Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2000 .

Reference Books:

1. Ghoshdastidar, P.S, "Heat Transfer", Oxford, 2004.
2. Nag, P.K., "Heat Transfer", Tata McGraw Hill, New Delhi, 2002 .
3. Ozisik, M.N., "Heat Transfer", McGraw Hill Book Co., 1994.
4. Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 1998.
5. Sutton,G.P., Rocket Propulsion Elements,John Wiley and Sons, Fifth Edition, 1986.

18AE2028	**COMPUTATIONAL FLUID DYNAMICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite:18AE2014 Gas dynamics
Co-requisite: 18AE2029 Computational Fluid Dynamics Laboratory
Course Objectives:
1. To provide knowledge on governing equations of fluid dynamics
2. To provide an understanding of the solution methodologies of discretised equations
3. To impart knowledge of turbulence and combustion models and its behaviour

Course Outcomes:
After completing the course the student will be able to
1. Understand the governing equations for fluid flow and its classification.

2. Choose the proper turbulent models for the given flow situation.
3. Apply proper solution methodology for PDE.
4. Arrive the proper domain for the numerical simulation for the given flow situation.
5. Define the boundary conditions and generate the grids.
6. Solve the real life fluid dynamic problems.

MODULE 1: GOVERNING EQUATIONS (9 LECTURES HOURS)
Governing equations of fluid flow and heat transfer, Navier-Stoke's equations, Conservative, differential and integral form of transport equations; Classifications of PDEs.

MODULE 2: INTRODUCTION TO CFD (8 LECTURE HOURS) Discretisation and grids, Problem solving with CFD, Introduction to Finite difference method and finite volume method, explicit and implicit approaches, one dimensional steady state diffusion, one dimensional unsteady diffusion (heat conduction).

MODULE 3: CONVECTION DIFFUSION PROBLEMS: (7 LECTURE HOURS)
Steady one dimensional convection diffusion. The central difference, upwind differencing and hybrid schemes. Properties of discretion schemes and convergence.

MODULE 4:- SOLUTION METHODOLOGY (7 LECTURE HOURS)
Introduction, direct method- TDMA, application of TDMA point iterating method- Jacobi, Gauss Seidel, Relaxation Methods.

MODULE 5: BOUNDARY CONDITIONS AND CONTINUITY MOMENTUM COUPLING (7 LECTURE HOURS)
Boundary Conditions – Inlet, outlet, Wall, constant pressure, symmetric and cyclic. Staggered grid and momentum equations. SIMPLE and SIMPLER algorithms.

MODULE 6: TURBULENCE (7 LECTURE HOURS)
Turbulence, Transition from Laminar to turbulent flows. Time averaged Navier-Stokes equations. Turbulence Models – zero equation- One equation - two equation and Reynolds stress models, Usage of turbulence models.

Text Books:

1. Versteeg, H.K, and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Second Edition, Longman, 2017.
2. John F. Wendt, "Computational Fluid Dynamics: An Introduction" third edition, Springer, 2008.

References:

1. Anderson, J.D., "Computational fluid dynamics – the basics with applications", McGraw-Hill, 1995.
2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.
2. Muralidhar, K and Sundarajan .T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
3. Bose, T.K., "Numerical Fluid Dynamics", Narosa publishing House, 1997.
4. Suhas V. Patankar, "Numerical Heat Transfer and Fluid Flow", McGraw-Hill, reprint 2017.

18AE2029	COMPUTATIONAL FLUID DYNAMICS LABORATORY	L T P C 0 0 2 1

Course Objectives:
1. To familiarize the students with the working of CFD codes.
2. To familiarize the students with actual setting up of the problem and solution procedure.
3. To extract the required data, post process and compare with available data.

Course Outcomes:
After completing the course the student will be able to
1. 1 Define the body shape in a CFD code.
2. Create the solution domain and grid generation.
3. Apply boundary conditions and generate the solution.
4. Validate the aerodynamic quantities from computed data.

5. Perform CFD Analysis over 2D and 3D objects.
6. Solve the problems using different turbulence models.

List of Experiment:

1. Laminar Pipe Flow.
2. Turbulent Pipe Flow.
3. Modelling a mixing Elbow (2-D).
4. Flat Plate Boundary Layer.
5. Forced Convection over a Flat Plate.
6. Steady Flow past a Cylinder.
7. Unsteady Flow past a Cylinder.
8. Flow Over an Airfoil.
9. Flow simulation over an aircraft.
10. Flow simulation over a rocket.
11. Supersonic Flow over a Wedge.
12. Compressible Flow in a Nozzle.

Reference:

1. Rae, W.H. and Pope, A. "Low Speed Wind Tunnel Testing", John Wiley Publication, 1999.
2. Pope, A., and Goin, L., "High Speed wind Tunnel Testing", John Wiley Publication, 1999.

18AE2030	WIND TUNNEL TECHNIQUES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide knowledge of various types of wind tunnels and test techniques.
2. To introduce the basic concepts of measurement of pressure, velocity, forces and moments on models.
3. To provide knowledge of various flow visualization techniques.

Course Outcome:

After completing the course the student will be able to

1. Understand the various types of wind tunnels and test techniques.
2. Choose proper high speed wind tunnel for required test.
3. Choose correct model for wind tunnel testing.
4. Estimate the forces and moments for given model.
5. Arrive the pressure, velocity and temperature using measurement techniques.
6. Choose the proper flow visualization techniques.

MODULE 1: LOW SPEED WIND TUNNELS (10 LECTURE HOURS)

Flow similarity, Types of Wind Tunnel- subsonic, supersonic, transonic and hypersonic, Low Speed: layouts and nomenclature, types - closed circuit and open circuit, closed jet and open jet test section – application, Special purpose tunnels - Smoke Tunnels – Water Tunnels – Spin tunnel etc.,

MODULE 2: SUPERSONIC WIND TUNNEL (8 LECTURE HOURS)

Classification, Blow down, continuous and intermittent tunnel, Runtime mass flow rate, Size of pressure vessel, Starting and stopping Loads, Model Sizing, Calibration, Estimation

MODULE 3: HYPERSONIC WIND TUNNEL (8 LECTURE HOURS)

Classification; Runtime Calculation; Shock Tube: Driver – driven section – Diaphragm – Type of operation – Shock Speed and Initial Diaphragm Pressure Ratio. Model sizing; Starting and stopping Loads - Calibration of test section for various Tunnels.

MODULE 4: MEASUREMENTS OF FORCES AND MOMENTS (8 LECTURE HOURS) Forces, moments and Reference Frames, Balances- Internal and External, Requirements and Specifications, Fundamentals of Model Installations.

MODULE 5: WIND TUNNEL MEASUREMENTS (6 LECTURE HOURS)

Pressure measurements – Barometers, Manometers, Pressure Transducer, Pressure sensitive Paints, Pitot-static tube, Velocity Measurements -Laser Doppler Anemometer, Hot-wire Anemometer, PIV – PLIF - LDV, Temperature Measurements–Thermocouples, Temperature sensitive Paints, Heat flux measurements.

MODULE 6: FLOW VISUALIZATION TECHNIQUES (5 LECTURE HOURS)
Path – Streak – Stream and Timelines; Techniques: Smoke, Tuft, Streaks, Surface oil flow, Interferometer, Schlieren and Shadowgraph technique.

Text Book:

3. Rae, W.H. and Pope, A. "Low Speed Wind Tunnel Testing", John Wiley Publication, 1999.
4. Pope, A., and Goin, L., "High Speed wind Tunnel Testing", John Wiley Publication, 1999.
5. Rathakrishnan E, Instrumentation, Measurements and Experiments in fluids. CRC Press, London, 2007.

References:

1. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010
2. J Lukosiewitz, M Dekkar, "Experimental Methods of Hypersonic", 1973.
3. Rathakrishnan E, "Gas Dynamics", PHI Learning Pvt Ltd, 2013.

18AE2031	**HELICOPTER AERODYNAMICS**	**L T P C** **3 0 0 3**

Pre-requisites: NIL
Course Objectives:

1. To impart the knowledge of basic layout of helicopter.
2. To impart the knowledge of aerodynamics of helicopter.
3. To impart the knowledge to design a rotor blade.

Course Outcomes:
After completing the course the student will be able to

1. Understand the basic of helicopters.
2. Describe the aerodynamics performance of rotor blade.
3. Explain power units and flight performance of helicopter.
4. Get knowledge of the dynamic stability and control of helicopter.
5. Clarify concept of rotor vibrations.
6. Design the rotor blade.

MODULE 1: INTRODUCTION TO HELICOPTER (9 LECTURES HOURS)
Helicopter as an aircraft, Basic features, Layout, Generation of lift, Main rotor, Gearbox, tail rotor, power plant, drive to main and tail rotor, considerations on blade, flapping and feathering, Rotor controls various types of rotor, Geometry of the rotor, Blade loading, Effect of solidity, profile drag, compressibility etc., Blade area required, number of Blades, Blade form, Power losses, Rotor efficiency.
MODULE 2: AERODYNAMICS OF ROTOR BLADE (8 LECTURE HOURS)
Aerofoil characteristics in forward flight, Hovering and Vortex ring state, Blade stall, maximum lift of the helicopter calculation of Induced Power, High speed limitations; parasite drag, power loading, ground effect.
MODULE 3: POWER UNITS AND FLIGHT PERFORMANCE (7 LECTURE HOURS)
Piston engines, Gas turbines, Ramjet principle, Comparative performance, Horsepower required, Range and Endurance, Rate of Climb, Best Climbing speed, Ceiling in vertical climb, Autorotation.
MODULE 4: DYNAMIC STABILITY AND CONTROL (7 LECTURE HOURS)
Physical description of effects of disturbances, Longitudinal dynamic stability, stick fixed dynamic stability, longitudinal stability characteristics, lateral dynamic stability, lateral stability characteristics, control response. Differences between stability and control of airplane and helicopter.
MODULE 5: ROTOR VIBRATIONS (7 LECTURE HOURS)
Dynamic model of the rotor, Motion of the rigid blades, flapping motion, lagging motion, feathering motion, Properties of vibrating system, phenomenon of vibration, fuselage response, vibration absorbers, Measurement of vibration in flight.
MODULE 6: ROTOR BLADE DESIGN (7 LECTURE HOURS)
General considerations, Airfoil selection, Blade construction, Materials, Factors affecting weight and cost, Design conditions, Stress analysis.

Text Books:

1. Rathakrishnan.E, Helicopter aerodynamics, PHI, 2018
2. John Seddon, Simon Newman, "Basic Helicopter Aerodynamics", John Wiley & Sons, Ltd, 2011.

Reference Books:

1. J Gordon Leishman, " Principles of Helicopter Aerodynamics", Cambridge University Press, 2006.
2. Lalit Gupta, Helicopter Engineering; Himalayan Books New Delhi 1996
3. Joseph Schafer, Basic Helicopter Maintenance, Jeppesen 1980.
4. R W Prouty, Helicopter Aerodynamics, Phillips Pub Co 1985.
5. John Fay, The Helicopter and How It Flies, Himalayan Books 1995

18AE2032	FINITE ELEMENT ANALYSIS	L	T	P	C
		3	0	0	3

Pre-requisites: 18AE2016 Aerospace Structures-II
Co-requisites: 18AE2033 Finite Element Analysis Laboratory

Course Objectives:

1. To impart the basic concept of finite element.
2. To introduce the finite element modeling in designing Aerospace Structural Components.
3. To provide the knowledge on various finite element procedures and solution techniques.

Course Outcome:

After completing the course the student will be able to

1. Analyze the discrete and continuum problem using finite element method.
2. Understand the different Numerical solution to the FEA Problems.
3. Identify mathematical model for solution of common engineering problems.
4. Describe the usage of professional-level finite element software to solve engineering problems in Solid mechanics, fluid mechanics and heat transfer
5. Analyze the functions of different elements and Stiffness Matrix.
6. Perform the Axisymmetric problems.

MODULE 1: APPROXIMATE METHODS AND ITS SOLUTIONS (7 LECTURE HOURS)

Approximate solution of boundary value problems-Methods of weighted residuals, Approximate solution using variational method, Modified Galerkin method, Boundary conditions and general comments, Two dimensional example.

MODULE 2: ANALYSIS OF BAR (7 LECTURE HOURS)

Basic finite element concepts-Basic ideas in a finite element solution, General finite element solution procedure, Finite element equations using modified Galerkin method, Applications Axial deformation of bars, Axial spring element.

MODULE 3: ANALYSIS OF TRUSS (7 LECTURE HOURS)

Analysis of trusses-Two dimensional truss element, Three dimensional space truss element, and temperature changes.

MODULE 4: BEAM AND FRAMES (9 LECTURE HOURS)

Beam bending-Governing differential equation for beam bending, Two node beam element, Exact solution for uniform beams subjected to distributed loads using superposition, Calculation of stresses in beams, Thermal stresses in beams .Analysis of structural frames-Plane frame element, Thermal stresses in frames, Three dimensional space frame element.

MODULE 5: BOUNDARY VALUE PROBLEMS (8 LECTURE HOURS)

General one dimensional boundary value problem and its applications-One dimensional heat flow, Fluid flow between flat plates-Lubrication Problem, Column buckling - Two dimensional elasticity-Governing differential equations, Constant strain-triangular element, Four node quadrilateral element, Eight node isoparametric element.

MODULE 6: AXISYMMETRIC PROBLEMS (7 LECTURE HOURS)

Axisymmetric elasticity problems-Governing equations for axisymmetric elasticity, Axisymmetric linear triangular element, Axisymmetric four node isoparametric element.

Text Book:

1. Robert D. Cook, David S. Malkus, Michael E. Plesha, “Concepts and Applications of Finite Element Analysis”, John Wiley and Sons, 4th ed., 2007.
2. J.N. Reddy , “An Introduction to the Finite Element Method,”, McGraw-Hill International Editions, 3rd ed., 2009.

References:

1. Segerlind,L.J. “Applied Finite Element Analysis”, Second Edition, John Wiley and Sons Inc., New York, 1984.
2. Tirupathi R. Chandrupatla and Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 2002
3. Rao S.S., “Finite Element Methods in Engineering”, Pergamon Press, 4th Ed., 2005.
4. Robert D. Cook “Finite Element Modeling For Stress Analysis”, John Wiley and Sons, 1995.
5. Roy R. Craig, Jr., “Structural Dynamics: An Introduction to Computer Methods,” John Wiley and Sons, 1981.

18AE2033	FINITE ELEMENT ANALYSIS LABORATORY	L	T	P	C
		0	0	2	1

Course Objective:

1. To provide the knowledge on various structural analysis software packages
2. To impart the understanding of the stress analysis of different types of structural components
3. To impart the Knowledge on programming for various structural analysis

Course Outcome:

After completing the course the student will be able to

1. Understand the various structural software packages.
2. Solve the static structural analysis of one dimensional members.
3. Solve the static structural analysis of two dimensional & three dimensional problem.
4. Analyze the Static Thermal analysis of various objects.
5. Understand the various structural programming – open source software packages.
6. Programming for various structures problem.

List of Experiments:

1. Static stress analysis axial bar.
2. Two dimensional (truss) frame with multiple materials and element types.
3. Three dimensional truss- Airframe.
4. Simple two dimensional heat transfer problem.
5. Modal analysis of Aircraft wing.
6. Plate buckling analysis.
7. Box Beam- Torsional and bending problem.
8. Fluid-structure interaction-Oscillating plate using ANSYS workbench.
9. Programming of one dimensional bar with single material and axial load using Scilab.
10. Programming of one dimensional step bar, multiple material with different axial load direction using Scilab.
11. Programming for vibration analysis of bar using Scilab.
12. Programming for one- dimensional heat transfer problem using Scilab.
13. Programming for 2D truss using Scilab.

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

18AE2034	THEORY OF ELASTICITY	L	T	P	C
		3	0	0	3

Pre-requisites: 18AE2005 Strength of Materials

Course Objectives:

1. To impart an understanding of the basic concepts of stress, strain, displacement and transformations.
2. To provide the in-depth knowledge in formulating stress and strain equations.

3. To solve two-dimensional elasticity problems.

Course Outcomes:

After completing the course the student will be able to

1. Understand the elastic properties of solids.
2. Get the knowledge in various elasticity theory.
3. Formulate the governing equations of elastic behaviour for real problem.
4. Constitute elasticity equations in polar form to solve axisymmetric problems.
5. Predict stress distribution of various section due to torsional load.
6. Calculate the stresses in simplified form.

MODULE 1: ASSUMPTIONS IN ELASTICITY (8 LECTURES HOURS)

Definitions- notations and sign conventions for stress and strain, Components of stress and strain, Hooke's law, Plane stress and Plane strain, Equations of equilibrium.

MODULE 2: BASIC EQUATIONS OF ELASTICITY (8 LECTURES HOURS)

Strain – displacement relations, Stress – strain relations, Lame's constant – cubical dilation, Compressibility of material, bulk modulus, Shear modulus, Compatibility equations for strains, Principal stresses and principal strains, Mohr's circle, Saint Venant's principle.

MODULE 3: PLANE STRESS AND PLANE STRAIN PROBLEMS- (8 LECTURES HOURS)

Airy's stress function, Bi-harmonic equations, Polynomial solutions, Simple two-dimensional problems in Cartesian coordinates like bending of cantilever and simply supported beams, etc.

MODULE 4: AXI – SYMMETRIC PROBLEMS -POLAR COORDINATES (7 LECTURES HOURS)

Equations of equilibrium, Strain displacement relations, Stress – strain relations, Axi – symmetric problems, Kirsch, Michell's and Boussinesque problems.

MODULE 5: TORSION (7LECTURES HOURS)

Navier's theory, St. Venant's theory, Prandtl's theory on torsion, The semi- inverse method and applications to shafts of circular, elliptical, equilateral triangular and rectangular sections.

MODULE 6: STRESS DUE TO ROTATION (7 LECTURES HOURS)

Rotation stresses in thin cylinder or ratating ring, Expression for Radial and circumferential stresses in a solid dusc and disc with central hole, Disc of uniform strength, long cylinder.

Text Books:

1. Enrico Volterra & J.H. Caines, "Advanced Strength of Materials", Prentice Hall New Jersey, 2001.
2. Timoshenko, S., and Goodier, T.N., "Theory of Elasticity", Tata McGraw–Hill Education, 2001.

Reference Books

1. R.C. Ugural, S.K. Fenster . "Advanced strength and applied elasticity", Elsevier, 2003
2. S.Timoshenko, "Strength of material part-2", East-West press pvt.Ltd, .N. Delhi, 1991
3. Egor P. Popov, " Engineering Mechanics Of Solids", 2 Edition, Prentice-Hall, 2002
4. James M. Gere, Stephen Timoshenko, "Mechanics of Materials" 2 Edition CBS Publisher, 2004
5. P.N. Chandramouli, "Theory of Elasticity",Yesdee Publisher,2017.

18AE2035	DESIGN AND ANALYSIS OF COMPOSITE STRUCTURES	L	T	P	C
		3	0	0	3

Pre-requisites: 18AE2016 Aerospace Structures-II

Course Objectives:

1. To impart knowledge on composite materials and Design.
2. To impart knowledge on behaviour of composite structures and Failure criteria .
3. To impart knowledge on manufacturing, testing, various application of composite materials.

Course Outcomes:

After completing the course the student will be able to

1. Classify the composite materials and get knowledge in manufacture of composites.
2. Discuss the design the composite structures.
3. Estimate the behaviour Composite Materials under Various Loads.

4. Analyse the different Failure modes of Composite Materials.
5. Design the composite plate.
6. Choose composite material and structures for various application.

MODULE 1: INTRODUCTION OF COMPOSITE MATERIALS (9 LECTURES HOURS)

Limitation of conventional Engineering materials, Introduction to composite materials, Role of Matrix and Reinforcements in composites, Different Matrix Materials and Reinforcements, Types of Composites, Composites Verse Traditional Materials.

MODULE 2: DESIGN PROPERTIES OF COMPOSITES (8 LECTURE HOURS)

Micromechanical Model for Elastic Properties, Relation of Matrix Element and Engineering Material Constants, Discontinuous Fibers and Whisker Reinforced Polymer Composites, Hybrid Composite, Thermophysical Properties, Tensile Strength, Particulate-Reinforced Composite, True Particulate Composites, Fiber-Rein forced Composites, Laminar composites.

MODULE 3: MECHANICAL BEHAVIOUR OF COMPOSITE MATERIALS (7 LECTURE HOURS)

Constitutive relations for anisotropic materials in liner elasticity: Indices and Tensor notations, Anisotropic Material and constitutive relations, Matrix relation for changes of axis. Orthotropic layer behaviour: Stiffness and compliance matrices and matrix relation for changes of axis, stress and strain matrices.

MODULE 4: FAILURE CRITERIA (7 LECTURE HOURS)

Maximum stress theory, Maximum strain theory, Polynomial failure criteria: Tsai-Hill criterion, Tsai-Wu Criterion, Hoffman Criterion. Tensile and shear strength of unidirectional layer, Determination of failure stresses from three tension tests.

MODULE 5: MULTI-LAYER PLATES (7 LECTURE HOURS)

Kirchhoff-Love hypotheses for thin plates, stress-displacement relationships, Global plate equations, Global stiffnesses of a symmetrical composite and asymmetrical laminate, Boundary conditions, Determination of transfer shear stress, Strain energy of the plate.

MODULE 6: MANUFACTURING, TESTING AND APPLICATIONS (7 LECTURE HOURS)

Manufacture of Laminated Fibre-Reinforced Composite Materials. Mechanical Test Methods, Fracture and Fatigue Test, Fatigue resistance test and thermal test. Applications: Military Aircraft, Civil Aircraft, Space Applications, Automotive application and Commercial applications.

Text Books:

1. Christian Decolon., “Analysis of Composite Structures” Hermes Penton Ltd,2004.
2. M C Gupta, A P Gupta., “ Polymer Composite” Second Edition, New Age International (P) Ltd, 2015.

References:

1. R.M. Jones, “Mechanics of Composite Materials”, 2nd Edition, Taylor & Francis, 1999
2. B.D. Agarwal and L.J. Broutman, “Analysis and Performance of fiber composites”, John-Wiley and Sons, 1990.
3. Autar K. Kaw, Mechanics of Composite Materials, CRC Press LLC, 1997.
4. Valery V.Vasiliev, Evgeny V.Morozov, “ Advanced Mechanics of Composite Materials and structural elements”, Third Edition, Elsevier,2013
5. G.Lubin, “Hand Book on Fibre glass and advanced plastic composites”, Van Nostrand Co., New York, 1989.
6. P.M.Mohite, “Composite Material and Structures” NPTEL, Aerospace Engineering: https://nptel.ac.in/courses/101104010/
7. R.Velmurugan, “Composite Materials”, NPTEL, Aerospace Engineering: https://nptel.ac.in/syllabus/101106038/

18AE2036	INTRODUCTION TO NON DESTRUCTIVE TESTING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide the knowledge in various processes involved in non-destructive testing.
2. To impart knowledge in discontinuities in materials.

3. To impart knowledge in NDT application in Aerospace maintenance field.

Course Outcome:

After completing the course the student will be able to

1. Understanding various types of discontinuities.
2. Knowledge in non – destructive testing, its scope and purpose.
3. Understand the different NDT processes.
4. Evaluate the properties of material without causing damage.
5. Learn dynamic behavior of defect with NDT tools.
6. Choose the best NDT method for different application.

MODULE 1: INTRODUCTION OF NON-DESTRICTIVE TESTING (5 LECTURE HOURS)

Non-Destrictive Testing (NDT) and Destructive. History of Non-Destrictive Testing(NDT). Scope and features of NDT.

MODULE 2: VISUAL INSPECTION AND LIQUID PENETRANT TESTING: (8 LECTURE HOURS)

Testing, Visual Inspection-Basic principle, Optical aids used for Visual Inspection. Liquid Penetrant Testing- Principles, Procedures, Penetrant Testing Methods, Sensitivity, Applications and Limitations, Standards.

MODULE 3: MAGNETIC PARTICLE TESTING AND EDDY CURRENT TESTING (8 LECTURE HOURS)

Magnetizing techniques, Procedures, Equipments for MPT, Sensitivity, and Limitations. Eddy Current Testing –Principles, Instrumentation, Techniques in MPT, Applications and limitations.

MODULE 4: RADIOGRAPHY (8 LECTURE HOURS)

Electromagnetic Radiation Sources, Radiation attenuation in the specimen, Effect of radiation on film, Radiographic Imaging, Inspection Techniques in Radiography, Applications and limitations.

MODULE 5: ACOUSTIC EMISSION TESTING AND ULTRASONIC TESTING(8 LECTURE HOURS)

Instrumentation of Acoustic Emission Technique,Sensitivity, Applications and limitations. Ultrasonic Testing-Basic properties of sound beam, Inspection methods,Techniques for Normal Beam Inspection and Angle Beam Inspection, Modes of display, applications and limitations.

MODULE 6: THERMOGRAPHY (8 LECTURE HOURS)

History and development, theory and basic principles, Detectors and Equipment, Techniques, Variables, Evaluation of test results and reports, Applications-electronics industry, aerospace applications and electrical applications, advantages and limitations, Standards.

Text Books:

1. Baldev Raj, T. Jayakumar, M. Thavasimuthu, “Practical Non-destructive Testing”, Woodhead Publishing,2002.
2. P. E. Mix, “Introduction to non-destructive testing”, Wiley Interscience,, John Wiley &Sons, Inc, Publ.,2005.

Reference Books:

1. Lalith Gupta, “Aircraft General Engineering”, Himalaya Book House, Delhi 2003.
2. Ravi Prakash, “Non-Destructive Testing”, New Age Sciences, New Delhi,2009.
3. Louis Cartz, “Nondestructive Testing: Radiography, Ultrasonics, Liquid Penetrant,Magnetic Particle, Eddy Current”, Asm International, 1995.
4. C. Hellier, “Handbook of Nondestructive Evaluation”, McGraw-Hill, 1994.

		L	T	P	C
18AE2037	**STRUCTURAL VIBRATION**	**3**	**0**	**0**	**3**

Pre-requisites: 18AE2016 Aerospace Structures-II

Course Objective:

1. To impart knowledge on mathematical modeling of a vibratory system and find the response.
2. To impart skills in analyzing the vibration behavior of mechanical systems under different types of loading.
3. To impart knowledge about the methods of reducing unwanted vibration.

Course Outcome:
After completing the course the student will be able to

1. Classify vibration systems and derive equations of motion from free -body diagrams.
2. Solve vibration problems with multi degrees of freedom.
3. Identify modes of a system and compute its natural frequencies.
4. Propose solutions to reduce vibration using Isolation.
5. Identify instruments used in noise and vibration control tests.
6. Understand the Damping Concepts.

MODULE 1: SINGLE DEGREE OF FREEDOM SYSTEMS (7 LECTURE HOURS)
Introduction to simple harmonic motion, D'Alembert's principle, free vibrations – damped vibrations – forced vibrations, with and without damping – support excitation – transmissibility - vibration measuring instruments.

MODULE 2: MULTI DEGREES OF FREEDOM SYSTEMS (7 LECTURE HOURS)
Two degrees of freedom systems - static and dynamic couplings - vibration absorber- principal coordinates - principal modes and orthogonal conditions - eigen value problems – hamilton's principle - lagrangean equations and application

MODULE 3: CONTINUOUS SYSTEMS (7 LECTURE HOURS)
Vibration of elastic bodies - vibration of strings – longitudinal, lateral and torsional vibrations.

MODULE 4: APPROXIMATE METHODS (8 LECTURE HOURS)
Approximate methods – rayleigh's method – dunkerlay's method – rayleigh-ritz method, matrix iteration method.

MODULE 5: DAMPING (8 LECTURE HOURS)
Vibration isolation- Structural vibration limits - Vibration intensity- Vibration velocity - Structural damage - Effects of damping on vibration response of structures - The measurement of structural damping - Sources of damping- Inherent damping – Added Active damping systems - Energy dissipation in non-linear structures.

MODULE 6: NONLINEAR VIBRATIONS (8 LECTURE HOURS)
Phase Plane-Conservative systems – Stability of Equilibrium- Method of Isoclines – Perturbation Method – Method of Iteration - Self-Excited oscillations – Runge-Kutta Method.

Text Books

1. Singiresu.S.Rao., "Mechanical Vibrations", Addison Wesley Longman ,2003.
2. V.P Singh "Mechanical Vibrations" Dhanpat Rai & Co, 2014.

Reference Books

1. Benson H Tongue, " Principles of vibration"(2nd edition)Oxford University Press, 2002.
2. Kelly, "Fundamentals of Mechanical Vibrations", Mc Graw Hill Publications, 2000.
3. Thomson, W.T.,--"Theory of Vibration with Applications" CBS Publishers and Distributers, NewDelhi,2002.
4. Rao V. Dukkipati, J. Srinivas., Vibrations :problem solving companion, Narosa Publishers, 2007.
5. William T. Thomson, Marie Dillon Dahleh, "Theory of Vibration with Applications" Prentice Hall Publishers, 1997.

18AE2038	AEROELASTICITY	L T P C 3 0 0 3

Pre-requisites: 18AE2016 Aerospace Structures-II
Course Objectives:

1. To impart the basic concepts of Aero-elasticity.
2. To provide knowledge about the Static Aero-elastic phenomena.
3. To understand the Dynamic Aero-elastic phenomena.

Course Outcome:
After completing the course the student will be able to

1. Remember the various structural vibration and solution technique.

2. Understand the Aero-elastic phenomena.
3. Identify the varies technique to control Aero-elastic instability of bodies.
4. Explain the static Aero-elastic behaviour of the Aircraft.
5. Clarify the Dynamic Aero-elastic behaviour of the Aircraft.
6. Analyse the Flutter and Gust behaviour of the Aircraft.

MODULE 1: REVIEW OF FOUNDATIONS OF MECHANICS (8 LECTURE HOURS)
Uniform Beam Torsional and Bending Dynamics-Principle of Virtual Work - Hamilton's Principle - Lagrange's Equations – Rayleigh-Ritz's Method-Galerkin's Method.

MODULE 2: INTRODUCTION TO AEROELASTICITY (8 LECTURE HOURS)
History of Aeroelastic failures of Aircrafts and Tacoma Bridge. Aeroelasticity Triangle**,** divergence and aileron reversal.

MODULE 3: STATIC AEROELASTICITY (8 LECTURE HOURS)
Introduction-Typical Section Model-an Airfoil-control surface-nonlinear effects; One Dimensional Aero-elastic Model of Airfoils-Eigenvalue and Eigen function approach – solution to the One Dimensional Aero-elastic Model- Two Dimensional Aero-elastic Model of Lifting Surfaces Aero-elastic equations of equilibrium and Matrix-lumped element solution method- Divergence and Control Reversal.

MODULE 4: DYNAMIC AEROELASTICITY-FLUTTER (8 LECTURE HOURS)
Dynamics of the Typical Section Model of an Airfoil - Sinusoidal motion -Periodic motion- Arbitrary motion-Random motion; Flutter - an introduction to dynamic Aero-elastic instability - Quasi-steady, aerodynamic theory- Solutions to the Aero-elastic Equations of Motion-Time Domain and Frequency Domain.

MODULE 5: DYNAMIC AEROELASTICITY-GUST (7 LECTURE HOURS)
Introduction to Gust - General form of equations in the time domain - Rigid aircraft in heave/pitch Motion- Frequency domain turbulence response – General form of equations in the frequency domain.

MODULE 6: EXPERIMENTAL AEROELASTICITY (7 LECTURE HOURS)
Review of Structural Dynamics Experiments- Wind Tunnel Experiments- Sub-critical flutter testing- Approaching the flutter boundary- Safety devices- Research tests.

Text Book

1. Jan R. Wright, Jonathan E. Cooper, "Introduction to Aircraft Aeroelasticity and Loads" John wiley & sons, Ltd ,2007.
2. Earl H. Dowell, Robert Clark, David Cox, H.C. Curtiss, Jr, John W. Edwards, Kenneth C. Hall, David A. Peters, Robert Scanlan, Emil Simiu, Fernando Sisto and Thomas W. Strganac, "A Modern Course in Aeroelasticity", Fourth Revised and Enlarged Edition, 2004.

References:

1. Deway H. Hodges "Introduction to Structural Dynamics and Aero-Elasticity" Cambridge University Press,2002.
2. R.L. Bisplinghoff, H. Ashley, and R.L. Halfman, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 1996.
3. R.H. Scanlan and R.Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.
4. E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Ltd., 1986.

18AE2039	CRYOGENIC PROPULSION	L	T	P	C
		3	0	0	3

Pre-requisites: 18AE2018 Propulsion-II

Course Objective
1. To study the engineering concept of cryogenic propulsion.
2. To know the various application of cyyogenic fluids.
3. To know the various storage and transfer system.

Course Outcome
After completing the course the student will be able to
1. Understand the thermal, physical and flow properties of cryogenic fluids.

2. Understand the liquefaction systems to produce cryogenic fluids
3. Know the various method of cryogenic refrigeration systems
4. Explain the various cryogenic fluid storage and transfer lines
5. Design of various insulations for cryogenic propellant tanks
6. Know the various applications of cryogenics in propulsion systems

MODULE 1: INTRODUCTION TO CRYOGENIC ENGINEERING (8 LECTURE HOURS) Introduction to cryogenic systems-Historical background - Low temperature properties of materials – Thermal properties – Electric and magnetic properties – properties of cryogenic fluids – Fluids other than hydrogen and helium - Hydrogen– Helium 3– Helium 4.

MODULE 2: LIQUEFACTION SYSTEMS (8 LECTURE HOURS)
Thermodynamically ideal system – Joule-Thomson effect –Adiabatic expansion – Liquefaction systems- Simple Linde Hampson system-Precooled Linde Hampson system-Claude system – kapitza system – Heylandt system – comparison of liquefaction systems.

MODULE 3: CRYOGENIC REFRIGERATION SYSTEMS (8 LECTURE HOURS)
Concept of ideal refrigeration systems – Joule-Thompson refrigeration systems – Philips refrigerator – Vuilleumier refrigerator – Solvay refrigerator – Gifford-Mcmanon refrigerator-Magnetic cooling – Magnetic refrigeration systems – Dilution refrigerators.

MODULE 4: CRYOGENIC FLUID STORAGE AND TRANSFER SYSTEMS (7 LECTURE HOURS) Cryogenic fluid storage vessels- Basic storage vessels – Inner and outer vessel design – Piping- Draining the vessels –Safety devices– Cryogenic fluid transfer systems- Uninsulated and porous insulated lines –Vacuum insulated lines – Cryogenic valves.

MODULE 5: INSULATION REQUIREMENTS FOR CRYOGENIC PROPELLANT TANKS (7 LECTURE HOURS) Basic insulation types, selection of tanks insulation designs, Insulation requirements for cryogenic propellant tanks, challenges and problems associated with cryogenic propellant tanks.

MODULE 6: APPLICATION OF CRYOGENIC FLUIDS IN PROPULSION (7 LECTURE HOURS) Properties of liquid hydrogen, Properties of liquid Oxygen, Properties of liquid helium, Properties of liquid Nitrogen, working principle of cryogenic engines, Advantages of cryogenic engines over solid and liquid engines.

Text Books:

1. Thomas M. Flynn, “Cryogenic Engineering”, Second Edition, Revised and Expanded, CRC Press, 2004.
2. R.Radebaugh, Klaus D.Timmerhaus, Richard P.Reed, “Cryogenic Engineering”, Springer-Verlag New York, 2007.

Reference Books:

1. A.R. Jha, “Cryogenic Technology and Applications”, Butterworth-Heinemann, 2005
2. Wolfgang Kitshe, “Operation of a Cryogenic Rocket Engine: An Outline with Down-to-Earth and Up-to-Space Remarks”, Springer-Verlag Berlin Heidelberg, 2011.
3. Ray Radebaugh, J.Patrick Kelley, “ Application of Cryogenic Technology: Volume 10”, Springer US, 1991.
4. R. Barron , “Cryogenic Systems”, Oxford University Press, 1985
5. H.S.Yang, H.Nagai,N.Takano, M.Murakami, Quan-Sheng Shu, “Advances in Cyyogenic Engineering”, Springer US, 2000.

		L	T	P	C
18AE2040	**ROCKET AND MISSILES**	**3**	**0**	**0**	**3**

Pre-requisite: 18AE2018 Propulsion-II

Course Objectives:
1. To impart the knowledge on rocket and missile aerodynamics.
2. To impart the knowledge on rocket and missile in free space and gravitational field .
3. To impart the knowledge on staging & control of rockets.

Course Outcomes:
After completing the course the student will be able to

1. Discuss types of rockets and missiles with respect to Indian & International scenario.
2. Analysis the Aerodynamics of the rockets & missiles .
3. Understand performance of rocket and missiles within the atmosphere.
4. Estimate the rocket performance in free space and gravitational field.
5. Design the basic staging of rockets and missiles.
6. Identify the control methods of rockets and missiles.

MODULE 1: CLASSIFICATION OF ROCKETS AND MISSILES (9 LECTURES HOURS) Various methods of classification of missiles and rockets – Basic aerodynamic characteristics of surface to surface, surface to air, air to surface and air to air missiles – Examples of various Indian space launch vehicles and missiles.

MODULE 2: AERODYNAMICS OF ROCKETS AND MISSILES(7 LECTURE HOURS) Airframe components of rockets and missiles – forces acting on a missile while passing through atmosphere – classification of missiles – slender body aerodynamics

MODULE 3 AERODYNAMICS FORCES AND PERFORMANCE OF ROCKETS AND MISSILES (8 LECTURE HOURS) Method of describing forces and moments – lift force and lateral moment –lateral aerodynamic damping moment – longitudinal moment – drag estimation – upwash and downwash in missile bodies – rocket dispersion .

MODULE 4:- ROCKET MOTION IN FREE SPACE AND GRAVITATIONAL FIELD (7 LECTURE HOURS) One dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields – description of vertical, inclined and gravity turn trajectories – determination of range and altitude – simple approximations to determine burn out velocity and altitude – estimation of culmination time and altitude.

MODULE 5 STAGING OF ROCKETS AND MISSILES (7 LECTURE HOURS) Design philosophy behind multi-staging of launch vehicles and ballistic missiles – optimization of multi-stage vehicles – stage separation techniques in atmosphere and in space – stage separation dynamics and lateral separation characteristics.

MODULE 6: CONTROL OF ROCKETS AND MISSILES (7 LECTURE HOURS) Introduction to aerodynamic and jet control methods – various types of aerodynamic control methods for tactical and short range missiles- aerodynamic characteristics - various types of thrust vector control methods

Text Books:

1. George P.Sutton, and Oscar Biblarz, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 8th Edition, 2010.
2. Ashish Tewari, "Atmospheric and Space Flight Dynamics", Birkhauser, 2007

References:

1. E. Roy, "Orbital Motion", Fourth Edition, IOP Publishing Ltd 2005.
2. J. W. Cornelisse, H.F.R. Schoyer, and K.F. Wakker,. "Rocket Propulsion and Spaceflight Dynamics", Pitman, 2001.
3. William E.Wiesel, "Spaceflight Dynamics", McGraw-Hill, 3rd Edition, 2010.
4. Howard D. Curtis, "Orbital Mechanics for Engineering Students", ELSEVIER, Butterworth, Heinemann, 3rd Edition, 2013.

18AE2041	ADVANCED SPACE DYNAMICS	L	T	P	C
		3	0	0	3

Pre-requisites: 18AE2023 - Space Dynamics

Course Objectives:

1. To impart the knowledge related to the basics of celestial mechanics.
2. To impart the knowledge related to orbital transfer technique.
3. To impart the knowledge related to the orbits in restricted three-body problem.

Course Outcome:

After completing the course the student will be able to

1. Ability to understand two-body orbital motion and regularization.
2. Gain knowledge of orbital transfer technique..

3. Understand planar restricted three-body problem
4. Understand orbital motion in planar restricted three-body problem.
5. Attain knowledge of 3-dimensional restricted three-body problem and identification of comets.
6. Gain knowledge of halo orbits and perturbed restricted 3-body problem.

MODULE 1: TWO-BODY PROBLEM, REGULARISATION (10 LECTURE HOURS)
Fundamental principles and definitions, Two-body problem, Derivation of equation of motion, Perturbed motion, Energy relations, Perturbing potential, Singular differential equations, One-dimensional motion-first and second step of regularization.

MODULE 2: LAMBERT'S THEOREM (5 LECTURE HOURS)
Definition and derivation of Lambert's theorem and its applications.

MODULE 3: PLANAR RESTRICTED THREE-BODY PROBLEM (6 LECTURE HOURS)
Planar circular restricted three-body problem – Definition of Lagrangian, Equations of motion in sidereal and synodic coordinate systems, Derivation of Jacobi integral.

MODULE 4: LOCATIONS AND LINEAR STABILITY OF THE LAGRANGIAN POINTS (13 LECTURE HOURS) Definition of Lagrangian point, Computation of location of collinear and equilateral points. Motion near the equilibrium points, derivation of variational equations, characteristic equation, Motion around the collinear and equilateral points, critical mass.

MODULE 5: THREE-DIMENSIONAL RESTRICTED PROBLEM AND TISSERAND CRITERION (6 LECTURE HOURS) Three-dimensional restricted three-body problem, Tisserand's criterion for the identification of comets.

MODULE 6: HALO ORBITS AND PERTURBED RESTRICTED THREE-BODY PROBLEM (5 LECTURE HOURS) Halo orbits, Lissajous orbits, Perturbed restricted three-body problem with oblateness and radiation pressure.

Textbooks:

1. Howard D. Curtis, Orbital Mechanics for Engineering Students, Elsevier Butterworth-Heinemann, Third Edition, 2010.
2. Pini Gurfil, and P. Kenneth Seidelmann, "Celestial Mechanics and Astrodynamics: Theory and Practice", Springer, 2016
3. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", 1st edition, 2015

References:

1. Victor G. Szebehely, "Theory of Orbits - The Restricted Problem of Three Bodies", Academic Press, New York and London,1967.
2. Stiefel, E. L. and Scheifele, G. " Linear and Regular Celestial Mechanics", Springer-Verlag Berlin, 1971.
3. J.M.A.Danby, "Fundamental of Celestial Mechanics" ,Inc., 2nd Edition, Willman-Bell,USA,1992
4. Carl D. Murray and Stanley F. Dermott, "Solar System Dynamics", Cambridge University Press, 1999
5. Vladimir A. Chobotov, "Orbital Mechanics", AIAA Education Series, AIAA Education Series, Published by AIAA, 2002.

		L	T	P	C
18AE2042	**AIR TRAFFIC CONTROL AND AERODROME DETAILS**	**3**	**0**	**0**	**3**

Pre-Requisites: 18AE2025 Navigation, Guidance and Control of Aerospace Vehicles
Course Objectives:
1. To impart the knowledge of air traffic services.
2. To impart the knowledge of aerodrome data.
3. To impart the knowledge of civil aviation requirements.

Course Outcomes:
After completing the course the student will be able to
1. Recall the basic concepts of ATS and its services.

2. Distinguish the flight operations between different altitudes.
3. Exemplify the working routines of radar services.
4. Identify the Aerodrome layouts and the design.
5. Illustrate the runway restrictions, various approach systems and guidances.
6. Understand the need for Civil Aviation Requirements.

MODULE 1: AIR TRAFFIC CONTROL (5 LECTURE HOURS)
Objectives of ATS - Parts of ATC service – Scope and Provision of ATCs –VFR & IFR operations – Classification of ATS air spaces – Varies kinds of separation – Altimeter setting procedures – Establishment, designation and identification of units providing ATS – Division of responsibility of control.

MODULE 2: AREA CONTROL SERVICE (8 LECTURE HOURS) Area control service, assignment of cruising levels minimum flight altitude ATS routes and significant points – RNAV and RNP – Vertical, lateral and longitudinal separations based on time / distance –ATC clearances – Flight plans – position report.

MODULE 3: RADAR SERVICES (8 LECTURE HOURS)
Radar service, Basic radar terminology – Identification procedures using primary / secondary radar – performance checks – use of radar in area and approach control services – assurance control and co-ordination between radar / non radar control – emergencies – Flight information and advisory service – Alerting service – Co-ordination and emergency procedures – Rules of the air.

MODULE 4: AERODROME DETAILS (7 LECTURE HOURS)
Aerodrome data - Basic terminology – Aerodrome reference code – Aerodrome reference point – Aerodrome elevation – Aerodrome reference temperature – Instrument runway, physical Characteristics; length of primary / secondary runway – Width of runways – Minimum distance between parallel runways etc. – obstacles restriction.

MODULE 5: RUNWAY AIDS (9 LECTURE HOURS)
Visual aids for navigation Wind direction indicator – Landing direction indicator – Location and characteristics of signal area – Markings, general requirements – Various markings – Lights, general requirements – Aerodrome beacon, identification beacon – Simple approach lighting system and various lighting systems – VASI & PAPI - Visual aids for denoting obstacles; object to be marked and lighter – Emergency and other services.

MODULE 6: INTRODUCTION TO CAR (8 LECTURE HOURS)
Airworthiness, Air Transport, Air Safety, Air Space & Air Navigation Service Standards, Aviation Environment Protection.

Text Book:
1. Air Traffic Management, "PANS – RAC – ICAO DOC 4444", Sixteenth Edition, 2016.
2. Airport Authority of India, "Manual of Air Traffic Services Part I", Fourth Edition, Amended 2017.

References:
1. Andrew Ford, "Aircraft Manual (India) Volume I", Shroff, Amended 2017.
2. India (Republic). Aeronautical Information Service, "AIP: Aeronautical information publication, India", 2006.
3. M.Mulder, "Air Traffic Control" Sciyo, 2010.
4. Antonin Kazda, Robert E.Caves, "Airport Design and Operation", Second edition, Elsevier Science, 2007.
5. Michael S.Nola, "Fundamentals of air traffic control", Delmar Cengage Learing, 2010.
6. Christopher D.Wickens, Anne S.Mavor, Raja Parasuraman, James P.McGee, "The future of Air Traffic Control: Human Operators and Automation", National Academies Press, 1998.
7. Robert E.Caves, Geoffrey D.Gosling, "Strategic Airport Planning", Emerald Group Publishing Limited, 1999.
8. Norman J.Ashford, Paul H. Wright, "Airport Engineering", Wiley-Interscience, 1992.
9. Bouwman, Ronald, "Fundamentals of Ground Radar for Air Traffic Control Engineers and Technicians", SciTech Publishing, 2009.

10. Lucio Bianco, Amedeo R. Odoni, "Large Scale Computation and Information Processing in Air Traffic Control", Springer-Verlag Berlin Heidelberg, Year: 1993.

18AE2043	AIRCRAFT SYSTEMS	L T P C 3 0 0 0

Course Objective:
1. To impart knowledge on importance and operating principles of aircraft systems.
2. To impart knowledge on aircraft environmental and flight conditions.
3. To impart knowledge on importance and operating principles of aircraft protection systems.

Course Outcomes:
After completing the course the student will be able to
1. Understand the principles Aircraft Hydraulic systems.
2. Obtain knowledge on the Landing Gear systems.
3. Obtain knowledge on Fuel systems and Engine starting systems.
4. Diagnose aircraft engine starting systems performance.
5. Obtain knowledge on Cabin atmosphere control systems.
6. Understand the basics of auxilliary systems in aircraft.

MODULE 1: AIRCRAFT HYDRAULIC SYSTEMS (8 LECTURE HOURS)
Hydraulic fluid – Types of Hydraulic Fluids – Phosphate Ester Base Fluids - Basic Hydraulic Systems – Contamination check and control – filters - Reservoirs – Pumps - Pressure Regulation Actuating cylinders – Relief valves - Selector valves – Aircraft Pneumatic systems – Pneumatic system components – typical Pneumatic power system.

MODULE 2: LANDING GEAR SYSTEMS (7 LECTURE HOURS)
Main landing gear Alignment, support, Retraction – Emergency extension systems – Landing gear safety devices – Nose wheel steering systems – Brake Systems – Brake assemblies - inspection and maintenance of brakes – Aircraft landing wheels – Aircraft tires – Aircraft tire maintenance – Antiskid system – Landing gear system maintenance.

MODULE 3: FUEL SYSTEMS (8 LECTURE HOURS)
characteristics and properties of Aviation Gasoline – Turbine engine fuels – fuel system contamination – fuel system components – indicators – multiengine fuel systems – fuel jettison systems – Reciprocating engine ignition systems – battery ignition system – magneto ignition system operating principles - auxiliary ignition units.

MODULE 4: ENGINE STARTING SYSTEMS (8 LECTURE HOURS)
Reciprocating engine starting systems – Gas Turbine engine starters – Air turbine starters – Lubrication systems – principles of engine lubrication – Requirements and characteristics – Reciprocating engine lubrication system – Turbine engine lubrication system – Engine cooling system – Turbine engine cooling.

MODULE 5: CABIN ATMOSPHERE CONTROL SYSTEMS (8 LECTURE HOURS)
need for oxygen – air conditioning and pressurization systems – basic requirements – sources of cabin pressure – cabin pressure control systems – air distribution - air conditioning system – heating systems – cooling systems – electronic cabin temperature control system – oxygen systems – portable oxygen equipments – smoke protection equipments – oxygen cylinders – oxygen masks.

MODULE 6: AUXILIARY SYSTEMS (7 LECTURE HOURS)
Fire protection systems-Ice protection system –Rain-Removal systems –Water and Waste systems – Position and warning system – Auxiliary power units.

Text Books:
1. Ion Moir and Allan Seabridge, Aircraft Systems, John Wiley & Sons Ltd, England, Third edition, 2008.
2. Roy Langton, Chuck Clark, Martin Hewitt and Lonnie Richards, Aircraft Fuel Systems, Wiley & Sons Ltd, England, 2009.

References:
1. General Hand Books of Airframe and Power plant Mechanics", U.S. Dept. of Transportation, Federal Aviation Administration, The English Book Store, New Delhi1995.

2. Mekinley, J.L. and Bent, R.D., “Aircraft Power Plants”, McGraw-Hill, 1993.
3. Pallet, E.H.J., “Aircraft Instruments & Principles”, Pitman & Co., 1993.
4. Treager, S., “Gas Turbine Technology”, McGraw-Hill, 1997.
5. McKinley, J.L., and Bent, R.D., “Aircraft Maintenance & Repair”, McGraw-Hill, 1993.
6. Michael Kroes, William Watkins, Frank Delp, Ronald Sterkenburg, “Aircraft Maintenance & Repair”, Seventh Edition, The McGraw-Hill Education, 2013.

18AE2044	BASICS OF ACOUSTICS	L T P C 3 0 0 3

Course Objective:
1. To impart the knowledge on fundaments of sound.
2. To impart the knowledge on sound reflection, refraction, diffraction and diffusion.
3. To impart the knowledge on sound absorption & absorption testing.

Course Outcomes:
After completing the course the student will be able to
1. Understand the premilary of sound levels and their units.
2. Understand the behavior of sound in free fields and Reflection of sound.
3. Obtain knowledge on sound diffraction and refraction.
4. Obtain knowledge on sound reverberation and diffusion field
5. Obtain knowledge on sound absorption and absorption quantifying methods.
6. Selecting and designing of absorbers.

MODULE 1: FUNDAMENTALS OF SOUND AND SOUND LEVELS (8 LECTURE HOURS)
Sine wave and Complex wave. Octave and Decibels. Acoustic Power, Sound intensity and Sound Pressure Level measurement.

MODULE 2: SOUND IN FREE FILED AND REFLECTION (8 LECTURE HOURS)
Sound Divergence, Sound intensity in free field, Sound field in an enclosed spaces, specular reflection, Reflection from concave, convex and parabolic surfaces. Standing waves. Corner reflection.

MODULE 3: DIFFRACTION AND REFRACTION (8 LECTURE HOURS)
Wavefront propagation and diffraction of sound by obstacles, Apertures, Slit and Various diffusion objects- Reflection of sound in solid, atmosphere, enclosed space and Ocean.

MODULE 4: REVERBERATION (7 LECTURE HOURS)
The perfectly diffused sound field,Evaluation of diffusion in a room, concave surface and convex surface. Decay of sound in room, Reverberation time calculation and measurement.

MODULE 5: ABSORPTION(7 LECTURE HOURS)
Dissipation of sound energy, Absorption coefficient - Glass fibre , Insulation materials, effect of thickness and density of Absorbents.

MODULE 6: ABSORTION TESTING AND ABSORBERS (7 LECTURE HOURS)
Reverberation chamber, Impedence Tube testing, Porous absorbers, resonant absorbers, Testing in common building materials and absorbers.

Text Books:
1. Alton F. Everest, “The Master Handbook of Acoustics”, McGraw-Hill Companies publisher, 2002
2. Glen M Ballou, “Handbook for Sound Engineers”, Elsevier, Focal Press, 2008.

References:
1. Jerry H. Ginsberg, “Acoustics-A Textbook for Engineers and Physicists, Volume I-Fundamentals”, ASA Press, Springer 2018.
2. Jerry H. Ginsberg, “Acoustics-A Textbook for Engineers and Physicists, Volume II – Applications”, ASA Press, Springer 2018.
3. Carl Q Howard_ Benjamin S Cazzolato, “Acoustic analyses using Matlab and Ansys” - CRC, Taylor and Francis, 2014.
4. Leo L. Beranek, “Acoustics” Amer Inst of Physics, 1986.
5. Michel Bruneau , “Fundamentals of acoustics”, ISTE Ltd, 2006.

18AE2045	BASICS OF AEROSPACE ENGINEERING	L T P C 3 0 0 0

NOTE: This course is offered to other dept/school students

Course Objectives:

1. To introduce the basic concepts of aircrafts, rockets, satellites and their development.
2. To impart knowledge about the basic parts and their function and construction.
3. To know the basics of propulsion and application of rockets.

Course Outcome:

After completing the course the student will be able to

1. Understand the evolution of aircrafts and flying vehicles.
2. Understand the parts and function of aircrafts.
3. Obtain knowledge on principles of flight.
4. Understand the fundamentals of structures and materials used.
5. Understand the principles of aircraft and rocket propulsion.
6. Obtain knowledge on the engines used in aircraft propulsion.

MODULE 1: HISTORY OF AEROSPACE ENGINEERING (7 LECTURE HOURS)

Historical evolution**;** Developments in aerodynamics, materials, structures and propulsion over the years.

MODULE 2: CLASSIFICATION AIRCRAFT (7 LECTURE HOURS)

Components of an airplane and their functions; Different types of flight vehicles, classifications; Basic instruments for flying.

MODULE 3: PRINCIPLES OF FLIGHT (7 LECTURE HOURS)

Principles of flight**-** Evolution of lift, drag and moment; altitude and standard atmosphere – Airfoil and nomenclature – Basic aerodymanics.

MODULE 4: AIRCRAFT MATERIALS AND STRUCTURES(8 LECTURE HOURS)

General types of Aircraft construction, Fuselage and Wing Structure; Aerospace materials, metallic and non-metallic materials.

MODULE 5: AIRCRAFT PROPULSION (8 LECTURE HOURS)

Basic ideas about piston, turboprop and jet engines, Basic Propeller theory; Principles of operation of rocket, types of rockets and typical applications, Exploration into space.

MODULE 6: AEROMODELLING (8 LECTURE HOURS)

Paper Plane Modeling, Remote control airplane Design and Force balancing. Case study.

Text Book :

1. John D Anderson Jr, "Introduction to Flight",Tata McGraw Hill Education Private Limited, NewDelhi, 5th Edition, 2009.
2. A.C Kermode, "Flight without Formulae" , Pearson Education,5th Edition, 2008.

References :

1. Anderson. David, Wand Scott Eberhardt. "Understanding Flight". 2nd ed. McGraw-Hill Professional, 2009.
2. Ashish Tewari, "Basic Flight Mechanics: A Simple Approach Without Equations", Springer, 2016.
3. Lloyd Dingle, Mike Tooley, "Aircraft engineering principles",Second Edition, Butterworth-Heinemann, 2005.
4. Jim Winchester, "Concept Aircraft" Thunder Bay Press, 2005.

18AE3001	ADVANCED AERODYNAMICS	L T P C 3 0 0 3

Course Objectives:

1. To familiarize student with the airfoils and wings and the flow over them.
2. To impart knowledge of compressibility effects over an aerofoil and finite wings.
3. To provide knowledge of high temperature effects over an hypersonic wings.

Course Outcome:

After completing the course the student will be able to

1. Assess the forces and moments due to flow.
2. Understand the flow behavior over various body shapes.
3. Apply the compressibility corrections for flow in C-D passages and instrument like Pitot static tube.
4. Assess the nature of compressible flow over airfoils and finite wings.
5. Use the computational tools to evaluate hypersonic flows.
6. Understand the basic principles of expansion waves

MODULE 1: INCOMPRESSIBLE FLOW (7 LECTURES HOURS)

Aerodynamic forces and moments. Centre of pressure. Rotation, deformation, vortex theorems, and Conservation laws: integral and differential formulations- mass, momentum and energy equation.

MODULE 2: POTENTIAL FLOW (7 LECTURES HOURS)

Elementary flows and its combination: non-lifting and lifting flow over cylinders. Kutta – Joukowski theorem and generation of lift, Kutta condition, thin airfoil theory, Vortex filament, Helmholtz theorems. Introduction to Prandtl's lifting line theory and lift distribution.

MODULE 3: INTRODUCTION TO COMPRESSIBLE FLOW (8 LECTURES HOURS)

Compressibility, Velocity of sound, Concept of Mach Number, Isentropic relations, Flow through converging-diverging nozzle, Performance under various back pressures, corrections of Pitot static tube for subsonic and supersonic Mach numbers.

MODULE 4: SHOCK WAVES (7 LECTURES HOURS)

Normal shock and its relations, Prandtl equation and Rankine – Hugoniot relation, Oblique shocks and corresponding equations, Hodograph and flow turning angle, shock polar, Flow past wedges, Strong, weak and detached shocks.

MODULE 5: EXPANSION WAVES (7 LECTURES HOURS)

Expansion waves & its corresponding equations, Flow past concave & convex corners, Intersection and Reflection of shocks with wall and expansion waves, Rayleigh and Fanno Flow.

MODULE 6: ELEMENTS OF HYPERSONIC FLOW (9 LECTURES HOURS)

Features of hypersonic flows, thin shock layers, Entropy layer, Viscous Interaction, High Temperature effects, Low Density Effects , Hypersonic Shock & Expansion Wave relation, Methods of calculating surface pressures- Newtonian and Modified Newtonian Laws, Centrifugal Force Correction, Tangent wedge and Tangent Cone Method, Shock Expansion Method.

References:

1. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010.
2. Rathakrishnan, E, Theoretical Aerodynamics, John Wiley & Sons, 2013.
3. John D.Anderson Jr.,"Hypersonic and High Temperature Gas dynamics", AIAA, 2nd Edition 2006.
4. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012.
5. L.M Milne Thomson, "Theoretical Aerodynamics", Dover Publications 2003.
6. Liepmann H W and Roshko A, "Elements of Gas dynamics", John Willey & Sons, 1957.
7. Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronald Press,1982.

18AE3002	ADVANCED AERODYNAMICS LAB	L	T	P	C
		0	0	2	1

Course Objectives:

1. To impart knowledge of basics of subsonic and supersonic flow over the model.
2. To impart knowledge of forces and moments over an aerofoil.
3. To impart knowledge of shock wave over various model.

Course Outcome:

After completing the course the student will be able to

1. Understand the aerodynamic variable connected with airflow.
2. Estimate lift and drag of various stream line and bluff bodies.

3. Visualize subsonic flow over various model.
4. Calibration of supersonic wind tunnel.
5. Visualize shock wave and Estimate shock angle over various model.
6. Effect of back pressure in C-D nozzle.

List of Experiments:

1. Calibration of subsonic wind tunnel for different velocities.
2. The pressure distribution over a symmetric and cambered aerofoil.
3. Smoke and Tuft flow visualization of symmetric and cambered aerofoil.
4. Estimation of the Lift and drag of symmetric and cambered aerofoil.
5. Identify the trailing vortices over a rectangular wing using smoke and tuft flow visualization technique.
6. Boundary layer calculation in the test section of subsonic wind tunnel.
7. Calibration and runtime calculation of supersonic wind tunnel for different Mach.
8. Flow visualisation over a sharp and blunt cone model using Schlieren technique.
9. Flow visualisation over a sharp and blunt cone model using shadowgraph technique.
10. Flow visualisation over a double wedge model using shadowgraph technique.
11. Flow visualisation over a sharp and blunt edge delta wing model using shadowgraph and Schlieren technique.
12. Effect of back pressure study of C-D nozzle using Open Jet Facility.
13. Calibration of six component strain gauge balancing.
14. Force measurement of aircraft model using six component strain gauge balancing.

18AE3003	AEROSPACE PROPULSION	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart knowledge on working principles, operation and performance of Gas Turbine Engine (GTE).
2. To impart knowledge on characteristics of GTE modules and its matching.
3. To impart knowledge on Ramjet, Scramjet and Rocket engines.

Course Outcome:

After completing the course the student will be able to

1. Assess the performance of aircraft engines for aerospace application.
2. Evaluate GTE performance at component and system level.
3. Design the inlets & nozzles for aircraft engines.
4. Analyze the combustion chamber related issues.
5. Evaluate the GTE performance.
6. Analyze the performance of space thrusters.

MODULE 1: ELEMENTS OF AIRCRAFT PROPULSION (7 LECTURE HOURS)

Classification of power plants- method of aircraft propulsion- propulsive efficiency- specific fuel consumption- thrust and power- factors affecting thrust and power- illustration of work cycle of gas turbine engine- characteristics of turboprop, turbofan and turbojet, ramjet, scram jet- methods of thrust augmentation.

MODULE 2: AXIAL FLOW COMPRESSORS, FANS AND TURBINES (8 LECTURE HOURS)

Introduction to centrifugal compressors- axial flow compressors- geometry- twin spools- three spools- performance and characteristics-velocity polygons- axial flow turbines- geometry- stage analysis and characteristics- vortex theory- 3D design of axial flow compressor and turbine.

MODULE 3: COMBUSTION CHAMBERS (7 LECTURE HOURS)

classification of combustion chambers- combustion chamber performance- flame stabilization- flame tube cooling- after burner- types and characteristics- operation and process.

MODULE 4: INLETS AND NOZZLES (7 LECTURE HOURS)

Subsonic and supersonic inlets- relation between minimum area ratio and external deceleration ratio- starting problem in supersonic inlets- performance and characteristics- Modes of inlet operation- Jet nozzle- efficiencies- over expanded, under expanded and optimum expansion in nozzles- thrust reversals.

MODULE 5: ENGINE PERFORMANCE (8 LECTURE HOURS)
Design & off-design performance, surge margin requirements, surge margin stack up, transient performance, qualitative characteristics quantities, transient working lines, starting process and wind milling of engines, thrust engine start envelope, starting torque and speed requirements, calculations for design and off-design performance from given test data – (case study for a single shaft jet engine), engine performance monitoring, matching of components of GTE.

MODULE 6: ROCKET PROPULSION (8 LECTURE HOURS)
Introduction to rocket propulsion- reaction principle- thrust equation- classification of rockets based on propellants used- solid, liquid and hybrid- comparison of these engines for rocket performance- electric propulsion- classification- electro thermal- electro static- electromagnetic thrusters- plasma rocketry MHD propulsion – laser rockets – solar thermal rockets – photon rockets – solar sail- geometries of ion thrusters- beam characteristics- hall thrusters.

Reference:

1. V. Ganesan, Gas Turbines, Second Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2014.
2. H. Cohen, G.F.C. Rogers and H.I.H. Saravanmuttoo, Gas Turbine Theory, Fifth Edition, Pearson Education Ltd, 2009.
3. Jack .D Mattingly, Elements of Gas Turbine Propulsion, Tata McGraw Hill Publishing Co. 2005.
4. Sutton G.P., Rocket Propulsion Elements, Eight Edition, John Wiley & Sons Inc., New Jersey, 2010.
5. Irwin E. Treager, Aircraft Gas Turbine Engine Technology, 3rd Edition, McGraw Hill Education, 2017.
6. P.P Walsh and P. Peletcher, 'Gas Turbine Performance' Blackwell Science, 1998.
7. Klause Hunecke, Jet Engines Fundamentals of Theory, Design and Operation, Motors book international publishers & Wholesalers, 6th edition, 1997.
8. Ahmed F El-Sayed, Fundamental of Aircraft and Rocket Propulsion, Springer Verlag London, 2016.

18AE3004	AEROSPACE PROPULSION LAB	L T P C 0 0 2 1

Course Objectives:
1. To introduce the concept of systems of rocket motors.
2. To assess the performance of air-breathing engines.
3. To impart knowledge on various engine component.

Course Outcomes:
After completing the course the student will be able to
1. Design the experiment for rocket motor performance.
2. Assess the real time situation and corrective measures associated with rocket motors.
3. Analyze the working of different parts of aircraft engine.
4. Get knowledge in combustion.
5. Identify suitable fuel injector.
6. Calculate of convective heat transfer coefficient for real time application.

Experiments
1. Estimation of Performance of a Rocket motor –To measure the thrust of the rocket motor and correlate to the chamber pressure and nozzle parameters.
2. Shock velocity measurement for different gasses using a shock tube.
3. Ignition Delay Studies –To estimate the time required for a propellant combination to ignite and sustain combustion.
4. Studies regarding Injector Performance – To assess the performance of the injectors of various types, their flow and atomization characteristics.
5. Storage losses in an insulated liquid Oxygen tank.

6. Impingement and cooling requirement of a Rocket exhaust over a ‘J’ type jet deflector, thermal response of the deflector.
7. Ramjet engine testing of a scaled engine.
8. Diffuser test of centrifugal compressor.
9. Estimation of convective heat transfer of the fluid with and without additives.
10. Cascade testing of a model for axial compressor blade row (symmetrical).
11. Cascade testing of a model for axial compressor blade row(cambered).
12. Nozzle performance test.

18AE3005	ORBITAL SPACE DYNAMICS	L 3	T 0	P 0	C 3

Course Objectives:
1. To impart the knowledge in two-body problem.
2. To impart the knowledge in restricted three-body problem.
3. To provide necessary knowledge to compute the orbits of satellites and interplanetary trajectories.

Course outcome:
After completing the course the student will be able to
1. Apply laws governing the orbital motion.
2. Compute the orbits of the satellites with perturbations.
3. Generate preliminary design of inter-planetary trajectories.
4. Study planar estricted three-body problem and identification of comets.
5. Understand orbital motion in restricted three-body problem.
6. Use knowledge of equilibrium points and their uses in perturbed problems.

MODULE 1: FUNDAMENTALS AND COMPUTATION OF ORBITAL ELEMENTS (9 LECTURES)
Fundamental principles - Kepler's laws, Problem of two bodies - Derivation of equation of motion, Solution of Kepler’s equation, Computation of orbital elements from state vectors.

MODULE 2: PERTURBATIONS (8 LECTURES)
Force model, Perturbations - Oblateness, Computation of Sun-synchronous orbit, Special perturbation techniques: Cowell's and Encke's methods, The osculating orbit.

MODULE 3: ORBITAL MANEUVERS (8 LECTURES)
Single impulse Maneuvers, Hohmann transfer, Sphere of influence, Synodic period, Derivation of Lambert’s theorem.

MODULE 4: RESTRICTED THREE-BODY PROBLEM AND TISSERAND’S CRITERION (7 LECTURES)
Planar circular restricted three-body problem - Equations of motion, Derivation of Jacobi integral, Tisserand's criterion for the identification of comets.

MODULE 5: LOCATION AND LINEAR STABILITY OF LAGRANGIAN POINTS (8 LECTURES)
Location of equilibrium points, Characteristic equation, Motion near the collinear and the equilateral points.

MODULE 6: THREE-DIMENSIONAL AND PERTURBED RESTRICTED THREE-BODY PROBLEM (5 LECTURES)
Three-dimensional circular restricted three-body problem, Perturbed circular restricted three-body problem with oblateness and radiation pressure.

References:

1. PiniGurfil, and P. Kenneth Seidelmann, “Celestial Mechanics and Astrodynamics: Theory and Practice”, Springer, 2016
2. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", 1st Edition, 2015.
3. J.M.A.Danby, “Fundamental of Celestial Mechanics” ,Inc., 2nd Edition, Willman-Bell,USA,1992.

4. Victor G. Szebehely, “Theory of Orbits - The Restricted Problem of Three Bodies”, Academic Press, New York and London,1967.
5. Carl D. Murray and Stanley F. Dermott, "Solar System Dynamics", Cambridge University Press, 1999.
6. Vladimir A. Chobotov, “Orbital Mechanics”, AIAA Education Series, AIAA EducationSeries, Published by AIAA, 2002
7. Howard D. Curtis, Orbital Mechanics for Engineering Students, Elsevier Butterworth-Heinemann, 2005.

18AE3006	FLIGHT MECHANICS	L T P C 3 1 0 4

Course Objectives:
1. To introduce the parameters effecting the Flight performance
2. To impart knowledge about the concept of Stability and control of Aircraft
3. To introduce with the concept of dynamic stability of Aircraft

Course Outcomes:
After completing the course the student will be able to
1. Understand the preliminary performance estimation.
2. Understand the performance characteristics in level Flight.
3. Get knowledge in Static longitudinal stability of aircraft.
4. Get knowledge in Static lateral stability of aircraft.
5. Get the knowledge of Directional stability of aircraft.
6. Analyse the Dynamic longitudinal stability of aircraft.

MODULE 1: REVIEW OF BASICS AERODYNAMICS AND PERFORMANCE TERMS (8 LECTURES HOURS, 2 TUTORIAL HOURS)
Atmospheric Structure and its significance- High-Lift Coefficient Devices- Basic Aerodynamic Assumptions for Aircraft Performance - Drag Components- Drag Polar: Aircraft Propulsion-Introduction-Piston Engines/Gas Turbine Engines Performance characteristics with variation of Altitude.

MODULE 2: PERFORMANCE CHARACTERISTICS IN LEVEL FLIGHTS (8 LECTURES HOURS, 2 TUTORIAL HOURS)
Performance characteristics of aircraft steady level flight- Maximum speed- Range and Endurance -Breguet formula: Rate of Climb- Maximum Climb Angle - Maximum Rate of Climb Velocity- Angle of climb; Gliding Flight - Turn flight; V - n diagram.

MODULE 3: STATIC LONGITUDINAL STABILITY (10 LECTURES HOURS, 2 TUTORIAL HOURS)
Degrees of Freedom of a system; Static Longitudinal Stability– Basic equations of equilibrium- Stability criterion: Stick fixed Longitudinal Stability- Wing and tail contribution; Effects of Fuselage and nacelles-Power effects- Neutral Point- Elevator hinge moment; Stick Free Longitudinal Stability – Neutral point and Static Margin; Stick Force gradients and Stick force.

MODULE 4: STATIC LATERAL STABILITY (8 LECTURES HOURS, 2 TUTORIAL HOURS)
Static Lateral Stability – Basic equations of equilibrium- Stability criterion Contribution of wing – Fuselage –Vertical tail; Dihedral Effect; Roll Control- Rolling moment due to aileron- Damping moment -Rate of roll achieved-Aileron reversal-Aerodynamic Balance.

MODULE 5: STATIC DIRECTIONAL STABILITY (7 LECTURES HOURS, 2 TUTORIAL HOURS)
Static Directional Stability – Basic equations of equilibrium- Stability criterion - Contribution of wing –Fuselage –Vertical tail- Propeller -Weather cocking Effect, Rudder Requirements, One engine In-operative Conditions, Rudder Lock-Problems.

MODULE 6: DYNAMIC LONGITUDINAL STABILITY (7 LECTURES HOURS, 2 TUTORIAL HOURS) Dynamic Longitudinal Stability – Equations of motion, stability Derivatives, Routh’s discriminant; Phugoid Motion and short term Motions- Dutch roll and Spiral instability, Auto rotation and Spin- Problems.

References:

1. J D Anderson, “Aircraft performance and Design”, McGraw-Hill, New York, 2000.
2. Perkins, C D and Hage, R E; “ Airplane Performance Stability and Control”, Willey Toppan, 2010.
3. Roskam, Jan and Lan, Chuan-tau E, “Airplane Aerodynamics and Performance”, DAR Corporation, Lawrence, Kansas, USA, 1997.
4. Houghton, E L and Carruthers, N B; “Aerodynamics for Engineering Students”, Edward Arnold Publishers, 1988.
5. Filippone, A, “Advanced Aircraft Flight Performance, Cambridge University Press, 2012
6. Roskam Jan, “Airplane Flight Dynamics and Automatic Flight Controls”. Design, Analysis and research Coorperation. 3rd Printing 2003
7. Nelson, R.C. “Flight Stability and Automatic Control”, McGraw-Hill Book Co., 1991

18AE3007	AEROSPACE STRUCTURAL ANALYSIS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart the knowledge on the structural behavior of aircraft components under different types of loads.
2. To provide the understanding in structural Analysis methods for aerospace vehicles.
3. To impart the knowledge stress distribution various section of aerospace component.

Course Outcomes:

After completing the course the student will be able to

1. Get knowledge in various methods of analysis of aerospace structural members.
2. Understand the basic structural members of an Aircraft and launch vehicle.
3. Solve stress problem in aircraft components.
4. Predict the shear flow, shear center in various open and close section of Aircraft structures.
5. Analyze the buckling property of plates and to predict the failure stress.
6. Design the Aircraft composite panel for Aerospace structure.

MODULE 1: INTRODUCTION TO ELASTICITY (**9 LECTURES HOURS)**

Assumptions in elasticity: Definitions- notations and sign conventions for stress and strain, Components of stress and strain, Hooke’s law, Plane stress and Plane strain, Equations of equilibrium. **Basic equations of elasticity:** Strain – displacement relations, Stress – strain relations, Lame’s constant – cubical dilation, Compressibility of material, bulk modulus, Shear modulus, Compatibility equations for strains, Principal stresses and principal strains, Mohr’s circle, Saint Venant’s principle.

MODULE 2: ANALYSIS OF AIRFRAME (8 LECTURE HOURS)

Introduction of basic method of analysis of Frame, Matrix analysis of pin-jointed frameworks - Application to statically indeterminate frameworks - Matrix analysis of space frame. Virtual work - Principle of virtual work -Applications of the principle of virtual work. Energy methods - Unit load method.

MODULE 3: STRUCTURAL IDEALIZATION AND BENDING OF AEROSPACE STRUCTURES (7 LECTURE HOURS)

Structural idealization-Principle of Idealization of a panel- Effect of idealization on the analysis of open and closed section beams - Deflection of open and closed section beams. Thin-Walled Beams - Bending of open and closed, thin-walled beams - Symmetrical bending - Unsymmetrical bending- Deflections due to bending - Calculation of section properties.

MODULE 4: SHEAR FLOW OF AEROSPACE STRUCTURES DUE TO SHEAR FORCE (7 LECTURE HOURS)

Shear of beams - General stress, strain and displacement relationships for open and single cell closed section thin-walled beams - Shear of open section beams - Shear of closed section beams. Torsion of beams- Torsion of closed section beams-Torsion of open section beams - Combined open and closed section beams –Bending-Shear-Torsion.

MODULE 5: BUCKLING OF THIN PLATES **(7 LECTURE HOURS)**

Buckling of thin plates- Inelastic buckling of plates- Experimental determination of critical load for a flat plate - Local instability -Instability of stiffened panels - Failure stress in plates and stiffened panels - Tension field beams.

MODULE 6: WING AND FUSELAGE ANALYSIS (7 LECTURE HOURS)

Shear force, bending moment and torque distribution along the span of the Wing-Tension field beam and Semi tension field beam (Wagner Bam). Fuselage Analysis - Shear and bending moment distribution along the length of the fuselage.

References:

1. Donaldson B K., "Analysis of Aircraft Structures", Cambridge Aerospace Series, 2008
2. Megson, T.M.G., "Aircraft Structures for Engineering Students", Elsevier Ltd.,2010
3. G Lakshmi Narasaiah, "Aircraft Structures", BS Publications, 2010
4. Sun C T, " Mechanics of Aircraft Structures", Wiley India, 2010
5. Peery, D.J., "Aircraft Structures", McGraw–Hill, 1982.
6. Stephen P. Timoshenko & S.Woinovsky Krieger, "Theory of Plates and Shells", 2nd Edition, McGraw-Hill, Singapore, 1990.
7. Rivello, R.M., "Theory and Analysis of Flight structures", McGraw-Hill, N.Y., 1993.

18AE3008	AEROSPACE STRUCTURAL ANALYSIS LABORATORY	L T P C 0 0 2 1

Course Objective:

1. To provide the basic knowledge on the testing equipment for various structural components.
2. To impart the practical exposure with the measuring equipment and sensors.
3. To impart the practical exposure with composite material manufacturing.

Course Outcome:

After completing the course the student will be able to

1. Select test equipment for different types of static loading.
2. Conduct tests, Analyse results, document and compare with analytical/theoretical results.
3. Assess different types of structural failures.
4. Make Composite material and Laminate.
5. Choose strain gauge for different application and get knowledge in strain gauge installation.
6. Understand the stress distribution with respect to different cross-section shape and loading condition.

Experiments

1. Compression test on columns, critical buckling loads – South well plot.
2. Unsymmetrical bending of beams-Z section.
3. Determination of the natural frequency of vibrations of a cantilever beam
4. Shear center location for open sections
5. Torsion of a thin walled tube having various closed cross section at the ends
6. Structural behavior of a semi tension field beam (Wagner Beam)
7. Using photo elastic techniques: Calibration of circular disc in compression to find the fringe value and Determination of stress concentration factor due to compression in circular ring
8. Composite material Manufacturing and Testing- Tensile and Three point bending
9. Strain Gauge Calibration.
10. Thin wall cylinder - Hoop Stress Analysis.
11. Tensile Test-Single lab bonded joint & riveted joint.
12. Compression Test-Honeycomb sandwich Plate

18AE3009	FLIGHT CONTROL SYSTEMS	L T P C 3 0 0 3

Course Objectives:

The objectives of this course are to make students to learn:

1. To impart the knowledge of control system design
2. To impart the knowledge of aerodynamic influence on control system

3. To impart the knowledge of sensors and actuators and their working

Course Outcomes:

After completing the course the student will be able to

1. Illustrate control system concepts
2. Recall the conceptual and preliminary design of control systems
3. Identify the different flight control systems
4. Exemplify the aerodynamic considerations in control system design.
5. Demonstrate the system performance
6. Illustrate the sensors and actuators in a control system

MODULE 1: INTRODUCTION TO CONTROL SYSTEMS (5 LECTURE HOURS)

Introduction to Control System open loop and closed loop control system-Transfer function poles and zeroes - Block diagram reduction- Signal flow graph - Mason's gain formula - Characteristics equation- Concept of stability - Routh's stability Criteria. Root Locus.

MODULE 2: CONTROL SYSTEM DESIGN (8 LECTURE HOURS)

Introduction to Control System Design - Open & Closed Loop Control, Control System Design Objectives, Control System Design Cycle.

MODULE 3: FLIGHT CONTROL SYSTEMS (8 LECTURE HOURS)

Introduction to Flight Control System – History, Guidance, Navigation and Control, Flight Control Channels, Flight Control Methods, SAS vs. Autopilot.

MODULE 4: AERODYNAMIC APPROACH (8 LECTURE HOURS)

Aerodynamic Considerations of Flight Control Systems **-** Static and Dynamic Stability **-** Stability and Manoeuvrability **-** Static Margin **-** Variations of the Center of Pressure **-** Hinge Moment **-** Aeroelastic Effects.

MODULE 5: SYSTEM PERFORMANCE (7 LECTURE HOURS)

Control System Performance - Canard Control, Wing Control, Tail Control, Fin Configuration Effects, Side Jet Control, Thrust Vector Control, Variation of Mass and CG.

MODULE 6: SYSTEMS, SENSORS & ACTUATORS (9 LECTURE HOURS)

Flight Control Actuators, Flight Control Sensors, An Overview of Controller Design, Design of Aerodynamic Control System for Missiles, Aircraft Control System Design, Thrust Vector Control, Digital control systems.

References:

1. N.S. Nise: Control Systems Engineering, Wiley-India, 2004.
2. Blakelock, J. H.; Automatic Control of Aircraft and Missiles, 2nd Edition, John Wiley & Sons, 1990.
3. McLean, D., "Automatic Flight Control Systems", Prentice Hall International (UK) Ltd, 1990.
4. Garnell, P., "Guided Weapon Control Systems", 2nd Edition, Pergamon Press, 1980.
5. Siouris, G.M. "Missile Guidance and control systems", Springer, 2003.
6. Fleeman, Eugene L.; Tactical Missile Design, First Edition, AIAA Education series, 2001.
7. Roskam, Jan; Airplane flight dynamic and Automatic flight control, 3th Printing, Desighn, Analysis and Research Corporation, 2001.

18AE3010	FLIGHT CONTROL SYSTEMS LABORATORY	L T P C 0 0 2 1

Course Objectives:

1. To impart the knowledge of the autopilot control systems.
2. To impart knowledge on LabVIEW & Matlab programming.
3. To give hands on training to design virtual instrumentation of flight sensors.

Course Outcomes:

After completing the course the student will be able to

1. Understand the control system for autopilots.
2. Design a virtual instrumentation.
3. Model aircraft control system using Simulink.
4. Understand the various system and sensors technology in unmanned aircraft.

5. Test the performance and stability of unmanned aircraft.
6. Design and built unmanned aircraft .

List of Experiment:

Aircraft Systems

1. Designing a Simulink model for longitudinal autopilot control system
2. Designing a Simulink model for lateral autopilot control system
3. Designing a Simulink model for missile autopilot control system
4. Designing a VI for Angular position measurement using mems gyro
5. Designing a VI for velocity measurement using hot wire anemometer
6. Designing a VI for temperature measurement
7. Designing a VI for acceleration measurement
8. Designing a VI for position fixing using GPS

Unmanned Aircraft Systems

1. Design & Calculation of UAV (Fixed Wing / Multirotor) – Study
2. Testing & Selection of appropriate propulsion system for UAVs
3. PID Calibration of multirotor flight controller
4. Mathematical modelling & simulation of UAV
5. UAV Programming & Debugging
6. Assembly & Testing of UAV
7. 3D Mapping - Post Processing
8. Piloting - Simulator Training
9. Basic Piloting of Multirotor

Note: Faculty conducting the laboratory will prepare a list of minimum 12 experiments and get the approval of HoD and notify it at the beginning of the semester

18AE3011	COMPUTER AIDED DESIGN LABORATORY	L	T	P	C
		0	0	2	1

Course Objective:

1. To train the students with CAD packages like Solid Works.
2. To impart the 2D and 3D modeling skills to the students.
3. To enable Students to design different parts of Aerospace structures.

Course Outcome:

After completing the course the student will be able to

1. Understand the Part modelling of the aerospace structural components.
2. Understand the basic assembly of the aerospace structural components.
3. Understand the basic sheet metal modelling of the aerospace structural components.
4. Understand the basic surface modelling of the aerospace structural components.
5. Understand the basic design optimization of the aerospace structural components.
6. Understand the basic drafting of the aerospace structural components.

List of Experiments:

1. Part Modelling and Assembly of Aerospace fuselage structural Parts- Fuselage Bulkhead, Longeron, etc.
2. Part Modelling and Assembly of Aerospace wing structural Part- Spar, ribs, torque box
3. Part Modelling and Assembly of Aerospace propeller structural Parts- Blade design, Hub, and Shaft.
4. Part Modelling and Assembly of Aerospace turbine structural Parts- Blade design, Hub, and Shaft.
5. Part Modelling and Assembly of Aerospace Compressor structural Parts- Blade design, Hub, and Shaft.
6. Part Modelling and Assembly of Aerospace Helicopter rotor structural Parts- Blade design, Hub, and Shaft.
7. Sheet metal design-Basic modelling
8. Sheet metal design-Internal component of wing
9. Surface modelling –Basic structure

10. Surface modelling-Wing structures
11. CD Nozzle Design and Design Optimization.
12. Draft diagram of structural components.

18AE3012	ADVANCED COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

Co-requisite: 18AE3013 Advanced Computational Fluid Dynamics Laboratory

Course Objectives:

The objectives of this course are to make students to learn:

4. To provide knowledge on governing equations of fluid dynamics
5. To provide an understanding of the solution methodologies of discretised equations
6. To impart knowledge of turbulence and combustion models and its behaviour

Course Outcomes:

After completing the course the student will be able to

7. Understand the governing equations for fluid flow and its classification.
8. Knowledge about turbulent behaviour of flow and methods to accounts for it.
9. Attain the numerical simulation of PDE and its applications to thermal problems.
10. Apply the numerical procedure for convection – diffusion problems.
11. Knowledge of performing CFD Analysis.
12. Apply the boundary conditions and solve CFD problems using turbulence and combustion models.

MODULE 1: GOVERNING EQUATIONS (9 LECTURES HOURS)

Governing equations of fluid flow and heat transfer, Navier-Stoke's equations, Conservative, differential and integral form of transport equations; Classifications of PDEs and numerical methods for different PDEs.

MODULE 2: FINITE DIFFERENCE METHOD (8 LECTURE HOURS)

Introduction to finite difference method, Difference equations, explicit and implicit approaches, errors and an analysis of stability

MODULE 3: FINITE VOLUME METHOD (7 LECTURE HOURS)

Finite volume method for one dimensional steady state diffusion, finite volume method for two dimensional steady state diffusion problems, finite volume method for one dimensional unsteady diffusion (heat conduction)- Explicit, Implicit and Crank-Nicholson scheme

MODULE 4: SOLUTION METHODOLOGY (7 LECTURE HOURS)

Introduction, TDMA, application of TDMA, point iterating method- Jacobi, Gauss Seidel, Relaxation Methods, Multi-grid Techniques-Multigrid procedure with examples

MODULE : GRID GENERATION (7 LECTURE HOURS)

Introduction, structured and unstructured grids, hybrid grids; Unstructured grids of triangular and tetrahedral, structured grids of quadrilateral and hexahedral, Cartesian Mesh, adaptive mesh

MODULE 6: TURBULENCE (7 LECTURE HOURS)

Introduction, Turbulence models, Reynold's Averaged Navier-Stoke's Equation - RANS, Large Eddy Simulation and Direct Numerical Simulation.

References:

1. Versteeg, H.K, and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method",Second Edition,Longman, 2017
2. Anderson, J.D., "Computational fluid dynamics – the basics with applications", 1995.
3. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw-Hill Publishing Company Ltd., 1998.
4. Muralidhar, K and Sundarajan .T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
5. Bose, T.K., "Numerical Fluid Dynamics", Narosa publishing House, 1997.
6. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", McGraw-Hill, 1980. AneBooks2004 Indian Edition.

18AE3013	ADVANCED COMPUTATIONAL FLUID DYNAMICS LABORATORY	L T P C 0 0 2 1

Course Objectives:

1. To familiarize the students with the working of CFD codes.
2. To familiarize the students with actual setting up of the problem and solution procedure.
7. To extract the required data, post process and compare with available data.

Course Outcomes:

After completing the course the student will be able to

1. Define the body shape in a CFD code.
3. Understand the solution domain and grid generation.
4. Apply boundary conditions and generate the solution.
5. Validate the aerodynamic quantities from computed data.
6. Perform CFD Analysis over 2D and 3 D objects.
7. Solve problems using turbulence models

List of Experiment:

Computational Fluid Dynamics using Fluent Software.

1. Flow past over a flat plate at M=0.1, α = o^o and 10^o
2. Supersonic Flow over a flat plate
3. Flow over an Airfoil
4. Flow simulation over ONERA M6 wing.
5. Flow analysis of gaseous combustion
6. Flow with thermal boundary layer.

Computational Fluid Dynamics using open source software (Scilab or Python)

7. Coding- Basic Mathematical equations –Matrix's, ODE, PDE, Numerical Equations.
8. Coding-One Dimensional flow in duct(CD Nozzle)
9. Coding- One Dimensional Mesh generation.
10. Explicit discretisation for one dimensional unsteady conduction
11. Implicit discretisation for one dimensional unsteady conduction
12. Transient flow analysis in an axial compressor stage

Reference books:

1. Farrashkhalvat, M. Miles J.P. "Basic Structured Grid Generation: With an introduction to unstructured grid generation", A Butterworth-Heinemann, 2003.
2. Fluent Manual, "Fluent 6.3 UDF Manual" Fluent Inc, 2006.

18AE3014	COMPUTATIONAL HEAT TRANSFER	L T P C 3 0 0 3

Co-requisite:

Course Objectives:

1. To understand the different solution methods of heat transfer under steady and transient conditions.
2. To understand the concepts of computational heat transfer through extended surfaces.
3. To learn the heat transfer analysis in practical applications of heat transfer.

Course Outcomes:

After completing the course the student will be able to

1. Know the mathematical concepts of computational heat transfer.
2. Know the different applications of heat transfer.
3. Understand the different computational methods of heat transfer.
4. Understand the heat transfer methods in FDM and FEM.
5. Apply the computational heat transfer methods in practical applications.
6. Analyse the real time problems of heat transfer in aerospace applications.
7. Understand the working of various sensors and instruments for thermal measurements.

MODULE 1: CONDUCTION HEAT TRANSFER (7 LECTURES HOURS) -General 3D-heat conduction equation in Cartesian, cylindrical and spherical coordinates. Computation (FDM) of One –dimensional steady state heat conduction –with and without Heat generation

MODULE 2: CONDUCTION HEAT TRANSFER (7 LECTURE HOURS)
2D-heat conduction problem with different boundary conditions- Numerical treatment for extended surfaces. Numerical treatment for 3D- Heat conduction. Numerical treatment to 1D-steady heat conduction using FEM

MODULE 3 TRANSIENT HEAT TRANSFER (9 LECTURE HOURS)
Introduction to implicit,explicit Schemes and Crank-Niolson Schemes, Computation(FDM) of One –dimensional un-steady heat conduction –with heat Generation-without Heat generation - 2D- transient heat conduction problem with different boundary conditions using Implicit, explicit Schemes.

MODULE 4:- CONVECTIVE HEAT TRANSFER (8 LECTURE HOURS)
Convection- numerical treatment (FDM) of steady and unsteady 1-D and 2- D heat convection-diffusion steady-unsteady problems- Computation of thermal and Velocity boundary layer flows. Upwind scheme. Stream function-vorticity approach-Creeping flow.

MODULE 5 RADIATIVE HEAT TRANSFER (7 LECTURE HOURS)
Radiation fundamentals-Shape factor calculation-Radiosity method- Absorption Method-Monte-Carlo method-Introduction to Finite Volume Method- Numerical treatment of radiation enclosures using finite Volume method

MODULE 6: HEAT TRANSFER MEASUREMENTS (7 LECTURE HOURS)
Temperature measurements- Thermocouples- RTD sensors, Thermistor, Thermopiles, Thin platinum sensors, heat flux measurements – Gardon Gauge, Thick film heat flux gauge, Thin film sensors.

References:

1. R.H. Pletcher Tannehill C.Jhon, Dale A. Andersons, “Computational fluid Mechanics and Heat Trasnfer”, 3rd Edition, CRC press 2012
2. S.C. Sachdeva, “Fundamentals of Engineering Heat & Mass Transfer”, Wiley Eastern Ltd., New Delhi, 1981
3. Yunus A. Cengel, “Heat Transfer – A Practical Approach”, Tata McGraw Hill Edition, 2003.
4. T.W. Lee, “Thermal and Flow Measurements” CRC Press, 2008.
5. 3 John H. Lienhard, “A Heat Transfer Text Book”, Prentice Hall Inc., 1981.
6. 4.J.P. Holman, “Heat Transfer”, McGraw-Hill Book Co., Inc., New York, 6th Edition, 1991.

18AE03015	CRYOGENIC ENGINEERING	L	T	P	C
		3	0	0	3

Course objective:
1. To Impart the knowledge on the engineering concept of cryogenic propulsion.
2. To Impart the knowledge on various types of insulation for storage vessels.
3. To Impart the knowledge on various methods used for producing cryogenic fluid.

Course outcome:
After completing the course the student will be able to
1. Understand the thermal, physical and flow properties of cryogenic fluids.
2. Understand the liquification and refrigeration systems of cryogenic propellant.
3. Identify the various method of cryogenic insulations system.
4. Explain the various method of cryogenic storage system.
5. Know the various method of cryogenic instrumentation system.
6. Understand the various cryogenic equipment’s used in Aerospace application.

MODULE 1: INTRODUCTION TO CRYOGENIC ENGINEERING: (8 LECTURE HOURS)
Historical and background of cryogenic - introduction to cryogenic propellants – liquid hydrogen, liquid helium, liquid nitrogen and liquid oxygen and their properties, refrigeration and liquefaction principals; Joule Thomson effect and inversion curve; adiabatic and isenthalpic expansion with their comparison

MODULE 2 : LIQUIFICATION AND REFRIGERATION SYSTEMS (8 LECTURE HOURS)
Cryogenic fluids, Solids at cryogenic temperatures; Superconductivity, Recuperative– Linde – Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon; Regenerative – Stirling cycle and refrigerator, Slovay refrigerator, Gifford-McMahon refrigerator, Vuilleumier refrigerator, Pulse Tube refrigerator; Liquefaction of natural gas

MODULE 3: CRYOGENIC INSULATION: (7 LECTURE HOURS)
Vacuum insulation, Evacuated porous insulation, Gas filled Powders and fibrous materials, Solid foams, Multilayer insulation, Liquid and vapour Shields, Composite insulations.
MODULE 4: STORAGE AND INSTRUMENTATION OF CRYOGENIC LIQUIDS (7 LECTURE HOURS)
Design considerations of storage vessel; Dewar vessels; Industrial storage vessels; Storage of cryogenic fluids in space; Transfer systems and Lines for cryogenic liquids; Cryogenic valves in transfer lines; Two phase flow in Transfer system; Cool-down of storage and transfer systems, Measurement of strain, pressure, flow, liquid level and Temperature in cryogenic environment; Cryostats.
MODULE 5: VACUUM TECHNOLOGY (7 LECTURE HOURS)
Vacuum technology in cryogenics- Components of vacuum systems - Mechanical vacuum pumps - Diffusion pumps – ION pumps – Cryopumping – Vacuum gauges – Vacuum valves. Applications of cryogenics in engineering.
MODULE 6: CRYOGENIC EQUIPMENT (8 LECTURE HOURS)
Cryogenic heat exchangers – recuperative and regenerative, variables affecting heat exchanger and system performance, Cryogenic compressors, Pumps, expanders, Turbo alternators, Effect of component inefficiencies; System Optimization, Magnetocaloric refrigerator, 3He-4He Dilution refrigerator; Cryopumping; Cryogenic Engineering applications in energy, aeronautics, space, industry, biology, preservation Application of Cryogenic Engineering in transport

References:

1. Guglielmo Ventura, Lara Risegari, “The Art of Cryogenics: Low-Temperature Experimental Techniques”, Elsevier Science, 2007.
2. R. Radebaugh, Klaus D. Timmerhaus, Richard P. Reed “Cryogenic Engineering “International Cryogenics Monograph Series, Springer-Verlag New York, 2007.
3. A.R.Jha, “Cryogenic Technology and Applications” Butterworth-Heinemann, 2005.
4. T.M. Flynn, Marcel Dekker., “Cryogenic Engineering”, New York, 1997.
5. Barron, R. F., “Cryogenic Systems”, Oxford University, 1985.
6. A.Bose and P. Sengupta, “Cryogenics: Applications and Progress”, Tata McGraw Hill, 1985.
7. R. Barron , “Cryogenic Systems”, Oxford University Press, 1985

18AE3016	ADVANCED FINITE ELEMENT ANALYSIS	L	T	P	C
		3	0	0	3

Course Objectives:
1. To impart the basic concept of finite element.
2. To introduce the finite element modeling in designing Aerospace Structural Components.
3. To provide the knowledge on various finite element procedures and solution techniques.

Course Outcome:
After completing the course the student will be able to
1. Analyze the discrete and continuum problem using finite element method.
2. Understand the different Numerical solution to the FEA Problems.
3. Analyze the functions of different elements and Stiffness Matrix.
4. Identify mathematical model for solution of common engineering problems.
5. Describe the usage of professional-level finite element software to solve engineering problems in Solid mechanics, fluid mechanics and heat transfer.
6. Analyse the Axisymmetric problems.

MODULE 1: APPROXIMATE METHODS AND ITS SOLUTIONS (7 LECTURES HOURS)
Approximate solution of boundary value problems-Methods of weighted residuals, approximate solution using variational method, Modified Galerkin method, Boundary condition, Problem.
MODULE 2: ANALYSIS OF BAR AND TRUSS (7 LECTURES HOURS)
Basic finite element concepts-Basic ideas in a finite element solution, General finite element solution procedure, Finite element equations using modified Galerkin method, Applications to Axial

deformation of bars, Axial spring element, Analysis of trusses-Two dimensional truss element, Three dimensional space truss element, and temperature changes

MODULE 3: ANALYSIS OF BEAM (7 LECTURES HOURS) Beam bending-Governing differential equation for beam bending, Two node beam element, Exact solution for uniform beams subjected to distributed loads using superposition, Calculation of stresses in beams, Thermal stresses in beams.

MODULE 4: ANALYSIS OF FRAME (7 LECTURES HOURS) Analysis of structural frames-Plane frame element, Thermal stresses in frames, Three dimensional space frame element

MODULE 5: BOUNDARY VALUE PROBLEMS (9 LECTURES HOURS)

General one dimensional boundary value problem and its applications-One dimensional heat flow, Fluid flow between flat plates-Lubrication Problem, Column buckling. Two dimensional elasticity-Governing differential equations, Constant strain-triangular element, Four node quadrilateral element, Eight node iso-parametric element

MODULE 6: AXISYMMETRIC PROBLEMS (8 LECTURES HOURS)

Axisymmetric elastic problems-Governing equations for axisymmetric elasticity, Axisymmetric linear triangular element, Axisymmetric four node iso-parametric element.

References:

1. Robert D. Cook, David S. Malkus, Michael E. Plesha, "Concepts and Applications of Finite Element Analysis", John Wiley and Sons, 4th ed., 2007.
2. J.N. Reddy , "An Introduction to the Finite Element Method,", McGraw-Hill International Editions, 3rd ed., 2009.
3. Segerlind,L.J. "Applied Finite Element Analysis", Second Edition, John Wiley and Sons Inc., New York, 1984.
4. Tirupathi R. Chandrupatla and Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 2002
5. Rao S.S., "Finite Element Methods in Engineering", Pergamon Press, 4th Ed., 2005.
6. Robert D. Cook "Finite Element Modeling For Stress Analysis", John Wiley and Sons, 1995.
7. Roy R. Craig, Jr., "Structural Dynamics: An Introduction to Computer Methods," John Wiley and Sons, 1981.

18AE3017	ADVANCED FINITE ELEMENT ANALYSIS LABORATORY	L	T	P	C
		0	0	2	1

Co-requisites:

Course Objective:

1. To provide the knowledge on various structural analysis software packages
2. To impart the understanding of the stress analysis of different types of structural components
3. To impart the Knowledge on programming for various structural analysis

Course Outcome:

After completing the course the student will be able to

1. Understand the various structural software packages
2. Solve the static structural analysis of one dimensional members
3. Solve the static structural analysis of two dimensional & three dimensional problem
4. Analyze the Static Thermal analysis of various objects
5. Understand the various structural programming – open source software packages
6. Programming for various structures problem

List of Experiments:

Structural Analysis using ANSYS Mechanical APDL

1. Static stress analysis axial bar.
2. Two dimensional (truss) frame with multiple materials and element types.
3. Three dimensional truss- Airframe.
4. Simple two dimensional heat transfer problem.
5. Plate buckling analysis

Structural Analysis using ANSYS Workbench

6. Modal analysis of Aircraft wing.
7. Fluid-structure interaction-Oscillating plate.

Solving structural problem using Mathematical programming using open source software Scilab or Python.

8. Programming of one dimensional bar with single material and axial load using Scilab.
9. Programming of one dimensional step bar, multiple material with different axial load direction using Scilab.
10. Programming for vibration analysis of bar using Scilab.
11. Programming for one- dimensional heat transfer problem using Scilab.
12. Programming for 2D truss using Scilab.

18AE3018	AEROSPACE MATERIALS	L T P C 3 0 0 3

Course Objectives:

The objectives of this course are to make students to learn:

1. To impart the knowledge about materials used in aircraft construction
2. To impart the knowledge about adhesives and sealants used in aircraft industries
3. To impart the knowledge about the non-metals used in aircraft construction

Course Outcomes:

After completing the course the student will be able to

1. Understand the different materials used and know the various types of hardness testing machine. Knowledge of Stress-strain curves for different type of materials.
2. Acquire knowledge about the properties of the material, the process of machining them and heat treating them.
3. Acquire knowledge about the specification of materials, their structural applications and properties.
4. Find out the different types of adhesives and sealant used, their advantages and the knowledge of the sandwich and honeycomb structure.
5. Understand the basic knowledge of composite materials.
6. Acquire knowledge about the composites used in aerospace industry

MODULE 1: MECHANICAL BEHAVIOUR OF ENGINEERING MATERIALS (8 LECTURES HOURS)

Knowledge of various types of hardness testing machines and various types of hardness numbers Linear and non-linear elastic properties - Stress and Strain Curves - Yielding and strain Hardening ,Toughness - Modules of resilience -- Bauchinger's effect - Effect of notches - Testing and flaw detection of materials and components.

MODULE 2: MATERIALS IN AIRCRAFT CONSTRUCTION - I (8 LECTURE HOURS)

Aluminium and its alloys: Types and identification. Properties - Castings - Heat treatment processes - Surface treatments. Magnesium and its alloys: Cast and Wrought alloys - Aircraft application, features specification, fabrication problems, Special treatments. Titanium and its alloys: Applications, machining, forming, welding and heat treatment.

MODULE 3: MATERIALS IN AIRCRAFT CONSTRUCTION - II (8 LECTURE HOURS)

Steels : Plain and low carbon steels , various low alloy steels, aircraft steel specifications ,corrosion and heat resistant steels, structural applications. Maraging Steels: Properties and Applications, Copper Alloys - Monel, K Monel, Super Alloys: Use - Nickel base - Cobalt base - Iron base - Forging and Casting of Super alloys - Welding, Heat treatment.

MODULE 4: ADHESIVE AND SEALANTS FOR AIRCRAFT (7 LECTURE HOURS)

Advantages of Bonded structure in airframes - Crack arresting - Weight saving - Technology of adhesive Bonding Structural adhesive materials - Test for bonding structure, Typical bonded joints &non destructive tests for bonded joint Bonded Sandwich structures - Materials - Methods of construction of honeycombs

MODULE 5: INTRODUCTION TO COMPOSITE MATERIALS FOR AEROSPACE I (7 LECTURE HOURS) Introduction, components in composite material, fibers – glass, Kevlar, boron, carbon and graphite, properties of fibers, fabrics, matrices – classification of polymer matrices.

MODULE 6: INTRODUCTION TO COMPOSITE MATERIALS FOR AEROSPACE II (7 LECTURE HOURS)

Classification of composites, lamina – geometrical properties of lamina, laminate, types of composites – polymer, hybrid, metal matrix, ceramic matrix, types of prepregs, comparison between composites and conventional metals.

References:

1. Brian Cantor, H Assender, et al, "Aerospace Materials", Series in Materials Science and Engineering, CRC Press,Taylor and Francis group, 2017.
2. Horst Buhl, "Advanced Aerospace Materials(Materials Research and Engineering", Springer-Verlsg, 2012.
3. Lalith Gupta, "Aircraft General Engineering" Himalaya Book House, Delhi 2003
4. George F. Titterton, "Aircraft Material & Process", Fifth Edition, Sterling Book House, 2007.
5. Lalith Gupta, "Advanced Composite Materials", Himalaya Book House, Delhi, 2006.
6. Pradip K. Saha,"Aircraft Manufacturing Processes", First edition, CRC Press,Taylor and Francis group, 2017.
7. Flake C Campbell Jr, "Manufacturing Technology for Aerospace Structural Materials" BH Pulisher, 2006.

		L	T	P	C
18AE3019	**COMPOSITE MATERIALS & STRUCTURES ANALYSIS**	**3**	**0**	**0**	**3**

Course Objectives:

The objectives of this course are to make students to learn:

1. To impart knowledge on composite materials and Design.
2. To impart knowledge on behaviour of composite structures and Failure criteria.
3. To impart knowledge on manufacturing, testing, various application of composite material.s

Course Outcomes:

After completing the course the student will be able to

1. Classify the composite materials and Get knowledge in manufacture of composites
2. Discuss the design the composite structures
3. Estimate the behaviour Composite Materials under Various Loads
4. Analyse the different Failure modes of Composite Materials
5. Design the composite plate
6. Choose composite material and structures for various application

MODULE 1: INTRODUCTION OF COMPOSITE MATERIALS (9 LECTURES HOURS)

Limitation of conventional Engineering materials, Introduction to composite materials, Role of Matrix and Reinforcements in composites, Different Matrix Materials and Reinforcements, Types of Composites, Composites Verse Traditional Materials.

MODULE 2: DESIGN PROPERTIES OF COMPOSITES (8 LECTURE HOURS)

Micromechanical Model for Elastic Properties, Relation of Matrix Element and Engineering Material Constants, Discontinuous Fibers and Whisker Reinforced Polymer Composites, Hybrid Composite, Thermophysical Properties, Tensile Strength, Particulate-Reinforced Composite, True Particulate Composites, Fiber-Rein forced Composites, Laminar composites.

MODULE 3: MECHANICAL BEHAVIOUR OF COMPOSITE MATERIALS (7 LECTURE HOURS)

Constitutive relations for anisotropic materials in liner elasticity: Indices and Tensor notations, Anisotropic Material and constitutive relations, Matrix relation for changes of axis. Orthotropic layer behaviour: Stiffness and compliance matrices and matrix relation for changes of axis, stress and strain matrices.

MODULE 4: FAILURE CRITERIA (7 LECTURE HOURS)

Maximum stress theory, Maximum strain theory, Polynomial failure criteria: Tsai-Hill criterion, Tsai-Wu Criterion, Hoffman Criterion. Tensile and shear strength of unidirectional layer, Determination of failure stresses from three tension tests.

MODULE 5: MULTI-LAYER PLATES (7 LECTURE HOURS)

Kirchhoff-Love hypotheses for thin plates, stress-displacement relationships, Global plate equations, Global stiffnesses of a symmetrical composite and asymmetrical laminate, Boundary conditions, Determination of transfer shear stress, Strain energy of the plate.

MODULE 6: MANUFACTURING, TESTING AND APPLICATIONS (7 LECTURE HOURS)

Manufacture of Laminated Fibre-Reinforced Composite Materials. Mechanical Test Methods, Fracture and Fatigue Test, Fatigue resistance test and thermal test. Applications: Military Aircraft, Civil Aircraft, Space Applications, Automotive application and Commercial applications.

References:

1. Christian Decolon., “Analysis of Composite Structures” Hermes Penton Ltd,2004.
2. M C Gupta, A P Gupta., “ Polymer Composite” Second Edition,New Age International (P) Ltd, 2015.
3. R.M. Jones, “Mechanics of Composite Materials”, 2nd Edition, Taylor & Francis, 1999
4. B.D. Agarwal and L.J. Broutman, “Analysis and Performance of fiber composites”, John-Wiley and Sons, 1990.
5. Autar K. Kaw, Mechanics of Composite Materials, CRC Press LLC, 1997.
6. Valery V.Vasiliev, Evgeny V.Morozov, “ Advanced Mechanics of Composite Materials and structural elements”, Third Edition, Elsevier,2013
7. G.Lubin, “Hand Book on Fibre glass and advanced plastic composites”, Van Nostrand Co., New York, 1989.
8. Composite Material and Structures(Web): https://nptel.ac.in/courses/101104010/
9. Composite Materials: https://nptel.ac.in/syllabus/101106038/

18AE3020	AERO-ELASTICITY	L T P C 3 0 0 3

Course Objectives:

The objectives of this course are to make students to learn:

1. To impart the basic concepts of Aero-elasticity
2. To provide knowledge about the Static Aero-elastic phenomena
3. To understand the Dynamic Aero-elastic phenomena

Course Outcomes:

After completing the course the student will be able to

1. Understand the Aero-elastic phenomena.
2. Control Aero-elastic instability of bodies.
3. Understand the vibration system.
4. Analyze the static Aero-elastic behavior of the Aircraft.
5. Analyze the Dynamic Aero-elastic behavior of the Aircraft.
6. Analyze the Flutter and Gust behavior of the Aircraft.

MODULE 1: REVIEW OF FOUNDATIONS OF MECHANICS (9 LECTURES HOURS)

Uniform Beam Torsional and Bending Dynamics-Principle of Virtual Work - Hamilton’s Principle - Lagrange’s Equations – Rayleigh-Ritz’s Method-Galerkin’s Method.

MODULE 2: STATIC AEROELASTICITY (8 LECTURE HOURS)

Introduction-Typical Section Model-An Airfoil-control surface-nonlinear effects; One Dimensional Aero-elastic Model of Airfoils-Eigenvalue and Eigen function approach – solution to the One Dimensional Aero-elastic Model- Two Dimensional Aero-elastic Model of Lifting Surfaces Aero-elastic equations of equilibrium and Matrix-lumped element solution method- Divergence and Control Reversal.

MODULE 3: DYNAMIC AEROELASTICITY-FLUTTER (7 LECTURE HOURS)

Dynamics of the Typical Section Model of An Airfoil - Sinusoidal motion -Periodic motion- Arbitrary motion-Random motion; Flutter - an introduction to dynamic Aero-elastic instability - Quasi-steady, aerodynamic theory- Solutions to the Aero-elastic Equations of Motion-Time Domain and Frequency Domain.

MODULE 4: DYNAMIC AEROELASTICITY-GUST (7 LECTURE HOURS)
Introduction to Gust - General form of equations in the time domain - Rigid aircraft in heave/pitch Motion- Frequency domain turbulence response – General form of equations in the frequency domain

MODULE 5: COUPLING OF STRUCTURAL AND AERODYNAMIC COMPUTATIONAL MODELS (7 LECTURE HOURS)
Mathematical modelling – static aeroelastic case- Two-dimensional coupled static aeroelastic model – pitch- Two-dimensional coupled static aeroelastic model – heave/pitch- Three-dimensional coupled static aeroelastic model- Mathematical modelling – dynamic aeroelastic response- Two-dimensional coupled dynamic aeroelastic model – bending and torsion- - Three-dimensional flutter analysis- Inclusion of frequency-dependent aerodynamics for state space modelling – rational fraction approximation.

MODULE 6: EXPERIMENTAL AEROELASTICITY (7 LECTURE HOURS)
Review of Structural Dynamics Experiments- Wind Tunnel Experiments- Sub-critical flutter testing- Approaching the flutter boundary- Safety devices- Research tests.

References:

1. Jan R. Wright, Jonathan E. Cooper, “Introduction to Aircraft Aeroelasticity and Loads” John wiley & sons, Ltd , 2007
2. Earl H. Dowell, Robert Clark, David Cox, H.C. Curtiss, Jr, John W. Edwards, Kenneth C. Hall, David A. Peters, Robert Scanlan, Emil Simiu, Fernando Sisto and Thomas W. Strganac, “A Modern Course in Aeroelasticity”, Fourth Revised and Enlarged Edition, 2004
3. Deway H. Hodges “Introduction to Structural Dynamics and Aero-Elasticity” Cambridge University Press, 2002
4. R.L. Bisplinghoff, H. Ashley, and R.L. Halfman, “Aeroelasticity”, II Edition Addison Wesley Publishing Co., Inc., 1996.
5. R.H. Scanlan and R.Rosenbaum, “Introduction to the study of Aircraft Vibration and Flutter”, Macmillan Co., New York, 1981.
6. E.G. Broadbent, “Elementary Theory of Aeroelasticity”, Bun Hill Ltd., 1986.

18AE3021	AIRCRAFT DESIGN	L	T	P	C
		3	0	0	3

Course Objectives:
1. To impart knowledge about inputs required for Aircraft design.
2. To introduce methodology for aerodynamic design of aircraft.
3. To introduce power plant selection to meet performance requirements.

Course Outcome:
After completing the course the student will be able to
1. Design an aircraft/Spacecraft with given configuration.
2. Estimate the design parameters required for its better performance.
3. Understand the design requirements of the Aircraft.
4. Analyze the weight estimation characteristics.
5. Understand the configuration of fuselage structures.
6. Analyze the Materials selection for the Aircraft Components.

MODULE 1: INTRODUCTION OF AIRCRAFT DESIGN (7 LECTURES HOURS)
Categories and types of aircrafts – various configurations – Layouts and their relative merits – strength, stiffness, fail-safe and fatigue requirements – Maneuvering load factors – Gust and maneuverability envelopes – Balancing and maneuvering loads on tail planes.

MODULE 2: POWER PLANT SELESTION (7 LECTURES HOURS)
Characteristics of different types of power plants – Propeller characteristics and selection – Relative merits of location of power plant.

MODULE 3: WEIGHT ESTIMATION & AERODYNAMICS DESIGN (8 LECTURES HOURS)
Selection of geometric and aerodynamic parameters – Weight estimation and balance diagram – Drag estimation of complete aircraft

MODULE 3: PERFORMANCE AND STABILITY PARAMETER ESTIMATION (8 LECTURES HOURS)
Level flight, climb, takeoff and landing calculations – range and endurance – static and dynamic stability estimates – control requirements.

MODULE 5: LOAD DISTRIBUTION OF AIRCRAFT (7 LECTURES HOURS)
Layout peculiarities of subsonic and supersonic aircraft – optimization of wing loading to achieve desired performance – loads on undercarriages and design requirements.

MODULE 6: STRUCTRAL DESGIN OF AIRCRAFT (8 LECTURES HOURS)
Estimation of loads on complete aircraft and components – Structural design of fuselage, wings and undercarriages, controls, connections and joints. Materials for modern aircraft – Methods of analysis, testing and fabrication.

References:

1. D.P. Raymer, "Aircraft conceptual design", AIAA Series, 2012.
2. Darrol Stinton, "The Design of the airplane" Oxford BSP Professional Books,1993
3. E. Torenbeek, "Synthesis of Subsonic Airplane Design", Delft University Press,London, Springer, 2010.
4. H.N.Kota, Integrated design approach to Design fly by wire" Lecture notes Interline Pub., Bangalore, 1992.
5. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate OffsetCo., U.S.A., 1980.
6. A.A. Lebedenski, "Notes on airplane design", Part-I, I.I.Sc., Bangalore, 1971.
7. G. Corning, "Supersonic & Subsonic Airplane Design", 4th Edition, Edwards Brothers Inc., Michigan, 1989.
8. Jan Roskam and J. Roskam, " Airplane Design Part I : Preliminary Sizing of Airplanes" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
9. Jan Roskam and J. Roskam, "Airplane Design, Part II : Preliminary Configuration Design and Integration of the Propulsion System" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
10. Jan Roskam and J. Roskam, "Airplane Design Part III: Layout Design of Cockpit, Fuselage, Wing and Empennage: Cutaways and Inboard Profiles (Volume 3)" Fifth Printing, Design, Analysis and Research Corporation (DARcorporation), 2017.
11. Jan Roskam and J. Roskam, "Airplane Design Part IV: Layout Design of Landing Gear and Systems (Volume 4)" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
12. Jan Roskam and J. Roskam, "Airplane Design Part V: Component Weight Estimation" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
13. Jan Roskam and J. Roskam, "Airplane Design Part VI : Preliminary Calculation of Aerodynamic Thrust and Power Characteristics" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
14. Jan Roskam and J. Roskam, "Airplane Design Part VII: Determination of Stability, Control and Performance Characteristics (Volume 7)" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
15. Jan Roskam and J. Roskam, "Airplane Design Part VIII: Airplane Cost Estimation: Design, Development, Manufacturing and Operating" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.

18AE3022	EXPERIMENTAL STRESS ANALYSIS	L T P C 3 0 0 3

Course Objectives:

1. To impart the knowledge in experimental method of finding the response of the structure to different types of load.
2. To provide the basic knowledge in Electrical-Resistance strain gauges and it application.
3. To impart the knowledge in photo-elasticity techniques.

Course Outcomes:

After completing the course the student will be able to

1. Get the knowledge of the general aspects of strain measurements.
2. Choose the electrical resistance strain gauge for different application.
3. Ability to understand the principle of operation of different type of optical techniques.
4. Get the knowledge of the 2D and 3DPhotoelastic stress analysis.
5. Identify the suitable stress coating methods.
6. Get the knowledge of the advanced method of stress analysis.

MODULE 1: BASICS OF EXPERIMENTAL STRESS ANALYSIS (9 LECTURES HOURS)

Principle of measurements-Accuracy, sensitivity and range- Definition of strain and its relation to experimental determinations Properties of strain gauge systems, Types of strain gauge systems-Mechanical, Optical, Acoustical and Electrical extensometers.

MODULE 2: ELECTRICAL-RESISTANCE STRAIN GAUGES (8 LECTURE HOURS)

Electrical-Resistance strain gauges and circuits, Principle of operation and requirements - Types and their uses- Materials for strain gauge-Calibration and temperature compensation-Cross sensitivity-Rosette analysis- Wheatstone bridge-Potentiometer circuits for static and dynamic strain measurements Strain indicators- Transducer applications- Load cells- Diaphragm pressure transducers..

MODULE 3: OPTICAL METHOD OF STRESS ANALYSIS (7 LECTURE HOURS)

Polariscope – interferometer, Moiré Method, Concepts of photoelastic effects, Photoelastic materials-Stress optic law- Plane Polariscope –Circular Polariscope -Transmission and Reflection type, Effect of stressed model in Plane and Circular Polariscope, Interpretation of fringe pattern- Isoclinics and Isochromatics.

MODULE 4: THREE DIMENSIONAL PHOTOELASTICITY (7 LECTURE HOURS)

Introduction, Locking in model deformations – Material for three- dimensional photoelasiticity, Machining, cementing and slicing three dimensional models. Shear –Difference method, Frozen-stress method, Scattered-Light method.

MODULE 5: BIREFRINGENT COATINGS(7 LECTURE HOURS)

Coating stresses and strain- Coating sensitivity – Coating materials- Application of coatings- Effect of coating thickness-Fringe-Order Determinations in coatings- Stress separation methods.

MODULE 6: INTRODUCTION TO HOLOGRAPHIC INTERFEROMETRY(7 LECTURE HOURS)

Hologtaphy: The Laser Light, Hologram, Reconstruction. Holographic Interferometry: Interference Fringes in a double exposure hologram, Interference Fringes in a real time hologram. Description by means of Ellipses, Displacement Vector lying on plane, Displacement Vector lying not on plane, order determination when no zero fringe is present. Strains from displacement.

References:

1. Alessandro Freddi, Giorgio Olmi, Luca Cristofolini, “Experimental Stress for Materials and Structures”, Springer, 2015.
2. James F. Doyle, “Modern Experimental Stress Analysis: Completing the Solution of Partially Specified Problems”, John Wiley & Sons Ltd, 2004.
3. UC Jindal, Experimental Stress Analysis, Pearson Ltd, 2012.
4. Sadhu Singh,”Experimental Stress Analysis”,Khanna Publishers, 2009.
5. A.J. Durelli and V.J. Parks, “Moire Analysis of Strain”, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1980.
6. Gregory R. Toker, “Holographic Interferometry” CRC Press, Taylor & Francis Inc, 2017.
7. Experimental Stress Analysis (An Overview(Video)): https://nptel.ac.in/courses/112106198/

18AE3023	BOUNDARY LAYER THEORY	L T P C 3 0 0 3

Course Objectives:

1. To introduce the concept of boundary layers and its applications.
2. To familiarize the students with viscous flow phenomena.
3. To impart knowledge on laminar and thermal boundary layer equations.

Course outcome:

After completing the course the student will be able to

1. Define the fundamentals Boundary layer theory.
2. Solve the equations involved in boundary layer theory.
3. Analyze the different kinds of Boundary Layer control.
4. Differentiate between the turbulent and laminar boundary layers .
5. Estimate the boundary layer thickness for flow over a different body.
6. Attain the knowledge of boundary layer effects in hypersonic flows.

MODULE 1: FUNDAMENTALS OF BOUNDARY LAYER THEORY (5 LECTURE HOURS)
Boundary layer concept- boundary layer on a flat plate, Description of Flow fields, continuity, Momentum and Navier-Stokes equations, Stress-Strain rate relationship, Stokes Hypothesis, Energy equation.

MODULE 2: EXACT SOLUTIONS OF NAVIER-STOKES EQUATIONS (8 LECTURE HOURS) Steady Plane Flows-CouetteFlow, Poiseuille Flow, Flow of Immiscible fluids in a Channel, Steady Axisymmetric Flows-Flow at a rotating disk and axisymmetric free jet. Unsteady Axisymmetric Flows-Vortex Decay.

MODULE 3: LAMINAR BOUNDARY LAYER EQUATIONS (10 LECTURE HOURS)
Boundary Layer equations, Derivation of boundary layer equations, Wall friction, separation and displacement, friction drag, Plate boundary layer. Integral relations of boundary layer-Momentum Integral equation, Energy Integral equation.

MODULE 4: BOUNDARY LAYER OVER AXISYMMETRIC BODIES (7 LECTURE HOURS)
Governing Equations for Axisymmetric Flow**,** Mangler transformation, Relation between flow over plate and Sharp Cone.

MODULE 5: THERMAL BOUNDARY LAYER (8 LECTURE HOURS) Thermal boundary layers with coupling of the velocity field of the temperature field-Boundary layer equations. Compressible Boundary layers- Simple solutions of energy equation, Integral methods, Boundary layers in hypersonic flows.

MODULE 6: BOUNDARY LAYER CONTROL (7 LECTURE HOURS)
Different Kinds of Boundary Layer control, Continuous suction and blowing-Massive suction, Massive Blowing, Plate flow with uniform suction or blowing, Airfoil. Three –Dimensional boundary layers-boundary layer at cylinder, Boundary layer at a yawing cylinder.

References:

1. Schlichting, Herrmann, Gersten, Klaus Translated by Mayes-“Boundary Layer Theory” 8th rev. and enlarged ed. 2000.
2. Frank White, “Viscous Fluid flow” – McGraw Hill, 2005.
3. Ian. J. Sobey, “Introduction to interactive Boundary Layer Theory”, Oxford University Press, USA, 2001.
4. Ronald L., Panton, “Incompressible fluid flow”, John Wiley & Sons, 2005.
5. J. Reynolds, “Turbulent flows in Engineering”, John Wiley & Sons, 1992.
6. Tuncer Cebeci and Peter Bradshaw, “Momentum transfer in boundary layers”, Hemisphere Publishing Corporation, 1977.
7. Holger Babinsky, John K. Harvey, “Shock Wave-Boundary-Layer Interactions (Cambridge Aerospace Series)”,Cambridge, 2014.
8. Schlichting, “Boundary Layer Theory” Seventh Edition, Mc Graw Hill Education, Indian Edition,2014.

18AE3024	INTRODUCTION TO HYPERSONIC FLOWS	L 3	T 0	P 0	C 3

Course Objective:
1. To introduce the features of in-viscid hypersonic flows, viscous hypersonic flows and high temperature effects
2. To provide knowledge regarding estimation of flow over bodies under hypersonic conditions
3. To introduce the high temperature issues of hypersonic wings

Course Outcome:
After completing the course the student will be able to
1. Solve the problems involving in-viscid and viscous hypersonic flows
2. Estimate the high temperature effects in hypersonic aerodynamics
3. Asses the design issues for hypersonic wings
4. Apply the computational tools to evaluate hypersonic flows
5. Distinguish the high Mach number flow from the supersonic flows
6. Estimate flow parameters over a vehicles under hypersonic conditions

MODULE 1: INTRODUCTION TO HYPERSONIC FLOWS (5 LECTURE HOURS)
Features of hypersonic flows, thin shock layers, Entropy layer, Viscous- Inviscid Interaction, High Temperature effects, Low Density Effects.

MODULE 2: INVISCID HYPERSONIC FLOWS (10 LECTURE HOURS)
Hypersonic Shock relations, Hypersonic Shock relations, Hypersonic Expansion Wave relation, Methods of calculating surface pressures- Newtonian Flows, Modified Newtonian Laws, Centrifugal Force Correction, Tangent wedge Method, Tangent Cone Method, Shock Expansion Method.

MODULE 3: HYPERSONIC INVISCID FLOW FIELD (10 LECTURE HOURS)
Approximate Methods for inviscid hypersonic flows, Mach number independence Principle, Hypersonic slender body theory for all angle of attack, hypersonic similarity laws, Thin Shock layer theory.

MODULE 4: INTRODUCTION TO VISCOUS HYPERSONIC FLOWS (10 LECTURE HOURS)
Viscous hypersonic flows-Boundary layer Equations, Navier-Stokes equations, Similarity Parameters, Boundary Conditions, Hypersonic Boundary Layer Theory, Self-similar Solution – Flat Plate and Stagnation Point, Non-similar Boundary Layer, Local similarity Method, Hypersonic Transition, Turbulent Boundary layer,

MODULE 5: AERODYNAMIC HEATING AND VISCOUS-INVISCID INTERACTION (10 LECTURE HOURS)
Hypersonic Aerodynamic Heating, axi-symmetric analogue for three dimensional bodies, hypersonic viscous Interactions.

Reference :

1. John D.Anderson Jr., “Hypersonic and High Temperature Gas dynamics”, AIAA, 2nd Edition 2006.
2. John J Bertin., “Hypersonic Aerothermodynamics”, AIAA Education Series., Washington DC, 1994
3. Hayes, Wallace.D and Probstein R F., “Hypersonic Inviscid Flow”, Dover Publications, 2004.
4. Ernst Heinrich Hirschel., “Basics of Aerothermodynamics”, Springer Verlag Berlin, 2005.
5. Vladimir V. Lunev, Real Gas Flows with High Velocities, CRC Press, 2009 .
6. Maurice Rasmussen, Hypersonic Flow, John Wiley & Sons, 1994.

18AE3025	FATIGUE AND FRACTURE MECHANICS	L 3	T 0	P 0	C 3

Course Objectives:
The objectives of this course are to make students to learn:
1. To impart knowledge on the structural fatigue and its behavior.
2. To impart knowledge on the physical aspects of fatigue and the failure mechanism of components.

3. To impart knowledge on the concept of fail-safe design process.

Course Outcomes:

After completing the course the student will be able to

1. Understand the concepts of fatigue behavior of structures.
2. Discuss the fatigue behavior in statistical aspects.
3. Discuss the fatigue behavior in physical aspects.
4. Estimate the fracture characteristics of structures.
5. Understand the principles of safe-life and fail-safe design.
6. Discuss the case study of fatigue failures in aerospace structures.

MODULE 1: FATIGUE OF STRUCTURES (9 LECTURES HOURS)

S.N. curves - Endurance limits - Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams - Notches and stress concentrations - Neuber's stress concentration factors - Plastic stress concentration factors - Notched S.N. curves.

MODULE 2: STATISTICAL ASPECTS OF FATIGUE BEHAVIOR (8 LECTURE HOURS)

Low cycle and high cycle fatigue - Coffin - Manson's relation - Transition life - cyclic strain hardening and softening - Analysis of load histories - Cycle counting techniques -Cumulative damage - Miner's theory - Other theories.

MODULE 3: PHYSICAL ASPECTS OF FATIGUE: (7 LECTURE HOURS)

Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations - fatigue fracture surfaces.

MODULE 4: FRACTURE MECHANICS (7 LECTURE HOURS)

Strength of cracked bodies - Potential energy and surface energy - Griffith's theory - Irwin - Orwin extension of Griffith's theory to ductile materials - stress analysis of cracked bodies - Effect of thickness on fracture toughness - stress intensity factors for typical geometries.

MODULE 5: FAIL-SAFE DESIGN AND AEROSPACE APPLICATION: (7 LECTURE HOURS)

Safe life and Fail-safe design philosophies - Importance of Fracture Mechanics in aerospace structures - Application to composite materials and structures.

MODULE 6: CASE STUDY OF FATIGUE FAILURE IN AEROSPACE COMPONENTS (7 LECTURE HOURS)

Case study: Military Aircraft failures, Civil Aircraft failures, Space objects failures due to fatigue and fracture.

References:

1. S,Suresh, " Fatigue of Materials", Second Edition, Cambridge University Press, 2001.
2. J.Schijive, " Fatigue of Structures and Materials",Second Edition, Springer, 2009.
3. Prasanth Kumar – "Elements of fracture mechanics" – Wheeter publication, 1999.
4. Barrois W, Ripely, E.L., "Fatigue of aircraft structure", Pergamon press. Oxford, 1983.
5. Sin. C.G., "Mechanics of fracture" Vol. I, Sijthoff and w Noordhoff International Publishing Co., Netherlands, 1989.
6. Knott, J.F., "Fundamentals of Fracture Mechanics", Buterworth & Co., Ltd., London, 1983.
7. T. S. Srivatsan, M. Ashraf Imam, Raghavan Srinivasan, "Fatigue of Materials: Advances and Emergences in Understanding", John Wiley & Sons,Inc,Publication, 2010.
8. Engineering Fracture Mechanics: https://nptel.ac.in/courses/112106065/

18AE3026	FUNDAMENTAL OF COMBUSTION	L T P C 3 0 0 3

Course objectives:

1. To impart knowledge on importance and basics of combustion.
2. To understand various types of flames
3. To impart knowledge on combustion in various engines.
4. To impart knowledge on deflagration, detonation and supersonic combustion.

Course outcome

After completing the course the student will be able to

1. To analyze a given system by applying laws of combustion.
2. Ability to evaluate the premixed and non-premixed combustion.
3. To measure burning velocity and their effects on combustion.
4. Ability to design the combustor for engines.
5. Analysis of reaction and mixing processes.
6. Evaluate performance of rocket fuels.

MODULE 1: FUNDAMENTAL CONCEPTS IN COMBUSTION (7 LECTURE HOURS)

Thermo - chemical equations - Heat of reaction, Law of Mass action, Order of reaction- first order, second order and third order reactions - reacting flows - modeling of reacting flows - premixed flames – detonation and explosion.

MODULE 2: INTRODUCTION TO TURBULENCE (7 LECTURE HOURS)

Introduction to turbulence- Influence of turbulence in combustion - turbulent premixed combustion - non-premixed combustion- turbulent non premixed combustion - spray combustion - combustion instability.

MODULE 3: CHEMICAL KINETICS AND FLAMES (8 LECTURE HOURS)

Measurement of burning velocity - Various methods - Effect of various parameters on burning velocity - Flame stability - Detonation - Deflagration - Rankine - Hugoniot curve - Radiation by flames.

MODULE 4: COMBUSTION IN GAS TURBINE ENGINES (8 LECTURE HOURS)

Combustion in gas turbine combustion chambers - Re-circulation - Combustion efficiency - Factors affecting combustion efficiency - Fuels used for gas turbine combustion chambers - Combustion stability - Flame holder types.

MODULE 5: COMBUSTION IN ROCKETS (8 LECTURE HOURS)

Solid propellant combustion - Double base and composite propellant combustion- Various combustion models, thrust time curve, Combustion in liquid rocket engines - Single fuel droplet combustion model - Combustion in hybrid rockets.

MODULE 6: SUPERSONIC COMBUSTION (7 LECTURE HOURS)

Introduction - Supersonic combustion controlled by mixing, diffusion and heat convection - Analysis of reaction and mixing processes - Supersonic burning with detonation shocks.

References:

1. H. Lefebvre, Dilip R. Ballal, “Gas Turbine Combustion”, Taylor & Francis Group,2012.
2. Law, C. K., “Combustion Physics”, Cambridge Univ. Press, 2006.
3. Sutton, G.P., and Biblarz, “Rocket Propulsion Elements”, 7th Edition John Wiley and Sons, Inc., New York, 2017.
4. Turns, S.R., “An Introduction to Combustion Concepts and Applications”, 2nd Edition. McGraw Hill International Editions, New Delhi, 2000.
5. Glassman, I. and Yetter, R. A., “Combustion”, 4th ed., Academic Press, 2008.
6. Kuo, K. K., “Principles of Combustion”, 2nd ed., John Wiley, 2005.
7. Warnatz, J., Maas, U., and Dibble, R. W., “Combustion”, 4th ed., Springer, 2006.

18AE3027	UNMANNED AIRCRAFT SYSTEMS	L	T	P	C
		3	0	0	3

Course Objective:

1. To incorporate awareness about the basic terminology, models and prototypes of UAV system
2. To impart the knowledge on design considerations of UAV systems
3. To be able to design a UAV system for specific requirements

Course Outcome:

After completing the course the student will be able to

1. Understand the basic terminologies and classification of UAS.
2. Relate the design parameters of UAV systems.
3. Obtain knowledge on the application of UAV standards to design UAS .
4. Obtain knowledge on payloads and launch systems for UAS.
5. Understand the basic principles of UAV Testings.

6. Apply the principles to design UAS for specific applications.

MODULE 1: INTRODUCTION TO UAS (7 LECTURE HOURS)

Introduction to Unmanned Aircraft Systems (UAS) – Systematic basis of UAS – System composition - Categories and Roles – Elements of UAS – Unmanned Aircraft system operations

MODULE 2: DESIGN OF UAV SYSTEMS (8 LECTURE HOURS) Design and selection of UAS – Aerodynamics and airframe configurations – Aspects of airframe design - Unmanned Aircraft characteristics – Long range, Medium and Close range UAVs – Mini, Micro and Nano UAVs – Novel hybrid combinations

MODULE 3: UAV STANDARDS (8 LECTURE HOURS)

Unmanned Design standards and Regulatory aspects – Airframe design – Ancillary equipment – Design of Stealth

MODULE 4: UAV PAYLOADS (8 LECTURE HOURS)

Sensors and payloads – payload types – Communications, Control and stability, Navigation – Launch and recovery

MODULE 5: UAV TESTING (7 LECTURE HOURS)

Certification and ground testing – inflight testing - Human factors in UAS – Future of UAS and challenges,

MODULE 5: ROLE OF UAV (7 LECTURE HOURS)

Launch of HTOL & VTOL systems – recovery of HTOL & VTOL systems - Naval roles – Army roles – Civilian roles – paramedical and commercial roles – commercial applications

References:

1. Reg Austin, "Unmanned Aircraft Systems: UAVS Design Development and Deployment", First edition, John Wiley and Sons, 2010.
2. Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, "Introduction to Unmanned Aircraft systems", CRC press, Taylor and Francis, New York, 2012. Richard Microcontroller Systems for a UAV, A. Skafidas, 2002.
3. Paul.G.Fahlstrom, Thomas.J.Gleason, "Introduction to UAV systems", Uav Systems, Ins. 2013.
4. Armand.J. Chaput, "Design of UAV Systems" , Lockheed Martin Aeronautics Company, 2001.

18AE2028	INDUSTRIAL AERODYNAMICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart information about non-aeronautical uses of aerodynamics, such as road vehicle, building aerodynamics.
2. To familiarize the concept of wind energy system and its applications.
3. To provide the knowledge on solution of problems in flow induced vibrations.

Course Outcome:

After completing the course the student will be able to

1. Understand the airflow over a surface.
2. Apply the principles of aerodynamics to different ground vehicles.
3. Asses various wind energy system.
4. Predict the behavior of airflow over civil structures.
5. Analyse the flow field over trains.
6. Estimate the flow induced vibrations the cables and bridges.

MODULE 1: ATMOSPHERIC BOUNDARY LAYER (7 LECTURE HOURS)

Atmospheric circulation-local winds – terrain types – mean velocity profiles- power law and logarithmic law, wind speeds, turbulence profiles, Roughness parameters – simulation techniques in wind tunnels

MODULE 2: BLUFF BODY AERODYNAMICS (7 LECTURE HOURS) Boundary layers and separation, 2-D wake and vortex formation, Strouhal and Reynolds numbers, separation and reattachments, power requirements and drag coefficients of automobiles, effect of cut back angle, and aerodynamics of trains

MODULE 3: WIND ENERGY COLLETORS (7 LECTURE HOURS)

Horizontal and vertical axis machines, energy density of different rotors, power coefficient, Betz coefficient by momentum theory.

MODULE 4: BUILDING AERODYNAMICS (8 LECTURE HOURS)

Pressure distribution on low rise buildings, wind forces on buildings, environmental winds in city blocks, and special problems of tall buildings, building codes, ventilation and architectural aerodynamics.

MODULE 5: FLOW INDUCED VIBRATION (8 LECTURE HOURS)

Vortex shedding, effect of Reynolds number on wake formation in turbulent flows, across wind galloping, wake galloping, along wind galloping of circular cables, oscillation of tall structures and launch vehicles under wind loads, stall flutter.

MODULE 6: WINDTUNNEL TESTING (8 LECTURE HOURS)

Simulation of the Natural wind at small scale, Test Methods to Determine wind loads on the structural systems, Aeroelastic Model Testing, Test Methods to Determine Cladding loads, Other types of wind related study.

References:

1. Gino Sovran, “Aerodynamics Drag Mechanisms of Bluff Bodies and Road Vehicles” Springer;2012
2. Sachs P, “Wind Forces in Engineering:, Pergamon Press,1988
3. Tom Lawson, Building Aerodynamics”, Imperial College Press; first edition, 2001
4. John D.Holmes, “Wind Loading of Structures”, CRC Press, second Edition, 2007
5. Steven R.H, Rex E.B., “Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites”, John Wiley& Sons, 2003.
6. Blevins R.D., “Flow Induced Vibrations”, Van Nostrand, 1990.
7. Wolf-Heinrich Hucho, “Aerodynamics of Road Vehicles. From Fluid Mechanics to Vehicle Engineering” Butterworth-Heinemann Ltd, Year: 1987.
8. Antony Wood, “Wind Tunnel Testing of High-Rise Buildings” Routledge Publisher, 2013.
9. Wind tunnel testing for buildings and other structures : ASCE/SEI 49-12, American Society of Civil Engineers, Year: 2012
10. J. B. Barlow, W. H. Rae, A. Pope, “Low Speed Wind Tunnel Testing”, John Wiley & Sons Publisher, 1999.

18AE2029	COMPOSITE STRUCTURES AND ACOUSTICS	L	T	P	C
		3	0	0	3

Course Objective:

1. To impart basic understanding about Composite Materials
2. To impart the knowledge on composite structures.
3. To impart the knowledge on fundaments of sound

Course Outcome:

After completing the course the student will be able to

1. Identify the composite materials for specific application.
2. Analyse the different Failure modes of Composite Materials.
3. Design the composite structures.
4. Understand the behavior of sound in free fields and Reflection of sound.
5. Obtain knowledge on sound diffraction, refraction, reverberation and diffusion, sound absorption and absorption quantifying methods.
6. Selecting and designing of absorbers.

MODULE 1: INTRODUCTION OF COMPOSITE MATERIALS (9 LECTURES HOURS)

Limitation of conventional Engineering materials, Introduction to composite materials, Role of Matrix and Reinforcements in composites, Different Matrix Materials and Reinforcements, Types of Composites, Composites Verse Traditional Materials. Micromechanical Model for Elastic Properties, Relation of Matrix Element and Engineering Material Constants, Discontinuous Fibers and Whisker Reinforced Polymer Composites, Hybrid Composite, Thermophysical Properties, Tensile Strength, Particulate-Reinforced Composite, True Particulate Composites, Fiber-Rein forced Composites, Laminar composites.

MODULE 2: MECHANICAL BEHAVIOUR OF COMPOSITE MATERIALS (7 LECTURE HOURS)

Constitutive relations for anisotropic materials in liner elasticity: Indices and Tensor notations, Anisotropic Material and constitutive relations, Matrix relation for changes of axis. Orthotropic layer behaviour: Stiffness and compliance matrices and matrix relation for changes of axis, stress and strain matrices. Failure Criteria: Maximum stress theory, Maximum strain theory, Polynomial failure criteria: Tsai-Hill criterion, Tsai-Wu Criterion, Hoffman Criterion. Tensile and shear strength of unidirectional layer, Determination of failure stresses from three tension tests.

MODULE 3: MULTI-LAYER PLATES (7 LECTURE HOURS)

Kirchhoff-Love hypotheses for thin plates, stress-displacement relationships, Global plate equations, Global stiffnesses of a symmetrical composite and asymmetrical laminate, Boundary conditions, Determination of transfer shear stress, Strain energy of the plate.

MODULE 4: FUNDAMENTALS OF SOUND, SOUND IN FREE FILED AND REFLECTION (8 LECTURE HOURS)

Sine wave and Complex wave. Octave and Decibels. Acoustic Power and Sound Intensity. Sound Pressure Level measurement. Sound Divergence, Sound intensity in free field, Sound field in an enclosed spaces, specular reflection, Reflection from concave, convex and parabolic surfaces. Standing waves. Corner reflection.

MODULE 5: DIFFRACTION, REFRACTION, DIFFUSTION AND REVERBERATION (7 LECTURE HOURS)

Wavefront propagation and Diffraction, Diffraction of sound by obstacles, Apertures, Slit and Various objects- Reflection of sound in solid, atmosphere, enclosed space and Ocean. The perfectly diffuse sound field, Evaluation of diffusion in a room, concave surface and convex surface. Growth of sound in room, Decay of sound in room, Reverberation time calculation and measurement.

MODULE 6: ABSORPTION, ABSORTION TESTING AND ABSORBERS (7 LECTURE HOURS)

Dissipation of sound energy, Absorption coefficient - Glass fiber, Insulation materials, effect of thickness and density of Absorbents. Reverberation chamber testing, Impedance Tube testing, Porous absorbers, resonant absorbers, Absorption coefficient, common building materials and absorbers.

Reference:

1. Christian Decolon., "Analysis of Composite Structures" Hermes Penton Ltd,2004.
2. M C Gupta, A P Gupta., " Polymer Composite" Second Edition,New Age International (P) Ltd, 2015.
3. Alton F. Everest, "The Master Handbook of Acoustics", McGraw-Hill Companies publisher, 2002
4. C.T. Herakovich, "Mechanics of Fibrous Composites", John Wiley & Sons, Inc. New York, 1998.
5. R.M. Jones, "Mechanics of Composite Materials", Taylor & Francis, Inc. 1999.
6. B.D. Agarwal and L.J. Broutman, "Analysis and Performance of fiber composites", John-Wiley and Sons, 1990.
7. Autar K. Kaw, Mechanics of Composite Materials, CRC Press LLC, 1997.
8. Carl Q Howard_ Benjamin S Cazzolato, "Acoustic analyses using Matlab and Ansys" - CRC, Taylor and Francis, 2014.
9. Alton F. Everest, "The Master Handbook of Acoustics", McGraw-Hill Companies publisher, 2002.
10. Glen M Ballou, "Handbook for Sound Engineers", Elsevier, Focal Press, 2008. B.D. Agarwal and L.J. Broutman, "Analysis and Performance of Fibre Composites", John Wiley & Sons, Inc. New York.
11. Jerry H. Ginsberg, "Acoustics-A Textbook for Engineers and Physicists, Volume I-Fundamentals", ASA Press, Springer 2018.

12. Jerry H. Ginsberg, “Acoustics-A Textbook for Engineers and Physicists, Volume II – Applications”, ASA Press, Springer 2018

18AE2030	ELEMENTS TO AEROSPACE ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the basic concepts of aircrafts, rockets and their functions.
2. To give an introduction on aerodynamics, aircraft structure and aircraft propulsion.
3. To provide knowledge about the basic parts and their function and construction details of aerospace vehicles.

Course Outcomes:

After completing the course the student will be able to

1. Understand the nature of aerospace technologies.
2. Identify the different types of Aircraft components and their functions.
3. Assess the forces and moments due to flow over the aircraft components.
4. Apply the principles of aerodynamics to different parts of an aeroplane.
5. Evaluate the performance of propulsion system.
6. Apply the knowledge of gravitational law, Kepler’s law and Newton’s law to the space vehicle

MODULE 1: HISTORICAL EVOLUTION AND STANDARD ATMOSPHERE (8 LECTURE HOURS) History of aviation, History and Mission of Indian Space Research Organization, National Aerospace Laboratories(NAL), Gas Turbine Research Establishment (GTRE), Hindustan Aeronautics Limited (HAL)& Defence Research and Development Organisation. Different types of flight vehicles and Classifications, Components of an airplane and their functions, Standard atmosphere-Isothermal layer and gradient layer.

MODULE 2: PRINCIPLES OF FLIGHT (8 LECTURE HOURS) Basic aerodynamics, Aerofoils, wings and their nomenclature; lift, drag and pitching moment coefficients, centre of pressure and aerodynamic centre, NACA airfoil nomenclature.

MODULE 3: AEROSPACE STRUCTURES (8 LECTURE HOURS) General types of construction, Types of structure, typical wing and fuselage structure-monocoque- Semi-monocoque, Honeycomb and Sandwich structure, Aircraft materials.

MODULE 4: PROPULSION SYSTEMS (7 LECTURE HOURS)

Principles of Thrust generation, Reciprocating engine, propeller, turboprop engine, Basic ideas about jet propulsion, Types of jet engines - turbofan and turbojet engines.

MODULE 5: ROCKETS & MISSILES (7 LECTURE HOURS)

Principles of operation of rocket, Rocket engine-specific impulse, Rocket equation, Single and Multi-stage rockets, Types of Rockets, Types of Missiles. Rocket and Missile developed by India.

MODULE 6: SPACE FLIGHT (7 LECTURE HOURS)

Introduction to space mission, Kepler’s, laws, Introduction to earth and planetary entry.

Reference:

1. Anderson, J.D., “Introduction to Flight”, Tata McGraw-Hill, sixth Edition, 2013.
2. Kermode A C., “Mechanics of Flight”, Pearson Education Low Price Edition, 2005.
3. Kermode, A.C., “Flight without Formulae”, McGraw-Hill, 1997.
4. Sutton, G.P. “Rocket Propulsion Elements”, John Wiley.
5. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012.
6. Megson, T.M.G., “Aircraft Structures for Engineering Students”, 2007.
7. Howard D. Curtis, “Orbital Mechanics for Engineering Students”, Elsevier Butterworth-Heinemann, Third Edition, 2010.
8. https://www.hal-india.co.in, https://www.isro.gov.in, https://www.nal.res.in.
9. https://www.ada.gov.in , https://www.drdo.gov.in.
10. https://www.grc.nasa.gov/WWW/K-12/UEET/StudentSite/aeronautics.html.
11. https://en.wikipedia.org/wiki/History_of_aviation.

18AE3031	ROAD VEHICLE AERODYNAMIS	L T P C 3 0 0 0

NOTE: This course is offered to other dept/school students

Course Objectives:

1. To impart information uses of aerodynamics in road vehicle.
2. To familiarize the concept of aerodynamics force influences the road vehicles design.
3. To provide the knowledge on wind tunnel testing for road vehicles.

Course Outcome:

After completing the course the student will be able to

1. Understand the fundamentals of fluid mechanics.
2. Apply the principles of aerodynamics to different ground vehicles.
3. Discuss the behavior of airflow over the bluff body.
4. Explain the flow field over the high performance vehicles.
5. Infer the flow field over commercial vehicle.
6. Select the wind tunnel testing method and measuring technique for road vehicle.

MODULE 1: INTRODUCTION & FUNDAMENTALS OF FLUID MECHANICS (8 LECTURE HOURS)

Introduction: Basic principle, Historical development, Basic shapes, streamlined shapes.

Fluid Mechanics: Properties of incompressible fluids: density, viscosity, thermal conductivity, Flow phenomena related to vehicles: External flow, Internal flow. External flow problem: Basic equations for inviscid incompressible flow, Applications: The two-dimensional flow around a vehicle-shaped body. Effects of viscosity: Laminar and turbulent boundary-layer development, Separation, Friction drag, Pressure drag, Overall forces and moments, Thermal boundary layers, Special Problem: Aerodynamic noise, Aeroelastic effects.

MODULE 2: PERFORMANCE OF CARS AND LIGHT VANS (8 LECTURE HOURS)

Introduction- Resistance to vehicle motion: Equation of resistance to motion, Analysis of the resistances to motion: Aerodynamic drag - Rolling resistance - Climbing resistance - Acceleration resistance. Performance: Motive force diagram- Acceleration time and elasticity - The estimation of fuel consumption: Concept of estimation- The specific fuel consumption map- Gear ratio matching - Driving cycles- Gear change points. Fuel consumption and performance: Comparison of drag and rolling resistance, Top speed, Impact of aerodynamic drag and weight on fuel consumption, Fuel consumption of light vans

MODULE 3: AERODYNAMIC DRAG OF PASSENGER CARS (8 LECTURE HOURS)

The passenger car as a bluff body - Flow field around a passenger car , Analysis of aerodynamic drag, Global considerations, Components of drag- Procedure- Forebody- Windshield, A-pillar- Vehicle rear ends, Sides, Underside, Wheels and wheel wells, Front spoiler, Rear spoiler Attachments, Drag from flow through the car, Trailers and roof luggage racks, Strategies for aerodynamic development of passenger cars- Detail optimization- Shape optimization- Drag reduction in the course of model improvement measures.

MODULE 4: HIGH-PERFORMANCE VEHICLES (7 LECTURE HOURS)

Introduction- Some historical milestones- The influence of aerodynamics on high-performance vehicles- Drag and lift, Handling- Driving tests- Angle of attack and yawed air flow – Draughting - Theoretical investigation - Cooling and ventilation- Design alternatives - Drag and lift.

MODULE 5: COMMERCIAL VEHICLES (7 LECTURE HOURS)

Introduction- Tractive resistance and fuel consumption - Drag reduction and fuel consumption, Aerodynamic drag coefficients of different commercial vehicles- Wind influence—definition of yaw angle- Characterization of air resistance in actual operating conditions. Reducing aerodynamic drag. Drag minimization on trucks, Minimizing drag of buses and delivery vans.

MODULE 6: WIND TUNNELS FOR AUTOMOBILE AERODYNAMICS (7 LECTURE HOURS)

Requirements for a vehicle wind tunnel- Simulation of road driving, Principles of wind tunnel technology, Limitations of simulation, Tests with scale models- Influence of the Reynolds number.

Existing automobile wind tunnels. Measuring equipment and transducers, Pressure measurements, Air flow velocity measurements, Temperature measurement, Measurement of aerodynamic coefficients

References:

1. Gino Sovran, “Aerodynamics Drag Mechanisms of Bluff Bodies and Road Vehicles” Springer, 2012.
2. Wolf-Heinrich Hucho, “Aerodynamics of Road Vehicles. From Fluid Mechanics to Vehicle Engineering” Butterworth-Heinemann Ltd, Year: 1987.
3. Blevins R.D., “Flow Induced Vibrations”, Van Nostrand, 1990.
4. J. B. Barlow, W. H. Rae, A. Pope, “Low Speed Wind Tunnel Testing”, John Wiley & Sons Publisher, 1999.

18AE3032	**WIND TURBIN DESIGN**	**L T P C** **3 0 0 3**

NOTE: This course is offered to other dept/school students

Course Objectives:

1. To impart knowledge on aerodynamics in wind turbine design
2. To familiarize the concept of wind energy system and its applications
3. To provide the knowledge on wind tunnel testing

Course Outcome:

After completing the course the student will be able to

1. Understand the atmospheric impact on wind energy.
2. Understand the basic fluid mechanics influences in wind turbine.
3. Apply the principles of aerodynamics to different aerofoil and blade shape.
4. Asses various wind energy system.
5. Analyse the performance the wind turbine.
6. Design the wind turbine blade.

MODULE 1: ATMOSPHERIC BOUNDARY LAYER (7 LECTURE HOURS)

Atmospheric circulation-local winds – terrain types – mean velocity profiles- power law and logarithmic law, wind speeds, turbulence profiles, Roughness parameters – simulation techniques in wind tunnels

MODULE 2: INTRODUCTION & FUNDAMENTALS OF FLUID MECHANICS (8 LECTURE HOURS)

Introduction: Basic principle, Historical development, Basic shapes, streamlined shapes.

Fluid Mechanics: Properties of incompressible fluids: density, viscosity, thermal conductivity, Flow phenomena related to vehicles: External flow, Internal flow. External flow problem: Basic equations for inviscid incompressible flow, Applications: The two-dimensional flow around a vehicle-shaped body. Effects of viscosity: Laminar and turbulent boundary-layer development, Separation, Friction drag, Pressure drag, Overall forces and moments, Thermal boundary layers, Special Problem: Aerodynamic noise, Aeroelastic effects.

MODULE 3: WIND ENERGY COLLETORS (7 LECTURE HOURS)

Horizontal and vertical axis machines, energy density of different rotors, power coefficient, Betz coefficient by momentum theory.

MODULE 4: SELECTION OF AEROFOIL (8 LECTURE HOURS)

Rotor Aerodynamic Theory: Introduction-Aerodynamic Lift - Power in the Wind -The Actuator Disc Concept-Open Flow Actuator Disc-Actuator Disc in Augmented Flow and Ducted Rotor Systems-Blade Element Momentum Theory -Optimum Rotor Design-Limitations of Actuator Disc and BEM Theory

MODULE 5: DESIGN OF WINDTURBINE BLADE (8 LECTURE HOURS)

Rotor Aerodynamic Design- Optimum Rotors and Solidity-Rotor Solidity and Ideal Variable Speed Operation-Solidity and Loads-Aerofoil Design Development - Sensitivity of Aerodynamic Performance to Planform Shape-Aerofoil Design Specification-Aerofoil Design for Large Rotors

Rotor Structural Interactions -Blade Design in General-Basics of Blade Structure -Simplified Cap Spar Analyses-The Effective t/c Ratio of Aerofoil Sections-Blade Design Studies-Example of a Parametric Analysis - Industrial Blade Technology

MODULE 6: WINDTUNNEL TESTING (7 LECTURE HOURS) Simulation of the Natural wind at small scale, Test Methods to determine wind loads on the wind turbine blade, structural systems, Aeroelastic Model Testing, Test methods to determine force, Moment on each blade, power produced by wind turbine.

References

1. Muyiwa Adaramola, “Wind Turbine Technology: Principles and Design”, Taylor and Francis, CRC Press, 2014.
2. Jamieson, Peter, “Innovation In Wind Turbine Design”, John Wiley, 2018.
3. John D.Holmes, “Wind Loading of Structures”, CRC Press, second Edition, 2007
4. Steven R.H, Rex E.B., “Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites”, John Wiley& Sons, 2003.
5. Blevins R.D., “Flow Induced Vibrations”, Van Nostrand, 1990.
6. P. Brøndsted and R. Nijssen , “Advances in Wind Turbine Blade Design and Materials”, Woodhead Publishing, 2013.
7. Sachs P, “Wind Forces in Engineering:, Pergamon Press,1988

18AE3033	BUILDING AERODYNAMICS	L T P C 3 0 0 0

NOTE: This course is offered to other dept/school students

Course Objectives:

1. To impart information about non-aeronautical uses of aerodynamics, such building aerodynamics
2. To familiarize the concept of influences of Aerodynamics force over building structures.
3. To provide the knowledge on solution of problems in tall building structures

Course Outcome:

After completing the course the student will be able to

1. Understand the airflow over a surface
2. Apply the principles of aerodynamics to different building
3. Predict the behavior of airflow over civil structures
4. Analyse the flow field over long building and other long structures.
5. Estimate the flow induced vibrations the cables and bridges
6. Know the Analyse the flow parameter over building through the wind tunnel testing

MODULE 1: ATMOSPHERIC BOUNDARY LAYER (8 LECTURE HOURS)

Atmospheric circulation-local winds – terrain types – mean velocity profiles- power law and logarithmic law, wind speeds, turbulence profiles, Roughness parameters – simulation techniques in wind tunnels

MODULE 2: INTRODUCTION & FUNDAMENTALS OF FLUID MECHANICS (7 LECTURE HOURS)

Introduction: Basic principle, Historical development, Basic shapes, streamlined shapes.

Fluid Mechanics: Properties of incompressible fluids: density, viscosity, thermal conductivity, Flow phenomena related to vehicles: External flow, Internal flow. External flow problem: Basic equations for inviscid incompressible flow,

MODULE 3: AERODYNAMICS (8 LECTURE HOURS) Aerodynamic forces, effects of viscosity: Laminar and turbulent boundary-layer development, Separation, Friction drag, Pressure drag, overall forces and moments, Thermal boundary layers, Special Problem: Aerodynamic noise, Aeroelastic effects.

MODULE 4: BUILDING AERODYNAMICS (7 LECTURE HOURS)

Pressure distribution on low rise buildings, wind forces on buildings, environmental winds in city blocks, and special problems of tall buildings, building codes, ventilation and architectural aerodynamics.

MODULE 5: FLOW INDUCED VIBRATION (8 LECTURE HOURS)

Vortex shedding, effect of Reynolds number on wake formation in turbulent flows, across wind galloping, wake galloping, along wind galloping of circular cables, oscillation of tall structures and launch vehicles under wind loads, stall flutter.

MODULE 6: WINDTUNNEL TESTING (7 LECTURE HOURS)
Simulation of the Natural wind at small scale, Test methods to determine wind loads on the structural systems, Aeroelastic model testing, Test methods to determine cladding loads, other types of wind related study.

References:

1. Gino Sovran, "Aerodynamics Drag Mechanisms of Bluff Bodies and Road Vehicles" Springer;2012
2. Tom Lawson, Building Aerodynamics", Imperial College Press; first edition, 2001
3. John D. Holmes, "Wind Loading of Structures", CRC Press, second Edition, 2007
4. Steven R.H, Rex E.B., "Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites", John Wiley& Sons, 2003.
5. Blevins R.D., "Flow Induced Vibrations", Van Nostrand, 1990.
6. Wolf-Heinrich Hucho, "Aerodynamics of Road Vehicles. From Fluid Mechanics to Vehicle Engineering" Butterworth-Heinemann Ltd, Year: 1987.
7. Antony Wood, "Wind Tunnel Testing of High-Rise Buildings" Routledge Publisher, 2013.
8. Wind tunnel testing for buildings and other structures : ASCE/SEI 49-12, American Society of Civil Engineers, Year: 2012
9. J. B. Barlow, W. H. Rae, A. Pope, "Low Speed Wind Tunnel Testing", John Wiley & Sons Publisher, 1999.
10. Sachs P, "Wind Forces in Engineering:, Pergamon Press,1988

18AE3034	INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS	L	T	P	C
		3	0	0	3

NOTE: This course is offered to other dept/school students

Course Objective:

1. To incorporate awareness about the basic terminology, models and prototypes of UAV system
2. To impart the knowledge on design considerations of UAV systems
3. To be able to design a UAV system for specific requirements

Course Outcome:

After completing the course the student will be able to

1. Understand the basic terminologies and classification of UAS
2. Relate the design parameters of UAV systems
3. Obtain knowledge on the application of aerodynamic principles to design UAS
4. Understand the principles of communication systems used in UAVs
5. Obtain knowledge on payloads and launch systems for UAS
6. Apply the principles to design UAS for specific applications

MODULE 1: INTRODUCTION TO UAS (8 LECTURE HOURS) Introduction to Unmanned Aircraft Systems (UAS) – Systematic basis of UAS – System composition - Categories and Roles – Elements of UAS – Unmanned Aircraft system operations

MODULE 2: DESIGN OF UAV SYSTEMS (8 LECTURE HOURS) Design and selection of UAS – Aerodynamics and airframe configurations – Aspects of airframe design - Unmanned Aircraft characteristics – Long range, Medium and Close range UAVs – Mini, Micro and Nano UAVs – Novel hybrid combinations

MODULE 3: UAV STANDARDS (7 LECTURE HOURS) Unmanned Design standards and Regulatory aspects – Airframe design – Ancillary equipment – Design of Stealth

MODULE 4: UAV PAYLOADS (7 LECTURE HOURS)
Sensors and payloads – payload types – Communications, Control and stability, Navigation – Launch and recovery

MODULE 5: UAV TESTING (7 LECTURE HOURS) Certification and ground testing – inflight testing - Human factors in UAS – Future of UAS and challenges,

MODULE 5: ROLE OF UAV (8 LECTURE HOURS)
Launch of HTOL & VTOL systems – recovery of HTOL & VTOL systems - Naval roles – Army roles – Civilian roles – paramedical and commercial roles – commercial applications

References:

1. Reg Austin, “Unmanned Aircraft Systems: UAVS Design Development and Deployment”, First edition, John Wiley and Sons, 2010.
2. Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, “Introduction to Unmanned Aircraft systems”, CRC press, Taylor and Francis, New York, 2012. Richard Microcontroller Systems for a UAV, A. Skafidas, 2002.
3. Paul.G.Fahlstrom, Thomas.J.Gleason Introduction to UAV systems, UAV SYSTEMS, Ins.. 2013.
4. Armand.J. Chaput, “Design of UAV Systems” , Lockheed Martin Aeronautics Company, 2001.

18AE3035	FOUNDATIONS OF SPACE ENGINEERING	L T P C 3 0 0 3

NOTE: This course is offered to other dept/school students

Course objective:

1. To impart the knowledge on coordinate systems used in astronautics.
2. To impart fundamental knowledge on rocket and spacecraft trajectories .
3. To impart a basic knowledge of space environment.

Course outcome:

After completing the course the student will be able to

1. Understand the most common coordinate system used in astronautics: inertial vs. body-fixed frames.
2. Transform between these systems using rotational matrices.
3. Understand the fundamental principles of orbital motion.
4. Perceive the design of trajectories in the atmosphere and space.
5. Attain a general knowledge on the composition of space environment.
6. Attain knowledge of space debris.

MODULE 1 - MATHEMATICAL FUNDAMENTALS (8 LECTURES)

Vectors and scalars, Dot and cross product of vectors, Derivative of a vector function, Gradient, Integral of a vector function, Plane motion – radial and transverse components, tangential and normal components, Spherical trigonometry laws and applications.

MODULE 2- PHYSICAL PRINCIPLES AND TIME MEASURES (8 LECTURES)

Kepler’s laws, Newton’s laws, Work and energy, Force and momentum, Impulse and momentum, Law of conservation of total energy, Angular momentum, Universal time, Dynamical time, Julian date, Solar and sidereal days.

MODULE 3- COORDINATE SYSTEMS AND TRANSFORMATION (8 LECTURES)

Two and three dimensional coordinate systems, Polar and Cartesian coordinates, Spherical polar coordinates, Inertial and body-fixed coordinate systems, Rotation and rotation matrices, Two and three dimensional rotation, Three-angle sets for specifying orientation: Roll-pitch-yaw, Euler angles, Euler parameters.

MODULE 4- INTRODUCTION TO ATMOSPHERIC AND SPACECRAFT TRAJECTORY (8 LECTURES) Rocket equation, Staging, Central force motion, Newtonian gravitation, Properties of conic sections, Escape velocity, Two-body motion: energy and velocity on orbit, Classical orbital elements, Velocity azimuth and flight path angle.

MODULE 5 - INTRODUCTION TO SPACE ENVIRONMENT (6 LECTURES)

Sun and solar wind, Earth's atmosphere, Ionosphere and communications, Geomagnetic field, Micro-meteoroids.

MODULE 6- SPACE DEBRIS (7 LECTURES) Introduction to space debris, Space debris environment in low earth orbit, Debris measurements, Space debris environment in geosynchronous equatorial orbit, Spatial density, Collision hazards associated with orbit operations.

References:

1. Gerald R. Hintz, “Orbital Mechanics and Astrodynamics – Techniques and tools for space missions”, Springer, First edition, 2015

2. William T. Thomson, “Introduction to Space Dynamics”, Dover Publications, 2000
3. William E. Wiesel, “Spaceflight Dynamics”, Aphelion Press, USA, Third Edition, 2010 2. David A. Vallado,”Fundamentals of Astrodynamics and Applications”, Microcosm and Kluwer , Second Edition, 2004
4. Jerry Jon Sellers, Understanding Space: An Introduction to Astronautics, 3rd ed. McGraw-Hill, 2005.
5. John E. Prussing, Bruce A. Conway, Orbital Mechanics, 2nd ed. Oxford University Press, 2012.
6. J.W.Cornelisse, H.F.R. Schoyer, and K.F. Wakker, ”Rocket Propulsion and Spaceflight Dynamics”, Pitman, 2001
7. Alan C. Tribble, “The Space Environment: Implications for Spacecraft Design”, Princeton University Press, 2003.
8. J.R.Wertz, D.F.Everett, and J J. Puschell, “Space Mission Engineering: The New SMAD”, Microcosm Press, 2011.
9. V. A. Chobotarev, “ Orbital Mechanics, Third Edition, AIAA Educational Series, Reston, Virginia, 2002.

19AE1001	FUNDAMENTALS OF SPACE SCIENCE	L	T	P	C
		3	0	0	3

Course objective:

1. To impart the knowledge of universe used in astronautics.
2. To impart fundamental knowledge on solar system and orbits.
3. To impart a basic knowledge of Indian space program.

Course outcome:

After completing the course the student will be able to:

1. Understand the structure of universe used in astronautics.
2. Understand the structure of the solar system used in astronautics.
3. Understand the fundamental principles of coordinate and time-keeping systems.
4. To understand the different kind of orbits-elliptic, parabolic and hyperbolic.
5. Attain knowledge of space debris.
6. Attain knowledge of Indian Space Programme.

MODULE 1 – THE ASTRONOMICAL BACKGROUND (8 LECTURES)

The fundamental law of celestial mechanics, Solar system, Sun, Various bodies that travel in orbits around the Sun, Star, Important properties of the planets, Superior and inferior planets, Asteroids, Comets, Meteors, Edgeworth-Kuiper belt, Conjunctions- inferior – superior, Stellar motions, Binary systems, Triple and higher systems of stars, Globular clusters, Galactic and open clusters, Clusters of Galaxies.

MODULE 2 - STRUCTURE OF THE SOLAR SYSTEM (8 LECTURES)

Introduction, Circular and elliptic orbits, orbital period, mean motion, semi-major-axis, eccentricity, Kepler’s laws of planetary motion, Newton’s universal law of gravitation, The Titius-Bode law, resonance, Resonance in the Solar System, Commensurability, Commensurabilities in mean motion, Recent developments.

MODULE 3 - COORDINATE AND TIME-KEEPING SYSTEMS (7 LECTURES)

Introduction, Position on the Earth’s Surface – latitude, longitude, poles, Greenwich, Geocentric and geodetic latitudes, ellipticity, The Horizontal System, The Equatorial System, The Ecliptic System, Sidereal time, Mean solar time, The Julian date, Ephemeris Time.

MODULE 4 - THE TWO-BODY PROBLEM (8 LECTURES)

Newton’s Laws of Motion, The mean, eccentric and true anomalies, Kepler’s equation; The Elliptic Orbit, Velocity in an elliptic orbit, The Parabolic Orbit; The Hyperbolic Orbit, Velocity in a hyperbolic orbit; Classification of Orbits with respect to the Energy Constant.

MODULE 5 – SPACE DEBRIS (7 LECTURES)

Introduction to space debris, Space debris environment in low earth orbit, Debris measurements, Space debris environment in geosynchronous equatorial orbit, Spatial density, Collision hazards associated with orbit operations.

MODULE 6- INDIAN SPACE MISSIONS (7 LECTURES)
Introduction, about Indian Space Programme, ISRO, Different ISRO Centres, Initial progress made by India in space activities, Different missions by ISRO- SLV-3, ASLV, PSLV, CHADRAYAAN -1 and 2, MARS Mission- MANGALYAAN. Future missions.

References:

1. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics – Techniques and tools for space missions", Springer, First edition, 2015
2. A. E. Roy, "Orbital Motion", Fourth Edition, Routledge; 2005.
3. J. M. A. Danby, Fundamentals of Celestial Mechanics, Willmann-Bell, Inc., USA, 2003.
4. .David A. Vallado, "Fundamentals of Astrodynamics and Applications", Microcosm and Kluwer , Second Edition, 2004.
5. Jerry Jon Sellers, "Understanding Space: An Introduction to Astronautics", 3rd ed. McGraw-Hill, 2005.
6. John E. Prussing, Bruce A. Conway, Orbital Mechanics, 2nd ed. Oxford University Press, 2012.
7. V. A. Chobotarev, "Orbital Mechanics", Third Edition, AIAA Educational Series, Reston, Virginia, 2002.
8. "About ISRO – Future Programme". Indian Space Research Organisation, September 2014.

19AE2001	FLIGHT STABILITY AND AEROMODELLING LABORATORY	L	T	P	C
		0	0	2	1

Co-requisite: 18AE2019 Aircraft Stability and Control

Course Objectives:

1. To introduce the concept of Stability and control of Aircraft.
2. To impart knowledge about various Aircraft motions and related stability.
3. To introduce the concept of dynamic stability of Aircraft.

Course Outcomes:

After completing the course the student will be able to

1. Understand the degree of freedom of aircraft system.
2. Analyse the static stability behaviour of the aircraft.
3. Understand the dynamic longitudinal stability of aircraft.
4. Calculate the center of gravity of an aircraft.
5. Calibration of control surface movement of an aircraft.
6. Design the Paper planes, Glider.

List of Experiments:

Paper Plane

1. Modelling and Testing of Paper Planes

RC Controlled Glider

2. Modelling and Testing of Unpowered Glider
3. Modelling and Testing of Powered Glider
4. Calibration of Remote Control system.

Cessna Aircraft

5. Aircraft "Jacking" procedure
6. Aircraft "Leveling" procedure
7. Calculation of Weight and CG location of the Cessna 152 Aircraft
8. Calibration of Aileron of the Cessna 152 Aircraft.
9. Calibration of Elevator of the Cessna 152 Aircraft.

Aerodynamics and Stability Analysis of low Reynold's number using XFLR 5 Software (open Source).

10. Modelling low Reynold's number aircraft using XFLR 5.
11. Aerodynamics Analysis of low Reynold's number using XFLR 5.
12. Stability Analysis of low Reynold's number using XFLR 5.

References:

1. Perkins, C D and Hage, R E; "Airplane Performance Stability and Control", Willey Toppan, 2010.
2. U.S. Department of Transportation, FAA, "Airframe and Powerplant Mechanics (AC-65-9A) General Handbook" Ninth Indian reprint, Shroff Publisher & Distributors PVT.LTD. 2009.
3. U.S. Department of Transportation, FAA, "Airframe and Powerplant Mechanics (AC-65-15A) Airframe Handbook" Ninth Indian reprint, Shroff Publisher & Distributors PVT.LTD. 2009.
4. Techwinder, "XFLR5 is an analysis tool for airfoils, wings and planes" http://www.xflr5.com, https://sourceforge.net/projects/xflr5/.
5. Woodroffe, David, "The Complete Paper Aeroplane Book", Constable, 2013.

The faculty conducting the Laboratory will prepare a list of 6 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

AEROSPACE ENGINEERING

LIST OF COURSES

Sl.No	Code No.	Name of the Course	L	T	P	Credits
1	18AE2001	Introduction to Aerospace Engineering	3	0	0	3
2	18AE2002	Aerospace Materials and Processes	3	0	0	3
3	18AE2003	Basic of Fluid Mechanics	3	0	0	3
4	18AE2004	Fluid Mechanics Laboratory	0	0	2	1
5	18AE2005	Strength of Materials	3	0	0	3
6	18AE2006	Strength of Materials Laboratory	0	0	2	1
7	18AE2007	Thermodynamics	3	0	0	3
8	18AE2008	Thermodynamics Laboratory	0	0	2	1
9	18AE2009	Aerodynamics	3	0	0	3
10	18AE2010	Aerospace Structures-I	3	0	0	3
11	18AE2011	Propulsion-I	3	0	0	3
12	18AE2012	Propulsion Laboratory	0	0	3	1.5
13	18AE2013	Airplane performance	3	0	0	3
14	18AE2014	Gas dynamics	3	0	0	3
15	18AE2015	Aerodynamics Laboratory	0	0	3	1.5
16	18AE2016	Aerospace Structures-II	3	0	0	3
17	18AE2017	Aerospace Structures Laboratory	0	0	3	1.5
18	18AE2018	Propulsion-II	3	0	0	3
19	18AE2019	Aircraft Stability and Control	3	0	0	3
20	18AE2020	Flight Stability and Aeromodelling Laboratory	0	0	2	1
21	18AE2021	CAD/CAM Laboratory	0	0	3	1.5
22	18AE2022	Aircraft Instrumentation & Avionics	3	0	0	3
23	18AE2023	Space Dynamics	3	0	0	3
24	18AE2024	Aircraft Design Project	0	0	4	2

18AE2001	INTRODUCTION TO AEROSPACE ENGINEERING	L T P C 3 0 0 3

Course Objectives:

1. To introduce the basic concepts of aircrafts, rockets and their functions.
2. To give an introduction on aerodynamics, aircraft structure and aircraft propulsion.
3. To provide knowledge about the basic parts and their function and construction details of aerospace vehicles.

Course Outcomes:

After completing the course the student will be able to

1. Understand the nature of aerospace technologies.
2. Identify the different types of Aircraft components and their functions.
3. Assess the forces and moments due to flow over the aircraft components.
4. Apply the principles of aerodynamics to different parts of an aeroplane.
5. Evaluate the performance of propulsion system.
6. Apply the knowledge of gravitational law, Kepler's law and Newton's law to the space vehicle

MODULE 1: HISTORICAL EVOLUTION AND STANDARD ATMOSPHERE (8 LECTURE HOURS)

History of aviation, History and Mission of Indian Space Research Organization, National Aerospace Laboratories(NAL), Gas Turbine Research Establishment (GTRE), Hindustan Aeronautics Limited (HAL)& Defence Research and Development Organisation. Different types of flight vehicles and Classifications, Components of an airplane and their functions, Standard atmosphere-Isothermal layer and gradient layer.

MODULE 2: PRINCIPLES OF FLIGHT (8 LECTURE HOURS)

Basic aerodynamics, Aerofoils, wings and their nomenclature; lift, drag and pitching moment coefficients, centre of pressure and aerodynamic centre, NACA airfoil nomenclature.

MODULE 3: AEROSPACE STRUCTURES (8 LECTURE HOURS)

General types of construction, Types of structure, typical wing and fuselage structure-monocoque-Semi-monocoque, Honeycomb and Sandwich structure, Aircraft materials.

MODULE 4: PROPULSION SYSTEMS (7 LECTURE HOURS)

Principles of Thrust generation, Reciprocating engine, propeller, turboprop engine, Basic ideas about jet propulsion, Types of jet engines - turbofan and turbojet engines.

MODULE 5: ROCKETS & MISSILES (7 LECTURE HOURS)

Principles of operation of rocket, Rocket engine-specific impulse, Rocket equation, Single and Multi-stage rockets, Types of Rockets, Types of Missiles. Rocket and Missile developed by India.

MODULE 6: SPACE FLIGHT (7 LECTURE HOURS)

Introduction to space mission, Kepler's, laws, Introduction to earth and planetary entry.

Text Books:

1. Anderson, J.D., "Introduction to Flight", Tata McGraw-Hill, sixth Edition, 2013
2. Kermode A C., "Mechanics of Flight", Pearson Education Low Price Edition, 2005.

Reference:

1. Kermode, A.C., "Flight without Formulae", McGraw-Hill, 1997.
2. Sutton, G.P. "Rocket Propulsion Elements", John Wiley,
3. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012
4. Megson, T.M.G., "Aircraft Structures for Engineering Students", 2007
5. Howard D. Curtis, "Orbital Mechanics for Engineering Students", Elsevier Butterworth-Heinemann, Third Edition, 2010.
6. https://www.hal-india.co.in, https://www.isro.gov.in, https://www.nal.res.in, https://www.ada.gov.in , https://www.drdo.gov.in
7. https://www.grc.nasa.gov/WWW/K-12/UEET/StudentSite/aeronautics.html
8. https://en.wikipedia.org/wiki/History_of_aviation

18AE2002	AEROSPACE MATERIALS AND PROCESSES	L T P C 3 0 0 3

Course Objectives:

1. To impart the knowledge on crystal structure and microstructures of metals and alloys
2. To impart the knowledge on Aerospace Materials properties
3. To impart the knowledge on Material Characterisation

Course Outcomes:

After completing the course the student will be able to

1. Explain how the mechanical properties of metals and alloys are influenced by their microstructure
2. Understand the material properties
3. Classify the different materials
4. Choose the manufacturing methods
5. Identify the testing method of materials
6. Select the right material for a particular application
7. Develop new material combination based on requirement

MODULE 1: THE STRUCTURE OF METALS AND ALLOYS & PHASE DIAGRAMS. (8 LECTURE HOURS)

Introduction, Nature of metallic bonding, Crystal structures of metals-Body centred cubic (BCC) crystal, Face centred cubic (FCC) crystal and Hexagonal close packed (HCP) crystal, structure of alloys, Imperfections in crystals, experimental study of structure. **Phase Diagrams:** The Phase rule, Binary phase diagrams, Free energy composition curves for binary systems, Microstructural changes during cooling, The Iron Carbon Equilibrium diagram, Effect of alloying elements on the Fe-C diagram, The Copper-Zinc Phase diagram.

MODULE 2: TESTING OF AIRCRAFT MATERIALS (7 LECTURE HOURS)

Basics terms: Hardness; Brittleness; Malleability; Ductility; Elasticity, Density Fusibility; Conductivity; Contraction and Expansion. *Heat-treatment Terms:* Critical Range, Annealing; Normalizing; Heat Treatment; Hardening; Quenching, Tempering'; Carburizing; Casehardening. *Physical-test Terms:* Strain; Stress; Tensile Strength; Elastic Limit; Proportional Limit; Proof Stress; Yield Strength: Yield Point; Elongation (Percentage); Reduction of Area (Percentage); Modulus of Elasticity. **Testing**: Tension Testing, Hardness Testing Bending Tests, Reverse Bend Test, Flattening Test, Impact Tests: Crushing Tests, Hydrostatic Test, Torsion Test, Fatigue Testing, Inspection Methods: NDT. ASTM. Standards for testing materials.

MODULE 3: STEEL AND ITS ALLOYS (8 LECTURE HOURS)

Plain Carbon Steels, Alloy Steels, Effect of Individual Elements: Carbon; Manganese; Silicon, Sulphur; Phosphorus; Nickel; Chromium; Molybdenum; Vanadium; Tungsten; Titanium, S.A.E. Steel Numbering System, Air Force-Navy Aeronautical Specifications, Military specifications. Carbon Steels, Nickel Steels, Nickel-chromium Steels, Molybdenum Steels, Chrome-vanadium Steels, Special Steels: Silicon-chromium Steel; Nitriding Steel; Austenitic Manganese Steel. Heat Treatment of Steel.

MODULE 4: NICKEL, COPPER AND ITS ALLOYS (8 LECTURE HOURS)

Inconel, Monet, K Monet: Chemical Properties; Physical Properties; Annealing and Stress Relieving; Working Properties; Welding; Soldering and Brazing; Corrosion Resistance: Available Shapes; Uses, Specifications. **Copper:** Copper Tubing; Copper-Silicon-Bronze Tubing; Copper Wire; Beryllium Copper. **Brass:** Muntz Metal; Manganese Bronze (Brass); Hy-Ten-SI Bronze; Naval Brass (Tobin Bronze); Red Brass. **Bronze:** Gun Metal; Phosphor Bronze; Phosphor Bronze Casting Alloy; Aluminum Bronze; Aluminum Bronze Casting Alloy; Bronze Cable, Season Cracking. **Pure Magnesium**: Production Methods; Physical Properties,

MODULE 5: MAGNES1UM, TITANIUM AND ITS ALLOYS (7 LECTURE HOURS)

Magnesium Alloys: Chemical Composition, Magnesium-alloy. Wrought Magnesium Alloys: Extrusions; Forgings; Sheet, Plate, Strip Shop Fabrication Processes: Machining; Shearing. **Titanium:** Physical Properties: Metallurgy; Chemical Composition; Specifications; Mechanical Properties; Elevated Temperature. Shape memory alloys.

MODULE 6: WROUGHT ALUMINUM ALLOYS (7 LECTURE HOURS)

Nomenclature, Classification of Wrought Alloys, Corrosion, Alclad Aluminum Alloys, Extrusions, Forgings, Spot-welding Aluminum Alloys, Heat Treatment: Heat Treatment of Aluminum-Alloys, **Aluminum-Alloy Castings:** Sand Casting: Applications. Permanent-mold Castings: Applications. Die Casting. Design of Castings: Heat-treated Castings.

Text Book:

1. Raghavan, V., Physical Metallurgy: Principles and Practice I. PHI Learning, 2015.
2. George F. Titterton, Aircraft Materials and Processes, Himalayan Books, reprinted 2015.

References:

1. Cantor, B., Assender, H., and Grant, P. (Eds.), Aerospace Materials, CRC Press 2001.
2. Reed, R. C., The Superalloys: Fundamentals and Applications, Cambridge Univ. Press 2006.
3. ASM Speciality Handbook: Heat Resistant Materials, ASM International (1997).
4. Campbell, F. C., Manufacturing Technology for Aerospace Structural Materials, Elsevier 2006.
5. Kainer, K. U. (Ed.), Metal Matrix Composites, Wiley-VCH 2006.
6. https://www.astm.org/Standards/aerospace-material-standards.html

18AE2003	BASICS OF FLUID MECHANICS	L T P C 3 0 0 3

Course Objectives:

1. To introduce the basic concepts of fluid statics
2. To provide knowledge of basic laws governing fluid motion and its application
3. To introduce the concept of basic airflow

Course Outcomes:

After completing the course the student will be able to

1. Know the properties of different fluids and pressure measurements
2. Apply mathematical knowledge to predict the properties and characteristics of a fluid.
3. Understand the nature of buoyancy of submerged and floating bodies
4. Attain the Knowledge of flow measurement systems
5. Estimate the friction factor of pipe flow and losses associated it
6. Get knowledge of the non-dimensional parameters used in airflow.

MODULE 1: BASICS OF FLUID FLOW (8 LECTURE HOURS)

Definition of a fluid – Continuum hypothesis – Fluid properties - Pressure, Temperature, Density, Viscosity - stress-strain rate relationship, Measurement of pressure –Fluid statics – Total and Centre of pressure of submerged surfaces-Stability of submerged and floating bodies.

MODULE 2: BASIC EQUATIONS (8 LECTURE HOURS)

Motion of a fluid particle – Types of flow-Continuity equation-Velocity and acceleration-velocity potential and stream function- Path lines, Stream lines and Streak lines,-Fluid deformation– Rotation-Vorticity, Elementary flows- Uniform flow, Source flow, Sink flow, Doublet flow, Vortex flow, Super imposed flows- Semi-Infinite Body, Rankine Body.

MODULE 3: INCOMPRESSIBLE INVISCID FLOW (8 LECTURE HOURS)

Equations of motion-Euler's equation of motion- Energy equation-Momentum equation – Bernoulli's equation and its Applications — Flow measurement – Orifice meter – Venturimeter- Pitot tube.

MODULE 4: INCOMPRESSIBLE VISCOUS FLOW(7 LECTURE HOURS)

D' Alembert's Paradox, Viscous stress-strain rate relationship, Flow of viscous fluid through circular pipes – Velocity profiles – Frictional loss in pipe flow-Calculation of minor and major energy losses in pipes.

MODULE 5: DIMENSIONAL ANALYSIS (7 LECTURE HOURS)

Dimensional analysis – The Buckingham-Pi theorem – Nondimensional numbers-Mach Number, Reynolds Number, Strouhal Number, Knudsen Number, etc.,

MODULE 6: IMPACT OF JETS (7 LECTURE HOURS)

Impact of jets –Force exerted by a jet on stationary and moving vertical, horizontal and inclined plates.

Text Books:

1. Rathakrishnan.E, "Fundamentals of Fluid Mechanics", Prentice-Hall, 2007
2. White F.M., "Fluid Mechanics", 7th Edition, Tata McGraw-Hill Education, 2011

References:

1. Robert W Fox & Alan T Mc.Donald, "Introduction to fluid Mechanics", John Wiley and Sons,1995
2. Kuethe, A.M. and Chow, C.Y., "Foundations of Aerodynamics", First Indian Reprint, John Wiley & Sons, 2010.
3. Yuan S W, "Foundations of fluid Mechanics", Prentice-Hall, 1987
4. Graebel, W.P. "Engineering Fluid Mechanics" Taylor and Francis, 2001
5. Fluid Mechanics : http://nptel.ac.in/courses/112105171/
6. Fluid Mechanics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-01-unified-engineering-i-ii-iii-iv-fall-2005-spring-2006/fluid-mechanics/

18AE2004	FLUID MECHANICS LABORATORY	L T P C 0 0 2 1

Co- requisite: 18AE2003 Basics of Fluid Mechanics

Course Objectives:

1. To give hands on training on principle and working of different flow measuring instruments
2. To impart knowledge on working of different types of turbines.
3. To demonstrate energy losses in pipe connections

Course Outcomes:

After completing the course the student will be able to

1. Recall the principles of instruments used in flow related measurements
2. Describe the flow measurement methods
3. Demonstrate energy losses in pipe connections
4. Appraise the flow measurement techniques
5. Select flow measuring techniques.
6. Investigate the operation of flow measuring instruments

List of Experiments

1. Determination of Darcy's Friction Factor.
2. Calibration of Flow Meters.
3. Flow over weirs / Notches.
4. Flow through Mouth piece / orifice.
5. Determination of Minor Losses in pipes
6. Determination of Manning's Co-efficient of Roughness.
7. Calibration of pressure Gauges.
8. Impact of jet on vanes.
9. Reynolds' Experiment.

NOTE: The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

18AE2005	STRENGTH OF MATERIALS	L T P C 3 0 0 3

Course Objectives:

1. To provide an understanding the concepts of stress and strain, Shear force and Bending moment
2. To provide knowledge regarding the methods of determining the deflections of beams and Torsion of shaft
3. To impart basic knowledge about Joints and springs

Course Outcome:

After completing the course the student will be able to

1. Understand the basic material behaviour like elasticity, plasticity etc.
2. Draw the shear force and bending moment diagram for different loading of beams
3. Predict the deflection of beams under bending loads
4. Arrive at the methods to solve torsional problems
5. Analysis of a spring under different load condition
6. Identify the structural Joints for Aircraft repair in different applications

MODULE 1: STRESSES AND STRAINS (7 LECTURE HOURS)

Introduction, types of structures, Elasticity, Plasticity, loads and stresses , Hooke's law, stress-strain curve, Analysis of bars of varying sections, Analysis of bars of composite sections, thermal stresses, thermal stresses in composite bars, elastic constants ; Principle planes and stresses, Analytical and graphical methods for determining stresses on oblique section.

MODULE 2: SHEAR FORCE AND BENDING MOMENT DIAGRAM (10 LECTURE HOURS)

Types of beams, important points for drawing shear force and bending moment diagram, Shear force and bending moment for different beams carrying point load, uniformly distributed load, gradually varying loads and combinations of these at different sections of the beam.

MODULE 3: DEFLECTION OF BEAMS (10 LECTURE HOURS)
Simple bending, Theory of simple bending, Expression for bending stress, bending stress in symmetrical section, Relation between deflection, slope and radius of curvature, Methods for determining deflection- Double integration method, Macaulay's method and Moment Area method.
MODULE 4: TORSION OF SHAFTS (7 LECTURE HOURS)
Shear stress produced in a shaft subjected to torsion, torque and power transmitted by a solid and circular shaft, Strength of a shaft and Polar moment of inertia, Torque in terms of polar moment of inertia, strength of a shaft of varying sections and composite shaft, combined bending and torsion, strain energy stored in a body due to torsion.
MODULE 5: SPRINGS & JOINTS (7 LECTURE HOURS)
Stiffness of a spring, Types of spring, Closely-coiled Helical Springs- Axial load- Axial twist, Open coiled helical spring, Torsion spring – Problems. Types of Structural joints, bonded joints, Bolted joints- Riveted Joints, Aircraft Structural Repair Joints.
MODULE 6: THEORIES OF FAILURE (4 LECTURE HOURS)
Introduction, Maximum principal stress theory, Maximum principal strain theory, Maximum shear stress theory, Maximum strain energy theory, Maximum shear strain energy theory.

Text Books:

1. Stephen Timoshenko, "Strength of Materials: Elementary Theory and Problems", 3rd edition, CBS Publishers &Distributors PVT.LTD.
2. James M. Gere, Barry J. Goodno, "Mechanics of Materials", 8th edition, Cengage Learning, 2007

References:

1. Rajput R K, "Strength of Materials", S Chand & Co Ltd, New Delhi, 2006
2. Sun C T, " Mechanics of Aircraft Structures", Wiley, India, 2010
3. Dr Sadhu Singh, "A Textbook on Strength of Materials", Khanna Publishers Pvt. Ltd**,** New Delhi , 2013
4. Bansal R K., "Strength of Materials", Laxmi Publishing Co, New Delhi, 2007
5. Ramamurtham.S. "Strength of Materials" Dhanpat Rai Publishing Co, New Delhi, 2008.
6. http://nptel.ac.in/courses/Webcourse-contents/IIT-ROORKEE/strength%20of%20materials/homepage.htm

18AE2006	**STRENGTH OF MATERIALS LABORATORY**	**L T P C** **0 0 2 1**

Co- requisite: 18AE2005 Strength of Materials

Course Objective
1. To apply the theory of structural mechanics on real specimens
2. To give hands on training on testing of real specimens
3. To provide knowledge in failure of material

Course Outcome
After completing the course the student will be able to
1. Determine the important mechanical properties of materials
2. Identify the materials behavior
3. Verify the theorems studied in structural mechanics
4. Understand the structural behavior based on various loads, supports and shape
5. Estimate stiffness of springs
6. Choose material based on requirement

Experiments
1. Tensile Test of solid rod using Universal Testing Machine
2. Verification of Maxwell Theorem on Cantilever Beam
3. Verification of Maxwell Theorem on Simply Supported Beam
4. Torsion Test of shaft and Beam
5. Rockwell's Hardness Test
6. Brinell's Hardness Test

7. Vickers Hardness Test
8. Charpy’s Impact test
9. Izod Impact Test
10. Compression of open coil helical spring

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

Reference:

1. Jindal, U.C, “Strength of Materials”, Asian Books Pvt. Ltd, 2007

18AE2007	THERMODYNAMICS	L T P C 3 0 0 3

Course Objectives:

The objectives of this course are to make students to learn:

1. To impart the knowledge of work, heat, and laws of thermodynamics.
2. To impart the knowledge of the concept of entropy and exergy
3. To impart the knowledge of the working of gas turbine cycles

Course Outcomes:

After completing the course the student will be able to

1. Define fundamental thermodynamic laws and concepts, work, various types of works and heat and its applications,
2. Explain Zeroth, First & Second law of thermodynamics and its applications.
3. Explain entropy and Exergy in thermodynamic systems
4. Calculate the performance of various gas power cycles.
5. Explain the principles of combustion in engines
6. Explain the selection of air conditioning system; evaluate thermal performance of refrigeration cycles.

MODULE 1: FUNDAMENTALS OF THERMODYNAMICS (9 LECTURES HOURS)

Thermodynamic definition and scope, Microscopic and Macroscopic approaches. Thermodynamic properties; definition and units, intensive, extensive properties, specific properties, pressure, specific volume, Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium,

Work and Heat: Thermodynamic definition of work; examples, sign convention, Shaft work; Electrical work. Other types of work. Heat; definition, units and sign convention.

MODULE 2: THERMODYNAMIC LAWS (8 LECTURE HOURS)

Laws of Thermodynamics Zeroth law of thermodynamics, Temperature; concepts, scales, -thermometer - Joules experiments, Statement of the First law of thermodynamics, steady state-steady flow energy equation, applications, analysis of unsteady processes. Keivin –Planck & Clausius statement of Second law of Thermodynamics, PMM I and PMM II. Clausius Theorem & inequality, Available and unavailable energy.

MODULE 3: ENTROPY (7 LECTURE HOURS)

Entropy : Increase of Entropy principle – Entropy change in Pure substances – Isentropic Processes – Property diagrams – Entropy change of liquids and solids - Ideal gases and Entropy change – Isentropic efficiencies of steady flow devices – Entropy Balance.

MODULE 4: GASES AND GAS MIXTURES (7 LECTURE HOURS)

Avogadro’s law – equation of state of a gas – Ideal gas – Equations of state – virial expansions – law of corresponding states – Properties of mixtures – Law of partial pressures – Properties of gas mixtures

MODULE 5: COMBUSTION THERMODYNAMICS AND GAS POWER CYCLES (7 LECTURE HOURS)

Fuels and combustion – Theoretical and Actual combustion – Enthalpy of formation and combustion – Adiabatic flame temperature. **Gas power cycles** : Basic considerations – Carnot cycle – Air standard cycles and assumptions – Otto cycle – Diesel Cycle – Brayton cycle – with regeneration – with inter cooling, reheat and regeneration – ideal jet propulsion cycles

MODULE 6: REFRIGERATION AND PSYCHROMETRY (7 LECTURE HOURS)

Refrigeration: Vapour absorption refrigeration system, vapor compression refrigeration system; description, analysis, refrigerating effect, capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties. **Psychrometry:** Dry bulb temperature, wet bulb temperature, dew point temperature; specific and relative humidity - psychrometric processes; heating, cooling, dehumidifying and humidifying. Adiabatic mixing of moist air. Summer and winter air conditioning.

Text Books:

1. Nag. P. K, Engineering Thermodynamics, Tata McGraw Hill Pub. 5th Edition, 2013.
2. Yunus, A. Cenegal and Michael A.Boies, Thermodynamics: An engineering approach, Tata MacGraw Hill publishing company, Seventh Edition 2011.

References:

1. Holman J. P, Thermodynamics, McGraw Hill, Fifth edition, 2007
2. Rathakrishnan.E, Fundamentals of Engineering Thermodynamics, Prentice-Hall, India, 2005.
3. Arora C. P, Thermodynamics, McGraw Hill, 2003.
4. Ramalingam K K, Thermodynamics, Sci-Tech Publications, 2006.
5. Van Wylen G J and R.E. Sontang, Fundamental of Classical Thermodynamics, Wiley eastern, third edition, 1985.
6. Basic Thermodynamics: http://nptel.ac.in/courses/112105123/
7. https://www.grc.nasa.gov/WWW/K-12/airplane/thermo.html
8. https://www.edx.org/course/thermodynamics-iitbombayx-me209-1x-1
9. Combustion: http://nptel.ac.in/courses/101106037/

18AE2008	THERMODYNAMICS LABORATORY	L T P C 0 0 2 1

Co-requisite: 18AE2007 Thermodynamics

Course Objectives:

1. To impart the knowledge of laws of thermodynamics
2. To give hands on training to Estimate the performance of thermodynamics system
3. To impart knowledge on working of IC Engines.

Course Outcomes:

After completing the course the student will be able to

1. Estimate the performance of Heat pump,
2. Estimate the performance of Refrigerator
3. Estimate the performance of Air-conditioning
4. Measure the performance of compressors and draw the characteristic curves
5. Measure the performance of blowers and draw the characteristic curves blowers
6. Study the valve timing and port timing of IC engines

List of Experiment:

1. Determination of COP of Heat pump
2. Determination of Performance of Refrigeration
3. Determination of Performance of Air compressor
4. Performance characteristics of Compressor
5. Performance of Blower
6. Performance test on IC engine
7. Heat balance test on IC engine
8. Valve timing diagram of Four stroke Engine
9. Port timing diagram of Two stroke engine
10. Study of Nozzle and Diffuser

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD and notify it at the beginning of the semester.

18AE2009	AERODYNAMICS	L T P C 3 0 0 3

Prerequisite: 18AE2003 Basics of Fluid Mechanics

Course Objectives:

1. To impart knowledge of basics of air flow
2. To provide details regarding the flow over aerofoils and wings
3. To impart knowledge of forces and moments over an aerofoil

Course Outcomes:

After completing the course the student will be able to

1. Understand the aerodynamic variable connected with airflow
2. Apply the conservation laws for given aerodynamic situation
3. Analyse the basic flows satisfying the governing equations
4. Assess the flow field over the aerofoils
5. Estimate the flow over aircraft wings and Fuselage
6. Evaluate the forces and moments over vehicles utilizing different kinds of flows

MODULE 1: BASICS OF AIR FLOW (8 LECTURE HOURS)

Fundamental Aerodynamic variables, Aerodynamic forces and moments, Centre of pressure, Aerodynamics Centre, Types of flow, Gradient of Scalar and vector fields, Line, surface and volume integrals and the relationships between them. Continuity equation. Momentum equation and drag of a two dimensional body. Energy equation

MODULE 2: FLUID FLOW (8 LECTURE HOURS)

Euler's and Bernoulli's equations. Pitot tube, Pressure co-efficient. Stream function, Velocity potential and their relationship. Laplace Equation and relationship with continuity equation, Path lines, Stream lines and Streak lines, Overview of Elementary flows, non-lifting and lifting flow over cylinders. Kutta – Joukowski theorem and generation of lift.

MODULE 3: INCOMPRESSIBLE FLOW OVER AIRFOIL (8 LECTURE HOURS)

Joukowski transformation and conformal mapping. -Airfoil characteristics. Airfoil Nomenclature. The vortex sheet. The Kutta condition. Kelvin's circulation theorem. Introduction to classical thin airfoil theory – symmetric and cambered airfoil.

MODULE 4: INCOMPRESSIBLE FLOW OVER FINITE WINGS (7 LECTURE HOURS)

Down wash and induced drag. Vortex filament, Helmholtz theorems. Biot-Savart law, Introduction to Prandtl's lifting line theory and Elliptic lift distribution.

MODULE 5: NUMERICAL METHODS (7 LECTURE HOURS)

2-D Panel Methods-Source panel method-vortex panel methods, Vortex Lattice Methods.

MODULE 6: BOUNDARY LAYERS (7 LECTURE HOURS) Introduction to Boundary Layers and Reynolds number effects. Development of Boundary Layer equations. Boundary layer thickness- Displacement thickness – Momentum Thickness – Energy Thickness. Momentum integral theorem and applications.

Text Books:

1. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010
2. E.Rathakrishnan., "Theoretical Aerodynamics" , John Wiley & Sons, 2013

References:

1. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012
2. L.M Milne Thomson, "Theoretical Aerodynamics", 1996
3. Jan Roskam, Chuan-Tau Edward Lan, Airplane Aerodynamics and Performance, DAR Corporation, 1997
4. John J Bertin, "Aerodynamics for Engineers", Sixth edition, Edward Arnold publications, 2012

5. https://www.edx.org/course?search_query=Aerodynamics
6. http://www.nptel.ac.in/courses/101105059/
7. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-100-aerodynamics-fall-2005/

18AE2010	AEROSPACE STRUCTURES – I	L T P C 3 0 0 3

Prerequisite: 18AE2005 Strength of Materials

Course Objective:

1. To impart the knowledge of aircraft material and it behaviour.
2. To impart the knowledge on the methods of structural analysis under different types of loads.
3. To provide the knowledge on basic theory of vibrations, elasticity and failures.

Course Outcome:

After completing the course the student will be able to

1. Identify the suitable aircraft material and it behaviour
2. Apply the methods of statically determinate and indeterminate structural analysis under different conditions
3. Understand the concept of Column buckling
4. Solve the vibration problem with different DOF
5. Get the knowledge in basic theory of elasticity
6. Analyse the airframe structures

MODULE 1: INTRODUCTION TO AEROSPACE STRUCTURES ANALYSIS (5 LECTURE HOURS)

Stress strain curve- young's modulus- Poisson's ratio, basics of elasticity: Plane stress, Plane strain, Stress-Strain Relationships, Two dimensional problems, St. Venant's Principle.

MODULE 2: TRUSS (8 LECTURE HOURS)

Plane Truss Analysis – Method of Joint and Space Truss Analysis, Plane Truss-Deflection of Joints: Energy methods of analysis, Virtual Load method.

MODULE 3: BEAMS (12 LECTURE HOURS)

Beam-Shear force and Bending Moment: Maxwell's Reciprocal theorem, Claypeyron's three moment equation, Moment Distribution. Method. Castigliano's principles, Symmetrical and Unsymmetrical Bending: Stresses and deflections in beams of symmetrical and unsymmetrical sections. Stiffened Thin walled Beam.

MODULE 4: BUCKLING OF COLUMN (7 LECTURE HOURS)

Buckling of columns, Inelastic buckling, Effect of initial imperfections, Stability of beams under transverse and axial loads, Energy method for the calculation of buckling loads in columns, Flexural-torsional buckling of thin-walled columns.

MODULE 5: BASIC THEORY OF VIBRATION (8 LECTURE HOURS) Free and forced vibrations of undamped and damped SDOF systems, free vibrations of undamped 2-DOF systems-Mode shape, Oscillation of beams, Approximation methods for determining natural frequencies Problems.

MODULE 6: FATIGUE AND FRACTURE MECHANICS (5 LECTURE HOURS)

Historical background and overview-Case Study: Fatigue -Comet airplane, Different approaches to fatigue. Fracture mechanics and its implications for fatigue-Griffith fracture theory- Case study: Damage –tolerant design of aircraft fuselage.

Text Book:

1. Megson, T.M.G., "Aircraft Structures for Engineering Students", fourth edition, Elsevier Ltd, 2010.
2. Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.

References:

1. Donaldson B K, "Analysis of Aircraft Structures" Cambridge Aerospace Series, 2008.
2. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 1980.
3. Rajput R K, "Strength of Materials",S.Chand (P)LTP, 2006.
4. G Lakshmi Narasaiah "Aircraft Structures", BS Publications.,2010
5. Sun C T, " Mechanics of Aircraft Structures", Wiley India,2010

6. F.S.Tse, I.E. Morse and H.T. Hinkle, “Mechanical Vibration”, Prentice Hall of India Pvt., Ltd.,New Delhi, 1988.
7. R.K. Vierck, “Vibration Analysis”, 2nd Edition, Thomas Y. Crowell & Co., Harper & Row Publishers, New York, U.S.A., 1989.
8. S.Suresh, “Fatigue of Materials”, Second Edition, Cambridge University press, 2003
9. Aerospace Structural Dynamics: http://nptel.ac.in/courses/101105022/
10. Introduction to Aerospace Structures and Materials: https://www.edx.org/course/introduction-to-aerospace-structures-and-materials
11. Structural Mechanics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-20-structural-mechanics-fall-2002

18AE2011	**PROPULSION-I**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Prerequisite: 18AE2007 Thermodynamics

Course Objective:

1. To familiarize with Principles of Propulsion systems
2. To introduce working principles of Compressors and turbines
3. To familiarize with the concept of Matching of compressors and turbines and Off design performance

Course Outcome:

After completing the course the student will be able to

1. Understand the performance of air breathing engines
2. Analyse the performance of different propulsion cycles.
3. Understand the working of sub-systems of the propulsion system.
4. Assess the performance of compressor and turbine
5. Evaluate the combustion chamber, cooling and afterburner performance
6. Find the causes of under-performance and remedial measures

MODULE 1: FUNDAMENTALS OF AIR-BREATHING ENGINES (7 LECTURE HOURS)

Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, cycle analysis jet engines. Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust

MODULE 2: AIR-BREATHING ENGINES PERFORMANCE (8 LECTURE HOURS)

Efficiency and engine performance of turbojet, turboprop, turbo shaft, turbofan and ramjet engines, thrust augmentation of turbojets and turbofan engines. Principles of pulsejets and ramjets, thermodynamic cycle, performance parameters

MODULE 3: CENTRIFUGAL COMPRESSOR: (7 LECTURE HOURS)

Thermodynamics of Compressors, types of compressor, Centrifugal compressor: Centrifugal compressor stage dynamics, inducer, impeller and diffuser work done and pressure rise – Velocity diagrams.

MODULE 4: AXIAL COMPRESSOR: (7 LECTURE HOURS)

Angular momentum, work and compression, characteristic performance of a single axial compressor stage, efficiency of the compressor and degree of reactionVelocity triangles – degree of reaction.

MODULE 5: COMBUSTION CHAMBERS: **(7 LECTURE HOURS)**

Classification of combustion chambers – Important factors affecting combustion chamber design – Combustion process – Combustion chamber performance – Effect of operating variables on performance – Fuels and their properties and Fuel injection systems, Flame tube cooling – Flame stabilization – Use of flame holders and after burners.

MODULE 6: TURBINES: (9 LECTURE HOURS)

Thermodynamics of turbines, types of turbines, principle of operation of axial and radial turbine– design considerations – performance parameters turbine stage efficiency - basics of blade design principles–choice of blade profile, pitch and chord. Impulse and reaction blading of gas turbines – velocity triangles and power output– Estimation of stage performance – Limiting factors in gas turbine design- Overall turbine performance – methods of blade cooling

Text Books:
1. V. Ganesan, “Gas Turbines”, Tata Mc Graw - Hill Publishing Company Ltd, 2010
2. Hill, P.G. & Peterson, C.R., “Mechanics & Thermodynamics of Propulsion”, Addison – Wesley Longman INC, 1999.

References:
1. Irwin E. Treager, `Gas Turbine Engine Technology`, GLENCOE Aviation Technology Series, 7th Edition, Tata McGraw Hill Publishing Co. Ltd. Print 2003.
2. Cohen, H, Rogers. G.F.C. and Saravanamuttoo. H.I.H., “Gas Turbine Theory”, Pearson Education, 1989.
3. Oates, G.C., “Aero thermodynamics of Aircraft Engine Components”, AIAA Education Series, New York, 1985.
4. Mathur. M.L, and Sharma. R.P., “Gas Turbine, Jet and Rocket Propulsion”, Standard Publishers & Distributors, Delhi, 1999.
5. Jet Aircraft Propulsion: http://nptel.ac.in/courses/101101002/
6. Aerospace Propulsion: http://nptel.ac.in/courses/101106033/
7. Introduction to Propulsion Systems: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsion-systems-spring-2012/index.htm
8. Internal Flows in Turbomachines: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-540-internal-flows-in-turbomachines-spring-2006/

18AE2012	PROPULSION LABORATORY	L T P C 0 0 3 1.5

Co-requisite: 18AE2011 Propulsion -I

Course Objectives:
1. To impart knowledge on basic concepts and operation of various parts of jet engine
2. To provide practical exposure to the operation of various propulsion systems.
3. To impart knowledge on shock waves.

Course Outcomes:

After completing the course the student will be able to
1. Analyse the working of different parts of aircraft engine
2. Estimate of calorific value of fuels
3. Understand the performance of injector.
4. Evaluate the performance of axial compressor blades
5. Estimate ignition delay of fuels using shock tube
6. Evaluate the performance of nozzle.

LIST OF EXPERIMENTS
1. Study of an aircraft jet engine
2. Estimation of calorific value of fuels
3. Study on injector calibration
4. Shock speed measurement studies
5. Ignition delay studies using shock tube.
6. Storage losses of cryogenic fluids.
7. Cascade testing of a model for axial compressor blade row (symmetrical)
8. Cascade testing of a model for axial compressor blade row(cambered)
9. Study of convective heat transfer coefficient for liquids
10. Free convection heat transfer
11. Forced convection heat transfer
12. Nozzle performance test.

NOTE: The faculty conducting the Laboratory will prepare a list of minimum 9 experiments and get the approval of HoD and notify it at the beginning of the semester.

18AE2013	AIRCRAFT PERFORMANCE	L T P C 3 0 0 3

Prerequisite: 18AE2001 Introduction to Aerospace Engineering

Course Objectives:

1. To impart knowledge about the concepts of Flight performance
2. To introduce the various parameters affecting the performance
3. To introduce the various theories of propeller analysis and design

Course Outcomes:

After completing the course the student will be able to

1. Understand the preliminary design of aircraft based on the performance.
2. Differentiate performance characteristics of jet engine from propeller engine
3. Estimate the performance characteristics in level Flight
4. Assess the performance during turning maneuvers of aircraft
5. Realize the ground effects on performance
6. Estimate the pitch angle from performance characteristics of propeller and its applications

MODULE 1: BASICS OF AERODYNAMICS AND WING GEOMETRY (7 LECTURE HOURS)

Introduction - Aircraft Shape and Orientation - Effects of the Reynolds Number– Airfoil-lift - Drag Components - Drag polar, Drag Reduction Methods-High Lifting Devices. Numerical Problems

MODULE 2: EFFECTS OF ENGINE CHARACTERISTICS ON PERFORMANCE (8 LECTURE HOURS)

Introduction – Performance – Variation of Power and Specific fuel consumption with Velocity and Altitude –Reciprocating Engines – Gas Turbine Engines.

MODULE 3: PERFORMANCE CHARACTERISTICS OF LEVEL FLIGHTS (8 LECTURE HOURS)

Steady Level Flight –Fundamental Parameters - Equation of motion-Thrust Required-Fundamental Parameters-Thrust available and maximum speed- Power Required- Power available and maximum speed -Effect of Drag Divergence on Maximum Velocity- Minimum Drag Condition. Numerical Problems

MODULE 4: PERFORMANCE CHARACTERISTICS OF CLIMBING FLIGHTS (8 LECTURE HOURS)

Range and Endurance –Breguet formula - Introduction Maximum Climb Angle, Maximum Rate of Climb, Angle of climb and their variations with altitude- Effect of wind-Rate of Climb-Absolute ceiling and service ceiling ; Hodograph, Factors Influencing the Rate of Climb - Gliding Flight Maneuvering in the Vertical Plane. Numerical Problems

MODULE 5: TURNING CHARACTERISTICS (07 LECTURE HOURS)

Introduction- Level Turn- Minimum Turn Radius- Maximum Turn Rate- Instantaneous turn-Pull up and Pull down maneuvers, Cobra Maneuver. Numerical Problems.

MODULE 6: TAKEOFF AND LANDING CHARACTERISTICS (07 LECTURE HOURS)

Introduction to Take-off, Estimation of take-off distance-ground roll, obstacle clearing distance and height, Take off assist devices –Spoilers and landing distance–approach distance and flare distance. Numerical Problems.

Text Books:

1. J D Anderson, “Aircraft performance and Design”, McGraw-Hill, New York, 2000.
2. Roskam, Jan and Lan, Chuan-tau E, “Airplane Aerodynamics and Performance”, DAR Corporation, Lawrence, Kansas, USA, 1997.

Reference:

1. Perkins, C D and Hage, R E; “Airplane Performance Stability and Control”, Willey Toppan, 2010.
2. Houghton, E L and Carruthers, N B; “Aerodynamics for Engineering Students”, Edward Arnold Publishers, 1988.
3. Filippone, A, “Advanced Aircraft Flight Performance, Cambridge University Press, 2012.
4. David G. Hull, “Fundamentals of Airplane Flight Mechanics” Springer-Verlag Berlin Heidelberg 2007.

5. S.K. Ojha, "Flight Performance of Aircraft", AIAA, 1995.
6. Aircraft Performance, Stability and control with experiments in Flight: http://nptel.ac.in/courses/101104007/

18AE2014	GAS DYNAMICS	L T P C 3 0 0 3

Prerequisite: 18AE2009 Aerodynamics

Course Objectives:

1. To provide information regarding the behavior of compressible fluid flow
2. To impart knowledge regarding the difference between subsonic and supersonic flow
3. To Estimate flow over flying vehicles at subsonic and supersonic speeds

Course Outcome:

After completing the course the student will be able to

1. Understand the influence of compressibility to distinguish between the flow regime
2. Apply compressibility corrections for flow in C-D passages and instrument like Pitot static tube
3. Estimate the sudden changes in the flow field
4. Analyse the compressible flow field over an airfoil and finite wings
5. Estimate the influence of friction and heat transfer in the flow field
6. Choose proper flow visualisation techniques for the given situation

MODULE 1: ONE DIMENSIONAL COMPRESSIBLE FLOW: (8 LECTURES HOURS)

Compressibility, Velocity of sound, Concept of Mach Number, Isentropic relations, Normal shock and its relations, Prandtl equation and Rankine – Hugoniot relation, Flow through converging-diverging passages, Performance under various back pressures, corrections of Pitot static tube for subsonic and supersonic Mach numbers.

MODULE 2: OBLIQUE SHOCKS AND EXPANSION WAVES: (8 LECTURES HOURS)

Oblique shocks and corresponding equations, Hodograph and flow turning angle, shock polar, Flow past wedges, Strong, weak and detached shocks, Expansion waves & its corresponding equations, Flow

MODULE 3: FANNO AND RAYLEIGH FLOW (8 LECTURES HOURS)

Influence of Friction on compressible flow, governing equations, relation between flow parameters and length, diameter and friction coefficient of pipe. Limiting Mach number, Length and Mach number, Limiting length of pipe, Influence of Heat transfer on compressible flow, governing equations, relation between flow parameters and Heat Transfer. Limiting Mach number, Maximum heat transfer

MODULE 4: DIFFERENTIAL EQUATIONS OF MOTION FOR STEADY COMPRESSIBLE FLOWS: (7 LECTURES HOURS)

Potential equations, Small perturbation potential theory, solutions for supersonic flows - flow over a wavy wall and flow over airfoil, Prandtl-Glauert correction for subsonic flows.

MODULE 5: HIGH SPEED FLOW OVER AIRFOIL: (7 LECTURES HOURS)

Linearised two dimensional supersonic flow theory, Lift, drag, pitching moment and center of pressure of supersonic profiles, Lower and upper critical Mach numbers, Lift and drag divergence, shock induced separation.

MODULE 6: HIGH SPEED FLOW OVER FINITE WING: (7 LECTURES HOURS)

Finite wing, tip effects, Characteristics of swept wings, Effects of thickness, camber and aspect ratio of wings, transonic area rule, flow visualisation Techniques.

Text Books

1. Rathakrishnan, E., "Gas Dynamics", Third Edition, Prentice Hall of India, 2010
2. Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronald Press,1982

References:

1. Anderson Jr., D., – "Modern compressible flows", McGraw-Hill Book Co., New York 1999
2. Robert D Zucker, Oscar Biblarz, Fundamental of Gas Dynamics, Second Edition, John Willey &Sons, 2002

3. Liepmann H W and Roshko A, “Elements of Gasdynamics”, John Willey & Sons, 2001.
4. Zucrow, M.J. and Joe D Hoffman, “Gas Dynamics”, John Willey & Sons, 1976.
5. Compressible Flow: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-120-compressible-flow-spring-2003
6. Gas Dynamics: http://www.nptel.ac.in/courses/101106044/

18AE2015	AERODYNAMICS LABORATORY	L T P C 0 0 3 1.5

Co- requisite: 18AE2014 Gas Dynamics

Course Objectives:

1. To provide details regarding the flow over aerofoils and wings
2. To impart knowledge of forces and moments over an aerofoil
3. To impart knowledge of shock wave over various model

Course Outcomes:

After completing the course the student will be able to

1. Understand the aerodynamic variable connected with airflow
2. Draw pressure distribution over the various aerofoils.
3. Visualize subsonic flow over various model
4. Estimate effect of Reynolds number of low speed airfoil
5. Evaluate the forces and moments over aircraft model
6. Visualize shock wave and Estimate shock angle over various model

List of Experiments:

1. Calibration of subsonic wind tunnel for different velocities.
2. The pressure distribution over a symmetric and cambered aerofoil.
3. Smoke and Tuft flow visualization of symmetric and cambered aerofoil.
4. Estimation of the Lift and drag of symmetric and cambered aerofoil.
5. The pressure distribution over a cascade aerofoil.
6. Identify the trailing vortices over a rectangular wing using smoke and tuft flow visualization technique.
7. Force and moment measurements of rectangular wing
8. Smoke and tuft flow visualization Flow visualization over a car, building and aircraft using Water tunnel facility.
9. Boundary layer calculation in the test section of subsonic wind tunnel.
10. Assessment of small scale wind turbine by using Wind turbine tunnel.
11. Effect of Reynolds number of low speed airfoil using subsonic wind tunnel.
12. The calibration of Pitot tube for different velocities and different shapes.
13. Calibration and runtime calculation of supersonic wind tunnel for different Mach.
14. Flow visualisation over a sharp and blunt cone model using Schlieren technique.
15. Flow visualisation over a double wedge model using Schlieren technique.
16. Flow visualisation over a sharp and blunt cone model using shadowgraph technique.
17. Flow visualisation over a double wedge model using shadowgraph technique.
18. Flow visualisation over a sharp and blunt edge delta wing model using shadowgraph and Schlieren technique.
19. Effect of back pressure study of C-D nozzle using Open Jet Facility.

NOTE: The faculty conducting the Laboratory will prepare a list of minimum 9 experiments and get the approval of HoD and notify it at the beginning of the semester.

18AE2016	AEROSPACE STRUCTURE-II	L T P C 3 0 0 3

Prerequisite: 18AE2011 Aerospace Structures-I

Course Objective:

1. To impart the knowledge on the structural behaviour of aircraft components under different types of loads
2. To provide the understanding in structural design methods for aerospace vehicles

3. To impart the knowledge on the force distribution of different structures in Aircraft.

Course Outcome:

After completing the course the student will be able to

1. Predict the shear flow and shear centre in open and closed sections with effective and ineffective wall
2. Analysis the buckling characteristics of plates
3. Choose proper methods to analysis aerospace structural members.
4. Assess the load and stress distribution of wing and fuselage section.
5. Design the fail-safe and safe-life Aircraft structures.
6. Selection composites material for aerospace application.

MODULE 1: STRUCTURAL IDEALIZATION (8 LECTURE HOURS)

Principle, Idealization of a panel, Effect of idealization on the analysis of open and closed section beams, Deflection of open and closed section beams.

MODULE 2: SHEAR FLOW IN OPEN SECTIONS (8 LECTURE HOURS)

Thin walled beams, Concept of shear flow, Shear center, Elastic axis, with one axis of symmetry with effective and ineffective wall in bending, Unsymmetrical beam section.

MODULE 3: SHEAR FLOW IN CLOSED SECTION (8 LECTURE HOURS)

Bredt- Batho formula, Single and multi-cell structures, approximate methods, Shear flow in single and multi-cell structures under torsion, Shear flow in single and multi-cell structures under bending with effective and ineffective wall, Box Beams.

MODULE 4: BUCKLING OF PLATE (8 LECTURE HOURS)

Buckling of thin plates, Inelastic buckling of plates, Local instability, Instability of stiffened panels, Failure stress in plates and stiffened panels, Crippling stresses by Needham's and Gerard's methods. Buckling of Thin Walled Beam of Open and Closed section.

MODULE 5: WING & FUSELAGE ANALYSIS (9 LECTURE HOURS) Shear force, bending moment and torque distribution along the span of the Wing-Tension field beam and Semi tension field beam (Wagner Bam). Shear and bending moment distribution along the length of the fuselage. Aeroelasticity: Introduction to Aeroelasticity, Aeroelasticity Triangle, instability and failures of Aircraft structure.

MODULE 6: COMPOSITE MATERIALS (4 LECTURE HOURS)

Composites: metal matrix composites, polymer based composites, ceramic based composites, carbon-carbon composites. Smart Materials- type and Characteristics. Composite Manufacturing processes. Composite Joints. Aerospace Applications.

Text Book:

1. Donaldson B K., "Analysis of Aircraft Structures", Cambridge Aerospace Series, 2008
2. Megson, T.M.G., "Aircraft Structures for Engineering Students", Elsevier Ltd.,2010

References:

1. G Lakshmi Narasaiah, "Aircraft Structures", BS Publications, 2010
2. Sun C T, " Mechanics of Aircraft Structures", Wiley India, 2010
3. Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.
4. Stephen P. Timoshenko & S.Woinovsky Krieger, "Theory of Plates and Shells", 2nd Edition, McGraw-Hill, Singapore, 1990.
5. Rivello, R.M., "Theory and Analysis of Flight structures", McGraw-Hill, N.Y., 1993.
6. Composite Materials and Structures: http://www.nptel.ac.in/courses/101104010/

18AE2017	AEROSPACE STRUCTURES LABORATORY	L	T	P	C
		0	0	3	1.5

Co-requisite: 18AE2016 Aerospace Structures-II

Course Objective:

1. To provide the basic knowledge of the testing equipment for various structural components.
2. To impart the practical exposure with the measuring equipments and sensors.
3. To impart the practical exposure with composite material manufacturing

Course Outcome:

After completing the course the student will be able to

1. Select test equipment for different types of static loading
2. Conduct tests, analyze results, document and compare with analytical/theoretical results
3. Analyse the different types of structural failures
4. Manufacture the different Composite laminates
5. Choose strain gauge for different application
6. Understand the stress distribution based on cross-section shape and loading condition

Experiments

1. Deflection of simply supported and cantilever beams - Verification of Castigliano's Theorem
2. Determine the stiffness factors of an Elastically Supported Beam
3. Determine the tensile strength of Flat plates, riveted joints and bolted joints using UTM.
4. Compression test on columns, critical buckling loads – Southwell plot
5. Unsymmetrical bending of beams
6. Determination of the effective bending stiffness of a composite beam with the combination of Aluminium and steel
7. Determination of the natural frequency of vibrations of a cantilever beam
8. Shear center location for open sections
9. Torsion of a thin walled tube having closed cross section at the ends
10. Structural behaviour of a semi tension field beam (Wagner Beam)
11. Using photo elastic techniques: Calibration of circular disc in compression to find the fringe value and Determination of stress concentration factor due to compression in circular ring
12. Composite material Manufacturing and Testing- Tensile and Three point bending

The faculty conducting the Laboratory will prepare a list of 9 experiments and get the approval of HoD and notify it at the beginning of each semester.

18AE20018	PROPULSION-II	L T P C 3 0 0 3

Prerequisite: 18AE2011 Propulsion-I

Course Objective:

1. To impart knowledge on fundamentals of rocket propulsion
2. To impart knowledge on solid and liquid propulsion systems
3. To impart knowledge on advanced propulsion systems

Course Outcome:

After completing the course the student will be able to

1. Understand and evaluate the performance of chemical propellant
2. Select and design a suitable air inlets and nozzles
3. Select and design a suitable solid rocket motor
4. Select and design a suitable liquid rocket motor
5. Understand the working of sub-systems of the propulsion system.
6. Assess the performance of electric propulsion systems

MODULE 1: INLETS FOR AIR-BREATHING ENGINES AND NOZZLES: (8 LECTURE HOURS)

Internal flow and stall in subsonic inlets –major features of external flow near a subsonic inlet – external deceleration -relation between minimum area ratio and external deceleration ratio – Diffuser performance – Supersonic inlets- Modes of inlet operation.

Theory of flow in isentropic nozzles – convergent / convergent – divergent nozzles; nozzle efficiency – losses in nozzles – over expanded and under – expanded nozzles, types of nozzles conical nozzles, bell shaped nozzles, spike nozzles, expansion deflection nozzles, thrust reversal.

MODULE 2: FUNDAMENTAL OF ROCKET PROPULSION (7 LECTURE HOURS)

Overview of rockets, thrust equation and specific impulse, performance parameters, mass flow rate, characteristic velocity, thrust coefficient, efficiencies vehicle acceleration, drag, gravity losses, multi-staging of rockets staging and clustering, classification of chemical rockets.

MODULE 3: CHEMICAL PROPULSION: (7 LECTURE HOURS)

Molecular mass, specific heat ratio, energy release during combustion, stoichiometric & mixture ratio, types and classifications, criteria for choice of propellant, solid propellants, requirement, composition and processing, liquid propellants, energy content, storability.

MODULE 4: SOLID PROPULSION SYSTEMS: (8 LECTURE HOURS)

Classifications, booster stage and upper stage rockets, hardware components and functions, propellant grain configuration and applications, burn rate, burn rate index for stable operation, mechanism of burning, ignition and ignitors types, relation between web shape and thrust, action time and burn time, factors influencing burn rates, thrust vector control, performance of solid rockets. Micro grain structure of solid rocket motor.

MODULE 5: LIQUID PROPULSION SYSTEMS: (8 LECTURE HOURS)

Liquid propellant engines, thrust chamber and its cooling, injectors and types, propellant feed systems, turbo pumps, bipropellant rockets, mono propellant thrusters, cryogenic propulsion system, special features of cryogenic systems and performance of liquid rockets.

MODULE 6: ADVANCE PROPULSION SYSTEMS: (7 LECTURE HOURS)

Hybrid propellants and gelled propellants, electrical rockets, types and working principle of nuclear rockets, solar sail, concepts of advance propulsion systems, introduction to scramjet – preliminary concepts in supersonic combustion, integral ram-rocket.

Text books:

1. Sutton, G.P., Oscar Biblarz "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9thEdn., 2016.
2. Cohen, H., Rogers, G.F.C. and Saravanamutoo, H.I.H., "Gas Turbine Theory", 7th Edition, Longman Co., ELBS Ed., 2017

References:

1. Gordon C. Oates., "Aero thermodynamics of Gas Turbine and Rocket propulsion", AIAA Education series, New York, 1997
2. Mathur, M., and Sharma, R.P., "Gas Turbines and Jet and Rocket Propulsion", standard Publishers, New Delhi, 2014
3. Vigor Yang, "Liquid rocket thrust chamber: Aspect of modeling, analysis and design", American Institute of Aeronautics and Astronautics, 2004
4. Hill P.G. & Peterson, C.R., "Mechanics & Thermodynamics of Propulsion" Addison – Wesley publishing company INC, 1999.
5. Rocket Propulsion: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/
6. Space Propulsion: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-522-space-propulsion-spring-2015/
7. Aerospace Propulsion: http://nptel.ac.in/courses/101106033/
8. Jet and Rocket Propulsion: http://nptel.ac.in/courses/101104019/

18AE2019	AIRCRAFT STABILITY AND CONTROL	L T P C 3 0 0 3

Prerequisite: 18AE2013 Aircraft Performance

Course Objectives:

1. To introduce the concept of Stability and control of Aircraft.
2. To impart knowledge about various Aircraft motions and related stability.
3. To introduce the concept of dynamic stability of Aircraft.

Course Outcomes:

After completing the course the student will be able to

1. Understand the degree of freedom of aircraft system.
2. Analyse the static stability behaviour of the aircraft.
3. Understand the dynamic longitudinal stability of aircraft.
4. Perform the dynamic analysis to determine stability of aircraft.
5. Estimate the requirement of control force and power plant.
6. Assess the motion of unstable aircraft and related modes of instability.

MODULE 1: STATIC LONGITUDINAL STABILITY-I (**09 LECTURE HOURS**)
Degrees of Freedom of a system, Basic equations of motion- Wing and tail contribution; Effects of Fuselage and nacelles- Stick fixed neutral points- Power effects-Jet driven airplane and Propeller driven airplane, Elevator Requirements
MODULE 2: STATIC LONGITUDINAL STABILITY-II (**08 LECTURE HOURS**)
Basic equations of motion Elevator hinge moment, Estimation of hinge moment parameters, Stick Force gradients and Stick force per g load; Stick free Static Longitudinal Stability: Trim Taps, Stick free Neutral Point
MODULE 3: STATIC DIRECTIONAL STABILITY (**08 LECTURE HOURS**)
Basic equations of motion- Stick fixed Directional Stability- Contribution of wing –Fuselage – Vertical tail- Propeller, Directional control- Adverse yaw, One engine In-operative Conditions, Cross wind Landing, Spin recovery- Rudder effectiveness- Rudder Lock –Dorsal Fins- Stick free Directional Stability
MODULE 4: STATIC LATERAL STABILITY (**08 LECTURE HOURS**)
Dihedral Effect- Criterion for stabilizing dihedral effect -Selection of dihedral angle-Contribution of wing –Fuselage –Vertical tail- Propeller and Flaps- Rolling moment and its convention; Lateral Control- Aileron effectiveness, Aileron control force requirements, Aerodynamic Balancing.
MODULE 5: DYNAMIC STABILITY-I (**07 LECTURE HOURS**) Equations of motion-stick fixed and stick free, stability derivatives, Phugoid and short period, Longitudinal Dynamic Stability.
MODULE 6: DYNAMIC STABILITY-II (5 LECTURE HOURS)
Equation of motion- Lateral Dynamic Stability- Aileron fixed and free, Routh’s discriminant, Dutch roll and Spiral instability, Auto rotation and Spin recovery

Text Books:

1. Perkins, C D and Hage, R E; “Airplane Performance Stability and Control”, Willey Toppan, 2010
2. Nelson, R.C. “Flight Stability and Automatic Control”, McGraw-Hill Book Co., 2014

Reference:

1. J D Anderson, “Aircraft performance and Design”, McGraw-Hill, New York, 2000.
2. Etkin, Bernard, and Lloyd Duff Reid. “Dynamics of Flight Stability and Control”, Third Edition, John Wiley, New York, 1995.
3. Jan Roskam, J.Roskam, “Airplane Flight Dynamics and Automatic Flight Controls”. Design, Analysis and Research Corporation. 2003
4. David G. Hull, “Fundamentals of Airplane Flight Mechanics” Springer-Verlag Berlin Heidelberg 2007
5. M.V.Cook, “Flight Dynamics Principles” Second Edition, Elsevier, 2007.
6. Stevens, B., and F. Lewis. *Aircraft Control and Simulation*. 2nd ed. New York: Wiley-Interscience, 2003.
7. Blakelock, John H. Automatic Control of Aircraft and Missiles. 2nd ed. New York: Wiley-Interscience, 1991.
8. Franklin, Gene F., J. David Powell, and Abbas Emami-Naeini. *Feedback Control of Dynamic Systems*. 4th ed. Upper Saddle River, NJ: Prentice Hall, 2002.
9. McRuer, Duane, Irving Ashkenas, and Dunstan Graham. *Aircraft Dynamics and Automatic Control*. Princeton, NJ: Princeton University Press, 1973.
10. Bryson, Arthur E. *Control of Spacecraft and Aircraft*. Princeton, NJ: Princeton University Press, 1994.
11. Abzug, M., and E. Larrabee. Airplane Stability and Control. 2nd ed. New York: Cambridge University Press, 2002.
12. McCormick, B. Aerodynamics, Aeronautics, and Flight Mechanics. 2nd ed. New York: Wiley, 1994.
13. Flight Dynamics II (Stability): http://nptel.ac.in/courses/101106042/
14. Flight dynamics II - Airplane stability and control: http://nptel.ac.in/courses/101106043/
15. Aircraft Stability and Control: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-333-aircraft-stability-and-control-fall-2004/

18AE2020	FLIGHT STABILITY AND AEROMODELLING LABORATORY	L T P C 0 0 2 1

Co-requisite: 18AE2019 Aircraft Stability and Control

Course Objectives:

1. To incorporate awareness about the basic terminology, models and prototypes of UAV
2. To impart knowledge on design considerations of UAV systems
3. To obtain knowledge on aerodynamics and communication systems of UAV

Course Outcomes:

After completing the course the student will be able to

1. Know the evolution of UAS and the various models and prototypes
2. Understand the design parameters of UAV systems
3. Obtain knowledge on the application of aerodynamic principles to design UAS
4. Understand the principles of communication systems used in UAVs
5. Obtain knowledge on payloads and launch systems for UAS
6. Understand the application of UAS to various societal applications

List of Experiments:

1. Modelling and Testing of Paper Planes
2. Modelling and Testing of Unpowered Glider
3. Modelling and Testing of Powered Glider
4. Calibration of Remote Control system.
5. Aircraft "Jacking" procedure
6. Aircraft "Leveling" procedure
7. Calculation of CG of the Cessna 152 Aircraft
8. Parameters measurement of the Cessna 152 Aircraft.
9. Longitudinal Stability of the Cessna 152 Aircraft.
10. Directional Stability of the Cessna 152 Aircraft.
11. Lateral Stability of the Cessna 152 Aircraft.
12. Aircraft Stability Check using Flight Simulator

The faculty conducting the Laboratory will prepare a list of 6 experiments and get the approval of HoD and notify it at the beginning of each semester.

18AE2021	CAD/CAM LABORATORY	L T P C 0 0 3 1.5

Course Objective:

1. To impart the knowledge on the usage of computer in design and manufacturing
2. To impart the knowledge to visualization of objects in three dimensions and producing orthographic, sectional and auxiliary views of it.
3. To impart the knowledge of drafting.

Course Outcome:

After completing the course the student will be able to

1. Understand the CAD packages like Solid Works.
2. Develop 2D and 3D aircraft parts using software.
3. Create parts and assemble these for functional assembly
4. Draw the drafting diagram for manufacturing
5. Write CNC Program for different machining process
6. Get the hands-on experience of CNC manufacturing

List of Experiments:

Computer Aided Design (CAD)

1. 2D Sketch
2. Solid Modelling.
3. Surface modelling
4. Sheet Metal Design
5. Assembly of the Aircraft parts.

6. Drafting of Different parts.

Computer Aided Manufacturing (CAM)

7. CNC -Profile cut using Linear and circular interpolation codes
8. CNC - Step turning
9. CNC - Taper turning
10. CNC - Circular pocketing and slotting
11. CNC - Drilling
12. CNC -Thread cutting

The faculty conducting the Laboratory will prepare a list of minimum 9 experiments (Minimum 3 experiments from each CAD and CAM) and get the approval of HoD and notify it at the beginning of each semester.

18AE2022	AIRCRAFT INSTRUMENTATION & AVIONICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide the knowledge regarding basic concepts of flight instruments, their significance and operation.
2. To impart the concepts of measurements using air data sensor, Gyroscope and engine data.
3. To provide understanding of the basic concepts and functioning of the avionic system data buses

Course Outcomes:

After completing the course the student will be able to

1. Understand the basics of measurements and different parameters
2. Identify the fundamental cockpit instruments and their working principles
3. Differentiate various sensors and transducers used in aerospace vehicles
4. Apprehend the principles behind temperature, pressure, fuel flow and engine measurements
5. Analyse the functioning of military/civil aircraft data buses and communication process between them.
6. Identify display technologies and their working principles.

MODULE 1: GENERAL CONCEPTS OF MECHANICAL INSTRUMENTATION (8 LECTURE HOURS)

Generalized measurement system, Classification of instruments as indicators, recorders and integrators - their working principles, Precision and accuracy: measurement error and calibration, Functional elements of an instrument system and mechanisms

MODULE 2: CLASSIFICATION OF AIRCRAFT INSTRUMENTS (8 LECTURE HOURS)

Classification of aircraft instruments - Air data instruments – pitot static systems and instruments, gyroscopic instruments - Gyroscope and its properties, vacuum driven systems, heading instruments,

MODULE 3: AIRCRAFT INSTRUMENTS & SENSORS (8 LECTURE HOURS)

Position and displacement transducers and accelerometer, Temperature measuring instruments, Pressure measuring instruments, Engine Instruments, Fuel Quantity measurement, Fuel flow measurement, Position and displacement transducers and accelerometers.

MODULE 4: DIGITAL AVIONICS (7 LECTURE HOURS)

Introduction to Avionics, Role for Avionics in Civil and Military Aircraft systems, Avionics sub-systems and design, defining avionics System/subsystem requirements-importance of 'ilities' of avionic sub-system, Avionics system architectures.

MODULE 5: AVIONICS DATA BUSES (7 LECTURE HOURS)

Military and Commercial Data Buses: MIL-STD-1553B, ARINC-429, ARINC-629, CSDB, AFDX and its Elements

MODULE 6: COCKPIT DISPLAY SYSTEMS (7 LECTURE HOURS)

Trends in display technology, Alphanumeric displays, character displays etc., Civil and Military aircraft cockpits, MFDs, MFK, HUD, HDD, HMD, DVI, HOTAS, Synthetic and enhanced vision, situation awareness, Panoramic/big picture display, virtual cockpit. Power requirements.

Text Books:

1. A.K. Sawhney, "A course in Electrical and Electronic Measurement and Instrumentation", Dhanpat Raj and Sons, New Delhi, 1999.
2. Pallet, E.H.J., "Aircraft Instruments & Integrated systems", Longman Scientific and Technical, McGraw-Hill, 1992.
3. Spitzer, C.R., "Digital Avionics Systems", Prentice Hall, Englewood Cliffs, N.J., U.S.A., 1987

Reference Books:

1. Cary R. Spitzer, "The Avionics Handbook", CRC Press, 2000.
2. Collinson R.P.G., "Introduction to Avionics", Chapman and Hall, 1996Middleton, D.H. "Avionics Systems", Longman Scientific and Technical, Longman Group UK Ltd., England, 1989.
3. Jim Curren, "Trend in Advanced Avionics", IOWA State University, 1992
4. Doeblin.E.O., "Measurement Systems Application and Design", McGraw-Hill, New York, 1999.
5. Horowitz, P., and W. Hill. The Art of Electronics. 2nd ed. Cambridge, UK: Cambridge University Press, 1989.
6. Prototyping Avionics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-682-prototyping-avionics-spring-2006/
7. Principles of Automatic Control: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-06-principles-of-automatic-control-fall-2012/

18AE2023	SPACE DYNAMICS	L T P C 3 0 0 3

Prerequisite: 18AE2001 Introduction to Aerospace Engineering

Course Objectives:

1. To familiarize with the performance and stability of rockets
2. To impart knowledge of basics of orbital mechanics and its applications.
3. To familiarize with various factors affecting the satellite orbits

Course Outcome:

After completing the course the student will be able to

1. To estimate performance and stability of rockets.
2. To attain a general knowledge of laws governing the orbital motion.
3. To compute the orbits of the satellites.
4. To study the effects of perturbations on the orbital motion.
5. To compute preliminary orbit of a space object based on the initial data.
6. To generate preliminary design of inter-planetary trajectories.

MODULE 1: PERFORMANCE AND STABILITY OF ROCKETS (6 LECTURES)

Rocket performance – Specific impulse; Derivation of rocket equation; Single and two stage rockets. Static and dynamic stability of rockets.

MODULE 2: THE SOLAR SYSTEM (6 LECTURES)

Solar system – planets, moons, asteroids, comets and meteoroids; Kepler's laws of motion; Reference frames – geocentric, geographic, topocentric, heliocentric; Time systems, Julian days; The ecliptic - motion of vernal equinox.

MODULE 3: THE TWO-BODY PROBLEM (8 LECTURES)

Properties of conics; Angular momentum; Computation of position and velocity vectors from orbital elements and vice-versa; Solution of Kepler's equation – elliptic and hyperbolic orbits; Central force motion.

MODULE 4: ORBIT PERTURBATIONS (10 LECTURES)

Orbit perturbations – Osculating ellipse, In-plane and out-of-plane perturbation components, Earth's oblateness, Sun-synchronous orbits, air drag; Introduction to general and special perturbation methods; Cowell's and Encke's methods.

MODULE 5: PRELIMINARY ORBIT DETERMINATION (7 LECTURES)

Laplace method; Gauss method; Gibbs method from three position vectors.

MODULE 6: ORBITAL MANEUVERS (9 LECTURES)
Single impulse maneuvers; Plane change maneuvers; Hohmann transfers from circular to circular orbits; Sphere of influence; Synodic period, Method of patched conics; planetary rendezvous.

Textbooks:
1. Vladimir A. Chobotov, "Orbital Mechanics", AIAA Education Series, AIAA Education Series, Published by AIAA, 2002.
2. Howard D. Curtis, "Orbital Mechanics for Engineering Students", Elsevier Butterworth-Heinemann, Third Edition, 2010.

References:
1. Pini Gurfil, and P. Kenneth Seidelmann, "Celestial Mechanics and Astrodynamics: Theory and Practice", Springer, 2016
2. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", Springer, 2015
3. J.W.Cornelisse, H.F.R. Schoyer, and K.F. Wakker, "Rocket Propulsion and Spaceflight Dynamics", Pitman, 2001.
4. William E.Wiesel, "Spaceflight Dynamics", Aphelion Press, USA, Third Edition, 2010.
5. David. A. Vallado, "Fundamentals of Astrodynamics and Applications", Microcosm and Kluwer, Second Edition, 2004.
6. J. M. A. Danby, "Fundamentals of Celestial Mechanics", Willmann-Bell, Inc., USA, 1992.
7. Battin, Richard. An Introduction to the Mathematics and Methods of Astrodynamics. Revised ed. Reston, VA: AIAA, 1999.
8. Space Systems Engineering: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-83x-space-systems-engineering-spring-2002-spring-2003/
9. Space Flight Mechanics: http://nptel.ac.in/courses/101105029/
10. Space Technology: http://nptel.ac.in/courses/101106046/
11. Introduction to Aerospace Engineering: Astronautics and Human Spaceflight: https://www.edx.org/course/introduction-aerospace-engineering-mitx-16-00x-1
12. Human Spaceflight - An introduction: https://www.edx.org/course/human-spaceflight-introduction-kthx-sd2905-1x-0
13. Astrodynamics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-346-astrodynamics-fall-2008/

18AE2024	**AIRCRAFT DESIGN PROJECT**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

Prerequisite: 18AE2019 Aircraft Stability and Control
Course Objectives:
1. To impart the knowledge of Aerodynamic design of Aircraft.
2. To impart the knowledge of Performance analysis and stability aspects of different types of aircraft/Spacecraft.
3. To impart the knowledge of the structural design of the aircraft/space craft.

Course Outcomes:
After completing the course the student will be able to
1. Choose the type of aircraft/spacecraft for comparative studies
2. Calculate the aerodynamic parameter
3. Design the aircraft and assess the performance of the design
4. Analyse the stability of the designed vehicle
5. Design the aircraft wings, tail, fuselage, landing gears
6. Design and assess the strength of a structure

Activities to be carried out:
1. Comparative studies of different types of airplanes and their specifications and performance details with reference to the design work under taken.
2. Preliminary weight estimation, Selection of design parameters, power plant selection, aerofoil selection, fixing the geometry of Wing, tail, control surfaces Landing gear selection. Area Rule.

3. Preparation of layout drawing, construction of balance and three view diagrams of the airplane under consideration.
4. Drag estimation, Performance calculations, Stability analysis and V-n diagram.
5. Preliminary design of an aircraft wing – Shrenck's curve, structural load distribution, shear force, bending moment and torque diagrams
6. Detailed design of an aircraft wing – Design of spars and stringers, bending stress and shear flow calculations – buckling analysis of wing panels
7. Preliminary design of an aircraft fuselage – load distribution on an aircraft fuselage 4. Detailed design of an aircraft fuselage – design of bulkheads and longerons – bending stress and shear flow calculations – buckling analysis of fuselage panels
8. Design of control surfaces - balancing and maneuvering loads on the tail plane and aileron, rudder loads
9. Design of wing-root attachment
10. Landing gear design
11. Preparation of a detailed design report with CAD drawings
12. Aerodynamic and Stability Analyse using open source software like XFLR5.

References:

1. Jan Roskam and J. Roskam, " Airplane Design Part I : Preliminary Sizing of Airplanes" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
2. Jan Roskam and J. Roskam, "Airplane Design, Part II : Preliminary Configuration Design and Integration of the Propulsion System" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
3. Jan Roskam and J. Roskam, "Airplane Design Part III: Layout Design of Cockpit, Fuselage, Wing and Empennage: Cutaways and Inboard Profiles (Volume 3)" Fifth Printing, Design, Analysis and Research Corporation (DARcorporation), 2017.
4. Jan Roskam and J. Roskam, "Airplane Design Part IV: Layout Design of Landing Gear and Systems (Volume 4)" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
5. Jan Roskam and J. Roskam, "Airplane Design Part V: Component Weight Estimation" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
6. Jan Roskam and J. Roskam, "Airplane Design Part VI : Preliminary Calculation of Aerodynamic Thrust and Power Characteristics" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
7. Jan Roskam and J. Roskam, "Airplane Design Part VII: Determination of Stability, Control and Performance Characteristics (Volume 7)" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
8. Jan Roskam and J. Roskam, "Airplane Design Part VIII: Airplane Cost Estimation: Design, Development, Manufacturing and Operating" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
9. Daniel P. Raymer, "Aircraft Design: A Conceptual Approach" 5th Edition,
10. Daniel P. Raymer, "Simplified Aircraft Design for Homebuilders" 2002.
11. Snorri Gudmundsson, "General Aviation Aircraft Design: Applied Methods and Procedures" Butterworth-Heinemann, 2016. Chris Heintz, "Flying on Your Own Wings: A Complete Guide to Understanding Light Airplane Design"
12. Ira H. Abbott (Author), A. E. von Doenhoff (Author), "Theory of Wing Sections: Including a Summary of Airfoil Data"
13. Leland Nicolai, Grant Carichner,"Fundamentals of Aircraft and Airship Design" AIAA Education Series, 2010.
14. Aircraft Design : http://nptel.ac.in/courses/101104069/

LIST OF COURSES

Sl. No	Course Code	Name of the Course	Credits
1	16AE3002	Instrumentation, Measurements and Experiments in Aerodynamics	3:0:0
2	16AE3003	Aircraft Structural Health Monitoring	3:0:0
3	16AE3004	Wind Turbine Aerodynamics	3:0:0
4	16AE3005	Wind Tunnel Model Design and Development	3:0:0
5	17AE2001	Introduction to Aerospace Engineering	3:0:0
6	17AE2002	Fundamentals of Fluid Flow	3:1:0
7	17AE2003	Fluid Mechanics Laboratory	0:0:1
8	17AE2004	Solid Mechanics	3:0:0
9	17AE2005	Solid Mechanics Lab	0:0:1
10	17AE2006	Aircraft Instrumentation	3:0:0
11	17AE2007	CAD/CAM Laboratory	0:0:2
12	17AE2008	Aero Thermal Engineering	3:0:0
13	17AE2009	Thermal Engineering Laboratory	0:0:1
14	17AE2010	Aerodynamics	3:0:0
15	17AE2011	Aerodynamics Laboratory	0:0:2
16	17AE2012	Aircraft Structures – I	3:0:0
17	17AE2013	Aircraft Performance	3:0:0
18	17AE2014	Elements of Avionics	3:0:0
19	17AE2015	Foundations of Space Engineering	3:0:0
20	17AE2016	Gas Dynamics	3:0:0
21	17AE2017	Gas Dynamics Laboratory	0:0:2
22	17AE2018	Aircraft Structures – II	3:0:0
23	17AE2019	Aircraft Structures and Composite Laboratory	0:0:2
24	17AE2020	Aircraft Stability and Control	3:0:0
25	17AE2021	Aircraft Propulsion	3:0:0
26	17AE2022	Space Dynamics	3:0:0
27	17AE2023	Computational Fluid Dynamics	3:0:0
28	17AE2024	Computational Fluid Dynamics Laboratory	0:0:2
29	17AE2025	Rocket Propulsion	3:0:0
30	17AE2026	Propulsion Laboratory	0:0:2
31	17AE2027	Computational Structural Analysis Laboratory	0:0:2
32	17AE2028	Aircraft/Spacecraft Design Project	0:0:4
33	17AE2029	Instrumentation and Avionics Laboratory	0:0:2
34	17AE2030	Wind Tunnel Techniques	3:0:0
35	17AE2031	Finite Element Analysis in Aerospace Application	3:0:0
36	17AE2032	Heat Transfer	3:0:0
37	17AE2033	Experimental Stress Analysis	3:0:0
38	17AE2034	Composite Materials	3:0:0
39	17AE2035	Navigation, Guidance and Control of Aerospace Vehicles	3:0:0
40	17AE2036	Cryogenic Propulsion	3:0:0
41	17AE2037	Industrial Aerodynamics	3:0:0

42	17AE2038	Introduction to Unmanned Aircraft Systems	3:0:0
42	17AE2039	Aero-elasticity	3:0:0
44	17AE2040	Analytics for Aerospace Engineers	3:0:0
44	17AE2041	Advanced space dynamics	3:0:0
45	17AE2042	Air Traffic Control and Aerodrome details	3:0:0
46	17AE2043	Non Destructive Testing	3:0:0
47	17AE2044	Introduction to Hypersonic Flows	3:0:0
48	17AE2045	Aircraft Systems	3:0:0
49	17AE2046	Theory of Vibration	3:0:0
50	17AE2047	Basics of Aerospace Engineering	3:0:0
51	17AE3001	Vibration and Aero-Elasticity	3:0:0
52	17AE3002	Advanced Aerodynamics	3:0:0
53	17AE3003	Advanced Aerodynamics Laboratory	0:0:2
54	17AE3004	Aerospace Propulsion	3:0:0
55	17AE3005	Aero Propulsion Laboratory	0:0:2
56	17AE3006	Advanced Computational Fluid Dynamics	3:0:0
57	17AE3007	Computational Heat Transfer	3:0:0
58	17AE3008	Advanced Computational Fluid Dynamics Laboratory	0:0:1
59	17AE3009	Flight Performance and Dynamics	3:0:0
60	17AE3010	Aerospace Structural Analysis	3:0:0
61	17AE3011	Aerospace Structure and Composite Laboratory	0:0:2
62	17AE3012	Advanced Avionics	3:0:0
63	17AE3013	Aircraft Modelling Laboratory	0:0:1
64	17AE3014	Advanced Instrumentation and Avionics Laboratory	0:0:1
65	17AE3015	Orbital Space Dynamics	3:0:0
66	17AE3016	Boundary Layer Theory	3:0:0
67	17AE3017	Theory of Elasticity	3:0:0
68	17AE3018	Aircraft Design	3:0:0
69	17AE3019	Rockets and Missiles	3:0:0
70	17AE3020	Unmanned Aerial Systems	3:0:0
71	17AE3021	Finite Element Analysis and Programming	3:0:0
72	17AE3022	Elements of Aerospace Engineering	3:0:0

16AE3002 INSTRUMENTATION MEASUREMENTS AND EXPERIMENTS IN AERODYNAMICS
Credits: 3:0:0

Course Objective:

- To familiarize with the various experimental facilities and flow measurement techniques
- To conduct the test, acquire the data and analyse and document.
- To estimate experimental error involved

Course Outcome:
By the end of the course, the students will be able to:

- Choose proper experimental facilities
- Configure the experiment and draw inferences from acquired data
- Interpret uncertainty in experiments

Description:
Need and objective of Experimental study, Fundamental of Fluid Mechanics, Low speed and high speed Wind tunnels, Hypersonic tunnels, Wind tunnel Balance, Instrumentation and Calibration of Wind tunnels, Calibration and use of Hypersonic tunnels, Flow visualization techniques, Hypervelocity Facilities, Ludwieg Tube, Hot-Wire Anemometry, Analogue methods, Pressure Measurement Techniques, Velocity measurements, Temperature Measurements, Measurement of Wall shear stress, Mass and Volume flow Measurements, Special Flows, Data Acquisition and Processing, Uncertainty Analysis

References:
1. Rathakrishnan E., Instrumentation, “Measurements and Experiments in fluids”, CRC press, Boca Raton, FL, USA, 2007.
2. Alan S Morris & Reza Langari., “Measurement and Instrumentation: Theory and Application”, Second Edition, Academic press, 2015.
3. Dally., “Instrumentation for Engineering Measurements”, John Wiley, New York, 2003.
4. Holman J.P., “Experimental methods for Engineers”, 7th Edition, McGraw-Hill Book Co, 2005.
5. Kline S.J., “The purpose of uncertainty analysis”, J.Fluids Eng.,107 (June): 153-182, 1985.
6. Lomas, C.G., “Fundamentals of Hot-wire Anemometry”, Cambridge University Press, Cambridge, UK, 1986.
7. Liepmaan, H.W and Roshko A., “Elements of Gas Dynamics”, John Wiley & Sons, New York, 2001.

16AE3003 AIRCRAFT STRUCTURAL HEALTH MONITORING

Credits 3:0:0

Course Objective:
- Identify various structural health monitoring (SHM) techniques
- Interpret the acquired data using LABVIEW
- Choose appropriate SHM system based on availability of resource

Course Outcome:
By the end of the course, the students will be able to:
- Understand fundamental concepts in structural health monitoring and decide on required sensors
- Demonstrate understanding of working principles of sensors and actuators made from smart materials
- Describe and classify various diagnostic methods of structural health monitoring, with their associated advantages and disadvantages

Description:
Classical methods of structural design-Aircraft structural design & Damage monitoring systems in aircraft- Non-Destructive Testing- Introduction to Structural Health Monitoring -Vibration and Modal analysis-Vibration based damage identification methods- Vibration based SHM of a composite T-beam- Damage identification in skin-stiffener structures based on curvatures-Nonlinear dynamic behavior of an impact damaged skin-stiffener structure-Vibro-acoustic modulation based damage identification-Application of vibration based SHM.

References
1. W.J. Staszewski, C. Boller and G.R. Tomlinson, “Health Monitoring of Aerospace Structures”, John Wiley & Sons, Ltd, 2004.
2. Daniel Balageas, Claus-Peter Fritzen, Alfred Guemes, “Structural Health Monitoring”, John Wiley & Sons, 2006.
3. Arnaud Deraemaeker,Keith Worden, “New Trends in Vibration Based Structural Health Monitoring”, Springer Wien, NewYork,2010
4. Jayantha Ananda Epaarachchi, Gayan Chanaka Kahandawa , “Structural Health Monitoring Technologies and Next-Generation Smart Composite Structures”, CRC Press,2016
5. Ted Ooijevaar, “Vibration based structural health monitoring of composite skin-stiffener structures”, PhD thesis, University of Twente, Enschede, The Netherlands, March 2014.

16AE3004 WIND TURBINE AERODYNAMICS

Credits: 3:0:0

Course Objective:
- To provide knowledge on aerodynamics modelling of wind turbine blade
- To provide the knowledge and skills in aerodynamics required for a detailed understanding of the turbine design
- To impart the knowledge regarding effect of ground

Course Outcome:
By the end of the course, the students will be able to:
- Predict the structural forces and moments experienced by modern utility-scale wind turbines

- Design blades for wind turbine
- Account the ground effect by the atmospheric boundary layer

Description:

Introduction and types of turbine blade, 1-D momentum theory and Betz Limit; Effect of wake rotation; Blade element momentum theory; vortex line/lattice method; Introduction to wind turbine aero acoustics; Atmospheric boundary layers and its influence on wind mill performance.

References:

1. Martin O.L. Hansen, " Aerodynamics of Wind turbine", 2nd edition, Earthscan Ltd, Oxon, Newyork, 2009
2. A.R.Jha , "Wind turbine Technology", CRC Press, Boca Raton, Florida, 2011
3. A.P.Schaffarczyk, " Introduction to wind turbine Aerodynamics" Springer verlag, 2014
4. J.F. Brouckaret, " Wind turbine Aerodynamics" Von Karman Institute for Fluid Dynamics, 2007
5. Peter Jamieson, " Innovation in wind turbine design" John Wiley and sons, 2011
6. Wilson, R. E., Lissaman, P. B. S., Walker, S. N., "Aerodynamic Performance of Wind Turbines". Energy Research and Development Administration, 224, 1976
7. Hau, E., Wind Turbines: Fundamentals, Technologies, Application, Economics. Krailling, Springer, 2006

16AE3005 WIND TUNNEL MODEL DESIGN AND DEVELOPMENT

Credits: 3:0:0

Course Objective:

- To provide knowledge of types of model for different wind tunnel tests
- To introduce the basic concepts of model design and realisation methods
- To introduce the basic concept of mounting system for the models

Course Outcome:

By the end of the course, the students will be able to:

- Understanding of the various types of wind tunnel model requirements
- Choose the different model size and balance
- Choose the mounting system based on the model

Description:

Model sizing, strength requirements, materials characteristics- wood (Balsa, Andaman Padak, teak) ,stainless steel and special high strength steels; Realization techniques; geometry measurements, selection of Pressure tappings, tubing, conventional machining and rapid prototyping, electro forming, Estimation of loads on models; Mounting systems, Model design for hypersonic tunnel.

References:

1. Rae, W.H. and Pope, A. "Low Speed Wind Tunnel Testing", John Wiley Publication, 1999
2. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010
3. Salter C., "Experiments on thin turning vanes", ARC Reports and Memorand, No 2469.
4. L.M Milne Thomson, "Theoretical Aerodynamics", 1996
5. Pope, A., and Goin, L., "High Speed wind Tunnel Testing", John Wiley Publication, 1999
6. Pankhrust,R.C., and Holder D.W , "Wind tunnel technique", Sir Isaac pitman & sons, London, 1965

17AE2001 INTRODUCTION TO AEROSPACE ENGINEERING

Credits: 3:0:0

Course Objective:

- To introduce the basic concepts of aircrafts, rockets and their functions.
- To provide knowledge about the basic parts and their function and construction details of aerospace vehicles.
- To provide information about the national and international aerospace agencies.

Course Outcome:

Students will be able to

- Understand the nature of aerospace technologies.
- Assess the forces and moments due to flow over the aircraft components.
- Identify the various types of structural components and their functions.

- Evaluate the performance of propulsion system.
- Apply the knowledge of gravitational law, Kepler's law and Newton's law to the space vehicle.
- Knowledge in various types of aerospace vehicles and their applications.

Unit I - Historical Evolution: History of aviation, Different types of flight vehicles and Classifications, Components of an airplane and their functions, Standard atmosphere-Isothermal layer and gradient layer.
Unit II - Principles Of Flight: Basic aerodynamics, Airfoils, wings and their nomenclature; lift, drag and pitching moment coefficients, center of pressure and aerodynamic center, NACA airfoil nomenclature.
Unit III - Introduction to Aircraft Structures: General types of construction, Types of structure, Typical wing and fuselage structure, Honeycomb and Sandwich structure, Aircraft materials, Aircraft instruments.
Unit IV - Propulsion Systems: Principles of Thrust generation, Reciprocating engine, propeller, turboprop engine, Basic ideas about jet propulsion, Types of jet engines - turbofan and turbojet engines.
Unit V - Rockets and Orbital Dynamics: Principles of operation of rocket, Rocket engine-specific impulse, Rocket equation, Chemical rockets: Solid and liquid propellants, Introduction to orbital dynamics, Aerospace industries and institutions worldwide.

Text Books:
1. Anderson, J.D., "Introduction to Flight", Tata McGraw-Hill, sixth Edition, 2011
2. Sutton, G.P. "Rocket Propulsion Elements", John Wiley, 2009.

Reference Books:
1. Kermode, A.C., "Flight without Formulae", McGraw-Hill, 1997.
2. Kermode A C., "Mechanics of Flight", Pearson Education Low Price Edition, 2005.
3. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012
4. Megson, T.M.G., "Aircraft Structures for Engineering Students", 2007
5. Howard D. Curtis, "Orbital Mechanics for Engineering Students", Elsevier Butterworth-Heinemann, Third Edition, 2010

17AE2002 FUNDAMENTALS OF FLUID FLOW

Credit 3:1:0

Course Objective

- To introduce the basic concepts of fluid statics.
- To make the student understand the basic laws governing fluid motion and its application.
- To give an introduction on fluid machines and aerodynamics.

Course Outcome

Students will be able to

- Evaluate the properties of different fluids
- Understand the fundamentals of fluid flow equations
- Apply the aerodynamics concepts to fluid flow situations
- Analyse the fluid flow equations for real time aerodynamic applications
- Apply mathematical knowledge to predict the properties and characteristics in a given fluid flow situation
- Arrive at the proper non-dimensional parameters and thus devise simulation procedure

Unit I - Introduction to Fluid Mechanics-Definition of a fluid – Continuum hypothesis – Fluid properties - Pressure, Temperature, Density, Viscosity - stress-strain rate relationship, Measurement of pressure –Fluid statics – Total and Centre of pressure of submerged surfaces-Stability of submerged and floating bodies.
Unit II - Basic Equations-Motion of a fluid particle – Types of flow-Continuity equation-Velocity and acceleration –velocity potential and stream function- Path lines, Stream lines and Streak lines,-Fluid deformation – Rotation-Vorticity, Elementary flows- Uniform flow, Source flow, Sink flow, Doublet flow, Vortex flow, Super imposed flows- Semi-Infinite Body, Rankine Body.
Unit III - Incompressible Inviscid Flow-Equations of motion-Euler's equation of motion- Energy equation-Momentum equation – Bernoulli's equation and its Applications –– Flow measurement – Orifice meter – Venturi meter-Pitot tube.
Unit IV - Incompressible Viscous Flow-D' Alembert's Paradox, Viscous stress-strain rate relationship, Flow of viscous fluid through circular pipes – Velocity profiles – Frictional loss in pipe flow-Calculation of minor and major energy losses in pipes

Unit V - Dimensional Analysis and Impact of Jets-Dimensional analysis – The Buckingham-Pi theorem – Non-dimensional numbers-Mach Number, Reynolds Number, Strouhal Number, Knudsen Number, etc., Impact of jets – Force exerted by a jet on stationary and moving vertical, horizontal and inclined plates.

Text Books

1. Rathakrishnan.E, 'Fundamentals of Fluid Mechanics', Prentice-Hall, 2007
2. White F.M., "Fluid Mechanics", 7th Edition, Tata McGraw-Hill Education, 2011

Reference Books

1. Robert W Fox & Alan T Mc.Donald, 'Introduction to fluid Mechanics', John Wiley and Sons,1995
2. Kuethe, A.M. and Chow, C.Y., Foundations of Aerodynamics, First Indian Reprint, John Wiley & Sons, 2010.
3. Yuan S W, 'Foundations of fluid Mechanics', Prentice-Hall, 1987
4. Graebel, W.P. 'Engineering Fluid Mechanics' Taylor and Francis, 2001

17AE2003 FLUID MECHANICS LABORATORY

Credits: 0:0:1

Course Objective:

- To impart knowledge on the calibration of flow measurement devices
- To impart knowledge to predict losses due to friction and pipe fittings
- To provide hands on training for flow measurements

Course Outcome:

Students will be able to

- Recall the principle of instruments used in flow related measurements
- Describe the flow measurements methods
- Conduct flow measurements in pipes
- Evaluate performance of pumps and turbines
- Determine the head losses for internal flows
- Investigate influence of flow parameters

List of Experiments:

1. Determination of Darcy's Friction Factor.
2. Calibration of Venturi Meter.
3. Calibration of orifice Meter.
4. Determination of Minor Losses in sudden expansion and contracting pipe
5. Determination of Minor Losses in bends and elbows of the pipe
6. Reynolds experiments

17AE2004 SOLID MECHANICS

Credits: 3:0:0

Course Objective:

- To provide an understanding the concepts of stress and strain, Shear force and Bending moment
- To provide knowledge regarding the methods of determining the deflections of beams and Torsion of shaft
- To impart basic knowledge about Joints and springs

Course Outcome:

Students will be able to

- Understand the basic material behaviour like elasticity, plasticity etc.
- Draw the shear force and bending moment diagram for different loading of beams
- Predict the deflection of beams under bending loads
- Arrive at the methods to solve torsional problems
- Analyse behaviour of a spring under different loading conditions
- Identify the structural joints for repair

Unit I - Stresses and strains: Introduction, types of structures, loads and stresses , Hooke's law, stress-strain curve, Analysis of bars of varying sections, Analysis of bars of composite sections, thermal stresses, thermal stresses in composite bars, elastic constants ; Principal planes and stresses, Analytical and graphical methods for determining stresses on oblique section.

Unit II - Shear force and bending moment diagram: Types of beams, important points for drawing shear force and bending moment diagram, Shear force and bending moment for different beams carrying point load, uniformly distributed load, gradually varying loads and combinations of these at different sections of the beam.

Unit III - Deflection of beams: Simple bending, Theory of simple bending, Expression for bending stress, bending stress in symmetrical section, Relation between deflection, slope and radius of curvature, Methods for determining deflection- Double integration method, Macaulay's method and Moment Area method.

Unit IV - Torsion of shafts: Shear stress produced in a shaft subjected to torsion, torque and power transmitted by a solid and circular shaft, Strength of a shaft and Polar moment of inertia, Torque in terms of polar moment of inertia, strength of a shaft of varying sections and composite shaft, combined bending and torsion, strain energy stored in a body due to torsion.

Unit V - Springs and Joints: Stiffness of a spring, Types of spring, Closely-coiled Helical Springs- Axial load-Axial twist, Open coiled helical spring, Torsion spring – Problems. Joints **-** Types of Structural joints, bonded joints, Bolted joints- Riveted Joints, Structural repair of Joints.

Text Books:

1. Bansal R K., "Strength of Materials", Laxmi Publishing Co, New Delhi, 2007
2. Ramamurtham.S., "Strength of Materials", Dhanpat Rai Publishing Co, New Delhi, 2008

References:

1. R S Khurmi," Strength of Materials", S Chand & Co Ltd, New Delhi, 2005
2. Rajput R K, "Strength of Materials", S Chand & Co Ltd, New Delhi, 2006
3. Sun C T, " Mechanics of Aircraft Structures", Wiley, India, 2010
4. Dr. Sadhu Singh," A Textbook on Strength of Materials**",** Khanna Publishers Pvt. Ltd, New Delhi , 2013
5. Timoshenko S., Young, "Elements Of Strength Of Materials", Irwin Homewood Publishers,1990.

17AE2005 SOLID MECHANICS LABORATORY

Credits: 0:0:1

Co-requisite:17AE2004 Solid Mechanics

Course Objective

- To apply the theory of structural mechanics on real specimens
- To give hands on training on testing of real specimens
- To provide knowledge on failure of materials

Course Outcome

Students will be able to

- Determine the important mechanical properties of materials
- Identify the behaviour of materials
- Verify the Maxwell's theorem
- Understand the structural behaviour under various loads, shapes and supports
- Estimate stiffness of springs
- Choose material based on requirement

Experiments

1. Tensile Test of solid rod using Universal Testing Machine
2. Verification of Maxwell Theorem on Cantilever Beam
3. Verification of Maxwell Theorem on Simply Supported Beam
4. Torsion Test of shaft and Beam
5. Rockwell's Hardness Test
6. Brinell's Hardness Test
7. Vickers Hardness Test
8. Charpy's Impact test
9. Izod Impact Test
10. Compression of open coil helical spring

The faculty conducting the Laboratory will prepare a list of 6 experiments and get the approval of HoD / Director and notify it at the beginning of the semester.

17AE2006 AIRCRAFT INSTRUMENTATION

Credits: 3:0:0

Course Objectives:

- To provide the knowledge regarding basic concepts of flight instruments, their significance and operation.
- To impart the concepts of measurements using air data sensor, Gyroscope and engine data.
- To impart the basic concepts regarding Avionics systems and also the necessary knowledge on working of avionics system in aircraft.

Course Outcome:

Students will be able to

- Understand the basics of measurements and different parameters
- Appreciate the need for general measurements in aviation industry
- Identify the fundamental cockpit instruments and their working principles
- Select proper instrumentation requirements for aerospace vehicles
- Differentiate various sensors and transducers used in aerospace vehicles
- Apprehend the principles behind temperature, pressure, fuel flow and engine measurements

Unit I - General concepts of Mechanical Instrumentation: Generalized measurement system, Classification of instruments as indicators, recorders and integrators - their working principles, Precision and accuracy: measurement error and calibration, Functional elements of an instrument system and mechanisms

Unit II - Aircraft Instrumentation: Aircraft Instrumentation – Requirements and standards, Basics of aircraft instruments -Types and Cockpit Layout - Civil and Military aircraft cockpits – Cockpit instruments display – Fundamentals of helicopter instrumentation and spacecraft instrumentation, Position and displacement transducers and accelerometers.

Unit III - Classification of aircraft instruments: Classification of aircraft instruments - Air data instruments – pitot static systems and instruments, gyroscopic instruments - Gyroscope and its properties, vacuum driven systems, heading instruments.

Unit IV - Temperature, Pressure Measurements: Temperature measurement using physical parameter, Thermocouples, Air temperature sensors – RAT sensor – TAT Probe, Ratiometer, radiation pyrometer system, Pressure measurement- elastic type pressure gauges-Bourdon tube bellows-diaphragms- Bell Gauge, Direct reading pressure gauges, pressure switches.

Unit V - Engine Instruments & Fuel flow measurements: Engine Instruments - measurement of RPM, manifold pressure, torque, exhaust gas temperature, EPR, engine vibration, monitoring, Fuel Quantity measurement – float type, capacitance type, and basic gauge system, Fuel flow measurement – rotating vane type indicator, fuel flow transmitter.

Text Book

1. A.K. Sawhney, "A course in Electrical and Electronic Measurement and Instrumentation", Dhanpat Raj and Sons, New Delhi, 1999.
2. Pallet, E.H.J., "Aircraft Instruments & Integrated systems", Longman Scientific and Technical, McGraw-Hill, 1992.

References:

1. Murthy, D.V.S., "Transducers and Measurements", McGraw-Hill, 1995.
2. Doeblin.E.O., "Measurement Systems Application and Design", McGraw-Hill, New York, 1999.
3. Harry L.Stilz, "Aerospace Telemetry", Vol. I to IV, Prentice-Hall Space Technology Series.
4. Spitzer, C.R., "Avionics- Elements, Software and Functions", CRC Press, Taylor & Francis group LLC, 2007
5. Cary R .Spitzer, "The Avionics Handbook", CRC Press, 2000.
6. Collinson R.P.G., "Introduction to Avionics Systems", Springer Science + Business Media B.V, 2011.

17AE2007 CAD/CAM LABORATORY

Credits: 0:0:2

Course Objective:

- To impart the knowledge on the usage of computer in design and manufacturing
- To impart the knowledge to visualization of objects in three dimensions and producing orthographic, sectional and auxiliary views of it.
- To impart the knowledge of drafting.

Course Outcome:

Students will be able to

- Understand the CAD packages.
- Develop 2D and 3D aircraft parts using software.
- Create parts and assemble these for functional assembly
- Draft for manufacturing
- Write CNC Program for different machining process
- Get the hands-on experience of CNC manufacturing

List of Experiments:

1. 2D Sketch
2. Solid Modelling.
3. Surface modelling
4. Sheet Metal Design
5. Assembly of the Aircraft parts.
6. Drafting of Different parts.
7. Photogrammetry
8. CNC -Profile cut using Linear and circular interpolation code
9. CNC –Circular pocketing and slotting
10. CNC –Step turning, taper turning,
11. CNC- Thread cutting and Drilling
12. Additive manufacturing

17AE2008 AERO THERMAL ENGINEERING

Credit 3:0:0

Pre-Requisites:17ME2004 Engineering Thermodynamics

Course Objective:

- To integrate the concepts, laws and methodologies from the first course in thermodynamics into analysis of cyclic processes
- To apply the thermodynamic concepts into various thermal application like IC engines, Compressors, Turbines and Nozzle.
- To impart the knowledge on Aircraft Refrigeration and Air conditioning systems

Course Outcome:

Students will be able to

- Understand the concepts of thermodynamic cycles
- Understand the working principles of internal combustion engines
- Know the function of nozzles and turbines
- Know the working principle of air compressors
- Understand the concepts of refrigeration systems
- Apply the different gas power cycles in IC and R&AC applications.

(Use of standard refrigerant property data book, Gas Tables and Psychometric chart permitted)

Unit I - Thermodynamic air cycles -Otto, Diesel, Dual combustion, Brayton cycles, Calculation of mean effective pressure, and air standard efficiency - Comparison of cycles.

Unit II - Internal combustion engines- Classification - Components and their function. Valve timing diagram and port timing diagram - actual and theoretical p-V diagram of four stroke and two stroke engines. Simple and complete Carburettor- MPFI, Engine Fuel system: Fuel Metering Devices, and Ignition system and Types. Engine starting

systems. Principles of Combustion and knocking in SI and CI Engines. Lubrication and Cooling systems. Performance calculation.
Unit III - Air compressor-Classification and working principle of various types of compressors, work of compression with and without clearance, Volumetric efficiency, Isothermal efficiency and Isentropic efficiency of reciprocating compressors, Multistage air compressor and inter cooling –work of multistage air compressor
Unit IV - Refrigeration - Refrigerants – selection of refrigerants- environmental aspects- Vapour compression refrigeration cycle- super heat, sub cooling – Performance calculations - working principle of vapour absorption system, Ammonia –Water, Lithium bromide –water systems.
Unit V - Air conditioning: Air conditioning system - Processes, Types and Working Principles. Concept of RSHF, GSHF, ESHF- Cooling Load calculations. Influence of Altitude for air conditioning system.

Text Books:

1. Rajput. R. K., "Thermal Engineering" S. Chand Publishers, 2000
2. Kothandaraman.C.P., Domkundwar.S., Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, Dhanpat Rai & sons , 2002

References:

1. Sarkar, B.K, "Thermal Engineering" Tata McGraw-Hill Publishers, 2007
2. Arora.C.P, "Refrigeration and Air Conditioning" , Tata McGraw-Hill Publishers 1994
3. Ganesan V. "Internal Combustion Engines", Third Edition, Tata Mcgraw-Hill 2007
4. Rudramoorthy, R, "Thermal Engineering", Tata McGraw-Hill, New Delhi,2003
5. Ramalingam. K.K., "Thermal Engineering", SCITECH Publications (India) Pvt. Ltd., 2009
6. Airframe and Powerplant Mechanics (EA-AC 65-12A) Powerplant handbook, Shroff Publishers and Distributors PVT.LTD, 9th Edition, 2009

17AE2009 THERMAL ENGINEERING LABORATORY

Co- requisite: 17AE2008 Aero Thermal Engineering
Credits: 0:0:1

Course Objectives:

- To impart knowledge on the performance characteristics of various thermal systems and internal combustion engines
- To impart knowledge on the design calculations of different thermal equipment
- To provide hands on training for performance measurements of different thermal system

Course Outcomes:
Students will be able to

- Evaluate the performance of refrigeration, heat pump and air–conditioning cycles
- Conduct a variety of experiments in internal combustion engines
- Analyze the efficiency and performance of two stage reciprocating air compressor
- Calculate & compare the performance parameters of air blower
- Determine the performance of 4 stroke petrol engine
- Determine the performance of four stroke single cylinder Diesel engine

List of Experiments

1. Measurement of coefficient of performance in a vapour compression refrigeration cycle
2. Measurement of coefficient of performance in a heat pump apparatus
3. Determination of coefficient of performance in air–conditioning cycle
4. Measurement of performance parameters on air blower
5. Measurement of performance parameters on two stage reciprocating air compressor
6. Performance test on variable compression ratio, 4 stroke petrol engine
7. Performance test on four stroke single cylinder Diesel engine

The faculty conducting the Laboratory will prepare a list of 6 experiments and get the approval of HoD / Director and notify it at the beginning of the semester.

14AE2010 AERODYNAMICS

Credits: 3:0:0
Pre-requisites: 17AE2002–Fundamentals of fluid flow

Course Objectives:

- To impart knowledge of basics of air flow
- To provide details regarding the flow over airfoils and wings
- To impart knowledge of forces and moments over an aerofoil

Course Outcome:
Students will be able to

- Understand the aerodynamic variable connected with airflow
- Apply the conservation laws for given aerodynamic situation
- Analyse the basic flows satisfying the governing equations
- Assess the flow field over the aerofoils
- Estimate the flow over aircraft wings and Fuselage
- Evaluate the forces and moments over vehicles utilizing different kinds of flows

Unit I - Basics: Fundamental Aerodynamic variables, Aerodynamic forces and moments, Centre of pressure, Types of flow, Gradient of Scalar and vector fields, Line, surface and volume integrals and the relationships between them. Continuity equation. Momentum equation and drag of a two dimensional body. Energy equation.
Unit II - Fluid Flow: Laplace Equation and relationship with continuity equation, Overview of Elementary flows, non-lifting and lifting flow over cylinders. Kutta – Joukowski theorem and generation of lift.
Unit III - Incompressible flow over airfoil: Joukowski transformation and conformal mapping. -Airfoil characteristics. Airfoil Nomenclature. The vortex sheet. The Kutta condition. Kelvin's circulation theorem. Introduction to classical thin airfoil theory – symmetric and cambered airfoil.2-D Panel Methods.
Unit IV - Incompressible flow over finite wings: Down wash and induced drag. Vortex filament, Helmholtz theorems. Biot-Savart law, Introduction to Prandtl's lifting line theory and Elliptic lift distribution, Vortex Lattice Methods.
Unit V - Boundary Layers: Introduction to Boundary Layers and Reynolds number effects. Development of Boundary Layer equations. Boundary layer thickness- Displacement thickness – Momentum Thickness – Energy Thickness. Momentum integral theorem and applications.

Text Books:

1. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010
2. E.Rathakrishnan, "Theoretical Aerodynamics" , John Wiley & Sons, 2013

References:

1. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012
2. L.M Milne Thomson, "Theoretical Aerodynamics", 1996
3. Jan Roskam, Chuan-Tau Edward Lan, Airplane Aerodynamics and Performance, DAR Corporation, 1997
4. John J Bertin, "Aerodynamics for Engineers", Sixth edition, Edward Arnold publications, 2012

17AE2011 AERODYNAMICS LABORATORY

Credit 0:0:2
Co-requisites: 17AE2010– Aerodynamics

Course Objective:

- To impart knowledge of basics of air flow
- To provide details regarding the flow over airfoils and wings
- To impart knowledge of forces and moments over an aerofoil

Course Outcome:
Students will be able to

- Understand the aerodynamic variable connected with airflow
- Predict pressure distribution over the various airfoils.
- Estimate lift and drag of various stream line and bluff bodies
- Visualize subsonic flow over various model

- Estimate effect of Reynolds number of low speed airfoil
- Evaluate the forces and moments over aircraft model

List of Experiments:

1. Calibration of subsonic wind tunnel.
2. The pressure distribution over a symmetric and cambered aerofoil.
3. Measurement of the Lift and drag of symmetric and cambered aerofoil.
4. The pressure distribution over a cascade aerofoil.
5. Force and moment measurements of rectangular wing by using strain gauge balance.
6. Force and moment measurements of car model by using strain gauge balance.
7. Boundary layer measurements in the test section of subsonic wind tunnel.
8. Assessment of performance of a small scale wind turbine by using Wind turbine tunnel.
9. Simulation of earth boundary layer in subsonic wind tunnel.
10. Smoke and tuft flow visualization Flow visualization over a car.
11. Flow visualization over cylinder and aircraft using Water tunnel facility.
12. Smoke and Tuft flow visualization of symmetric and cambered aerofoil.
13. Oil flow visualisation in subsonic tunnel

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of the semester.

17AE2012 AIRCRAFT STRUCTURES - I

Credits: 3:0:0
Pre-requisites: 17AE2004 Solid Mechanics

Course Objective:

- To impart the knowledge of aircraft material and its behaviour.
- To impart the knowledge on the methods of structural analysis under different types of loads.
- To provide the knowledge on basic theory of vibrations, elasticity,fatigue and failures.

Course Outcome:

Students will be able to

- Identify the suitable aircraft material and its behaviour
- Apply the methods of statically determinate and indeterminate structural analysis under different conditions
- Perceive the concept of Column buckling
- Solve the vibration problem with different DOF
- Apply the knowledge in basic theory of elasticity
- Analyse the airframe structures

Unit I - Introduction to Aircraft Structures Analysis: Stress strain curve- young's modulus- Poisson's ratio, basics of elasticity: Plane stress, Plane strain, Stress-Strain Relationships, Two dimensional problems, St. Venant's Principle. Aerospace Materials, Properties and structural application of Non-ferrous; Ferrous Composites – Classification, properties and usage

Unit II - Truss and Beams: Truss – Method of Joint and Space Truss Analysis, Deflection of Joints: Energy methods, Virtual Load method. Beam - Maxwell's Reciprocal theorem, Clapeyron's three moment equation, Moment Distribution Method. Castigliano's principles, Symmetrical and Unsymmetrical Bending: Stresses and deflections in beams of symmetrical and unsymmetrical sections.

Unit III - Buckling of Column: Buckling of columns, Inelastic buckling, Effect of initial imperfections, Stability of beams under transverse and axial loads, Energy method for the calculation of buckling loads in columns, Flexural-torsional buckling of thin-walled columns.

Unit IV - Theories of failure: Introduction, Maximum principal stress theory, Maximum principal strain theory, Maximum shear stress theory, Maximum strain energy theory, Maximum shear strain energy theory; Introduction to Fatigue-Different types of Fracture Modes -SN Curve - Stress Concentration -Fatigue and Fracture of engineering Alloys.

Unit V - Basic Theory of Vibration: Free and forced vibrations of undamped and damped Single DOF systems, free vibrations of undamped 2-DOF systems- Mode shape, Oscillation of beams, Approximation methods for determining natural frequencies Problems.

Text Book:

1. Megson, T.M.G., "Aircraft Structures for Engineering Students", fourth edition, Elsevier Ltd, 2010.
2. Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.

References:

1. Donaldson B K, "Analysis of Aircraft Structures" Cambridge Aerospace Series, 2008.
2. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 1980.
3. Rajput R K, "Strength of Materials",S.Chand (P)LTP, 2006.
4. G Lakshmi Narasaiah "Aircraft Structures", BS Publications.,2010
5. Sun C T, " Mechanics of Aircraft Structures", Wiley India,2010
6. F.S.Tse, I.E. Morse and H.T. Hinkle, "Mechanical Vibration", Prentice Hall of India Pvt., Ltd.,New Delhi, 1988.
7. R.K. Vierck, "Vibration Analysis", 2nd Edition, Thomas Y. Crowell & Co., Harper & Row Publishers, New York, U.S.A., 1989.

17AE2013 AIRCRAFT PERFORMANCE

Credits: 3:1:0

Pre-requisites:17AE2001 - Introduction to Aerospace Engineering

Course Objective:

- To impart knowledge about the concepts of Flight performance
- To introduce the various parameters affecting the performance
- To introduce the various theories of propeller analysis and design

Course Outcome:

Students will be able to

- Understand the preliminary design ofaircraft based on the performance.
- Differentiate performance characteristics of jet engine from propeller engine
- Estimate the performance characteristics in level Flight
- Assess the performance during turning manoeuvres of aircraft
- Realize the ground effects on performance
- Estimate the pitch angle from performance characteristics of propeller and its applications

Unit I - Basics of Aerodynamics and Wing Geometry: Introduction - Aircraft Shape and Orientation Effects of the Reynolds Number– Airfoil-lift - Drag Components - Drag polar, Drag Reduction Methods.

Unit II - Effects of Engine Characteristics in performance: Introduction – Performance – Variation of Power and Specific fuel consumption with Velocity and Altitude –Reciprocating Engines – Gas Turbine Engines.

Unit III - Performance Characteristics of Level Flights: Steady Level Flight –Fundamental Parameters - Equation of motion, Maximum speed- Power available, Power Required - Minimum Drag Condition; Range and Endurance –Breguet formula - Effect of wind-Rate of Climb-Absolute ceiling and service ceiling - Introduction Maximum Climb Angle, Maximum Rate of Climb, Angle of climb and their variations with altitude; Hodograph, Factors Influencing the Rate of Climb - Gliding Flight Maneuvring in the Vertical Plane

Unit IV - Turning Characteristics: Introduction- Level Turn- Minimum Turn Radius- Maximum Turn Rate-Instantaneous turn-Pull up and Pull down manoeuvres, Cobra Maneuver.

Unit V - Takeoff and Landing characteristics: Introduction to Take-off, Estimation of take-off distance-ground roll, obstacle clearing distance and height, Take off assist devices –Spoilers and landing distance–approach distance and flare distance.

Text Books:

1. J D Anderson, "Aircraft performance and Design", McGraw-Hill, New York, 2000.
2. Roskam, Jan and Lan, Chuan-tau E, "Airplane Aerodynamics and Performance", DAR Corporation, Lawrence, Kansas, USA, 1997.

Reference:

1. Perkins, C D and Hage, R E; "Airplane Performance Stability and Control", Willey Toppan, 2010.
2. Houghton, E L and Carruthers, N B; "Aerodynamics for Engineering Students", Edward Arnold Publishers, 1988.
3. Filippone, A, "Advanced Aircraft Flight Performance, Cambridge University Press, 2012.
4. David G. Hull, "Fundamentals of Airplane Flight Mechanics" Springer-Verlag Berlin Heidelberg 2007.
5. S.K. Ojha, " Flight Performance of Aircraft", AiAA,1995

17AE2014 ELEMENT OF AVIONICS

Credits: 3:0:0
Pre-requisites:17AE2006 Aircraft Instrumentation

Course Objectives:

- To impart knowledge about basic concepts of micro-processors and controllers, their significance and functioning.
- To provide understanding of the basic concepts and functioning of the avionic system data buses.
- To inculcate the knowledge about integrated avionics systems and the need for them.

Course Outcome:
Students will be able to

- Understand the fundamentals of processors, controllers and their applications
- Analyse the functioning of military/civil aircraft data buses and communication process between them.
- Identify display technologies and their working principles.
- Evaluate the modular avionics systems, electromagnetic interference & compatibility testing.
- Assess the working of fault tolerant systems and its applications
- Know the importance of integrated avionics systems and their build.

Unit I - Introduction to Avionics: Introduction to microprocessors and controllers, Role for Avionics in Civil and Military Aircraft systems, Avionics sub-systems and design, defining avionics System/subsystem requirements-importance of 'ilities', Avionics system architectures.
Unit II - Data Buses and Architecture: MIL-STD-1553B, ARINC-429, ARINC-629, CSDB, AFDX and its Elements, Avionics system design, Development and integration-Use of simulation tools, stand alone and integrated Verification and Validation.
Unit III - Cockpit Display Systems: Trends in display technology, Alphanumeric displays, character displays etc., Civil and Military aircraft cockpits, MFDs, MFK, HUD, HDD, HMD, DVI, HOTAS, Synthetic and enhanced vision, situation awareness, Panoramic/big picture display, virtual cockpit. Power requirements.
Unit IV - Modular Avionics: Packaging - Trade-off studies - ARINC and DOD types - system cooling - EMI/EMC requirements & standards.
Unit V - Fault tolerant systems: Fault tolerant systems - Hardware and Software, Evaluating system design and Future architecture - Hardware assessment. Criticality, damaging modes and effects analysis - Software development process models - Software Assessment and Validation. Automatic Test Equipment - Speeds maintenance.

Textbooks:

1. Spitzer, C.R., "Digital Avionics Systems", Prentice Hall, Englewood Cliffs, N.J., U.S.A., 1987.
2. Collinson R.P.G., "Introduction to Avionics", Chapman and Hall, 1996.

References:

1. Cary R .Spitzer, "The Avionics Handbook", CRC Press, 2000
2. Middleton, D.H. "Avionics Systems", Longman Scientific and Technical, Longman Group UK Ltd., England, 1989.
3. Jim Curren, "Trend in Advanced Avionics", IOWA State University, 1992
4. Harry L.Stilz, "Aerospace Telemetry", Vol. I to IV, Prentice-Hall Space Technology Series.
5. Spitzer, C.R., "Avionics- Elements, Software and Functions", CRC Press, Taylor & Francis group LLC, 2007

17AE2015 FOUNDATIONS OF SPACE ENGINEERING

Credits: 3:0:0

Course objective:

- To impart the knowledge on coordinate systems used in astronautics
- To impart fundamental knowledge on rocket and spacecraft trajectories
- To impart a basic knowledge of space environment

Course outcome:
Students will be able to

- Comprehend the fundamental concepts of space engineering
- Understand the most common coordinate system used in astronautics: inertial vs. body-fixed frames.
- Transform between these systems using rotational matrices.
- Understand the fundamental principles of orbital motion.
- Perceive the design of trajectories in the atmosphere and space.
- Attain a general knowledge on the composition of space environment

Unit I - Mathematical fundamentals: Vectors and scalars, Dot and cross product of vectors, Derivative of a vector function, Gradient, Integral of a vector function, Plane motion – radial and transverse components, tangential and normal components, Spherical trigonometry laws and applications.
Unit II - Physical principles and time measures: Kepler's laws, Newton's laws, Work and energy, Force and momentum, Impulse and momentum, Law of conservation of total energy, Angular momentum, Universal time, Dynamical time, Julian date, Solar and sidereal days.
Unit III - Coordinate systems and transformation: Two and three dimensional coordinate systems, Polar and Cartesian coordinates, Spherical polar coordinates, Inertial and body-fixed coordinate systems, Rotation and rotation matrices, Two and three dimensional rotation, Three-angle sets for specifying orientation: Roll-pitch-yaw, Euler angles, Euler parameters.
Unit IV - Introduction to atmospheric and spacecraft trajectory: Rocket equation, Staging, Launch sites, Selection criteria for optimal launch trajectory, Central force motion, Newtonian gravitation, Properties of conic sections, Escape velocity, Two-body motion: energy and velocity on orbit, Classical orbital elements, Velocity azimuth and flight path angle.
Unit V - Introduction to space environment: Sun and solar wind, Earth's atmosphere, Ionosphere and communications, Geomagnetic field, Space debris, Micro-meteoroids.

Text Book:

1. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics – Techniques and tools for space missions", Springer, First edition, 2015
2. William T. Thomson, "Introduction to Space Dynamics", Dover Publications, 2000

References:

1. William E. Wiesel, "Spaceflight Dynamics", Aphelion Press, USA, Third Edition, 2010
2. David A. Vallado,"Fundamentals of Astrodynamics and Applications", Microcosm and Kluwer , Second Edition, 2004
3. Jerry Jon Sellers, Understanding Space: An Introduction to Astronautics, 3rd ed. McGraw-Hill, 2005.
4. John E. Prussing, Bruce A. Conway, Orbital Mechanics, 2nd ed. Oxford University Press, 2012.
5. J.W.Cornelisse, H.F.R. Schoyer, and K.F. Wakker, "Rocket Propulsion and Spaceflight Dynamics", Pitman, 2001
6. Alan C. Tribble, "The Space Environment: Implications for Spacecraft Design", Princeton University Press, 2003.
7. J.R.Wertz, D.F.Everett, and J J. Puschell, "Space Mission Engineering: The New SMAD", Microcosm Press, 2011.

17AE2016 GAS DYNAMICS

Credits: 3:1:0
Pre-requisites: 14AE2010 - Aerodynamics

Course Objective:
- To provide information regarding the behavior of compressible fluid flow
- To impart knowledge regarding the difference between subsonic and supersonic flow
- To Estimate flow over flying vehicles at subsonic and supersonic speeds

Course Outcome:
Students will be able to
- Understand the influence of compressibility to distinguish between the flow regime
- Apply compressibility corrections for flow in C-D passages and instrument like Pitot static tube
- Estimate the sudden changes in the flow field
- Analyse the compressible flow field over an airfoil and finite wings
- Estimate the influence of friction and heat transfer in the flow field

- Choose proper flow visualisation techniques for the given situation

Unit I - One dimensional compressible flow: Compressibility, Velocity of sound, Concept of Mach Number, Isentropic relations, Normal shock and its relations, Prandtl equation and Rankine – Hugoniot relation, Flow through converging-diverging passages, Performance under various back pressures, corrections ofPitot static tube for subsonic and supersonic Mach numbers.
Unit II - Oblique shocks and expansion waves: Oblique shocks and corresponding equations,Hodograph and flow turning angle, shock polar, Flow past wedges, Strong, weak and detached shocks, Expansion waves & its corresponding equations, Flow past concave & convex corners, Interaction of shocks with wall, shock wave and expansion waves, Rayleigh and Fanno Flow.
Unit III - Differential equations of motion for steady compressible flows:
Potential equations, Small perturbation potential theory, solutions forsupersonic flows - flow over a wavy wall and flow over airfoil, Prandtl-Glauert correction for subsonicflows.
Unit IV - High speed flow over airfoil: Linearised two dimensional supersonic flow theory, Lift, drag, pitching moment and center of pressure of supersonic profiles, Lower and upper critical Mach numbers, Lift and drag divergence, shock induced separation.
Unit V - High speed flow over finite wing: Finite wing, tip effects, Characteristics of sweptwings, Effects of thickness, camber and aspect ratio of wings, transonic area rule, flow visualisation Techniques.

Text Books

1. Rathakrishnan, E., "Gas Dynamics", Third Edition, Prentice Hall of India, 2010
2. Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronald Press,1982

References:

1. Anderson Jr., D., – "Modern compressible flows", McGraw-Hill Book Co., New York 1999
2. Robert D Zucker, Oscar Biblarz, Fundamental of Gas Dynamics, Second Edition, John Willey &Sons, 2002
3. Liepmann H W and Roshko A, "Elements of Gasdynamics", John Willey & Sons, 2001.
4. Zucrow, M.J. and Joe D Hoffman , "Gas Dynamics", John Willey & Sons, 1976.

17AE2017 GAS DYNAMICS LABORATORY

Credit 0:0:2
Co-requisites: 17AE2016 – Gas Dynamics

Course Objective:
- To impart knowledge of basics of high speed flow over the model
- To provide details regarding the supersonic flow over various model
- To impart knowledge of shock wave over various model

Course Outcome:
Students will be able to
- Calibrate of supersonic wind tunnel
- Predict pressure distribution over the various airfoils.
- Visualize supersonic flow over various model
- Visualize shock wave and Estimate shock angle over various model
- Estimate effect of Reynolds number of low speed airfoil
- Assess the effect of back pressure in C-D nozzle

List of Experiments:
1. Calibration and runtime calculation of supersonic wind tunnel.
2. Flow visualisation using Schlieren technique.
3. Flow visualisation using shadowgraph technique.
4. Oil Flow visualisation
5. Flow visualisation of - Correctly expanded, under expanded and over expanded circular jets.
6. Flow visualisation of - Correctly expanded, under expanded and over expanded elliptic jets.
7. Flow visualisation of - Correctly expanded, under expanded and over expanded rectangular jets.
8. Pressure distribution in a C-D Nozzle using OJF facility.
9. Axis switching characteristics(pressure measurements) of elliptic nozzle
10. Axis switching characteristics(pressure measurements) of rectangular nozzle
11. Jet pluming study using high altitude jet facility.

12. Multiple jet interaction studies
13. Background noise study in supersonic tunnel.

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of the semester

17AE2018 AIRCRAFT STRUCTURE-II

Credits: 3:0:0
Pre-requisites: 17AE2012 Aircraft Structures -I
Course Objective:

- To impart the knowledge on the structural behaviour of aircraft components under different types of loads
- To provide the understanding in structural design methods for aerospace vehicles
- To impart the knowledge on the force distribution of different structures in Aircraft

Course Outcome:
Students will be able to

- Predict the shear flow and shear centre in open sections with effective and ineffective wall
- Predict the shear flow and shear centre in closed sections with effective and ineffective wall
- Analyse the buckling characteristics of plates
- Choose proper methods to analyse aerospace structural members
- Assess the load and stress distribution of wing and fuselage section
- Design the fail-safe and safe-life Aircraft structures

Unit I - Structural Idealization: Principle, Idealization of a panel, Effect of idealization on the analysis of open and closed section beams, Deflection of open and closed section beams.
Unit II - Shear flow in open sections: Thin walled beams, Concept of shear flow, Shear center, Elastic axis, with one axis of symmetry with effective and ineffective wall in bending, Unsymmetrical beam section.
Unit III - Shear flow in closed section: Bredt-Batho formula, Single and multi-cell structures, approximate methods, Shear flow in single and multi cell structures under torsion, Shear flow in single and multi cell structures under bending with effective and ineffective wall, Box Beams.
Unit IV - Buckling of plate: Buckling of thin plates, Inelastic buckling of plates, Local instability, Instability of stiffened panels, Failure stress in plates and stiffened panels, Crippling stresses by Needham's and Gerard's methods.
Unit V - Wing and Fuselage Analysis: Shear force, bending moment and torque distribution along the span of the Wing-Tension field beam and Semi tension field beam (Wagner Bam). Fuselage Analysis - Shear and bending moment distribution along the length of the fuselage.

Text Book:

1. Donaldson B K., "Analysis of Aircraft Structures", Cambridge Aerospace Series, 2008
2. Megson, T.M.G., "Aircraft Structures for Engineering Students", Elsevier Ltd.,2010

References:

1. G Lakshmi Narasaiah, "Aircraft Structures", BS Publications, 2010
2. Sun C T, " Mechanics of Aircraft Structures", Wiley India, 2010
3. Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.
4. Stephen P. Timoshenko & S.Woinovsky Krieger, "Theory of Plates and Shells", 2nd Edition, McGraw-Hill, Singapore, 1990.
5. Rivello, R.M., "Theory and Analysis of Flight structures", McGraw-Hill, N.Y., 1993.

17AE2019 AIRCRAFT STRUCTURES AND COMPOSITE LABORATORY

Credits: 0:0:2
Co-requisites:17AE2018 Aircraft Structure-II

Course Objective:

- To provide the basic knowledge of the testing equipment for various structural components.
- To impart the practical exposure with the measuring equipment and sensors.
- To impart the practical exposure with composite material manufacturing

Course Outcome:
Students will be able to

- Select test equipment for different types of static loading
- Conduct tests, analyse results, document and compare with analytical/theoretical results
- Analyse the different types of structural failures
- Manufacture the different Composite laminates
- Choose strain gauge for different application
- Understand the stress distribution based on cross-section shape and loading conditions

List of Experiments:

1. Deflection of simply supported and cantilever beams - Verification of Castigliano's Theorem
2. Determine the stiffness factors of an elastically supported beam
3. Determine the tensile strength of flat plates, riveted joints and bolted joints using UTM.
4. Compression test on columns, critical buckling loads – Southwell plot
5. Unsymmetrical bending of beams
6. Determination of the effective bending stiffness of a composite beam with the combination of aluminium and steel
7. Determination of the natural frequency of vibrations of a cantilever beam
8. Shear centre location for open sections
9. Torsion of a thin walled tube having closed cross section at the ends
10. Structural behaviour of a semi tension field beam (Wagner Beam)
11. Using photo elastic techniques: Calibration of circular disc in compression to find the fringe value and Determination of stress concentration factor due to compression in circular ring
12. Composite material Manufacturing and Testing- Tensile and Three point bending

17AE2020 AIRCRAFT STABILITY AND CONTROL

Credit: 3:0:0
Pre-requisites: 17AE2013Aircraft Performance

Course Objective:

- To introduce the concept of Stability and control of Aircraft
- To impart knowledge about various Aircraft motions and related stability
- To introduce the concept of dynamic stability of Aircraft

Course Outcome:
Students will be able to

- Understand the degree of freedom of aircraft system
- Analyse the static stability behaviour of the aircraft.
- Understand the dynamic longitudinal stability of aircraft
- Perform the dynamic analysis to determine stability of aircraft
- Estimate the requirement of control force and power plant
- Assess the motion of unstable aircraft and related modes of instability

Unit I - Static Longitudinal Stability : Degrees of Freedom of a system, Basic equations of motion- Wing and tail contribution; Effects of Fuselage and nacelles- Stick fixed neutral points- Power effects-Jet driven airplane and Propeller driven airplane, Elevator Requirements.
Unit II - Stick Fixed Static Longitudinal Stability : Basic equations of motion Elevator hinge moment, Estimation of hinge moment parameters, Stick Force gradients and Stick force per g load; Stick free Static Longitudinal Stability: Trim Taps, Stick free Neutral Point.
Unit III - Static Directional Stability: Basic equations of motion- Contribution of wing –Fuselage –Vertical tail- Propeller, Directional control- Adverse yaw, One engine In-operative Conditions, Cross wind Landing, Spin recovery- Rudder effectiveness- Rudder Lock –Fins.
Unit IV - Static Lateral Stability: Dihedral Effect- Criterion for stabilizing dihedral effect -Selection of dihedral angle-Contribution of wing –Fuselage –Vertical tail- Propeller and Flaps- Rolling moment and its convention; Lateral Control- Aileron effectiveness, Aileron control force requirements, Aileron Balancing.
Unit V - Dynamic Longitudinal Stability: Equations of motion-stick fixed and stick free, stability derivatives, Phugoid and short period, Lateral Dynamics- Equation of motion- Aileron fixed and free, Routh's discriminant, Dutch roll and Spiral instability, Auto rotation and Spin recovery.

Text Book:

1. Perkins, C D and Hage, R E; " Airplane Performance Stability and Control", Willey Toppan, 2010
2. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 1991

References:

1. J D Anderson, "Aircraft performance and Design", McGraw-Hill, New York, 2000.
2. Etkin, B., "Dynamics of Flight Stability and Control", John Wiley, New York, 1995.
3. Roskam Jan, "Airplane Flight Dynamics and Automatic Flight Controls". Design, Analysis and research Coorperation. 2003.
4. David G. Hull, "Fundamentals of Airplane Flight Mechanics" Springer-Verlag Berlin Heidelberg 2007.

17AE2021 AIRCRAFT PROPULSION

Credits: 3:0:0

Pre-requisites: 17AE2006 – Thermal Engineering for Aerospace Engineering

Course Objective:

- To familiarize with Principles of Propulsion systems
- To introduce working principles of Compressors and turbines
- To familiarize with the concept of Matching of compressors and turbines and Off design performance

Course Outcome:

Students will be able to

- Understand the performance of air breathing engines
- Analyse the performance of different Propulsion cycles.
- Understand the working of sub-systems of the propulsion system.
- Assess the performance of compressor and turbine
- Evaluate the combustion chamber, cooling and afterburner performance
- Find the causes of under-performance and remedial measures

Unit I - Fundamentals Air-Breathing Engines: Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, Cycle analysis jet engines. Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust – Effect of pressure, velocity and temperature changes of air entering compressor – Methods of thrust augmentation – Characteristics of turboprop, turbofan and turbojet – Performance characteristics. Principles of Pulsejets and Ramjets, Thermodynamic Cycle, Performance Parameters

Unit II - Inlets and Nozzle for jet engines: Internal flow and Stall in subsonic inlets – Boundary layer separation – Major features of external flow near a subsonic inlet – Relation between minimum area ratio and eternal deceleration ratio – Diffuser performance – Supersonic inlets – Starting problem on supersonic inlets – Shock swallowing by area variation – External deceleration – Mode of inlet operation. **Nozzles:** Theory of flow in isentropic nozzles – Convergent / Convergent – divergent nozzles; Nozzle throat conditions – Nozzle efficiency – Losses in nozzles – Over expanded and under – expanded nozzles - Thrust reversal.

Unit III - Compressors: Thermodynamics of Compressors, Development of parameters for compressor, Principle of operation of Axial and Centrifugal compressors. Work done and pressure rise – Velocity diagrams – Diffuser vane design considerations. Concepts of prewhirl, Rotation stall. Elementary theory of axial flow compressor. Velocity triangles – degree of reaction. Centrifugal and Axial compressor performance characteristics.

Unit IV - Combustion Chambers: Classification of combustion chambers – Important factors affecting combustion chamber design – Combustion process – Combustion chamber performance – Effect of operating variables on performance – Fuels and their properties and Fuel injection systems, Flame tube cooling – Flame stabilization – Use of flame holders and after burners.

Unit V - Turbine: Thermodynamics of Turbines, Development of parameters for turbine, Types of turbines Principle of operation of Axial and Radial turbine– Design considerations – Performance parameters - Basics of blade design principles. Impulse and reaction blading of gas turbines – Velocity triangles and power output – Elementary theory – Vortex theory – Choice of blade profile, pitch and chord – Estimation of stage performance – Limiting factors in gas turbine design- Overall turbine performance – Methods of blade cooling – Matching of turbine and compressor for different types of Gas turbine Engines.

Text Books:
1. Hill, P.G. & Peterson, C.R., "Mechanics & Thermodynamics of Propulsion", Addison – Wesley Longman INC, 1999.
2. V. Ganesan, "Gas Turbines", Tata Mc Graw - Hill Publishing Company Ltd 1999

References:
1. Irwin E. Treager, `Gas Turbine Engine Technology`, GLENCOE Aviation Technology Series, 7th Edition, Tata McGraw Hill Publishing Co. Ltd. Print 2003.
2. Cohen, H, Rogers. G.F.C. and Saravanamuttoo. H.I.H., "Gas Turbine Theory", Pearson Education, 1989.
3. Oates, G.C., "Aero thermodynamics of Aircraft Engine Components" , AIAA Education Series, New York, 1985.
4. Mathur. M.L, and Sharma. R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers & Distributors, Delhi, 1999.

17AE2022 SPACE DYNAMICS

Credits: 3:0:0
Pre-requisites: 17AE2015 Foundations of Space Engineering

Course Objective:
- To familiarize with the performance of rockets
- To impart knowledge of basics of orbital mechanics
- To familiarize with various factors affecting the satellite orbits

Course Outcome:
Students will be able to
- Estimate performance of the rockets
- Attain a general knowledge of laws governing the orbital motion
- Use proper reference coordinate system for space trajectory analysis
- Compute the orbits of the satellites
- Study the effects of perturbations on the orbital motion
- Generate a preliminary design of inter-planetary trajectories

Unit I - Atmospheric rocket flight: Rocket performance – Specific impulse, Derivation of rocket equation; Single and two stage rockets.
Unit II - Solar system and coordinate frames: planets, moons, asteroids, comets and meteoroids, Kepler's laws of motion; Reference frames – geocentric and heliocentric; the ecliptic - Motion of vernal equinox.
Unit III - Orbit classification: Properties of conics, Angular momentum; Computation of position and velocity vectors from orbital elements and vice-versa; Solution of Kepler's equation – elliptic and hyperbolic orbits.
Unit IV - Orbit perturbations: Earth's Oblateness, Sun-synchronous orbits, air drag, luni-solar perturbations; General and special perturbation methods; Cowell's and Encke's methods.
Unit V - Interplanetary trajectory: Single impulse maneuvers; Change of orbital inclination; Hohmann transfers from circular to circular orbits; Sphere of influence; Synodic period.

Textbooks:
1. Vladimir A. Chobotov, "Orbital Mechanics", AIAA Education Series, AIAA Education Series, Published by AIAA, 2002
2. Howard D. Curtis, "Orbital Mechanics for Engineering Students", Elsevier Butterworth-Heinemann, Third Edition, 2010

References:
1. Pini Gurfil, and P. Kenneth Seidelmann, "Celestial Mechanics and Astrodynamics: Theory and Practice", Springer, 2016
2. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", Springer, 2015
3. J.W.Cornelisse, H.F.R. Schoyer, and K.F. Wakker, "Rocket Propulsion and Spaceflight Dynamics", Pitman, 2001
4. William E.Wiesel, "Spaceflight Dynamics", Aphelion Press, USA, Third Edition, 2010
5. David.A. Vallado, "Fundamentals of Astrodynamics and Applications", Microcosm and Kluwer , Second Edition,2004

17AE2023 COMPUTATIONAL FLUID DYNAMICS

Credits: 3:0:0
Pre-requisites: 17AE2016 Gas Dynamics

Course Objective:

- To provide knowledge on governing equations of fluid dynamics
- To provide an understanding of the solution methodologies of discretised equations
- To provide knowledge on turbulence behaviour and its models of the flow

Course Outcome:
Students will be able to

- Understand the governing equations for fluid flow and its classification
- Choose the proper turbulent models for the given flow situation
- Apply proper solution methodology for PDE
- Arrive the proper domain for the numerical simulation for the given flow situation
- Define the boundary conditions and generate the grids
- Solve the real life fluid dynamic problems

Unit I - Governing equations: Governing equations of fluid flow and heat transfer, Navier-Stoke's equations, Conservative, differential and integral form of transport equations; Classifications of PDEs and Numerical methods for different PDEs.
Unit II - Introduction to CFD - Discretisation and grid generation, Problem solving with CFD, Finite difference method and finite volume method for one dimensional steady state diffusion, Finite volume method for one dimensional unsteady diffusion (heat conduction) – Explicit, Implicit and Crank-Nicholson scheme.
Unit III - Convection diffusion problems: Steady one dimensional convection - diffusion, central difference, upwind differencing and hybrid schemes, Properties of discretisation schemes and convergence, Assessment of central difference, upwind differencing and hybrid schemes, Overview of Power law and QUICK schemes.
Unit IV - Various schemes: Staggered grid and momentum equations, SIMPLE, SIMPLER and SIMPLEC algorithms, Implementation of Boundary Conditions – Inlet, outlet, Wall, constant pressure, symmetric and cyclic.
Unit V - Turbulence: Turbulence, Transition from Laminar to turbulent flows. Time averaged Navier-Stokes equations. Turbulence Models – zero equation- One equation - two equation and Reynolds stress models, Usage of turbulence models.

Text Books

1. Versteeg, H.K, and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method",Prentice Hall, 2nd Edition, 2007
2. Anderson, J.D., "Computational fluid dynamics – the basics with applications", 2005.

References:

1. Ghoshdastidar, P.S., "Computer simulation of flow and heat transfer", Tata McGraw – Hill publishing Company Ltd., 1998.
2. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", McGraw-Hill, 1980. Ane-Books2004 Indian Edition.
3. Muralidhar, K and Sundarajan .T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2nd Ed, 2011
4. Bose, T.K., "Numerical Fluid Dynamics", Narosa publishing House, 1997.
5. Wendt, J.F, "Computational Fluid Dynamics", Springer, 3rd ed. 2009

17AE2024 COMPUTATIONAL FLUID DYNAMICS LABORATORY

Credits: 0:0:2
Co-requisites: 17AE2023 Computational Fluid Dynamics

Course Objective:

- To familiarize the students with the working of CFD codes
- To familiarize the students with actual setting up of the problem and solution procedure
- To extract the required data, post process and compare with available data

Course Outcome:
Students will able to

- Define the body shape in a CFD code
- Create the solution domain and grid generation
- Apply boundary conditions and generate the solution
- Validate the aerodynamic quantities from computed data
- Perform CFD Analysis over 2D and 3D objects.
- Solve the problems using different turbulence models.

List of Experiments:

1. Laminar Pipe Flow
2. Turbulent Pipe Flow
3. Modelling a mixing Elbow (2-D)
4. Flat Plate Boundary Layer
5. Forced Convection over a Flat Plate
6. Steady Flow past a Cylinder
7. Unsteady Flow past a Cylinder
8. Flow Over an Airfoil
9. Flow simulation over an aircraft
10. Flow simulation over a rocket
11. Supersonic Flow over a Wedge
12. Compressible Flow in a Nozzle
13. Analysis of 1D unsteady conduction by explicit and implicit schemes.

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

17AE2025 ROCKET PROPULSION

Credit 3:0:0
Pre-requisites: 17AE2021 Aircraft Propulsion

Course Objective:

- To impart knowledge on concepts of Solid Propulsion rocket motor
- To impart knowledge on concepts of Liquid Propulsion rocket motor
- To impart knowledge on concepts of Advanced Propulsion systems

Course Outcome:
Students will be able to

- Evaluate the performance of rocket nozzle
- Understand and evaluate the performance of chemical propellant
- Select and design a suitable solid rocket motor
- Select and design a suitable liquid rocket motor
- Evaluate the performance of cooling system
- Select and design advanced propulsion systems

Unit I - Fundamentals Of Rocket Propulsion: Overview of rockets, Rocket equation, Performance parameters, Staging and Clustering, Classification of rockets. Rocket nozzle and performance, Nozzle area ratio, conical nozzle and contour nozzle, under and over-expanded nozzles, Flow separation in nozzles, unconventional nozzles, Mass flow rate, Characteristic velocity, Thrust coefficient, Efficiencies, Specific impulse.
Unit II - Chemical Propellants: Molecular mass, specific heat ratio, Energy release during combustion, Stoichiometric & mixture ratio, Types and classifications, Criterion for choice of propellant, Solid propellants, requirement, composition and processing, Liquid propellants, energy content, storability.
Unit III - Solid Propulsion Systems: Classifications, Booster stage and upper stage rockets, Hardware components and functions, Propellant grain configuration and applications, Burn rate, burn rate index for stable operation, mechanism of burning, ignition and ignitors types, Action time and burn time, Factors influencing burn rates, thrust vector control.
Unit IV - Liquid Propulsion Systems: Liquid Propellant engines, Thrust chamber and its cooling, injectors and types, Propellant feed systems, Turbo pumps, Bipropellant rockets, Mono propellant thrusters, Cryogenic propulsion system, special features of cryogenic systems.

Unit V - Advance Propulsion Techniques: Hybrid propellants and gelled propellants. Electrical rockets, types and working principle, Nuclear rockets, Solar sail, Concepts of some advance propulsion systems, Introduction to scramjet – Preliminary concepts in supersonic combustion, Integral ram-rocket.

Text books:

1. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5th Edn., 2014.
2. Hill P.G. & Peterson, C.R., "Mechanics & Thermodynamics of Propulsion" Addison – Wesley Longman INC, 1999.

References:

1. Cohen, H., Rogers, G.F.C. and Saravanamutoo, H.I.H., "Gas Turbine Theory", Longman Co., ELBS Ed., 1989
2. Gorden, C.V., "Aero thermodynamics of Gas Turbine and Rocket propulsion", AIAA Education series, New York, 1989
3. Mathur, M., and Sharma, R.P., "Gas Turbines and Jet and Rocket Propulsion", standard Publishers, New Delhi, 1988
4. Vigor Yang, "Liquid rocket thrust chamber: Aspect of modeling, analysis and design", American Institute of Aeronautics and Astronautics, 2004

17AE2026 PROPULSION LABORATORY

Co-requisites: 17AE2025 Rocket Propulsion
Credit: 0:0:2

Course Objectives:

- To impart knowledge on basic concepts and operation of various propulsion system
- To provide practical exposure to the operation of various propulsion systems.
- To impart knowledge on shock tube.

Course Outcomes:

Students will be able to

- Understand the design the experiment for rocket motor performance.
- Assess the real time situation and corrective measures associated with rocket motors.
- Analyze the working of different parts of aircraft engine
- Estimation of calorific value of fuels
- Force distribution of axial compressor blade
- Solve Ignition delay studies using shock tube

List of Experiments

1. Study of an aircraft jet engine
2. Estimation of calorific value of fuels
3. Study on injector calibration
4. Shock speed measurement studies
5. Ignition delay studies using shock tube.
6. Storage losses of cryogenic fluids.
7. Cascade testing of a model for axial compressor blade row (symmetrical)
8. Cascade testing of a model for axial compressor blade row(cambered)
9. Study of convective heat transfer coefficient for liquids
10. Free convection heat transfer
11. Forced convection heat transfer
12. Nozzle performance test.

17AE2027 COMPUTATIONAL STRUCTURAL ANALYSIS LABORATORY

Pre-requisites: 17AE2018 Aircraft Structures-II
Credit 0:0:2

Course Objective:

- To provide the knowledge on various structural analysis software packages
- To impart the understanding of the stress analysis of different types of structural components
- To impart the Knowledge on programming for various structural analysis

Course Outcome:
Students will be able to

- Understand the various structural software packages
- Solve the static structural analysis of one dimensional members
- Solve the static structural analysis of two dimensional & three dimensional problem
- Analyze the Static Thermal analysis of various objects
- Understand the various structural programming – open source software packages
- Program for various structures problem

List of Experiments:

1. Static stress analysis axial bar
2. a. Two dimensional (truss) frame with multiple materials and element types
   b. Three dimensional truss- Airframe
3. Simple two dimensional heat transfer problem
4. Modal analysis of Aircraft wing
5. Plate buckling analysis
6. Box Beam- Torsional and bending problem.
7. Fluid-structure interaction-Oscillating plate using Ansys workbench.
8. Programming of one dimensional bar with single material and axial load using Scilab.
9. Programming of one dimensional step bar, multiple material with different axial load direction using Scilab.
10. Programming for vibration analysis of bar using Scilab.
11. Programming for one- dimensional heat transfer problem using Scilab.
12. Programming for 2D truss using Scilab.

17AE2028 AIRCRAFT/SPACECRAFT DESIGN PROJECT

Credits: 0:0:4
Pre-requisites: 17AE2020 Aircraft Stability and Control

Course Objective:

- To impart the knowledge of Aerodynamic design of Aircraft.
- To impart the knowledge of Performance analysis and stability aspects of different types of aircraft/Spacecraft.
- To impart the knowledge of the structural design of the aircraft/space craft.

Course Outcomes:
Students will be able to

- Choose the type of aircraft/spacecraft for comparative studies
- Calculate the aerodynamic parameter
- Design the aircraft and assess the performance of the design
- Analyse the stability of the designed vehicle
- Design the aircraft wings, tail, fuselage, landing gears
- Analysis the aircraft using XFLR5 (open source) software

Activities to be carried out:

1. Comparative studies of different types of airplanes and their specifications and performance details with reference to the design work under taken.
2. Preliminary weight estimation, Selection of design parameters, power plant selection, aerofoil selection, fixing the geometry of Wing, tail, control surfaces Landing gear selection.
3. Preparation of layout drawing, construction of balance and three view diagrams of the airplane under consideration.
4. Drag estimation, Performance calculations, Stability analysis and V-n diagram.
5. Preliminary design of an aircraft wing – Shrenck's curve, structural load distribution, shear force, bending moment and torque diagrams
6. Detailed design of an aircraft wing – Design of spars and stringers, bending stress and shear flow calculations – buckling analysis of wing panels
7. Preliminary design of an aircraft fuselage – load distribution on an aircraft fuselage 4. Detailed design of an aircraft fuselage – design of bulkheads and longerons – bending stress and shear flow calculations – buckling analysis of fuselage panels

8. Design of control surfaces - balancing and maneuvering loads on the tail plane and aileron, rudder loads
9. Design of wing-root attachment
10. Landing gear design
11. Preparation of a detailed design report with CAD drawings
12. Aerodynamic and Stability analyses using open source software like XFLR5.

17AE2029 INSTRUMENTATION AND AVIONICS LABORATORY

Credit: 0:0:2
Pre-requisites: 17AE2014 - Elements of Avionics

Course Objective:

- To impart the knowledge about different types of Instruments and control systems
- To train students to measure parameters accurately and their importance in different applications in the field of Avionics
- To provide a complete knowledge on navigation systems like GPS.

Course Outcome:

Students will be able to

- Understand the fundamentals of measurements.
- Understand the applications of these fundamental measurement systems.
- Understand the enormous amount of pressure that is put on these simple instrumentation in real time applications.
- Work with the avionics systems on an aircraft
- Apprehend the design concept of new control systems
- Familiarize with methods of troubleshoot and rectification of faulty instruments.

List of Experiments:

1. Stepper motor control
2. Displacement measurement using LVDT
3. Characteristics of load cells
4. Measurement of Pressure
5. Study of ON-OFF temperature control system
6. Design of Longitudinal autopilot for jet airplane
7. Measurement of Angular position using Gyroscope
8. Measurement of Air velocity using Hot wire Anemometer
9. Measurement of Acceleration using Accelerometer
10. Temperature measurement using thermocouple
11. Temperature measurement using RTD
12. Study on global positioning system
13. Programming with microprocessors

17AE2030 WIND TUNNEL TECHNIQUES

Credits: 3:0:0
Course Objective:

- To provide knowledge of various types of wind tunnels and test techniques.
- To introduce the basic concepts of measurement of pressure, velocity, forces and moments on models.
- To provide knowledge of various flow visualization techniques.

Course Outcome:

Students will be able to

- Understand the various types of wind tunnels and test techniques.
- Choose proper high speed wind tunnel for required test.
- Choose correct model for wind tunnel testing
- Estimate the forces and moments for given model
- Arrive the pressure, velocity and temperature using measurement techniques
- Choose the proper flow visualization techniques

Unit I - Low speed wind tunnels: Flow similarity, Types of Wind Tunnel- subsonic, supersonic, transonic and hypersonic, Low Speed: layouts and nomenclature, types - closed circuit and open circuit, closed jet and open jet test section – application, Special purpose tunnels - Smoke Tunnels – Water Tunnels – Spin tunnel etc.,
Unit II - Supersonic wind tunnel: Classification, Blow down, continuous and intermittent tunnel, Runtime calibration, mass flow rate, Size of pressure vessel, Starting and stopping Loads, Model Sizing.
Unit III - Hypersonic wind tunnel: – Classification; Runtime Calculation; Shock Tube: Driver – driven section – Diaphragm – Type of operation – Shock Speed and Initial Diaphragm Pressure Ratio, Model sizing; Starting and stopping Loads - Calibration of test section for various Tunnels.
Unit IV - Wind tunnel measurements: Forces, moments and Reference Frames, Balances- Internal and External, Requirements and Specifications, Fundamentals of Model Installations. Pressure measurements – Barometers, Manometers, Pressure Transducer, Pressure sensitive Paints, Pitot-static tube, Velocity Measurements -Laser Doppler Anemometer, Hot-wire Anemometer, PIV – PLIF - LDV, Temperature Measurements–Thermocouples, Temperature sensitive Paints, Heat flux measurements.
Unit I - Flow visualization techniques: Path – Streak – Stream and Timelines; Techniques: Smoke, Tuft, Streaks, Surface oil flow, Interferometer, Schlieren and Shadowgraph technique.

Text Book:

1. Rae, W.H. and Pope, A. "Low Speed Wind Tunnel Testing", John Wiley Publication, 1999
2. Pope, A., and Goin, L., "High Speed wind Tunnel Testing", John Wiley Publication, 1999
3. Rathakrishnan E, Instrumentation, Measurements and Experiments in fluids. CRC Press, London, 2007

References:

1. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010
2. J Lukosiewitz, M Dekkar, "Experimental Methods of Hypersonic", 1973
3. Rathakrishnan E, Gas Dynamics. PHI Learning Pvt Ltd, 2001

17AE2031 FINITE ELEMENT ANALYSIS IN AEROSPACE APPLICATION

Credits: 3:0:0

Course Objectives:

- To impart the basic concept of finite element theory
- To introduce concept of finite element method for analysis of aerospace structural components
- To provide the knowledge on various finite element procedures and solution techniques

Course Outcome:

Students will be able to

- Understand the different numerical solution to the FEA Problems
- Analyse the discrete and continuum problem using finite element method.
- Analyse the functions of different elements and stiffness matrix
- Solve the Axisymmetric problems
- Identify mathematical model for solution of common engineering problems
- Describe the usage of professional-level finite element software to solve engineering problems

Unit I - Basic of finite element analysis (FEA): Fundamental concepts of engineering analysis – historical background of FEA – General Steps Involved – Discretization – weighted residual methods – Rayleigh –Ritz Method (Variational Method); Applications- Introduction to MATLAB/SCI-LAB Programming.
Unit II - One dimensional finite element analysis – Co-ordinate systems - shape functions and stiffness matrix for bar element - shape functions and stiffness matrix beam element - shape functions and stiffness matrix for Truss element – related problems; Applications- MATLAB/SCI-LAB Programming- 1 D Elements – Truss Problems.
Unit III - Two dimensional finite element analysis – Plane stress and plain strain problems – Constant strain triangular element – Shape function – Strain displacement matrix – stress strain relationship matrix – stiffness matrix equation - Linear strain triangular element – four noded rectangular element – Isoparametric elements; Applications-Programming- Two dimensional elements.
Unit IV - Higher order elements – Shape function of quadratic and cubic element-Shape function of eight noded quadrilateral element - Shape function of Nine noded quadrilateral element – Axisymmetric elements – problems – consistent mass matrix for various elements – lumped mass matrix – evaluation of Eigen values and Eigen vectors; Applications- MATLAB/SCI-LAB Programming- Higher order elements

Unit V - Boundary Value Problems: One dimensional Heat transfer element – related problems – Applications to heat transfer in two dimension – related problems – application to fluid mechanics in two dimension – related problems – MATLAB/SCI-LAB programming for structural, heat transfer and fluid flow problems.

Text Books:
1. Robert D. Cook, David S. Malkus, Michael E. Plesha, "Concepts and Applications of Finite Element Analysis", John Wiley and Sons , 2007.
2. Young W.Kwon, Hyochoong Bang, "The Finite Element Method using MATLAB", CRC Press LLC, USA,1997.

References:
1. Segerlind,L.J. "Applied Finite Element Analysis", Second Edition, John Wiley and SonsInc., New York, 1984.
2. J.N. Reddy, "An Introduction to the Finite Element Method,", McGraw-Hill International Editions, 3rd ed., 2009
3. Tirupathi R. Chandrupatla and Ashok D. Belegundu, "Introduction to Finite Elements in Engineering", Prentice Hall, 2002
4. Rao S.S., "Finite Element Methods in Engineering", Pergamon Press, 4th Ed., 2005.
5. Robert D. Cook "Finite Element Modeling For Stress Analysis", John Wiley and Sons, 1995.
6. Roy R. Craig, Jr., "Structural Dynamics: An Introduction to Computer Methods," John Wiley and Sons, 1981.

17AE2032 HEAT TRANSFER

Credit 3:0:0
Pre-requisites: 17ME2004 Engineering Thermodynamics

Course Objective:
- To understand the mechanisms of heat transfer under steady and transient conditions.
- To understand the concepts of heat transfer through extended surfaces.
- To learn the thermal analysis and sizing of heat exchangers and to understand the basic concepts of mass transfer.

Course Outcome
Students will be able to
- Understand the fundamental modes of heat transfer
- Understand the phase change heat transfer
- Use the heat transfer correlation for different heat transfer applications
- Understand the concept of hydrodynamic and thermal boundary layers
- Analyse and design the different types of heat exchangers
- Apply heat transfer principles of different applications.

(Use of standard HMT data book permitted)

Unit I - Conduction: General Differential equation of Heat Conduction– Cartesian and Polar Coordinates – One Dimensional Steady State Heat Conduction –– plane and Composite Systems – Critical thickness of insulation - Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infinite and Infinite Solids –Use of Heisler"s charts.
Unit II - Convection: Dimensional analysis – forced and free convection- Significance of dimensionless number - Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection during external flow over Plates and Cylinders and Internal flow through tubes.
Unit III - Phase change heat transfer and heat exchangers: Nusselt"s theory of condensation - Regimes of Pool boiling and Flow boiling. Correlations in boiling and condensation. Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factors - Analysis – LMTD method – effectiveness, NTU method.
Unit IV - Radiation: Basic definitions - Black Body Radiation – Grey body radiation - Shape Factor – Electrical Analogy – Radiation between black surfaces - Radiation Shields - Radiation through gases.
Unit V - Numerical methods in heat transfer and applications: Numerical analysis of heat conduction – finite difference formulation of differential equations – one-dimensional and two-dimensional steady heat conduction – Transient heat conduction in a plane wall-Application of heat transfer – Gas turbines-Rocket Thrust Chambers - Aerodynamic Heating -Ablative Heat Transfer.

Text Books:

1. Yunus A. Cengel, "Heat Transfer A Practical Approach", Tata McGraw Hill, 2010
2. Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2000

Reference Books:

1. Ghoshdastidar, P.S, “Heat Transfer”, Oxford, 2004,
2. Nag, P.K., “Heat Transfer”, Tata McGraw Hill, New Delhi, 2002
3. Ozisik, M.N., “Heat Transfer”, McGraw Hill Book Co., 1994.
4. Kothandaraman, C.P., “Fundamentals of Heat and Mass Transfer”, New Age International, New Delhi, 1998.
5. Sutton,G.P., “Rocket Propulsion Elements”, John Wiley and Sons, Fifth Edition, 1986.

17AE2033 EXPERIMENTAL STRESS ANALYSIS

Credits: 3:0:0

Course Objectives:

- To impart the knowledge in experimental method of finding the response of the structure to different types of load.
- To provide the basic knowledge in Electrical-Resistance strain gauges and it application
- To impart the knowledge in photo-elasticity techniques

Course Outcome:

Students will be able to

- Get the knowledge of the general aspects of strain measurements
- Ability to understand the principle of operation of different type of strain gauges.
- Choose the electrical resistance strain gauge for different application
- Get the knowledge of the 2D Photo elastic stress analysis
- Get the knowledge of the three dimensional photo elasticity
- Identify the suitable stress coating methods

Unit I - Basics: Principle of measurements-Accuracy, sensitivity and range- Definition of strain and its relation to experimental determinations Properties of strain gauge systems, Types of strain gauge systems- Mechanical, Optical, Acoustical and Electrical extensometers.

Unit II - Strain Gauges: Electrical-Resistance strain gauges and circuits, Principle of operation and requirements - Types and their uses- Materials for strain gauge-Calibration and temperature compensation-Cross sensitivity-Rosette analysis- Wheatstone bridge-Potentiometer circuits for static and dynamic strain measurements Strain indicators- Transducer applications- Load cells- Diaphragm pressure transducers. Case Study-Six component strain gauge balancing, foil type strain gauge mounting on plate - cantilever beam- Aircraft wing section- strain analysis with respect to different load.

Unit III - Optical method of stress analysis: Polariscope – interferometer, Moiré Method,. Concepts of photoelastic effects, Photoelastic materials-Stress optic law- Plane Polariscope –Circular Polariscope -Transmission and Reflection type, Effect of stressed model in Plane and Circular Polariscope, Interpretation of fringe pattern - Isoclinics and Isochromatics. Case study- Aircraft wing spar and stringer cross section- Stress concentration, Principal stress and strain analysis using plane polariscope – circular polariscope.

Unit IV - Three dimensional photoelasticity: Introduction, Locking in model deformations – Material for three-dimensional photoelasiticity, Machining, cementing and slicing three dimensional models. Shear –Difference method, Frozen-stress method, Scattered- Light method.

Unit V - Birefringent Coatings: Coating stresses and strain- Coating sensitivity – Coating materials- Application of coatings- Effect of coating thickness-Fringe-Order Determinations in coatings- Stress separation methods. – Applications.

Text Book:

1. J.W. Dally and M.F. Riley, “Experimental Stress Analysis”, McGraw-Hill Book Co., New.York, 1988.
2. Srinath,L.S., Raghava,M.R., Lingaiah,K. Gargesha,G., Pant B. and Ramachandra,K., “Experimental Stress Analysis”, Tata McGraw Hill, New Delhi, 1984

References:

1. Hetenyi, “Handbook of Experimental Stress Analysis”, John Wiley & Sons Inc., New York, 1980.

2. G.S. Holister, “Experimental Stress Analysis, Principles and Methods”, Cambridge University Press, 1987.
3. A.J. Durelli and V.J. Parks, “Moire Analysis of Strain”, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1980.

17AE2034 COMPOSITES MATERIALS

Credits: 3:0:0

Course Objectives:

- To impart knowledge on Types and applications of composite materials
- To impart knowledge on Nature of various forms of reinforcement and matrix.
- To impart knowledge on Processing and testing of composite materials

Course Outcomes:

Students will be able to

- Understanding the mechanics of composite materials
- Understand the behaviour Composite Materials under Various Loads
- Understand the structure of the composite materials
- Analyze the different Failure modes of Composite Materials
- Analyze the laminated composites for various loading eases
- Get knowledge in manufacture of composites

Unit I - Micromechanics: Introduction - advantages and application of composite materials – types of reinforcements and matrices - micro mechanics – mechanics of materials approach, elasticity approach- bounding techniques – fiber volume ratio – mass fraction – density of composites; Effect of voids in composites.

Unit II - Macromechanics: Generalized Hooke’s Law - elastic constants for anisotropic, orthotropic and isotropic materials - macro mechanics – stress-strain relations with respect to natural axis, arbitrary axis – determination of in plane strengths of a lamina - experimental characterization of lamina; Failure theories of a lamina.

Unit III - Laminated Plate Theory: Governing differential equation for a laminate, stress – strain relations for a laminate, Different types of laminates, in plane and flexural constants of a laminate. hydrothermal stresses and strains in a laminate, Failure analysis of a laminate, impact resistance and inter laminar stresses; Netting analysis

Unit IV - Fabrication Process and Repair Methods: Various open and closed mould processes, manufacture of fibers, importance of repair and different types of repair techniques in composites – autoclave and non-autoclave methods.

Unit V - Sandwich Constructions:

Basic design concepts of sandwich construction - materials used for sandwich construction - failure modes of sandwich panels - bending stress and shear flow in composite beams.

Text Books:

1. R.M. Jones, “Mechanics of Composite Materials”, 2nd Edition, Taylor & Francis, 1999
2. B.D. Agarwal and L.J. Broutman, “Analysis and Performance of fiber composites”, John-Wiley and Sons, 1990

References:

1. L.R. Calcote, “Analysis of laminated structures”, Van Nostrand Reinhold Co.,1989.
2. Autar K. Kaw, “Mechanics of Composite Materials”, CRC Press LLC, 1997
3. G.Lubin, “Hand Book on Fibre glass and advanced plastic composites”, Van Nostrand Co., New York, 1989. 5.
4. B.D. Agarwal and L.J. Broutman, “Analysis and Performance of fiber composites”, John-Wiley and Sons, 1990

17AE2035 NAVIGATION, GUIDANCE AND CONTROL OF AEROSPACE VEHICLES

Credits: 3:0:0

Course Objectives:

- To impart the concept of Control system fundamentals and its analysis.
- To introduce the concepts and working principles of different navigation methods and guidance.
- To model of aerospace vehicles and flight control system.

Course Outcomes:
Students will be able to

- Understand the control system and assess its performance and stability using routh Hurwitz criterion and root locus.
- Analyze time and frequency domain specifications and perform analysis using bode plot, polar plot and Nyquist stability criteria.
- Deploy the skills effectively in design of control for aerospace vehicle systems
- Understand the working principles and specifications of navigation methods.
- Simulate and assess the performance of autopilots, augmentation systems and missile guidance systems.
- Apprehend the functionality of advanced navigation and guidance systems.

Unit I - Introduction to Control System: Introduction to Control System - open loop and closed loop control system-Transfer function poles and zeroes - block diagram reduction- signal flow graph - Mason's gain formula - Characteristics equation-concept of stability - Routh's stability Criteria, Root Locus.
Unit II - Time and Frequency Domain Analysis: Time domain - Transient and Steady State Response-Time domain Specifications - Second Order system. Frequency Domain Analysis Closed Loop Frequency Response-Bode Plot-Polar Plot-Nyquist Stability Criteria-Stability Analysis from Bode Plot
Unit III - Introduction to navigation systems: Introduction to navigation systems - Types Different co-ordinate systems - Transformation Techniques; Different types of radio navigation; - Introduction to Inertial Sensors; INS components; Introduction to GPS - system description - basic principles - position and velocity determination.
Unit IV - Introduction to guidance and control: Introduction to guidance and control, Need for automatic flight control systems; Displacement Autopilot - Pitch Orientation Control system; Methods of Obtaining Coordinates, Yaw Orientation Control system, Lateral Autopilot, Missile Autopilot.
Unit V - Introduction to Advanced systems: Introduction to Advanced systems, Introduction to Fly-by-wire flight control systems, Instrument Landing System, microwave landing system, Operating principles and design of guidance laws, Radar systems, command and housing guidance systems.

Text Books:

1. Gopal.M., "Control System", Tata McGraw Hill, 2008
2. Ching-Fang Lin, "Modern Navigation, Guidance and Control Processing", Prentice Hall Inc., Englewood Cliffs, New Jersey, 1991

References:

1. Myron Kyton, Walfred Fried, "Avionics Navigation Systems", John Wiley & Sons, 2nd edition, 1997
2. Nagaraja, N.S. "Elements of Electronic Navigation", Tata McGraw-Hill Pub. Co., 15th reprint, 2006.
3. Blake Lock, J.H "Automatic control of Aircraft and missiles", John Wiley Sons, Second Edition, 1991.
4. Stevens B.L & Lewis F.L, "Aircraft control & simulation", John Wiley Sons, Second Edition, 2003.
5. Collinson R.P.G. "Introduction to Avionics Systems", Springer Science- Business Media B.V, 2011.
6. Garnel.P. & East.D.J, "Guided Weapon control systems", Pergamon Press; 2nd edition, 1980.
7. Nelson R.C "Flight stability & Automatic Control", McGraw Hill, Second Edition, 2007.
8. Bernad Etikin, "Dynamic of flight stability and control", John Wiley, 1995.

17AE2036 CRYOGENIC PROPULSION

Credit 3:0:0

Course Objective

- To impart the knowledge on cryogenic fluids
- To impart the knowledge on Liquefaction & Cryogenic refrigeration systems
- To know the various application of these propulsion in Aerospace field

Course Outcome
Student will be able to

- Understand the thermal, physical and fluid dynamic properties of cryogenic fluids.
- Recognize the liquefaction systems to produce cryogenic fluids
- Known the Cryogenic refrigeration systems
- Recognize the methods of Cryogenic fluid storage and transfer systems for Aerospace application
- Categorize the Cryogenic Engine for Rockets
- Design the various cryogenic equipment used in Aerospace application.

Unit I - Introduction to Cryogenic Engineering: Introduction to cryogenic systems-Historical background - Low temperature properties of materials –Thermal properties – Electric and magnetic properties – properties of cryogenic fluids – Fluids other than hydrogen and helium - Hydrogen – Helium 4 – Helium 3.
Unit II - Liquefaction systems: Thermodynamically ideal system – Joule-Thomson effect –Adiabatic expansion – Liquefaction systems- Simple Linde Hampson system-Precooled Linde Hampson system-Claude system – kapitza system – Heylandt system – comparison of liquefaction systems.
Unit III - Cryogenic refrigeration systems: Concept of ideal refrigeration systems – Joule-Thompson refrigeration systems – Philips refrigerator – Vuilleumier refrigerator – Solvay refrigerator – Gifford-Mcmanon refrigerator-Magnetic cooling – Magnetic refrigeration systems – Dilution refrigerators.
Unit IV - Cryogenic fluid storage and transfer systems: Cryogenic fluid storage vessels- Basic storage vessels – Inner and outer vessel design – Piping- Draining the vessels –Safety devices – Insulations – Cryogenic fluid transfer systems- Uninsulated and porous insulated lines –Vacuum insulated lines – Cryogenic valves.
Unit V - Cryogenic Engine: Introduction to cryogenic engines, types and their application- Schematic diagram-working principle of Cryogenic engine, Precaution for testing the engine. Numerical problems

Text Books:

1. R. Barron , "Cryogenic Systems", Oxford University Press, 1985
2. T.M. Flynn, Marcel Dekker., "Cryogenic Engineering", New York, 1997

Reference Books:

1. Bose and P. Sengupta, "Cryogenics: Applications and Progress", Tata McGraw Hill, 1985
2. R.W. Vance and W.M. Duke , "Applied Cryogenic Engineering" , John Wiley & sons., 1962

17AE2037 INDUSTRIAL AERODYNAMICS

Credits: 3:0:0
Prerequisites: 16AE2001–Fluid Mechanics & 14AE2006 - Aerodynamics

Course Objective:

- To impart information about non-aeronautical uses of aerodynamics, such as road vehicle, building aerodynamics
- To familiarize the concept of wind energy system and its applications
- To provide the knowledge on solution of problems in flow induced vibrations

Course Outcome:
Students will be able to

- Understand the airflow over a surface
- Apply the principles of aerodynamics to different ground vehicles
- Asses various wind energy system
- Predict the behaviour of airflow over civil structures
- Analyse the flow field over trains
- Estimate the flow induced vibrations the cables and bridges

Unit I - Atmospheric Boundary Layer: Atmospheric circulation-local winds – terrain types – mean velocity profiles- power law and logarithmic law, wind speeds, turbulence profiles, Roughness parameters – simulation techniques in wind tunnels
Unit II - Bluff Body Aerodynamics: Boundary layers and separation, 2-D wake and vortex formation, Strouhal and Reynolds numbers, separation and reattachments, power requirements and drag coefficients of automobiles, effect of cut back angle, and aerodynamics of trains
Unit III - Wind Energy Collectors: Horizontal and vertical axis machines, energy density of different rotors, power coefficient, Betz coefficient by momentum theory.
Unit IV - Building Aerodynamics: Pressure distribution on low rise buildings, wind forces on buildings, environmental winds in city blocks, and special problems of tall buildings, building codes, ventilation and architectural aerodynamics.
Unit V - Flow Induced Vibration: Vortex shedding, effect of Reynolds number on wake formation in turbulent flows, across wind galloping, wake galloping, along wind galloping of circular cables, oscillation of tall structures and launch vehicles under wind loads, stall flutter.

Text Books

1. Gino Sovran, "Aerodynamics Drag Mechanisms of Bluff Bodies and Road Vehicles" Springer;2012
2. Sachs P, "Wind Forces in Engineering:, Pergamon Press,1988

References

1. Tom Lawson, Building Aerodynamics", Icp; first edition, 2001
2. John D.Holmes, "Wind Loading of Structures", CRC Press, second Edition, 2007
3. Steven R.H, Rex E.B., "Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites", John Wiley& Sons, 2003.
4. Blevins R.D., "Flow Induced Vibrations", Van Nostrand, 1990.

17AE2038 INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS

Credits: 3:0:0

Course Objective:

- To incorporate awareness about the basic terminology, models and prototypes of UAS
- To impart knowledge on design considerations of UAV systems
- To obtain knowledge on aerodynamics and communication systems of UAS

Course Outcome:

Students will be able to

- Know the evolution of UAS and the various models and prototypes
- Understand the design parameters of UAV systems
- Obtain knowledge on the application of aerodynamic principles to design UAS
- Understand the principles of communication systems used in UAVs
- Obtain knowledge on payloads and launch systems for UAS
- Understand the application of UAS to various societal applications

Unit I - Introduction to Unmanned Aircraft Systems – Aviation History and unmanned flight – Definitions and terminology – Classification of UAVs – UAV categories - Unmanned Aircraft systems

Unit II - Design and selection of UAV system - Conceptual phase – Preliminary design – detail design – selection of system – UAV mission – UAV design specifications – Initial sizing – Airfoil selection – structural requirements and engine selection

Unit III - Aspects of Airframe design – Lift induced drag – parasitic drag – Scale effects - Structure and Mechanics - Mechanical design - Selection of power plants

Unit IV - Payloads - Dispensable and non-dispensable pay loads – Communication media - Radio communication – Radio tracking - Antenna types

Unit V - Launch of HTOL & VTOL systems – recovery of HTOL & VTOL systems - Naval roles – Army roles – Civilian roles – paramedical and commercial roles – commercial applications

Text Books:

1. Reg Austin, "Unmanned Aircraft Systems: UAVS Design Development and Deployment", First edition, John Wiley and Sons, 2010.
2. Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, "Introduction to Unmanned Aircraft systems", CRC press, Taylor and Francis, New York, 2012.

References:

1. Paul.G.Fahlstrom, Thomas.J.Gleason "Introduction to UAV systems", UAV Systems, Ins. 2013.
2. Armand.J. Chaput, "Design of UAV Systems", Lockheed Martin Aeronautics Company, 2001.

17AE2039 AERO-ELASTICITY

Credits: 3:0:0

Pre-requisites:17AE2020 Aircraft Stability and Control

Course Objectives:

- To impart the basic concepts of Aeroelasticity
- To provide knowledge about the Static Aeroelastic phenomena
- To understand the Dynamic Aeroelastic phenomena

Course Outcome:
Students will be able to

- Understand the Aero-elastic phenomena
- Get Knowledge in preventing body (i.e. Aircrafts) from Aeroelastic instability
- Understand the vibration system
- Analyse the static Aeroelasticbehaviour of the Aircraft
- Analyse the Dynamic Aeroelasticbehaviour of the Aircraft
- Analyse the Flutter and Gust behaviour of the Aircraft.

Unit I - Introduction to Aero-elasticity: Introduction to Aero-elasticity- The aero-elastic triangle of forces- Prevention of Aero-elastic instabilities- Influence and stiffness coefficients-History of Aero-elasticity- Introduction to Unsteady Aerodynamics and Loads, introduction of elasticity to be introduced
Unit II - Vibration Systems: Vibration of Single Degree of Freedom Systems- Vibration of Multiple Degree of Freedom Systems- Vibration of Continuous Systems – Discretization Approach
Unit III - Static Aero-elasticity: Effect of Wing Flexibility on Lift Distribution and Divergence- Static aero-elastic behaviour of a two-dimensional rigid airfoil with spring attachment- Static aero-elastic behaviour of a fixed root flexible wing- Effect of trim on static aero-elastic behaviour- Effect of wing sweep on static aero-elastic behaviour
Unit IV - Dynamic Aero-elasticity-Flutter: General form of the aero-elastic equations- Simplified unsteady aerodynamic model- Aero-elastic behaviour of the binary model - Eigen value solution of flutter equations - Aero-elastic behaviour of a flexible wing- Aero-elastic behaviour of a multiple mode system- Flutter speed prediction for binary systems.
Unit V - Dynamic Aero-elasticity-Gust: Introduction to Gust - General form of equations in the time domain - Rigid aircraft in heave/pitch Motion- Frequency domain turbulence response – General form of equations in the frequency domain

Text Book

1. Jan R. Wright Jonathan E. Cooper "Introduction to Aircraft Aeroelasticity and Loads" John wiley & sons, Ltd ,2007
2. Y.C. Fung, "An Introduction to the Theory of Aeroelasticity", John Wiley & Sons Inc., New York, 2008.

References:

1. Earl H. Dowell, Robert Clark, David Cox, H.C. Curtiss, Jr, John W. Edwards, Kenneth C. Hall, David A. Peters, Robert Scanlan, Emil Simiu, Fernando Sisto and Thomas W. Strganac, "A Modern Course in Aeroelasticity", Fourth Revised and Enlarged Edition, 2004.
2. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 1996.
3. R.H. Scanlan and R.Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.
4. E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd., 1986

17AE2040 ANALYTICS FOR AEROSPACE ENGINEERS

Credits: 3:0:0

Course Objectives:

- To impart knowledge on various operations research techniques to ensure the effective utilization of resources
- To understand network models for project planning and scheduling
- To obtain knowledge on Quality Management Systems

Course Outcome:
Students will be able to

- Understand the importance of customer satisfaction and motivation
- Distinguish the roles of a manager and customer
- Apply mathematical models for physical problems to find optimal Solutions
- Design network models for project planning, scheduling and project management
- Understand the principles of quality management
- Apply Quality management concepts in product/service industry to the end users

Unit I - Quality Concepts : Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement
Unit II – Motivation and Performance: Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen
Unit III - Analysis Models: Network analysis: Project Networks – Critical Path Method – Project Evaluation and Review technique - Queuing Models, Decision Models
Unit IV - Quality Management : Quality Planning – Quality Costs, Total Quality Management (TQM) – Deming's Philosophy – Quality Function Deployment – Procedures and Benefits
Unit V - Benchmarking: Procedures and Benefits Statistical Methods : Introduction to Seven tools of quality Six Sigma Concepts.

Text Books:

1. Dale H.Besterfiled, et al., "Total Quality Management", Pearson Education, Inc. 2003. (Indian reprint 2004).
2. N P Agarwal, R k tailor, "Human Resource Management" RBSA Publishers, Jaipur, 2009.

References:

1. Handy Taha. A., "Operations Research" (Sixth Edition) Prentice – Hall of India Private Limited, New Delhi, 2010.
2. S. Bhaskar., "Operations Research" Anuradha Publications, Chennai, 2013.

17AE2041 ADVANCED SPACE DYNAMICS

Credits: 3:0:0
Pre-requisites: 17AE2022 - Space Dynamics

Course Objective:
- To impart the knowledge related to the basics of celestial mechanics,
- To impart the knowledge of orbital transfers
- To impart the knowledge related to the orbits in restricted three-body problem

Course Outcome:
Students will be able to
- Understand two-body orbital motion
- Gain knowledge of orbital transfer technique
- Understand the concept of dynamical systems
- Understand orbital motion in restricted three-body problem
- Attain knowledge of equilibrium points and its uses
- Gain knowledge of orbits in 3-dimensional restricted three-body problem

Unit I - Fundamental principles and definitions: Two-body problem: Central orbits, Derivation of equation of motion, Derivation of Lambert's theorem.
Unit II - Restricted three-body problem (RTBP): Planar circular restricted three-body problem - Equations of motion in sidereal and synodic coordinate systems, Derivation of Jacobi integral, Tisserand's criterion for the identification of comets.
Unit III - Solutions in RTBP: Totality of solutions; Concept of phase space; Manifold of the states of motion and their singularities; Computation of location of collinear and equilateral points.
Unit IV - Orbital motion in RTBP: Motion near the equilibrium points, derivation of variational equations, Characteristic equation, Motion around the collinear and equilateral points, Critical mass.
Unit V - 3-dimensional RTBP: Three-dimensional restricted three-body problem, Motion around the equilibrium points, Halo orbits, Lissajous orbits, Hill's problem.

Textbooks:

1. Howard D. Curtis, "Orbital Mechanics for Engineering Students", Elsevier Butterworth-Heinemann, Third Edition, 2010
2. Victor G. Szebehely, "Theory of Orbits - The Restricted Problem of Three Bodies", Academic Press, New York and London,1967

References:
1. Pini Gurfil, and P. Kenneth Seidelmann, “Celestial Mechanics and Astrodynamics: Theory and Practice”, Springer, 2016
2. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", 1st edition, 2015
3. J.M.A.Danby, “Fundamental of Celestial Mechanics” ,Inc., 2nd Edition, Willman-Bell,USA,1992
4. Carl D. Murray and Stanley F. Dermott, "Solar System Dynamics", Cambridge University Press, 1999
5. Vladimir A. Chobotov, “Orbital Mechanics”, AIAA Education Series, AIAA Education Series, Published by AIAA, 2002

17AE2042 AIR TRAFFIC CONTROL AND AERODROME DETAILS

Credits: 3:0:0

Course objective:
- To impart the knowledge on the scope and purpose of Air traffic services.
- To inculcate the importance of radar services in air traffic control.
- To impart the knowledge in procedure of the formation of aerodrome and its design and air traffic control.

Course outcome:
Students will be able to
- Understand the basic concepts of ATS and its services.
- Identify the flight operations between different altitudes.
- Know the working routines of radar services
- Appreciate the concepts of Aerodrome layouts and its design.
- Differentiate the runway restrictions and limitations.
- Apprehend the various approach and guidance systems.

Unit I - Air Traffic Services: Objectives of ATS - Parts of ATC service – Scope and Provision of ATCs –VFR & IFR operations – Classification of ATS air spaces – Varies kinds of separation – Altimeter setting procedures – Establishment, designation and identification of units providing ATS – Division of responsibility of control.
Unit II - Area control service: Assignment of cruising levels minimum flight altitude ATS routes and significant points – RNAV and RNP – Vertical, lateral and longitudinal separations based on time / distance –ATC clearances – Flight plans – position report
Unit III - Radar services and control: Radar services, Basic radar terminology – Identification procedures using primary / secondary radar – performance checks – use of radar in area and approach control services – assurance control and co-ordination between radar / non radar control – emergencies – Flight information and advisory service – Alerting service – Co-ordination and emergency procedures – Rules of the air.
Unit IV - Aerodrome Details: Aerodrome data - Basic terminology – Aerodrome reference code – Aerodrome reference point – Aerodrome elevation – Aerodrome reference temperature – Instrument runway, physical Characteristics; length of primary / secondary runway – Width of runways – Minimum distance between parallel runways etc. – obstacles restriction.
Unit V - Visual Aids: Visual aids for navigation Wind direction indicator – Landing direction indicator – Location and characteristics of signal area – Markings, general requirements – Various markings – Lights, general requirements – Aerodrome beacon, identification beacon – Simple approach lighting system and various lighting systems – VASI & PAPI - Visual aids for denoting obstacles; object to be marked and lighter – Emergency and other services.

Text Books:
1. AIP (India) Vol. I & II, “The English Book Store”, 17-1, Connaught Circus, New Delhi.

References
1. “Aircraft Manual (India) Volume I”, Latest Edition, The English Book Store, 17-1, Connaught Circus, New Delhi.
2. “PANS – RAC – ICAO DOC 4444”, Latest Edition, The English Book Store, 17-1, Connaught Circus, New Delhi.

14AE2043 NON - DESTRUCTIVE TESTING

Credits: 3:0:0

Course Objectives:

- To provide the knowledge in various processes involved in non-destructive testing
- To get trained in locating discontinuities
- To impart knowledge in NDT application in Aerospace maintenance field

Course Outcome:

Students will be able to

- Understanding various types of discontinuities
- Knowledge in non – destructive testing, its scope and purpose
- Understand the different NDT processes
- Evaluate the properties of material without causing damage
- Learn dynamic behavior of defect with NDT tools
- Choose the best NDT method for different application

Unit I - Visual Inspection and Liquid Penetrant Testing: Scope and features of NDT, NDT vs. Destructive Testing, Visual Inspection-Basic principle, Optical aids used for Visual Inspection. Liquid Penetrant Testing-Principles, Procedures, Penetrant Testing Methods, Sensitivity, Applications and Limitations, Standards.

Unit II - Magnetic Particle Testing and Eddy Current Testing: Magnetizing techniques, Procedures, Equipments for MPT, Sensitivity, and Limitations. Eddy Current Testing –Principles, Instrumentation, Techniques in MPT, Applications and limitations.

Unit III - Radiography: Electromagnetic Radiation Sources, Radiation attenuation in the specimen, Effect of radiation on film, Radiographic Imaging, Inspection Techniques in Radiography, Applications and limitations.

Unit IV - Acoustic Emission Testing and Ultrasonic Testing: Instrumentation of Acoustic Emission Technique, Sensitivity, Applications and limitations. Ultrasonic Testing-Basic properties of sound beam, Inspection methods, Techniques for Normal Beam Inspection and Angle Beam Inspection, Modes of display, applications and limitations.

Unit V - Thermography: History and development, theory and basic principles, Detectors and Equipment, Techniques, Variables, Evaluation of test results and reports, Applications-electronics industry, aerospace applications and electrical applications, advantages and limitations, Standards.

Text Books:

1. Baldev Raj, T. Jayakumar, M. Thavasimuthu, “Practical Non-destructive Testing”, Woodhead Publishing, 2002.
2. P. E. Mix, “Introduction to non-destructive testing”, Wiley Interscience,, John Wiley &Sons, Inc, Publ., 2005.

References:

1. Lalith Gupta, “Aircraft General Engineering”, Himalaya Book House, Delhi 2003.
2. Ravi Prakash, “Non-Destructive Testing”, New Age Sciences, New Delhi,2009.
3. Louis Cartz, “Nondestructive Testing: Radiography, Ultrasonics, Liquid Penetrant,Magnetic Particle, Eddy Current”, Asm International, 1995.
4. C. Hellier, “Handbook of Nondestructive Evaluation”, McGraw-Hill, 1994.

17AE2044 INTRODUCTION TO HYPERSONIC FLOWS

Credits: 4:0:0

Pre-requisites: 17AE2016 Gas Dynamics

Course Objective:

- To introduce the features of in-viscid hypersonic flows, viscous hypersonic flows and high temperature effects
- To provide knowledge regarding estimation of flow over bodies under hypersonic conditions
- To introduce the high temperature issues of hypersonic wings

Course Outcome:

Students will be able to

- Solve the problems involving in-viscid and viscous hypersonic flows

- Estimate the high temperature effects in hypersonic aerodynamics
- Asses the design issues for hypersonic wings
- Apply the computational tools to evaluate hypersonic flows
- Distinguish the high Mach number flow from the supersonic flows
- Estimate flow parameters over a vehicles under hypersonic conditions

Unit I - Introduction: Features of hypersonic flows, thin shock layers, Entropy layer, Viscous-Inviscid Interaction, High Temperature effects, Low Density Effects.

Unit II - Inviscid hypersonic flows

Hypersonic Shock relations, Hypersonic Similarity Parameters and Shock relations, Hypersonic Expansion Wave relation, Methods of calculating surface pressures- Newtonian Flows, Modified Newtonian Laws, Centrifugal Force Correction, Tangent wedge Method, Tangent Cone Method, Shock Expansion Method.

Unit III - Hypersonic inviscid flow field: Approximate Methods for inviscid hypersonic flows, Mach number independence Principle, Hypersonic slender body theory for all angle of attack, hypersonic similarity laws, Thin Shock layer theory.

Unit IV - Viscous hypersonic flows: Viscous hypersonic flows-Boundary layer Equations,Navier-Stokes equations, Similarity Parameters, Boundary Conditions, Hypersonic Boundary Layer Theory, Self-similar Solution – Flat Plate and Stagnation Point, Non-similar Boundary Layer, Local similarity Method, Hypersonic Transition, Turbulent Boundary layer,

Unit V - Aerodynamic heating and viscous-inviscid interaction: Turbulent boundary layer,Hypersonic Aerodynamic Heating, axisymmetric analogue for three dimensional bodies, hypersonicviscous Interactions.

Text Books:

1. John D.AndersonJr.,"Hypersonic and High Temperature Gas dynamics", AIAA, 2nd Edition 2006
2. John J Bertin., "Hypersonic Aerothermodynamics", AIAA Education Series., Washington DC, 1994

Reference Books:

1. Hayes, Wallace.D and Probstein R F., "Hypersonic Inviscid Flow", Dover Publications,2004
2. Ernst Heinrich Hirschel., "Basics of Aerothermodynamics", Springer Verlag Berlin, 2005
3. Wilbur L. Hankey (1988), Re-entry Aerodynamics, AIAA Education series, Washington DC
4. Vladimir V. Lunev, Real Gas Flows with High Velocities, CRC Press, 2009
5. Maurice Rasmussen, Hypersonic Flow, John Wiley & Sons (4 Oct 1994)

17AE2045 AIRCRAFT SYSTEMS

Credits: 3:0:0

Course Objective:

- To impart knowledge on different aircraft systems
- To impart knowledge on aircraft environmental and flight conditions
- To impart knowledge on different aircraft systems inspection and maintenance

Course Outcome:

- Ability to understand the working of hydraulic and pneumatic systems in aircrafts
- Ability to understand the concept of landing gear and braking systems in aircrafts
- Ability to understand the environmental control systems inside the aircraft
- Ability to characterize the different engine systems and their functioning
- Ability to understand and gain knowledge about fuel systems
- Ability to inspect and maintain different parts in an aircraft system

Unit I - Aircraft Hydraulic systems: Hydraulic fluid – Types of Hydraulic Fluids – Phosphate Ester Base Fluids - Basic Hydraulic Systems – Contamination check and control – filters - Reservoirs – Pumps - Pressure Regulation Actuating cylinders – Relief valves - Selector valves – Aircraft Pneumatic systems – Pneumatic system components – typical Pneumatic power system.

Unit II - Landing Gear systems: Main landing gear Alignment, support, Retraction – Emergency extension systems – Landing gear safety devices – Nose wheel steering systems – Brake Systems – Brake assemblies - inspection and maintenance of brakes – Aircraft landing wheels – Aircraft tires – Aircraft tire maintenance – Antiskid system – Landing gear system maintenance.

Unit III - Fuel systems: characteristics and properties of Aviation Gasoline – Turbine engine fuels – fuel system contamination – fuel system components – indicators – multiengine fuel systems – fuel jettison systems – Reciprocating engine ignition systems – battery ignition system – magneto ignition system operating principles - auxiliary ignition units.
Unit IV - Engine starting systems: Reciprocating engine starting systems – Gas Turbine engine starters – Air turbine starters – Lubrication systems – principles of engine lubrication – Requirements and characteristics – Reciprocating engine lubrication system – Turbine engine lubrication system – Engine cooling system – Turbine engine cooling.
Unit V - Cabin atmosphere control systems: need for oxygen – air conditioning and pressurization systems – basic requirements – sources of cabin pressure – cabin pressure control systems – air distribution - air conditioning system – heating systems – cooling systems – electronic cabin temperature control system – oxygen systems – portable oxygen equipments – smoke protection equipments – oxygen cylinders – oxygen masks.

Text Books:

1. Ion Moir and Allan Seabridge, "Aircraft Systems", John Wiley & Sons Ltd, England, Third edition, 2008
2. Roy Langton, Chuck Clark, Martin Hewitt and Lonnie Richards, "Aircraft Fuel Systems", Wiley & Sons Ltd, England, 2009

References:

1. General Hand Books of Airframe and Power plant Mechanics", U.S. Dept. of Transportation, Federal Aviation Administration, The English Book Store, New Delhi1995
2. Mekinley, J.L. and Bent, R.D., "Aircraft Power Plants", McGraw-Hill, 1993
3. Pallet, E.H.J., "Aircraft Instruments & Principles", Pitman & Co., 1993
4. Treager, S., "Gas Turbine Technology", McGraw-Hill, 1997
5. McKinley, J.L., and Bent, R.D., "Aircraft Maintenance & Repair", McGraw-Hill, 1993

17AE2046 THEORY OF VIBRATION

Credits: 3:0:0

Course Objective:
- To impart knowledge on mathematical modeling of a vibratory system and find the response
- To impart skills in analyzing the vibration behavior of mechanical systems under different types of loading.
- To impart knowledge about the methods of reducing unwanted vibration

Course Outcome:
Students will be able to
- Classify vibration systems and derive equations of motion from free -body diagrams.
- Solve vibration problems with multi degrees of freedom.
- Identify modes of a system and compute its natural frequencies.
- Propose solutions to reduce vibration using Isolation
- Identify instruments used in noise and vibration control tests
- Understand the Damping Concepts

Unit I - Single degree of freedom systems: Introduction to simple harmonic motion, D‟Alembert‟s principle, free vibrations – damped vibrations – forced vibrations, with and without damping – support excitation – transmissibility - vibration measuring instruments.
Unit II - Multi degrees of freedom systems: Two degrees of freedom systems - static and dynamic couplings - vibration absorber- principal coordinates - principal modes and orthogonal conditions - eigen value problems - hamilton‟s principle - lagrangean equations and application
Unit III - Continuous systems: Vibration of elastic bodies - vibration of strings – longitudinal, lateral and torsional vibrations
Unit IV - Approximate methods: Approximate methods - Rayleigh's method - Dunkerlay‟s method – Rayleigh-ritz method, matrix iteration method
Unit V - Damping: Vibration isolation- Structural vibration limits - Vibration intensity- Vibration velocity - Structural damage - Effects of damping on vibration response of structures - The measurement of structural damping - Sources of damping- Inherent damping – Added Active damping systems - Energy dissipation in non-linear structures

Text Books:

1. Singiresu.S.Rao., "Mechanical Vibrations", Addison Wesley Longman ,2003.
2. V.P Singh, "Mechanical Vibrations" DHANPAT RAI & CO,2016

References:

1. Benson H Tongue, " Principles of vibration"(2nd edition)Oxford University Press, 2002
2. Kelly, "Fundamentals of Mechanical Vibrations", Mc Graw Hill Publications, 2000.
3. Thomson, W.T., "Theory of Vibration with Applications" CBS Publishers and Distributers, NewDelhi,2002
4. Rao V. Dukkipati, J. Srinivas., Vibrations:problem solving companion,Narosa Publishers, 2007.

17AE2047 BASICS OF AEROSPACE ENGINEERING

(University)- This course is offered to other dept/school students

Credits: 3:0:0

Course Objective:

- To introduce the basic concepts of aircrafts, rockets, satellites and their development
- To impart knowledge about the basic parts and their function and construction
- To know the basics of propulsion and application of rockets

Course Outcome:

Students will be able to

- Understand the evolution of aircrafts and flying vehicles
- Understand the parts and function of aircrafts
- Obtain knowledge on principles of flight
- Understand the fundamentals of structures and materials used
- Understand the principles of aircraft and rocket propulsion
- Obtain knowledge on the engines used in aircraft propulsion

Unit I - Introduction: Historical evolution**;** Developments in aerodynamics, materials, structures and propulsion over the years.

Unit II - Mechanics of Flight: Principles of flight - Components of an airplane and their functions; Different types of flight vehicles, classifications; Basic instruments for flying

Unit III - Aerodynamics- Evolution of lift, drag and moment; altitude and standard atmosphere – Airfoil and nomenclature – Basic aerodymanics

Unit IV - Aircraft Structures: General types of Aircraft construction, Fuselage and Wing Structure; Aerospace materials, metallic and non-metallic materials;

Unit V - Propulsion: Basic ideas about piston, turboprop and jet engines, Basic Propeller theory; Principles of operation of rocket, types of rockets and typical applications, Exploration into space.

Text Book:

1. John D Anderson Jr, "Introduction to Flight", Tata McGraw Hill Education Private Limited, New Delhi, 5th Edition, 2009.
2. A.C Kermode, "Flight without Formulae", Pearson Education, 2008.

References:

1. Anderson. David, Wand Scott Eberhardt. "Understanding Flight". 2nd ed. McGraw-Hill Professional, 2009.
2. Course material of Faculty Enablement Programme on "Introduction to Aircraft Industry", conducted by Infosys, Mysore through Campus connect programme.

17AE3001 VIBRATION AND AERO-ELASTICITY

Credits: 3:0:0

Course Objective:

- To impart knowledge on mathematical modeling of a vibratory system and find the response
- To impart skills in analyzing the vibration behavior of mechanical systems under different types of loading.
- To impart knowledge about the methods of reducing unwanted vibration

Course Outcome:

Students will be able to

- Classify vibration systems and derive equations of motion from free -body diagrams.

- Solve vibration problems with multi degrees of freedom.
- Identify modes of a system and compute its natural frequencies.
- Propose solutions to reduce vibration using Isolation
- Identify instruments used in noise and vibration control tests
- Understand the Damping Concepts

Unit I - Single degree of freedom systems: Introduction to simple harmonic motion, D'Alembert‟s principle, free vibrations – damped vibrations – forced vibrations, with and without damping – support excitation – transmissibility - vibration measuring instruments.
Unit II - Multi degrees of freedom systems: Two degrees of freedom systems - static and dynamic couplings - vibration absorber- principal coordinates - principal modes and orthogonal conditions - eigen value problems - Hamilton's principle - Lagrangean equations and application
Unit III - Continuous systems &Approximate methods: Vibration of elastic bodies - vibration of strings – longitudinal, lateral and torsional vibrations. Approximate methods - Rayleigh‟s method – Dunkerlay's method – Rayleigh-Ritz method- Matrix iteration method.
Unit IV - Damping: Vibration isolation- Structural vibration limits - Vibration intensity- Vibration velocity - Structural damage - Effects of damping on vibration response of structures - The measurement of structural damping - Sources of damping- Inherent damping – Added Active damping systems - Energy dissipation in non-linear structures.
Unit V - Elements of Aero-elasticity: Concepts – Coupling – Aero elastic instabilities and their prevention – Collar's Triangle- Basic ideas on wing divergence, loss and reversal of aileron control–Flutter and its prevention.

References :

1. Singiresu.S.Rao., "Mechanical Vibrations", Addison Wesley Longman ,2003.
2. V.P Singh "Mechanical Vibrations" DHANPAT RAI & CO,2016
3. Benson H Tongue, " Principles of vibration"(2nd edition)Oxford University Press, 2002
4. Kelly, "Fundamentals of Mechanical Vibrations", Mc Graw Hill Publications, 2000.
5. Thomson, W.T., "Theory of Vibration with Applications" CBS Publishers and Distributers,NewDelhi,2002
6. Rao V. Dukkipati, J. Srinivas., "Vibrations : problem solving companion", Narosa Publishers, 2007.
7. Y.C. Fung, "An Introduction to the Theory of Aeroelasticity", John Wiley & Sons Inc., New York, 2008.

17AE3002 ADVANCED AERODYNAMICS

Credits: 3:0:0

Course Objective:
- To familiarize student with the airfoils and wings and the flow over them
- To impart knowledge of compressibility effects over an aerofoil and finite wings
- To provide knowledge of high temperature effects over an hypersonic wings

Course Outcome:
Students will be able to
- Understand the flow behaviour over various body shapes
- Assess the forces and moments due to flow
- Apply the compressibility corrections for flow in C-D passages and instrument like Pitot static tube
- Assess the nature of compressible flow over airfoils and finite wings
- Solve the problems involving in-viscid and viscous hypersonic flows
- Use the computational tools to evaluate hypersonic flows

Unit I - Incompressible Flow: Aerodynamic forces and moments. Centre of pressure. Rotation, deformation, vortex theorems, and Conservation laws: integral and differential formulations- mass, momentum and energy equation,
Unit II - Potential Flow: Elementary flows and its combination: non-lifting and lifting flow over cylinders. Kutta – Joukowski theorem and generation of lift, Kutta condition, thin airfoil theory, Vortex filament, Helmholtz theorems. Introduction to Prandtl's lifting line theory and lift distribution.
Unit III - Introduction to Compressible Flow: Compressibility, Velocity of sound, Concept of Mach Number, Isentropic relations, Flow through converging-diverging passages, Performance under various back pressures, corrections of Pitot static tube for subsonic and supersonic Mach numbers

Unit IV - Shocks and Expansion Waves: Normal shock and its relations, Prandtl equation and Rankine – Hugoniot relation, Oblique shocks and corresponding equations, Hodograph and flow turning angle, shock polar, Flow past wedges, Strong, weak and detached shocks, Expansion waves & its corresponding equations, Flow past concave & convex corners, Intersection and Reflection of shocks with wall and expansion waves, Rayleigh and Fanno Flow.
Unit V - Elements of Hypersonic Flow: Features of hypersonic flows, thin shock layers, Entropy layer, Viscous Interaction, High Temperature effects, Low Density Effects , Hypersonic Shock & Expansion Wave relation, Methods of calculating surface pressures- Newtonian and Modified Newtonian Laws, Centrifugal Force Correction, Tangent wedge and Tangent Cone Method, Shock Expansion Method.

References:

1. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010
2. Rathakrishnan, E, Theoretical Aerodynamics, John Wiley & Sons, 2013
3. John D.Anderson Jr.,"Hypersonic and High Temperature Gas dynamics", AIAA, 2nd Edition 2006E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012.
4. L.M Milne Thomson, "Theoretical Aerodynamics", 1996
5. Liepmann H W and Roshko A, "Elements of Gasdynamics", John Willey & Sons, 1957
6. Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronald Press,1982

17AE3003 ADVANCED AERODYNAMICS LABORATORY

Credits: 3:0:0

Course Objective:
- To impart knowledge of basics of subsonic and supersonic flow over the model
- To impart knowledge of forces and moments over an aerofoil
- To impart knowledge of basics of
- To impart knowledge of shock wave over various model

Course Outcome:
Students will be able to
- Understand the aerodynamic variable connected with airflow
- Estimate lift and drag of various stream line and bluff bodies
- Visualize subsonic flow over various model
- Calibration of supersonic wind tunnel
- Visualize shock wave and Estimate shock angle over various model
- Effect of back pressure in C-D nozzle

List of Experiments:
1. Velocity distribution at three transverse locations of the test section of subsonic wind tunnel.
2. Estimation of the Lift and drag of symmetric and cambered aerofoil using pressure measurements.
3. The pressure distribution over a cascade aerofoil.
4. Force and moment measurements of aircraft model by using strain gauge balance.
5. Boundary layer measurements on an airfoil around flow separation region.
6. Flow visualisation of multi-storey building simulating the earth boundary layer in subsonic wind tunnel.
7. Smoke flow visualization over a car.
8. Simulation of von-Karman Vortex Street in the water tunnel facility.
9. Study of starting process of supersonic wind tunnel.
10. Flow visualisation using oil flow, Schlieren and shadowgraph technique.
11. Study of Mach disc formation in the conical nozzle flow exhaust.
12. Flow separation studies in an over expanded nozzle.
13. Jet pluming study using high altitude jet facility.
14. Multiple jet interaction studies
15. Background noise study in supersonic tunnel.

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of the semester

17AE3004 AEROSPACE PROPULSION

Credits: 3:0:0

Course Objective:

- To impart knowledge on working principles, operation and performance of Gas Turbine Engine (GTE),
- To impart knowledge on characteristics of GTE modules and its matching
- To impart knowledge on Ramjet, Scramjet and Rocket engines

Course Outcome:

Students will be able to

- Assess the performance of engine for aerospace application
- Evaluate GTE performance at component and system level
- Design the inlets for aircraft engines.
- Analyze the combustion chamber related issues
- Evaluate different rocket engines.
- Analyze the performance of space thrusters

Unit I - Elements of aircraft propulsion: Classification of power plants- Method of aircraft propulsion- Propulsive efficiency- Specific Fuel consumption- Thrust and power- Factors affecting thrust and power- Illustration of work cycle of gas turbine engine- Characteristics of turboprop, turbofan and turbojet, Ramjet working principle, use of ramjet in missiles.

Unit II - Axial flow compressors, fans and turbines: Introduction to centrifugal compressors- Axial flow compressors- geometry- twin spools- three spools- Performance and Characteristics-velocity polygons- axial flow turbines- geometry- stage analysis and characteristics- Design & off-design Performance. Surge margin requirements, surge margin stack up. Engine performance monitoring.

Unit III - Combustion chambers: Classification of combustion chambers- Combustion chamber performance- Flame stabilization- Flame tube cooling- After burner- Types and characteristics- Operation and process. Scram jet- Supersonic combustion in scramjet engine- Methods of thrust augmentation. Introduction to Shock tube-ignition delay studies.

Unit IV - Inlets: Subsonic and Supersonic inlets- Relation between minimum area ratio and external deceleration ratio- Starting problem in supersonic inlets- Performance and characteristics- Modes of inlet operation.

Unit V - Nozzle: Jet nozzle- Efficiencies- Over expanded, under expanded and optimum expansion in nozzles- Thrust Reversals- Off design operation and matching of various GTE. Introduction to High Altitude test facility - working principle – Introduction to open Jet facility and its working Principle.

References:

1. Sutton G.P., “Rocket Propulsion Elements”, Eight Edition, John Wiley & Sons Inc.,New Jersey, 2010
2. Hill, P.G. & Peterson, C.R., “Mechanics & Thermodynamics of Propulsion”, Addison – Wesley Longman INC, 1999.
3. V. Ganesan, “Gas Turbines, Second Edition”, Tata McGraw Hill Education Private Limited, New Delhi, 2014.
4. H. Cohen, G.F.C. Rogers and H.I.H. Saravanmuttoo, “Gas Turbine Theory”, Fifth Edition, Pearson Education Ltd, 2009
5. P.P Walsh and P. Peletcher, “Gas Turbine Performance” Blackwell Science, 1998, ISBN 0632047843.
6. Jack .D Mattingly, “Elements of Gas Turbine Propulsion”, Tata McGraw Hill Publishing Co. 2005
7. E. Irwin Treager, “Aircraft Gas Turbine Engine Technology”, 3rd Edition 1995 'ISBN-00201828
8. KlauseHunecke, “Jet Engines Fundamentals of Theory, Design and Operation”, Motors book international publishers & Wholesalers, 6th edition, 1997.
9. Ahmed F El-Sayed, “Fundamental of Aircraft and Rocket Propulsion”, Springer Verlag London,2016.

17AE3005 AEROSPACE PROPULSION LABORATORY

Credit: 0:0:2

Course Objective:

- To introduce the concept of systems of rocket motors
- To assess the performance of air-breathing engines
- To impart knowledge on various engine component

Course Outcome:

Students will be able to

- Design the experiment for rocket motor performance.
- Assess the real lie situation and corrective measures associated with rocket motors.
- Analyze the working of different parts of aircraft engine.
- Get knowledge in combustion
- Identify suitable fuel injector
- Calculate of convective heat transfer coefficient for real time application.

List of Experiments:

1. Shock velocity measurement using a shock tube.
2. Ignition Delay studies in shock tube.
3. Heat transfer measurement in shock tube.
4. Blast pressure measurement in shock tube.
5. Injector Performance study.
6. Estimation of cryogenic fuel evaporation losses.
7. Cooling requirement studies for a Rocket exhaust over a 'J' type jet deflector.
8. Ramjet engine testing of a scaled engine.
9. Diffuser test of centrifugal compressor.
10. Estimation of convective heat transfer of the fluid with and without additives.
11. Cascade testing of a model for axial compressor blade row (symmetrical)
12. Cascade testing of a model for axial compressor blade row(cambered)
13. Nozzle performance test.
14. Nozzle thrust measurements for cold flow.
15. Thrust measurements of propeller

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of the semester

17AE3006 ADVANCED COMPUTATIONAL FLUID DYNAMICS

Credits: 3:0:0

Course Objective:

- To provide knowledge on governing equations of fluid dynamics
- To provide an understanding of the solution methodologies of discretised equations,
- To impart knowledge of turbulence and combustion models and its behaviour.

Course Outcome:

Students will be able to

- Understand the governing equations for fluid flow and its classification
- Knowledge about turbulent behaviour of flow and methods to accounts for it
- Attain the numerical simulation of PDE and its applications to thermal problems
- Apply the numerical procedure for convection – diffusion problems
- Knowledge of performing CFD Analysis
- Apply the boundary conditions and solve CFD problems using turbulence and combustion models

Unit I - Governing Equations: Governing equations of fluid flow and heat transfer, Navier-Stoke's equations, Conservative, differential and integral form of transport equations; Classifications of PDEs and Numerical methods for different PDEs.

Unit II - FDM & FVM for Diffusion: Finite difference method and finite volume method for one dimensional steady state diffusion, Finite volume method for two and three dimensional steady state diffusion problems, Finite volume method for one dimensional unsteady diffusion (heat conduction) – Explicit, Implicit and Crank- Nicholson scheme.

Unit III - Solution Methodology: Introduction, TDMA, application of TDMA, point iterating method- Jacobi, Gauss Seidel, Relaxation Methods, Multi-grid Techniques-Multigrid procedure with examples, multi grid cycles.

Unit IV - Grid Generation: Introduction, Structured and Unstructured Grids, Hybrid Grids, Algebraic, Elliptic, Hyperbolic Grid generation. Unstructured grids of triangular and Tetrahedral, Unstructured grids of Quadrilateral and Hexahedral, Cartesian Mesh, Adaptive Mesh.

Unit V - Turbulence: Introduction,Turbulence models, Reynold's Averaged Navier-Stoke's Equation - RANS, Large Eddy Simulation, Detached EddySimulation, and Direct Numerical Simulation.

References:

1. Versteeg, H.K, and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”,Prentice Hall, 2nd Edition, 2007
2. Anderson, J.D., “Computational fluid dynamics – the basics with applications”, 2005.Ghoshdastidar, P.S., “Computer simulation of flow and heat transfer”, Tata McGraw – Hill publishing Company Ltd., 1998.
3. Patankar, S.V., “Numerical Heat Transfer and Fluid Flow”, McGraw-Hill, 1980. Ane-Books2004 Indian Edition.
4. Muralidhar, K and Sundarajan .T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 2nd Ed, 2011
5. Bose, T.K., “Numerical Fluid Dynamics”, Narosa publishing House, 1997

17AE3007 COMPUTATIONAL HEAT TRANSFER

Credits: 3:0:0

Course Objective:

- To understand the different solution methods of heat transfer under steady and transient conditions.
- To understand the concepts of computational heat transfer through extended surfaces.
- To learn the heat transfer analysis in practical applications of heat transfer.

Course Outcome:

Students will be able to

- Know the mathematical concepts of computational heat transfer
- Know the different applications of heat transfer
- Understand the different computational methods of heat transfer
- Understand the heat transfer methods in FDM and FEM
- Apply the computational heat transfer methods in practical applications
- Analyse the real time problems of heat transfer in aerospace applications
- Understand the working of various sensors and instruments for thermal measurements.

Unit I - Conduction Heat Transfer-General 3D-heat conduction equation in Cartesian, cylindrical and spherical coordinates. Computation (FDM) of One –dimensional steady state heat conduction –with and without Heat generation- 2D-heat conduction problem with different boundary conditions- Numerical treatment for extended surfaces. Numerical treatment for 3D- Heat conduction. Numerical treatment to 1D-steady heat conduction using FEM.

Unit II - Transient Heat Conduction - Introduction to Implicit, explicit Schemes and Crank-Niolson Schemes, Computation(FDM) of One – dimensional un-steady heat conduction –with heat Generation-without Heat generation - 2D- transient heat conduction problem with different boundary conditions using Implicit, explicit Schemes. Importance of Cell Fourier number. Analysis for 1-D,2-D transient heat Conduction problems.

Unit III - Convective Heat Transfer -Convection- Numerical treatment (FDM) of steady and unsteady 1-D and 2-D heat convection-diffusion steady-unsteady problems- Computation of thermal and Velocity boundary layer flows. Upwind scheme. Stream function-vorticity approach-Creeping flow.

Unit IV - Radiative Heat Transfer - Radiation fundamentals-Shape factor calculation-Radiosity method-Absorption Method-Monte-Carlo method-Introduction to Finite Volume Method- Numerical treatment of radiation enclosures using finite Volume method. Developing a numerical code for 1D, 2D heat transfer problems.

Unit V - Heat transfer Measurements: Temperature measurements- Thermocouples- RTD sensors, Thermistor, Thermopiles, Thin platinum sensors, heat flux measurements – Gardon Gauge, Thick film heat flux gauge, Thin film sensors, Thermo- Non-contact types of measurement-Infrared camera, Pyrometer, Line reversal methods.

References:

1. R. H Pletcher, Tannehill C.Jhon, Dale A. Andersons, “Computational fluid Mechanics and Heat Trasnfer”, 3rd Edition, CRC press 2012.
2. Yunus A. Cengel, “Heat Transfer – A Practical Approach”, Tata McGraw Hill Edition, 2003.
3. T.-W. Lee, “Thermal and Flow Measurements” CRC Press, 2008.
4. S.C. Sachdeva, “Fundamentals of Engineering Heat & Mass Transfer”, Wiley Eastern Ltd., New Delhi, 1981.
5. John H. Lienhard, “A Heat Transfer Text Book”, Prentice Hall Inc., 1981.
6. J.P. Holman, “Heat Transfer”, McGraw-Hill Book Co., Inc., New York, 6th Edition, 1991.

7. T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002
8. C.Yk.Chow, “Introduction to Computational Fluid Dynamics”, John Wiley, 1979.
9. John D. Anderson, Jr., “Computational Fluid Dynamics”, McGraw-Hill Book Co., Inc., New York, 1995

17AE3008 ADVANCED COMPUTATIONAL FLUID DYNAMICS LABORATORY

Credits: 0:0:1

Course Objective:

- To familiarize the students with the working of CFD codes.
- To familiarize the students with actual setting up of the problem and solution procedure.
- To extract the required data, post process and compare with available data.

Course Outcome:

Student will be able to

- Define the body shape in a CFD code
- Understand the solution domain and grid generation.
- Apply boundary conditions and generate the solution.
- Validate the aerodynamic quantities from computed data.
- Perform CFD Analysis over 2D and 3 D objects.
- Solve problems using turbulence models.

List of Experiments:

1. Flow past over a flat plate at M=0.1, $\alpha = o^{o}$ and 10^{o}
2. Supersonic Flow over a flat plate
3. Flow Over an Airfoil
4. Flow simulation over ONERA M6 wing.
5. Flow analysis of gaseous combustion
6. Flow with thermal boundary layer.
7. Coding-One Dimensional flow in duct

14AE3009 FLIGHT PERFORMANCE AND DYNAMICS

Credits: 3:0:0

Course Objective:

- To introduce the parameters effecting the Flight performance
- To impart knowledge about the concept of Stability and control of Aircraft
- To introduce with the concept of dynamic stability of Aircraft

Course Outcome:

Students will be able to

- Understand the preliminary performance estimation
- understand the performance characteristics in level Flight
- perform the Static longitudinal analysis in the stability of aircraft
- perform the Static lateral & Directional analysis in the stability of aircraft
- perform the Static longitudinal analysis in the stability of aircraft
- identify the Aircraft response to control

Unit I - Performance Characteristics in Level Flights: Assumptions for Aircraft Performance - Drag Components- Drag Polar, Performance characteristics of aircraft steady level flight- Maximum speed- Range and Endurance - Breguet formula: Rate of Climb- Maximum Climb Angle - Maximum Rate of Climb Velocity- Angle of climb; Gliding Flight - Turn flight; V - n diagram.

Unit II - Static Longitudinal Stability: Degrees of Freedom of a system; Static Longitudinal Stability– Basic equations of equilibrium- Stability criterion: Stick fixed Longitudinal Stability- Wing and tail contribution; Effects of Fuselage and nacelles-Power effects- Neutral Point- Elevator hinge moment; Stick Free Longitudinal Stability – Neutral point and Static Margin; Stick Force gradients and Stick force.

Unit III - Static Lateral and Directional Stability: Static Lateral Stability – Basic equations of equilibrium- Stability criterion Contribution of wing –Fuselage –Vertical tail; Dihedral Effect; Roll Control- Rolling moment due to aileron- Damping moment -Rate of roll achieved-Aileron reversal-Aerodynamic Balance; Static Directional Stability – Basic equations of equilibrium- Stability criterion - Contribution of wing –Fuselage –Vertical tail-

Propeller -Weather cocking Effect, Rudder Requirements, One engine In-operative Conditions, Rudder Lock-Problems

Unit IV - Dynamic Longitudinal Stability: Dynamic Longitudinal Stability – Equations of motion, stability Derivatives, Routh's discriminant;Phugoid Motion and short term MotionsDutch roll and Spiral instability, Auto rotation and Spin-Problems.

Unit V - Aircraft Response to Control: Introduction-Equation of motion in a Non uniform atmosphere-Pure vertical/Plunging motion, Atmospheric turbulence, Harmonic analysis-Turbulence models, Wind shear -Problems.

References:

1. J D Anderson, "Aircraft performance and Design", McGraw-Hill, New York, 2000.
2. Perkins, C D and Hage, R E; " Airplane Performance Stability and Control", Willey Toppan, 2010
3. Roskam, Jan and Lan, Chuan-tau E, "Airplane Aerodynamics and Performance", DAR Corporation, Lawrence, Kansas, USA, 1997.
4. Houghton, E L and Carruthers, N B; "Aerodynamics for Engineering Students", Edward Arnold Publishers, 1988.
5. Filippone, A, "Advanced Aircraft Flight Performance, Cambridge University Press, 2012
6. Roskam Jan, "Airplane Flight Dynamics and Automatic Flight Controls". Design, Analysis and research Coorperation. 3rd Printing 2003
7. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 1991

17AE3010 AEROSPACE STRUCTURAL ANALYSIS

Credits: 3:0:0

Course Objective:

- To impart the knowledge on the structural behavior of aircraft components under different types of loads
- To provide the understanding in structural Analysis methods for aerospace vehicles
- To impart the knowledge stress distribution various section of aerospace component.

Course Outcome:

Students will be able to

- Get knowledge in various methods of analysis of aerospace structural members.
- Analyze the buckling property of plates and to predict the failure stress
- Understand the basic structural members of an Aircraft and launch vehicle.
- Predict the shear flow, and shear center in various open and close section of Aircraft structures
- Solve stress problem in aircraft components
- Design the Aircraft composite panel for Aerospace structure.

Unit I - Virtual work & Matrix methods-: Principle of virtual work -Applications of the principle of virtual work. Energy methods - Unit load method. Flexibility method, Total potential energy, the principle of the stationary value of the total potential energy, Principle of superposition, the reciprocal theorem, Temperature effects. Matrix methods- Stiffness matrix for an elastic spring -Stiffness matrix for two elastic springs in line-Matrix analysis of pin-jointed frameworks - Application to statically indeterminate frameworks - Matrix analysis of space frames - Stiffness matrix for a uniform beam Finite element method for continuum structures.

Unit II - Buckling of thin plates: Inelastic buckling of plates- Experimental determination of critical load for a flat plate - Local instability -Instability of stiffened panels - Failure stress in plates and stiffened panels - Tension field beams.

Unit III - Bending, Shear and Torsion of Thin-Walled Beams - Bending of open and closed, thin-walled beams – Symmetrical and Unsymmetrical bending. **Shear of beams** - General stress, strain and displacement relationships for open and single cell closed section thin-walled beams - Shear of open section beams and closed section beams. Torsion of beams- Torsion of closed and open section beams. Structural idealization-Principle of Idealization of a panel- Effect of idealization on the analysis of open and closed section beams - Deflection of open and closed section beams.

Unit IV - Stress Analysis of Aircraft Components: Wing spars and box beams- Tapered wing spar- Open and closed section beams-Beams having variable stringer areas. Fuselages - Bending –Shear-Torsion - Cut-outs in fuselages. Wings-Three-boom shell – Bending-Torsion - Shear - Shear center -Tapered wings - Deflections - Cut-outs in wings. Fuselage frames and wing ribs - Principles of stiffener/web construction - Fuselage frames - Wing ribs.

Unit V - Composite Materials: Laminated composite structures - Elastic constants of a simple lamina - Stress–strain relationships for an orthotropic ply (macro- approach) - Thin-walled composite beams.

References:

1. Megson, T.H.G., “Aircraft Structures for Engineering Students”, 2010.
2. T. H. G. Megson “An Introduction to Aircraft Structural Analysis” Butterworth-Heinemann, 2010
3. G Lakshmi Narasaiah “Aircraft Structures”, BS Publications.,2010
4. Sun C T, “ Mechanics of Aircraft Structures”, Wiley India,2010
5. Peery, D.J., “Aircraft Structures”, McGraw–Hill, N.Y., 2011.
6. Donaldson B K, “Analysis of Aircraft Structures” Cambridge Aerospace, 2008
7. G F Titterton, “Aircraft Materials and Processes”, Himalayan Books, New Delhi, 1956

17AE3011 AEROSPACE STRUCTURE AND COMPOSITE LABORATORY

Credits: 0:0:2
Co-requisite: 17AE3010 **-** Aerospace Structural Analysis

Course Objective:

- To provide the basic knowledge on the testing equipment for various structural components.
- To impart the practical exposure with the measuring equipment and sensors.
- To impart the practical exposure with composite material manufacturing

Course Outcome:

Students will be able to

- Select test equipment for different types of static loading,
- Conduct tests, analyse results, document and compare with analytical/theoretical results
- Assess different types of structural failures
- MakeComposite material and Laminate
- Choose strain gauge for different application and get knowledge in strain gauge installation.
- Understand the stress distribution with respect to different cross-section shape and loading condition

List of Experiments:

1. Compression test on columns, critical buckling loads – Southwell plot.
2. Unsymmetrical bending of beams-Z section.
3. Determination of the natural frequency of vibrations of a cantilever beam
4. Shear centre location for open sections
5. Bending of beam with and without shear.
6. Torsion of a thin walled tube having various closed cross section at the ends
7. Structural behaviour of a semi tension field beam (Wagner Beam)
8. Using photo elastic techniques: Calibration of circular disc in compression to find the fringe value and Determination of stress concentration factor due to compression in circular ring
9. Composite material Manufacturing and Testing- Tensile and Three point bending
10. Strain Gauge Calibration
11. Thin wall cylinder - Hoop Stress Analysis
12. Brittle Lacquer Method

17AE3012 ADVANCED AVIONICS

Credits: 3:0:0

Course Objective:

- To impart the understanding in basic principles, theory and operation of flight instruments and modern avionics systems
- To familiarize the student with the concepts of guidance and control of an aircraft and to provide the necessary mathematical knowledge that are needed in modeling the guidance and control methods.
- To familiarize the student with the advanced concepts of remote sensing and image processing for aerospace applications.

Course Outcome:

Students will able to

- Understand the theory of transmission and reception of radio waves and functioning of radar systems.

- Understand the various approach guidance systems.
- Understand the advanced guidance and navigation systems.
- Design autopilots and missile guidance systems and ability to deploy these skills effectively in the design of control of aerospace systems.
- Appreciate the operation of various navigational systems used in the history of aviation
- Apprehend vision based navigation and control and modeling physical process.

Unit I - Advanced Avionics and other systems. Advanced Avionics Systems – Enhanced Ground Proximity Warning Systems, Indian Regional Navigation Satellite systems, Microwave landing systems, Instrument landing systems, Precision approach landing systems.
Unit II - HF Communication. HF Communication – HF range and propagation, Antennas in aircraft – location, structure, range, working principles. Single Side Band modulation, SELCAL, HF radio equipment. Radar guidance systems
Unit III - Inertial systems. Inertial guidance systems, Inertial navigation systems, Avionics system requirements, EFIS, Autopilot flight detector system, Flight management systems, Flight data and cockpit voice recorder
Unit IV - Navigation principles. Principle and operation of different navigation systems – location, operation of NAVAIDS, Transponder, Radar Altimeter & Traffic Collision Avoidance Systems.
Unit V - Autopilot and other applications. Longitudinal Autopilot, Lateral Autopilot, Fundamentals of UAV, Electronic warfare. Case studies - vision based navigation and control.

References:

1. Collinson, R.P.G., “Introduction to Avionics Systems”, 2nd Ed., Kluwer, 2003
2. Middleton, D.H., “Avionic Systems, Longman Scientific and Technical”, 1989
3. Blake Lock, J.H “Automatic control of Aircraft and missiles”, John Wiley Sons, New York, 1990Garnell.P. & East. D.J, “Guided Weapon Control Systems”, Pergamon Press, Oxford, 1977
4. Rafael C.Gonzalez and Richard E. Woods, “Digital Image Processing’, Third Edition, Pearson Education, 2008
5. Ron Graham, Alexander Koh, “Digital Aerial Survey: Theory and Practice”, Whittles Publishing; First Edition,2002

17AE3013 AIRCRAFT MODELING LABORATORY

Credits: 0:0:1

Course Objective:
- To train the students with CAD packages like Solid Works.
- To impart the 2D and 3D modeling skills to the students.
- To enable Students to design different parts of Aircraft.

Course Outcome:
Students will be able to
- Understand the construction of various parts of wing and fuselage
- Create solid model of different types of structural components
- Create surface model of different types of structural components
- Create sheet metal model of different types of structural components
- Design and assemble different parts of propeller
- Assemble different parts of aircraft

List of Experiments:
1. Part modelling of internal structural components - wing/fuselage.
2. Modeling of typical joints.
3. Surface modeling of airframe
4. Assembly of components, joints and airframe.
5. Modeling of propeller blade(Propeller/Helicopter)
6. Modeling of hub(Propeller/Helicopter).
7. Assembly of hub and propeller blade.

17AE3014 ADVANCED INSTRUMENTATION AND AVIONICS LABORATORY

Credit: 0:0:1

Course Objective:

- To impart the knowledge about different types of Instruments and control systems
- To train students to measure parameters accurately and their importance in different applications in the field of Avionics
- To provide a complete knowledge on navigation systems like GPS.

Course Outcome:

Students will be able to

- Familiarize Matlab and LabVIEW programming.
- Understand the applications of these fundamental measurement systems.
- Understand the enormous amount of pressure that is put on this simple instrumentation in real time applications.
- Work with the avionics systems on an aircraft
- Understand the design concept of new control systems
- Familiarize with methods of troubleshoot and rectification of faulty instruments.

List of Experiments:

1. Matlab programming of displacement autopilot for a jet airplane.
2. Matlab programming of lateral autopilot for an airplane.
3. Matlab programming of missile autopilot.
4. LabVIEW Programming of Measurement of Angular position using Gyroscope.
5. LabVIEW Programming of Measurement of Air velocity using Hot wire Anemometer
6. LabVIEW Programming of Measurement of Acceleration using Accelerometer.
7. LabVIEW Programming of Temperature measurement using thermocouple.
8. LabVIEW Programming of Temperature measurement using RTD.
9. LabVIEW Programming of Global positioning system.
10. LabVIEW Programming of Aircraft data bus communication.

17AE3015 ORBITAL SPACE DYNAMICS

Credits: 3:0:0

Course Objective:

- To impart the knowledge in two-body problem
- To impart the knowledge in restricted three-body problem
- To provide necessary knowledge to compute the orbits of satellites and interplanetary trajectories.

Course outcome:

Students will be able to

- Apply laws governing the orbital motion
- Compute the orbits of the satellites
- Study the effects of perturbations on the orbital motion
- Generate preliminary design of inter-planetary trajectories
- Understand orbital motion in restricted three-body problem
- Use knowledge of equilibrium points and its uses

Unit I - Fundamental principles: Kepler's laws, Problem of two bodies - Derivation of equation of motion, Solution of Kepler’s equation, Computation of orbital elements from state vectors.

Unit II - Orbit perturbations: Force model, Perturbations - Oblateness, Computation of Sun-synchronous orbit, Special perturbation techniques: Cowell's and Encke's method.

Unit III - Orbital maneuvers: Single impulse Maneuvers, Hohmann transfer, Sphere of influence, Derivation of Lambert’s theorem.

Unit IV - Restricted three-body problem: Planar circular restricted three-body problem - Equations of motion, Derivation of Jacobi integral, Tisserand's criterion for the identification of comets.

Unit V - Motion in restricted three-body problem: Location of equilibrium points, Characteristic equation, Motion near the collinear and the equilateral points.

References:

1. Pini Gurfil, and P. Kenneth Seidelmann, “Celestial Mechanics and Astrodynamics: Theory and Practice”, Springer, 2016
2. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", 1st Edition, 2015
3. J.M.A.Danby, “Fundamental of Celestial Mechanics” ,Inc., 2nd Edition, Willman-Bell, USA,1992
4. Victor G. Szebehely, “Theory of Orbits - The Restricted Problem of Three Bodies”, Academic Press, New York and London,1967
5. Carl D. Murray and Stanley F. Dermott, "Solar System Dynamics", Cambridge University Press, 1999
6. Vladimir A. Chobotov, “Orbital Mechanics”, AIAA Education Series, AIAA Education Series, Published by AIAA, 2002
7. Howard D. Curtis, Orbital Mechanics for Engineering Students, Elsevier Butterworth-Heinemann, 2005

17AE3016 BOUNDARY LAYER THEORY

Credits 3:0:0

Course Objective:

- To introduce the concept of boundary layers and its applications
- To familiarize the students with viscous flow phenomena.
- To impart knowledge on laminar and thermal boundary layer equations

Course outcome:

Students will be able to

- Define the fundamentals Boundary layer theory
- Solve the equations involved in boundary layer theory
- Analyze the different kinds of Boundary Layer control
- Differentiate between the turbulent and laminar boundary layers
- Estimate the boundary layer thickness for flow over a different body
- Attain the knowledge of boundary layer effects in hypersonic flows

Unit I - Fundamentals of boundary layer theory: Boundary layer concept-Laminar and Turbulent boundary layer on a flat plate, Boundary layer on an airfoil-separation of the boundary layer. Description of Flow fields, continuity, Momentum and Navier-Stokes equations. Energy equation, Stokes Hypothesis.

Unit II - Exact solutions of Navier-Stokes equations: Steady Plane Flows-Couette-Poiseuille Flows, Jeffery-Hamel Flows , Flow past a parabolic body and circular cylinder. Steady Axisymmetric Flows-Flow at a rotating disk and Axisymmetric free jet. Unsteady Axisymmetric Flows-Vortex Decay

Unit III - Laminar boundary layer equations: Boundary Layer equations, Wall friction, separation and displacement. Dimensional representation of the boundary layer equations, friction drag, Plate boundary layer. Integral relations of boundary layer-Momentum Integral equation, Energy Integral equation, Moment of Momentum Integral equations

Unit IV - Thermal boundary layer: Thermal boundary layers with coupling of the velocity field of the temperature field-Boundary layer equations. Compressible Boundary layers- Simple solutions of energy equation, Integral methods, Boundary layers in Hypersonic flows

Unit V - Boundary layer control: Different Kinds of Boundary Layer control, Continuous suction and blowing-Massive suction, Massive Blowing, Plate flow with uniform suction or blowing, Airfoil. Three –Dimensional boundary layers-boundary layer at cylinder, Boundary layer at a yawing cylinder.

References:-

1. Schlichting, Herrmann, Gersten, Klaus Translated by Mayes-“Boundary Layer Theory” 8th rev. and enlarged ed. 2000
2. Frank White, “Viscous Fluid flow” – McGraw Hill, 2005
3. Pantan, R. L., “Incompressible Flow”, Willey Student Edition, 2009
4. Ian. J. Sobey, “Introduction to interactive Boundary Layer Theory”, Oxford University Press, USA, 2001
5. Ronald L., Panton, “Incompressible fluid flow”, John Wiley & Sons, 2005
6. J. Reynolds, “Turbulent flows in Engineering”, John Wiley & Sons, 1992

7. TuncerCebeci and Peter Bradshaw, “Momentum transfer in boundary layers”, Hemisphere Publishing Corporation, 1977

17AE3017 THEORY OF ELASTICITY

Credits: 3:0:0

Course Objective:

- To impart an understanding of the basic concepts of stress, strain, displacement and transformations
- To provide the in-depth knowledge in formulating stress and strain equations
- To solve two-dimensional elasticity problems

Course Outcome:

Students will be able to

- Understand the elastic properties of solids
- Get the knowledge in various elasticity theory
- Formulate the governing equations of elastic behaviour for real problem
- Calculate the stresses in simplified form
- Constitute elasticity equations in polar form to solve axisymmetric problems
- Predict stress distribution of various section due to torsional load

Unit I - Assumptions in elasticity: Definitions- notations and sign conventions for stress and strain, Components of stress and strain, Hooke’s law, Plane stress and Plane strain, Equations of equilibrium.

Unit II - Basic equations of elasticity: Strain – displacement relations, Stress – strain relations, Lame’s constant – cubical dilation, Compressibility of material, bulk modulus, Shear modulus, Compatibility equations for strains, Principal stresses and principal strains, Mohr’s circle, Saint Venant’s principle.

Unit III - Plane stress and plane strain problems: Airy’s stress function, Bi-harmonic equations, Polynomial solutions, Simple two-dimensional problems in Cartesian coordinates like bending of cantilever and simply supported beams, etc.

Unit IV - Polar coordinates: Equations of equilibrium, Strain displacement relations, Stress – strain relations, Axi – symmetric problems, Kirsch, Michell’s and Boussinesque problems.

Unit V - Torsion: Navier’s theory, St. Venant’s theory, Prandtl’s theory on torsion, The semi- inverse method and applications to shafts of circular, elliptical, equilateral triangular and rectangular sections.

References:

1. Enrico Volterra& J.H. Caines, “Advanced Strength of Materials”, Prentice Hall New Jersey, 2001.
2. Timoshenko, S., and Goodier, T.N., “Theory of Elasticity”, Tata McGraw–Hill Education,2001.
3. R.C. Ugural, S.K. Fenster . “Advanced strength and applied elasticity”, Elsevier, 2003
4. S.Timoshenko, “Strength of material part-2”, East-West press pvt.Ltd, .N. Delhi, 1991
5. Egor P. Popov, “ Engineering Mechanics Of Solids”, 2 Edition, Prentice-Hall, 2002
6. James M. Gere, Stephen Timoshenko, “Mechanics of Materials” 2 Edition CBS, Publisher, 2004

17AE3018 AIRCRAFT DESIGN

Credits: 3:0:0

Course Objective:

- To impart knowledge about inputs required for Aircraft design
- To introduce methodology for aerodynamic design of aircraft
- To introduce power plant selection to meet performance requirements
- To introduce the methodology for structural design of aircraft

Course Outcome:

Students will be able to:

- Design an aircraft/Spacecraft with given configuration
- Estimate the design parameters required for its better performance
- Understand the design requirements of the Aircraft
- Analyze the weight estimation characteristics
- Understand the configuration of fuselage structures

- Analyze the Materials selection for the Aircraft Components

Unit I - Introduction and Design Requirements: Categories and types of aircrafts – various configurations – Layouts and their relative merits – strength, stiffness, fail-safe and fatigue requirements – Maneuvering load factors – Gust and maneuverability envelopes – Balancing and maneuvering loads on tail planes.
Unit II - Power Plants Selection: Characteristics of different types of power plants – Propeller characteristics and selection – Relative merits of location of power plant.
Unit III - Aerodynamic Parameter Estimation: Selection of geometric and aerodynamic parameters – Weight estimation and balance diagram, Aerofoil and Wing Selection.
Unit IV - Performance and Stability Calculation: Drag estimation of complete aircraft – Level flight, climb, takeoff and landing calculations – range and endurance – static and dynamic stability estimates – control requirements. Layout peculiarities of subsonic and supersonic aircrafts – optimization of wing loading to achieve desired performance, loads on undercarriages and design requirements.
Unit V - Structural Design: Estimation of loads on complete aircraft and components – Structural design of fuselage, wings and undercarriages, controls, connections and joints, Materials for modern aircraft – Methods of analysis, testing and fabrication.

References:

1. D.P. Raymer, "Aircraft conceptual design", AIAA Series, 2012.
2. DarrolStinton, "The Design of the airplane" Oxford BSP Professional Books,1993E. Torenbeek, "Synthesis of Subsonic Airplane Design", Delft University Press, London, Springer, 2010.
3. H.N.Kota, Integrated design approach to Design fly by wire" Lecture notes Interline Pub., Bangalore, 1992.
4. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., U.S.A., 1980.
5. A.A. Lebedenski, "Notes on airplane design", Part-I, I.I.Sc., Bangalore, 1971.
6. G. Corning, "Supersonic & Subsonic Airplane Design", 4th Edition, Edwards Brothers Inc., Michigan, 1989.

17AE3019 ROCKETS AND MISSILES

Credits: 3:0:0

Course Objective:
- To impart the knowledge on rocket and missile aerodynamics
- To impart the knowledge on rocket and missile in free space and gravitational field
- To impart the knowledge on staging & control of rockets

Course Outcome:
Students will be able to
- Discuss types of rockets and missiles with respect to Indian & international scenario
- Understand aerodynamics of rocket and missiles
- Design the basic staging of rockets and missiles
- Estimate the rocket motion in free space and gravitational field
- Understand the control of rockets missiles
- Design the basic launch vehicle

Unit I - Classification of rockets and missiles: Various methods of classification of missiles and rockets – Basic aerodynamic characteristics of surface to surface, surface to air, air to surface and air to air missiles – Examples of various Indian space launch vehicles and missiles – Current status of Indian rocket programme with respect to international scenario.
Unit II - Aerodynamics of rockets and missiles: Airframe components of rockets and missiles – forces acting on a missile while passing through atmosphere – classification of missiles – slender body aerodynamics – method of describing forces and moments – lift force and lateral moment –lateral aerodynamic damping moment – longitudinal moment – drag estimation – upwash and downwash in missile bodies – rocket dispersion.
Unit III - Rocket motion in free space and gravitational field: One dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields – description of vertical, inclined and gravity turn trajectories – determination of range and altitude – simple approximations to determine burn out velocity and altitude – estimation of culmination time and altitude.

Unit IV - Staging of rockets and missiles: Design philosophy behind multi-staging of launch vehicles and ballistic missiles – optimization of multi-stage vehicles – stage separation techniques in atmosphere and in space – stage separation dynamics and lateral separation characteristics.
Unit V - Control of rockets and missiles: Introduction to aerodynamic and jet control methods – various types of aerodynamic control methods for tactical and short range missiles- aerodynamic characteristics - various types of thrust vector control methods including secondary injection thrust vector control for launch vehicles and ballistic missiles.

References

1. George P.Sutton, and Oscar Biblarz, 'Rocket Propulsion Elements', John Wiley & Sons Inc., New York, 8th Edition, 2010.
2. Ashish Tewari, 'Atmospheric and Space Flight Dynamics', Birkhauser, 2007.
3. E. Roy, 'Orbital Motion', Fourth Edition, IOP Publishing Ltd 2005.
4. J. W. Cornelisse, H.F.R. Schoyer, and K.F. Wakker,. 'Rocket Propulsion and Spaceflight Dynamics', Pitman, 2001.
5. William E.Wiesel, 'Spaceflight Dynamics', McGraw-Hill, 3rd Edition, 2010.
6. Howard D. Curtis, 'Orbital Mechanics for Engineering Students', ELSEVIER, Butterworth, Heinemann, 3rd Edition, 2013.

17AE3020 UNMANNED AERIAL SYSTEMS

Credits: 3:0:0

Course Objective:

- To incorporate awareness about the basic terminology, models and prototypes of UAV system
- To impart the knowledge on design considerations of UAV systems
- To be able to design a UAV system for specific requirements

Course Outcome:

Students should be able to:

- Understand the basic terminologies and classification of UAS
- Relate the design parameters of UAV systems
- Obtain knowledge on the application of aerodynamic principles to design UAS
- Understand the principles of communication systems used in UAVs
- Obtain knowledge on payloads and launch systems for UAS
- Apply the principles to design UAS for specific applications

Unit I - Introduction to UAS : Introduction to Unmanned Aircraft Systems (UAS) – Systematic basis of UAS – System composition - Categories and Roles – Elements of UAS – Unmanned Aircraft system operations
Unit II - Design of UAV Systems : Design and selection of UAS – Aerodynamics and airframe configurations – Aspects of airframe design - Unmanned Aircraft characteristics – Long range, Medium and Close range UAVs – Mini, Micro and Nano UAVs – Novel hybrid combinations
Unit III - UAV Standards : Unmanned Design standards and Regulatory aspects – Airframe design – Ancillary equipment – Design of Stealth
Unit IV - UAV Payloads : Sensors and payloads – payload types – Communications, Control and stability, Navigation – Launch and recovery
Unit V - UAV Testing : Certification and ground testing – inflight testing - Human factors in UAS – Future of UAS and challenges

References:

1. Reg Austin, "Unmanned Aircraft Systems: UAVS Design Development and Deployment", First edition, John Wiley and Sons, 2010.
2. Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, "Introduction to Unmanned Aircraft systems", CRC press, Taylor and Francis, New York, 2012. Richard Microcontroller Systems for a UAV, A. Skafidas, 2002.
3. Paul.G.Fahlstrom, Thomas.J.Gleason Introduction to UAV systems, UAV SYSTEMS, Ins.. 2013.
4. Armand.J. Chaput, "Design of UAV Systems" , Lockheed Martin Aeronautics Company, 2001.

17AE3021 FINITE ELEMENT ANALYSIS AND PROGRAMMING

Credits: 3:0:0

Course Objective:

- To impart the basic concept of finite element Analysis (FEA)
- To provide the knowledge on various finite element procedures and solution techniques
- To impart the basic knowledge in FEA programming for Aerospace structural problems

Course Outcome:

Students will be able to

- Understand the different numerical solution to the FEA Problems
- Analyse the discrete and continuum problem using finite element method
- Identify the boundary condition for various aerospace structural problems.
- Program the various type of elements to solve different type of problems
- Solve the one dimension, Two dimensional and Three dimensional problems
- Find the solution for various complex problem in aerospace structures

Unit I - Approximation Techniques in Finite Element Analysis (FEA): History and Stages of Finite Element Method, Approximation Techniques in FEA: Methods of Weighted Residual, Weak Formulation, Piecewise Continuous Trial Function, Galerkin''s Finite Element Formulation, Variational Method, Rayleigh-Ritz Method; MATLAB/SCI-LAB programming- Application to Approximation Techniques.

Unit II - Two-Dimensional and Isoparametric Elements: Governing Equation, Linear Triangular Element, Bilinear Rectangular Element, Boundary Integral, Axisymmetric Analysis. Application to 2-D Steady State Analysis, Axisymmetric Analysis and Transient Analysis. One-Dimensional Elements, Quadrilateral Elements, Triangular Elements, Gauss Quadrature, MATLAB/SCI-LAB programming- Application to Gauss Quadrature.

Unit III - Truss and Beam Structures: One-Dimensional Truss, Plane Truss, Space Truss, MATLAB Application to Static Analysis, Eigen Value Analysis and Transient Analysis. Euler-Bernoulli Beam, Beam Elements with only displacement degrees of freedom, MATLAB/SCI-LAB programming- Application to Static Analysis, Eigenvalue Analysis and Transient Analysis.

Unit IV - Elasticity Problems: Plane Stress and Plane Strain, Force Vector, Energy Method, Three-Dimensional Solid, Axisymmetric solid, Dynamic Analysis, MATLAB/SCI-LAB programming- Application to 2-D Stress Analysis, Axisymmetric Analysis,3-D Stress Analysis.

Unit V - Plate Structures: Classical Plate Theory, Classical Plate Bending Elements, Shear Deformable Plate Element, Plate Element with Displacement Degrees of Freedom, Mixed Plate Element, Hybrid Plate Element , MATLAB/SCI-LAB programming- Application.

References:

1. Robert D. Cook, David S. Malkus, Michael E. Plesha, "Concepts and Applications of Finite Element Analysis", John Wiley and Sons , 2007.
2. Young W.Kwon, HyochoongBang "The Finite Element Method using MATLAB", CRC Press LLC, USA,1997.
3. Segerlind,L.J. "Applied Finite Element Analysis", Second Edition, John Wiley and Sons Inc., New York, 1984.
4. J.N. Reddy , "An Introduction to the Finite Element Method,", McGraw-Hill International Editions, 3rd ed., 2009
5. Tirupathi R. Chandrupatla and Ashok D. Belegundu, "Introduction to Finite Elements in Engineering", Prentice Hall, 2002
6. Rao S.S., "Finite Element Methods in Engineering", Pergamon Press, 4th Ed., 2005.
7. Roy R. Craig, Jr., "Structural Dynamics: An Introduction to Computer Methods", John Wiley and Sons, 1981.

17AE3022 ELEMENTS OF AEROSPACE ENGINEERING

Credits: 3:0:0

Course Objectives:

- To introduce the basic concepts of aircrafts, rockets, satellites and their application
- To familiarize with the basic parts and their function and construction
- To provide knowledge and understanding of aerospace materials

Course Outcomes:

Students will be able to

- Understand standard atmosphere and properties
- Understand Principles of flight
- Get Knowledge in aerodynamic shapes
- Understand Aerospace materials and aircraft structural component
- Classify the Aircraft instrumentation systems
- Categorize the Power plants used in various aircraft

Unit I - History of aviation: Early flying vehicles – hot air balloons – heavier than air flying machines - Classification of flight vehicles, airplanes and Helicopters – Components of an airplane and their functions.

Unit II - Basics of flight : International Standard Atmosphere, Temperature, pressure and altitude relationships, lift, drag and moment, Airfoil nomenclature, Flow characteristics of airfoils, NACA nomenclature, propagation of sound, Mach number, subsonic, transonic, supersonic, hypersonic flows.

Unit III - Aircraft Structures: General types of construction, Monocoque and Semi monocoque - construction, typical wing and fuselage Structures - Materials used in Aircraft.

Unit IV - Systems and instruments: Conventional control, Powered controls, Basic instruments for flying, typical systems for control actuation.

Unit V - Power plants used in aircrafts: Basic ideas about piston, turboprop and jet engines – comparative merits, Principle of operation of rocket, types of rocket and typical applications, Exploration into space.

References

1. John D Anderson Jr, "Introduction to Flight", Tata McGraw Hill Education Private Limited, New Delhi, 5th Edition, 2009.
2. A.C Kermode, "Flight without Formulae", Pearson Education, 5th Edition, 2008.
3. **C**ourse material of Faculty Enablement Programme on "Introduction to Aircraft Industry", conducted by Infosys, Mysore through Campus connect programme.
4. Manuel Soler, "Fundamentals of Aerospace Engineering", Createspace Independent Publishing, Platform, 2014.
5. Stephen Corda, "Introduction to Aerospace Engineering with a flight test", John Wiley & Sons, UK, 2017.
6. Shevell, R.S., "Fundamentals of flights", Pearson education 2004.

LIST OF COURSES

S. No	Course Code	Name of the Course	Credits
1	16AE2001	Structural Mechanics	3:0:0
2	16AE2002	Aircraft Structures – I	3:0:0
3	16AE2003	Aircraft Structures – II	3:0:0
4	16AE2004	Cryogenic Propulsion	3:0:0
5	16AE2005	Industrial Aerodynamics	3:0:0
6	16AE2006	Introduction to Unmanned Aircraft Systems	3:0:0
7	16AE2007	Analytics for Aerospace Engineers	3:0:0
8	16AE2008	Advanced space dynamics	3:0:0
9	16AE3001	Orbital Space Dynamics	3:0:0

REVISED VERSION COURSES

Course Code	Version	Name of the Course	Credits
14AE2004	1.1	Elements of Avionics	3:0:0
14AE2027	1.1	Navigation, Guidance and Control of Aerospace Vehicles	3:0:0
14AE3009	1.1	Advanced Avionics	3:0:0

16AE2001 STRUCTURAL MECHANICS

Credits: 3:0:0

Course Objectives:

- To provide an understanding regarding the concepts of stress and strain, Shear force and Bending moment
- To provide knowledge in the methods of determining the deflections of beams

Course Outcome:

- An understanding of material properties like elasticity, plasticity etc
- Knowledge in shear force and Bending moment diagram
- Ability to solve the bending and torsional problems.
- Knowledge in various methods of analysis of beam deflections

Stresses and strain due to different types of loads (including impact load); Principle Stress and Strain, Mohr Circle, Thermal and Hoop stresses. Theory of bending – simple equation, Shear force and bending moment on beams under different load conditions; Flinched beams Torsion equation – problem solution, Strain Energy due to axial load and torsion load, Stresses due to combined bending and Torsion; Deformations and Stresses in Springs, Study of deflection of beams - double integration method, Macaulay’s method, area moment method, Three- dimensional Hooke's law.

References:

1. Bansal R K, “Strength of Materials”, Laxmi Publishing co, New Delhi, 2007
2. Ramamurtham .S “Strength of Materials”, DhanpatRai Publishing co, New Delhi, 2008.
3. Rajput R K, "Strength of Materials”, S.Chand & Company Pvt. Ltd. 2009.
4. G Lakshmi Narasaiah “Aircraft Structures”, BS Publications.,2010
5. Ramamurtham .S “Strength of Materials”, DhanpatRai Publishing co, New Delhi, 2008.
6. Sun C T, “ Mechanics of Aircraft Structures”, Wiley India,2010

16AE2002 AIRCRAFT STRUCTURES - I

Credits: 3:0:0
Pre-requisites: 16AE2001 Structural Mechanics

Course Objective:
- To impart the knowledge on the methods of structural analysis under different types of loads
- To provide the knowledge on basic theories of vibration, elasticity and failures.

Course Outcome:
- Understand the concepts of principle stress and strain
- Familiarity with the methods of structural analysis under different conditions.
- Knowledge in basic theories of vibration, elasticity and failures.

Aerospace Materials, Properties and structural application of Non-ferrous; Ferrous and Composites. Column buckling - Euler's and Rankine's formulae, 2D and 3D Truss Analysis, Clayperon's three moment equation, Castigliano's principles, Maxwell's Reciprocal theorem, Unit load method and Moment Distribution Method. Energy methods of analysis, Virtual Load method, Stresses and deflections in beams of symmetrical and unsymmetrical sections. Shear center location of different sections, Basic Theory of Vibration - Free and forced vibrations of undamped and damped systems, Theories of Failure

References:

1. Megson, T.M.G., "Aircraft Structures for Engineering Students", 2007.
2. Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.
3. Ramamurtham .S "Strength of Materials", DhanpatRai Publishing co, New Delhi, 2008.
4. Rajput R K, "Strength of Materials", 2006
5. Donaldson B K, "Analysis of Aircraft Structures" Cambridge Aerospace Series, 2008
6. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 1980.
7. G Lakshmi Narasaiah "Aircraft Structures", BS Publications.,2010
8. Sun C T, " Mechanics of Aircraft Structures", Wiley India,2010
9. F.S.Tse, I.E. Morse and H.T. Hinkle, "Mechanical Vibration", Prentice Hall of India Pvt., Ltd.,New Delhi, 1988.
10. R.K. Vierck, "Vibration Analysis", 2nd Edition, Thomas Y. Crowell & Co., Harper & Row Publishers, New York, U.S.A., 1989.

16AE2003 AIRCRAFT STRUCTURES - II

Credits: 3:0:0
Pre-requisites: 16AE2002 Aircraft Structures -I

Course Objective:
- To impart the knowledge on the structural behavior of aircraft components under different types of loads
- To provide the understanding in structural design methods for aerospace vehicles

Course Outcome:
- Understand the concepts of shear flow in both open and closed sections
- Familiarity with the buckling property of plates and the concepts of shear flow
- Knowledge in various methods of analysis of aerospace structural members.

Shear flow in open sections - stiffened panels - thin walled open tubes – sections with stiffeners, Shear flow in closed sections - sections with stiffeners–two flange and three flange box beams- thin walled closed tubes, Bredt-Batho theory -Torsional shear flow in multi cell tubes, Flexural shear flow in multi cell stiffened structures. Stability problems of thin walled structures– Buckling of sheets under compression, shear, bending and combined loads - Crippling stresses by Needham's and Gerard's methods. WingAnalysis–Shear force, bending moment and torque distribution along the span of the Wing. Fuselage Analysis - Shear and bending moment distribution along the length of the fuselage. Introduction to Aero elasticity.

References:

1. Megson, T.M.G., "Aircraft Structures for Engineering Students", 2007.
2. G Lakshmi Narasaiah "Aircraft Structures", BS Publications.,2010
3. Sun C T, " Mechanics of Aircraft Structures", Wiley India,2010
4. Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.
5. Donaldson B K, "Analysis of Aircraft Structures" Cambridge Aerospace Series, 2008
6. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 1980.
7. Stephen P. Timoshenko & S.Woinovsky Krieger, Theory of Plates and Shells, 2nd Edition,McGraw-Hill, Singapore, 1990.
8. Rivello, R.M., Theory and Analysis of Flight structures, McGraw-Hill, N.Y., 1993.

16AE2004 CRYOGENIC PROPULSION

Credits: 3:0:0

Course Objectives:

- To study the engineering concept of cryogenic propulsion
- To know the various application of these propulsion in Aerospace field.

Course outcome:

- Understand the thermal, physical and fluid dynamic properties of cryogenic propellant.
- Know the various method of cryogenic insulations, its storage and instrumentation
- Understand the various cryogenic equipments used in Aerospace application.

Introduction, Low-temperature properties of engineering materials- thermal properties, properties of cryogenic fluids-Hydrogen, Helium 3 and Helium 4. Gas-liquefaction systems- system performance parameters, the thermodynamically ideal system, Joule-Thomson effect, adiabatic expansion. Liquefaction systems for gases- Simple Linde-Hampson system, precooled Linde-Hampson system, Linde dual-pressure system, Cascade system, claude system, Kapitza system. Cryogenic refrigeration systems-ideal refrigeration systems, Joule-Thomson refrigeration systems, Vuilleumier refrigerator, Solvay refrigerator Gifford-McMahon refrigerator, Magnetic cooling, magnetic refrigeration systems, Dilution refrigerators. Cryogenic fluid storage systems- cryogenic fluid storage vessels, Insulations. Vacuum technology- diffusion pumps, Ion pumps and cryopumping.

References:

1. Valery V. Kostionk, "A Text Book of Cryogenics", Discovery Publishing House, 2003
2. Mamata Mukhopadhyay, "Fundamentals of Cryogenic Engineering", PHI Learning- Technology & Engineering, 2010
3. Thomas Flynn , "Cryogenic Engineering", Second Edition, Revised and Expanded, Marckel Dekker Publications, CRC Press, 2004
4. William E. Bryson, "Cryogenics" , Hanser Gardner Pubns, 1999

16AE2005 INDUSTRIAL AERODYNAMICS

Credits: 3:0:0
Pre-requisites: 16AE2001 Fluid Mechanics

Course Objectives:
- To impart information about non-aeronautical uses of aerodynamics, such as road vehicle aero dynamics, building aerodynamics
- To provide the knowledge on solution of problems in flow induced vibrations

Course Outcome:
- Familiarity in the wind energy system in atmosphere
- Understanding the concept of vehicle and building aerodynamics.
- Knowledge in flow induced vibrations.

Atmosphere: Types of winds, Causes of variation of winds, Atmospheric boundary layer, Effect of terrain on gradient height, Structure of turbulent flows. Wind Energy Collectors: Horizontal axis and vertical axis machines. Power coefficient, Betz coefficient. Vehicle Aerodynamics: Power requirements and drag coefficients of automobiles, Effects of cut back angle. Building Aerodynamics: Pressure distribution on low rise buildings, wind forces on buildings. Environmental winds in city blocks, Building ventilation and architectural aerodynamics.

References:

1. Gino Sovran, "Aerodynamic Drag Mechanisms of Bluff Bodies and Road Vehicles" Springer; 2012
2. Wolf-Heinrich Hucho, "Aerodynamics of Road Vehicles", Published by SAE International, 1998
3. Tom Lawson , "Building Aerodynamics", Icp; 1st edition 2001
4. John D. Holmes, "Wind Loading of Structures", CRC Press, 2 edition, 2007
5. Steven R. Hanna, Rex E. Britter, "Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites", John Wiley & Sons, 2003.

16AE2006 INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS

Credits: 3:0:0

Course Objectives:
- To incorporate awareness about the basic terminology, models and prototypes of UAV system
- To impart the knowledge on design considerations of UAV systems

Course Outcome:
- Knowledge of the concepts of UAV models and prototypes
- Relate the design parameters of UAV systems

History of UAV –classification –basic terminology-models and prototypes – UAV categories – Design of UAV systems - Conceptual phase – Preliminary design – detail design – selection of system- Aspects of Airframe design - structure and Mechanics – Selection of power plants - Dispensable and non-dispensable pay loads – Radio communication – Antenna types – Launch of HTOL & VTOL systems – recovery of HTOL & VTOL systems - Naval roles – Army roles – Civilian roles – paramedical and commercial roles – commercial applications

References

1. Reg Austin, "Unmanned Aircraft Systems: UAVS Design Development and Deployment", First edition, John Wiley and Sons, 2010.

2. Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, “Introduction to Unmanned Aircraft systems”, CRC press, Taylor and Francis, New York, 2012.

16AE2007 ANALYTICS FOR AEROSPACE ENGINEERS

Credits: 3:0:0

Course Objectives:

- To impart knowledge on various operations research techniques to ensure the effective utilization of resources
- To understand network models for project planning and scheduling
- To obtain knowledge on Quality Management Systems

Course Outcome :

- Ability to Apply mathematical models for physical problems to find optimal Solutions
- Design network models for project planning, scheduling and project management
- Apply Quality management concepts in product/service industry to the end users

Quality Concepts : Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen - **Analysis Models** : Network analysis: Project Networks – Critical Path Method – Project Evaluation and Review technique - Queuing Models, Decision Models - **Quality Management** : Quality Planning – Quality Costs, Total Quality Management (TQM) – Deming’s Philosophy – Quality Function Deployment – Procedures and Benefits - Benchmarking – Procedures and Benefits Statistical Methods : Introduction to Seven tools of quality ,Six Sigma Concepts.

References:

1. Dale H.Besterfiled, et al., “Total Quality Management”, Pearson Education, Inc. 2003. (Indian reprint 2004).
2. N P Agarwal, R K Tailor, “Human Resource Management” RBSA Publishers, Jaipur, 2009.
3. Handy Taha. A., “Operations Research” (Sixth Edition) Prentice – Hall of India Private Limited, New Delhi, 2010.
4. S. Bhaskar., “Operations Research” Anuradha Publications, Chennai, 2013.

16AE2008 ADVANCED SPACE DYNAMICS

Credits: 3:0:0
Pre-requisites: 14AE2016 - Space Dynamics

Course Objectives:

- To impart the knowledge related to the basics of celestial mechanics,
- To impart the knowledge related to the orbits in restricted three-body problem.

Course Outcome:

- Ability to understand the different kinds of orbits
- Ability to understand the orbits in the restricted three-body problem.

Fundamental principles and definitions, Two-body problem: Derivation and solution of equation of motion, Derivation of Lambert’s theorem, Planar circular restricted three-body problem - Equations of motion in sidereal and synodic coordinate systems, Derivation of Jacobi integral, Tisserand's criterion for the identification of comets, Location of equilibrium points, Characteristic equation, Critical mass, Motion near the collinear and the equilateral points, Three-dimensional restricted three-body problem, Halo orbits.

References:

1. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", 1st Edition, 2015
2. J.M.A.Danby, "Fundamental of Celestial Mechanics", 2nd Edition, Willman-Bell,USA,1992.
3. Victor G. Szebehely, Hans Mark, "Adventures in Celestial mechanics", Wiley-VCH, Second Edition, 2004.
4. Victor G. Szebehely, "Theory of Orbits - The Restricted Problem of Three Bodies", Academic Press, New York and London,1967.
5. Carl D. Murray and Stanley F. Dermott, "Solar System Dynamics", Cambridge University Press, 1999.
6. Vladimir A. Chobotov, "Orbital Mechanics", AIAA Education Series, AIAA Education Series, Published by AIAA, 2002.
7. Howard D. Curtis, Orbital Mechanics for Engineering Students, Elsevier Butterworth-Heinemann, 2005.
8. David A. Vallado, "Fundamentals of Astrodynamics and Applications", Mc Grow-Hill, 1997.

16AE3001 ORBITAL SPACE DYNAMICS

Credits: 3:0:0

Course Objectives:

- To impart the knowledge in two-body, restricted three-body problem
- To provide necessary knowledge to compute the orbits of satellites and interplanetary trajectories.

Course outcome:

- Ability to solve the orbital problems related to Earth satellite orbits.
- Ability to generate interplanetary orbits in the frame work of restricted three-body problem.

Fundamental principles - Kepler's laws, Problem of two bodies - Derivation of equation of motion, Solution of Kepler's equation, Computation of orbital elements from state vectors, Force model, Perturbations - Oblateness, Computation of Sun-synchronous orbit, Special perturbation techniques: Cowell's and Encke's method, Single impulse Maneuvers, Hohmann transfer, Sphere of influence, Derivation of Lambert's theorem, Planar circular restricted three-body problem - Equations of motion, Derivation of Jacobi integral, Tisserand's criterion for the identification of comets, Location of equilibrium points, Characteristic equation, Motion near the collinear and the equilateral points.

References:

1. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", 1st Edition, 2015
2. J.M.A.Danby, "Fundamental of Celestial Mechanics" ,Inc., 2nd Edition, Willman-Bell, USA,1992.
3. Victor G. Szebehely, Hans Mark, "Adventures in celestial mechanics", Wiley-VCH, Second Edition, 2004.
4. Victor G. Szebehely, "Theory of Orbits - The Restricted Problem of Three Bodies", Academic Press, New York and London,1967.
5. Carl D. Murray and Stanley F. Dermott, "Solar System Dynamics", Cambridge University Press, 1999.

6. Vladimir A. Chobotov, "Orbital Mechanics", AIAA Education Series, AIAA Education Series, Published by AIAA, 2002.
7. Howard D. Curtis, Orbital Mechanics for Engineering Students, Elsevier Butterworth-Heinemann, 2005.
8. Pini Gurfil, P.Kenneth Seidelmann, "Celestial Mechanics and Astrodynamics: Theory and Practice", Springer-Verlay Berlin Heidelberg, 2016.

14AE2004 ELEMENTS OF AVIONICS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To impart knowledge about basic concepts of micro-processors and controllers, their significance and functioning.
- To provide understanding of the basic concepts and functioning of the avionic system data buses.

Course Outcome:
- An understanding of and ability to analyze the functioning of the digital systems.
- Exposure to the working of the air data buses and the trends in display technology.
- An understanding of the basic Avionics systems in Civil and Military Aircrafts.

Basic electronic controllers – microprocessors and microcontrollers, Introduction to Avionics - Role for Avionics in Civil and Military Aircraft systems, Avionic systems, - Civil and Military Electrical Power requirement standards and its comparison. Data Buses - MIL standard and its elements; Avionics System/subsystem and its requirement and design, Various Avionic architecture. Trends in display technology, Alphanumeric displays, character displays etc., MFDs, MFK, HUD, HDD, HMD, DVI, HOTAS, Synthetic and enhanced vision, situation awareness, Panoramic/big picture display, virtual cockpit

References:
1. Collinson R.P.G. "Introduction to Avionics Systems", Springer Science Business Media B.V, 2011.
2. Middleton, D.H. "Avionics Systems", Longman Scientific and Technical, Longman Group UK Ltd., England, 1989.
3. Spitzer, C.R. "Avionics- Elements, Software and Functions", CRC Press, Taylor & Francis group LLC, 2007
4. Jim Curren, "Trend in Advanced Avionics", IOWA State University, 1992.

14AE2027 NAVIGATION, GUIDANCE AND CONTROL OF AEROSPACE VEHICLES

Credits: 3:0:0 **(Version 1.1)**
Pre-requisites: 14AE2010 - Aircraft Instrumentation

Course Objectives:
- To provide the information regarding the concepts of navigation, guidance and control of an aircraft.
- To provide necessary mathematical knowledge required for modeling the guidance and control methods.

Course Outcome:
- To deploy the skills effectively in design of control for aerospace vehicle systems and in understanding the functioning of navigation methods.

- Exposure to various topics such as 6-DOF equations of motions, autopilots and augmentation systems and missile guidance systems.

Introduction to navigation systems- Types Different co-ordinate systems - Transformation Techniques; Different types of radio navigation; - Introduction to Inertial Sensors; INS components; Introduction to GPS - system description - basic principles - position and velocity determination. Introduction to Guidance and control; Need for automatic flight control systems; Displacement Autopilot Introduction to Fly-by-wire flight control systems, Lateral Autopilot; Operating principles and design of guidance laws, homing guidance laws. Stability Analysis – root locus method, Routh Hurwitz, Bode plot, Polar plot.

References:

1. Myron Kyton, Walfred Fried, 'Avionics Navigation Systems', John Wiley & Sons, 2nd edition, 1997
2. Nagaraja, N.S. "Elements of Electronic Navigation", Tata McGraw-Hill Pub. Co., 15th reprint, 2006.
3. Blake Lock, J.H 'Automatic control of Aircraft and missiles', John Wiley Sons, Second Edition, 1991.
4. Stevens B.L & Lewis F.L, 'Aircraft control & simulation', John Wiley Sons, Second Edition, 2003.
5. Collinson R.P.G. "Introduction to Avionics Systems", Springer Science + Business Media B.V, 2011.
6. Garnel.P. & East.D.J, 'Guided Weapon control systems', Pergamon Press; 2nd edition, 1980.
7. Nelson R.C 'Flight stability & Automatic Control', McGraw Hill, Second Edition, 2007.
8. Bernad Etikin,'Dynamic of flight stability and control', Revised, John Wiley, 1995.

14AE3009 ADVANCED AVIONICS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To impart the understanding in basic principles, theory and operation of flight instruments and modern avionics systems
- To familiarize the student with the concepts of guidance and control of an aircraft and to provide the necessary mathematical knowledge that are needed in modeling the guidance and control methods.
- To familiarize the student with the advanced concepts of remote sensing and image processing for aerospace applications.

Course Outcomes:

- An understanding of the theory of transmission and reception of radio waves and functioning of radar systems.
- An understanding of autopilots and missile guidance systems and ability to deploy these skills effectively in the design of control of aerospace systems.
- An understanding of vision based navigation and control and modeling physical process.

Principle and operation of ; NAVAIDS, Transponder, Airborne Weather Radar, Radar Altimeter & TCAS, Navigation and control laws, Flight Control Systems, Longitudinal Autopilot, Lateral Autopilot, Pitch orientation control system; Methods of obtaining coordination, yaw orientation control system, Fundamentals of UAV, Electronic warfare, Principles of aerial photography; Sensors for aerial photography; Case studies - vision based navigation and control.

References:

1. Collinson, R.P.G., Introduction to Avionics Systems, 2nd Ed., Kluwer, 2003
2. Middleton, D.H., Avionic Systems, Longman Scientific and Technical, 1989
3. IAP. Avionics Fundamentals, IAP., 1987
4. Blake Lock, J.H 'Automatic control of Aircraft and missiles', John Wiley Sons, New York, 1990
5. Garnell.P. & East. D.J, 'Guided Weapon Control Systems', Pergamon Press, Oxford, 1977
6. Rafael C.Gonzalez and Richard E. Woods, "Digital Image Processing', Third Edition, Pearson Education, 2008
7. Ron Graham, Alexander Koh, "Digital Aerial Survey: Theory and Practice", Whittles Publishing; First Edition,2002

LIST OF SUBJECTS

Sub.Code		Name of the Subject	Credits
15AE3001		Aero-elastic Theory	3:0:0
15AE3002		Boundary Layer Theory	3:0:0
15AE3003		Theory of Vibration	3:0:0
15AE3004		Aircraft Design	3:0:0
15AE3005		Flight Control System	3:0:0
15AE3006		Rocket Dynamics	3:0:0
15AE3007		Advanced Aircraft systems	3:0:0
15AE3008		Unmanned Aircraft Systems	3:0:0
15AE3009		Finite Element Analysis in Aerospace Application	3:0:0
15AE3010		Advanced Avionics Lab	0:0:1
15AE3011		Linear and Regular Orbital Mechanics	3:0:0
15AE3012		Numerical Methods in Orbit Application	3:0:0
		REVISED VERSION SUBJECT	
Sub. Code	**Version**	**Name of the Subject**	
14AE3010	1.1	Advanced Computational Fluid Dynamics Lab	0:0:1

15AE3001 AERO-ELASTIC THEORY

Credits: 3:0:0

Course Objectives:

- To impart the concepts of Aeroelasticity
- To provide knowledge about the Static and dynamic Aeroelastic phenomena

Course Outcome:

On completion of the course, students should be able to:

- Explain the Aero-elastic phenomena
- Predict the Aeroelastic behavior
- Prevent the body (i.e. Aircrafts) from Aeroelastic instability.

Introduction Aero elastic Problems. Deformation of Structures and Influence Coefficients. Energy Method. Classification and Solution of Aero elastic Problems. Static Aero elasticity. Divergence of 2-D airfoil and Straight Wing. Aileron Reversal. Control Effectiveness. Wing loading and deformations. Swept Wing. Dynamic Aero elasticity. Dynamic/Flutter model of 2-D Airfoil. Theodorsen Theory. Finite State Model. Flutter Calculation. U-g Method. P-k Method. Exact Treatment of Bending - Torsion Flutter of Uniform Wing. Flutter Analysis by Assumed Mode Method. Panel Flutter, Buffeting

References:

1. Y.C. Fung, “An Introduction to the Theory of Aeroelasticity”, John Wiley & Sons Inc., New York, 2008.
2. Earl H. Dowell, Robert Clark, David Cox, H.C. Curtiss, Jr, John W. Edwards, Kenneth C. Hall, David A. Peters, Robert Scanlan, Emil Simiu, Fernando Sisto and Thomas W. Strganac, “A Modern Course in Aeroelasticity”, Fourth Revised and Enlarged Edition, 2004.
3. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, “Aeroelasticity”, Dover Publication, 2013.
4. R.D.Blevins, “Flow Induced Vibrations”, Krieger Pub Co., 2001
5. R.H. Scanlan and R.Rosenbaum, “Introduction to the study of Aircraft Vibration and Flutter”, Macmillan Co., New York, 1981.
6. E.G. Broadbent, “Elementary Theory of Aeroelasticity”, Bun Hill Publications Ltd., 1986.

15AE3002 BOUNDARY LAYER THEORY

Credits: 3:0:0

Course Objectives:

- To familiarize the students with viscous flow phenomena.
- To impart knowledge on laminar and thermal boundary layer equations.

Course outcome:

On completion of the course, students should be able to:

- Define the fundamental Boundary layer theory
- Solve the equations involved in boundary layer theory
- Analyze the different kinds of Boundary Layer control

Navier-Stokes Equations, Creeping motion, Couette flow, Poiseuille flow through ducts, Ekman drift.Development of boundary layer, Review on the estimation of boundary layer thickness; displacement thickness; momentum and energy thicknesses for two dimensional flow; two dimensional boundary layer equations, Similarity solutions, Blasius solution. Physical and mathematical description of turbulence, Transition from laminar to turbulent boundary layers, turbulent boundary layer on a flat plate, mixing length hypothesis. Approximate integral methods (Von Karman and Polhausen Method).Two-dimensional turbulent boundary layer equations, Velocity profiles for Inner, outer and overlap layers.

References:

1. Schlichting, Herrmann, Gersten, Klaus Translated by Mayes-"Boundary Layer Theory" 8th rev. and enlarged ed. 2000
2. Frank White, "Viscous Fluid flow" – McGraw Hill, 2005
3. Ian. J. Sobey, "Introduction to interactive Boundary Layer Theory", Oxford University Press, USA, 2001
4. Ronald L., Panton, "Incompressible fluid flow", John Wiley & Sons, 2005.
5. J. Reynolds, "Turbulent flows in Engineering", John Wiley & Sons, 1992.
6. Tuncer Cebeci and Peter Bradshaw, "Momentum transfer in boundary layers", Hemisphere Publishing Corporation, 1977.

15AE3003 THEORY OF VIBRATION

Credits: 3:0:0

Course Objectives:

- To familiarize the fundamentals of Vibration Theory.
- To impart knowledge on how to apply theory of vibration to engineering problems
- To enable the students to mathematically formulate real-world vibration problems in engineering

Course outcome:

On completion of the course, students should be able to:

- Outline the basic mathematical modeling of vibrating mechanical systems
- Specify the basic equations of motion of vibratory systems
- Analyze the Model applied in vibration theory

Vibration theory, Characteristics of single and multi-degree of freedom linear systems, Analysis of the free response, response to harmonic excitation, and general forced response of linear systems, Distributed parameter systems, Types of problem and governing equations – unforced and harmonic forcing, transient, simplified lumped parameter representations, simplified analysis of continuous structures, natural frequencies and mode shapes Application to simple aerospace structural problems.

References:

1. Singiresu S. Rao, "Mechanical Vibrations", 4th Ed., Prentice-Hall, 2004.
2. Leonard Meirovitch, "Fundamental of Vibrations", McGraw-Hill, 2001.
3. S. Graham Kelly, "Fundamentals of Mechanical Vibrations", Mcgraw-Hill, 2000.
4. William T. Thomson, Marie Dillon Dahleh, "Theory of Vibration with Applications", 5^{th} Ed., Pearson New International, 2014.
5. W. Weaver, Jr., S.P. Timoshenko, D.H. Young, "Vibration Problems in Engineering", Oxford City Press, 2011.
6. Daniel, J. Inman, Engineering Vibration, 3rd Edition, Prentice Hall, 2008
7. Joseph W. Tedesco, William G. McDougal, C. Allen Ross, "Structural Dynamics: Theory and Applications", Addison Wesley 1999.
8. Roy R. Craig, "Structural Dynamics: An Introduction to Computer Methods", John Wiley & Sons, Inc., 1981.

15AE3004 AIRCRAFT DESIGN

Credits: 3:0:0

Course Objectives:

- To impart knowledge about inputs required for Aircraft design
- To introduce methodology for aerodynamic design of aircraft
- To introduce power plant selection to meet performance requirements
- To introduce the methodology for structural design of aircraft

Course Outcome:

On completion of the course, students should be able to:

- Design an aircraft/Spacecraft with given configuration
- Estimate the design parameters required for its better performance

Categories and types of aircrafts, Layouts and their relative merits, Selection of Wing Loading and Thrust –Weight Ratio, Air Vehicle Configuration, Maneuvering load factors, Balancing and maneuvering loads on tail planes, Power plant Selection, Aerodynamic Design, Weight estimation and balance diagram, Drag estimation of complete aircraft, Aircraft Performance analysis, Loads on undercarriages and design requirements, Estimation of loads on complete aircraft and components. Structural design, Material selection for different components.

References:

1. D.P. Raymer, “Aircraft conceptual design”, AIAA Series, 2012.
2. E. Torenbeek, “Synthesis of Subsonic Airplane Design”, Delft University Press, London, Springer, 2010.
3. H.N.Kota, Integrated design approach to Design fly by wire” Lecture notes \Interline Pub., Bangalore, 1992.
4. E.F. Bruhn, “Analysis and Design of Flight Vehicle Structures”, Tristate Offset Co., U.S.A., 1980.
5. A.A. Lebedenski, “Notes on airplane design”, Part-I, I.I.Sc., Bangalore, 1971.
6. G. Corning, “Supersonic & Subsonic Airplane Design”, 4th Edition, Edwards Brothers Inc., Michigan, 1989.

15AE3005 FLIGHT CONTROL SYSTEM

Credits: 3:0:0

Course Objectives:

- To impart the concepts of Fly by wire system
- To impart knowledge on the principles of guidance laws and augmentation systems
- To instruct the principles of working and the design of longitudinal and lateral autopilot

Course Outcome:

On completion of the course, students should be able to:

- Define the principles of FBW and augmentation systems
- Summarize the design parameters of autopilot systems

Conventional Systems - Power actuated systems – Modern control systems. Introduction to fly-by-wire control: Need for FBW systems - Historical perspectives in design Programs - Douglas Long Beach. Elements of DFBW control. Augmentation systems: Stability augmentation systems - control augmentation systems. Longitudinal autopilot: Displacement Autopilot - Pitch Orientation Control system - Glide Slope Coupler and Automatic Flare Control, Lateral autopilot: Damping of the Dutch Roll - Yaw Orientation Control system - Automatic lateral Beam Guidance. Missile autopilots and control: Missile Mathematical Model, Autopilot response and design.

References:

1. Stevens B.L & Lewis F.L, ‘Aircraft control & simulation’, John Wiley Sons, New York, 2003.
2. George Siouris, G.M. "Missile Guidance and control systems", Springer, 2003
3. Vernon R Schmitt, James W Morris and Gavin D Jenny, “Fly By Wire-A Historical Perspective”, SAE International, 1998.
4. Blake Lock, J.H ‘Automatic control of Aircraft and missiles ‘, John Wiley Sons, New York, 1990.
5. Nelson R.C ‘Flight stability & Automatic Control’, McGraw Hill, 1998 II edition.
6. Bernad Etkin,’Dynamic of flight stability and control’, John Wiley, 1995, III edition

15AE3006 ROCKET DYNAMICS

Credits: 3:0:0

Course Objectives:

- To impart the basic concepts of trajectory estimation.
- To impart knowledge on performance, stability and control of rockets

Course Outcome:

On completion of the course, students should be able to:

- Identify the motion of rocket in gravitation field and in an atmosphere
- Relate the stability concepts of the rockets.

Equations of motion, the thrust equation. Rocket performance, restricted staging in field-free space, motion of rocket in gravitation field and in an atmosphere, Staging and optimal staging – two and three stage rockets, Rocket Stability and control: static and dynamic stability; Static Longitudinal Stability and Control, Lateral and directional Stability and Control.

References

1. Howard D. Curtis, Orbital Mechanics for Engineering Students, ELSEVIER, Butterworth, Heinemann, 3rd Edition, 2013.
2. George P.Sutton, and Oscar Biblarz, Rocket Propulsion Elements, John Wiley & Sons Inc., New York, 8th Edition, 2010.
3. Ashish **Tewari**, Atmospheric and Space Flight Dynamics, Birkhauser, 2007.
4. E. Roy, Orbital Motion, Fourth Edition, IOP Publishing Ltd 2005.
5. J. W. Cornelisse, H.F.R. Schoyer, and K.F. Wakker,. Rocket Propulsion and Spaceflight Dynamics, Pitman, 2001.
6. William E.Wiesel, Spaceflight Dynamics, McGraw-Hill, 3rd Edition, 2010.

15AE3007 ADVANCED AIRCRAFT SYSTEMS

Credits: 3:0:0

Course Objectives:

- To impart knowledge in concepts of flight systems, their significance and operation.
- To impart exposure in sensors and measurements.
- To instruct the usage of electrical systems and engine systems.

Course Outcome:

On completion of the course, students should be able to:

- Specify the major flight instruments, sensors and operations
- Relate the concepts of electrical systems.

Hydraulic systems – Instrumentation and working principles. Typical Pneumatic Power system – Brake system – Components, Landing Gear Systems – Classification – Shock absorbers – Retractive mechanism. Fuel systems – lubricating systems - Starting and Ignition systems, Flow measurement systems, Direct reading pressure and temperature gauges, Collision avoidance and Ground Proximity Warning Systems, PFD Systems, Instrument warning systems.

References

1. Pallet, E.H.J., "Aircraft Instruments & Principles", Pitman & Co., 2001.
2. Murthy, D.V.S., "Transducers and Measurements", 2nd Ed. PHI learning Ltd, 2011
3. Doeblin.E.O, "Measurement Systems Application and Design", 5th Ed. Tata McGraw-Hill, 2007.
4. "General Hand Books of Airframe and Powerplant Mechanics", U.S. Dept. of Transportation, Federal Aviation Administation, the English Book Store, New Delhi, 1995.
5. Mekinley, J.L. and Bent, R.D., "Aircraft Power Plants", McGraw-Hill, 1993.

15AE3008 UNMANNED AIRCRAFT SYSTEMS

Credits: 3:0:0

Course Objectives:

- To incorporate awareness about the basic terminology, models and prototypes of UAV system
- To impart the knowledge on design considerations of UAV systems

Course Outcome:

On completion of the course, students should be able to:

- Specify the concepts of UAV models and prototypes
- Relate the design parameters of UAV systems

Introduction to Unmanned Aircraft Systems (UAS) – Categories and Roles – Elements of UAS – Unmanned Aircraft system operations – Design stages of UAS – Aerodynamics and airframe configurations – Aspects of airframe design - Unmanned Aircraft characteristics – Long range, Medium and Close range UAVs – Mini, Micro and Nano UAVs – Novel hybrid combinations – Sensors and payloads – payload types – Communications, Control and stability, Navigation – Launch and recovery – Certification and ground testing – inflight testing - Human factors in UAS – Future of UAS and challenges

References

1. Reg Austin, "Unmanned Aircraft Systems: UAVS Design Development and Deployment", First edition, John Wiley and Sons, 2010.
2. Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, "Introduction to Unmanned Aircraft systems", CRC press, Taylor and Francis, New York, 2012. Richard Microcontroller Systems for a UAV, A. Skafidas, 2002.
3. R. Said, H. Chayeb, "Power supply system for UAV", , 2002
4. Paul.G.Fahlstrom, Thomas.J.Gleason Introduction to UAV systems, UAV SYSTEMS, Ins.. 2013
5. Armand.J. Chaput, "Design of UAV Systems" , Lockheed Martin Aeronautics Company, 2001.

15AE3009 FINITE ELEMENT ANALYSIS IN AEROSPACE APPLICATION

Credits: 3:0:0

Course Objectives:

- To impart the basic concept of finite element and
- To introduce the finite element modeling in designing Aerospace Structural Components
- To provide the knowledge on various finite element procedures and solution techniques

Course Outcome:

On completion of the course, students should be able to:

- Analyze the discrete and continuum problem using finite element method.
- Identify mathematical model for solution of common engineering problems.
- Describe the usage of professional-level finite element software to solve engineering problems in Solid mechanics, fluid mechanics and heat transfer.

Finite element method – Element characteristic matrix – element assembly and solutions for unknowns – Structure stiffness equations – Element stiffness equations – Assembly of elements – Node numbering boundary conditions – stress computation – principle of stationary potential energy – Rayleigh Ritz method – shape functions – Equilibrium and Compatibility in the solution – Convergence Requirements - Co ordinate systems – Isoparametric elements – Stress Stiffening – Bending and Buckling of plates – shells – Heat conduction and selected Fluid flow problems related to Aerospace applications – Modeling and programming.

References:

1. Robert D. Cook, David S. Malkus, Michael E. Plesha, “Concepts and Applications of Finite Element Analysis”, John Wiley and Sons, 4th ed., 2007.
2. J.N. Reddy , “An Introduction to the Finite Element Method,”, McGraw-Hill International Editions, 3rd ed., 2009.
3. Rao S.S., “Finite Element Methods in Engineering”, Pergamon Press, 4th Ed., 2005.
4. Robert D. Cook “Finite Element Modeling For Stress Analysis”, John Wiley and Sons, 1995.
5. Roy R. Craig, Jr., “Structural Dynamics: An Introduction to Computer Methods,” John Wiley and Sons, 1981.

15AE3010 ADVANCED AVIONICS LAB

Credit: 0:0:1

Co-requisites: 14AE3009 Advanced Avionics

Course Objectives:

- To impart the knowledge about different types of Instruments and control systems
- To train students to measure parameters accurately and their importance in different applications in the field of Avionics

Course Outcome:

On completion of the course, students should be able to:

- Manage the work with the avionics systems on an aircraft
- Relate the design concept of new control systems
- Apply the methods of troubleshoot and rectification of faulty instruments.

The faculty conducting the Laboratory will prepare a list of 6 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

15AE3011 LINEAR AND REGULAR ORBITAL MECHANICS

Credits: 3:0:0

Course Objective:

- To impart the knowledge of orbital mechanics through linear and regular equations of motion.
- To impart the knowledge of orbital perturbations in terms of KS elements.

Course Outcome:

On completion of the course, students should be able to:

- Apply the knowledge of KS transformation to the satellite orbit predictions.

Pure Kepler motion, Energy relations, Singular differential equations, Regularization, One dimensional motion, Motion in a plane, Motion in space, KS regularized equations of motions, The initial value problem, Classical elements in terms of KS variables, Stability, Time element, A set of regular elements, Perturbations in terms of KS elements - Oblateness - Atmospheric drag - Third body gravitational attraction - Solar radiation pressure - Numerical examples, Use of KS transformation for orbit predictions.

References

1. Howard D. Curtis, Elsevier Butterworth-Heinemann, "Orbital Mechanics for Engineering Students", Third edition, 2013.
2. Oliver Montenbruck, Eberhard Gill, “Satellite Orbits: Models, Methods and Applications", Springer–Verlag Berlin Heidelberg New York, HAR/CDR edition, 2011.
3. William E. Wiesel, “Modern Astrodynamics", Create Space Independent Publishing Platform, Second edition, 2010.
4. David A. Vallado, Microcosm and Kluwer, "Fundamentals of Astrodynamics and Applications", , Third edition, 2007.
5. Archie E. Roy, "Orbital Motion", CRC Press, Fourth edition, 2004.
6. Vladimir A. Chobotov, "Orbital Mechanics", AIAA Education Series, Published by AIAA, 2002.
7. Carl D. Murray, Stanley F. Dermott, "Solar System Dynamics", Cambridge University Press, 2000.
8. Eduard .L. Stiefel, Gerhard Scheifele, "Linear and Regular Celestial Mechanics", Springer–Verlag Berlin Heidelberg New York, 1971.

15AE3012 NUMERICAL METHODS IN ORBIT APPLICATION

Credits: 3:0:0

Course Objective:

- To impart the knowledge tosolve problems in space dynamics numerically.

Course Outcome:

On completion of the course, students should be able to:

- Apply the knowledge of Numerical Methods to the applications of orbital Mechanics

Empirical formulae and curve fitting, principle of least squares, splines, Iterative method, Newton- Raphson method, Numerical integration: Simpson's 3/8 rule. Romberg integration, Numerical solution for ordinary differential equations: Runge-Kutta methods, Multistep method, stability, Solving boundary value problems of ordinary differential equation.

References

1. Venkataraman M.K., "Numerical methods in Science and Engineering", National Publishing Company, Revised Edition, 2005.
2. Kandasamy P., "Numerical Methods", S.Chand and Co, Reprint 2010.
3. M.K.Jain., Iyengar. S.R.K., Jain R.K., "Numerical Methods for Scientific and Engineering Computation", (6th Edition), New Age International, 2012.
4. S.S. Sastry, Introductory Methods Of Numerical Analysis, Prentice-Hall Of India Pvt Ltd, New Delhi, 2012.

14AE3010 ADVANCED COMPUTATIONAL FLUID DYNAMICS LAB (V-1.1)

(Changes in Course outcomes and Co-requisites)

Credits: 0:0:1

Co-requisites: 14AE3002 – Advanced Computational Fluid Dynamics

OR

14ME3003 – Advanced Fluid Mechanics.

Course Objective:

- To familiarize with the working of CFD codes
- To familiarize the students with actual setting up of the problem and solution procedure
- To extract the required data, post process and compare with available data

Course Outcome:

On completion of the course, students should be able to:

- Distinguish CFD Analysis.
- Apply the boundary conditions and solve CFD problems.
- Solve problems using turbulence and combustion models.

The faculty conducting the Laboratory will prepare a list of 6 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

LIST OF SUBJECTS

Sub. Code	Name of the Subject	Credits
13AE201	Fluid mechanics	4:0:0
13AE202	Fluid Mechanics Laboratory	0:0:2
13AE203	Thermodynamics	4:0:0
13AE204	Thermal Engineering	3:0:0
13AE205	Introduction to Aerospace Engineering	4:0:0
13AE206	Instrumentation and Avionics Laboratory	0:0:2
13AE207	Gas Dynamics	4:0:0
13AE208	Aircraft Propulsion	4:0:0
13AE209	Rocket Propulsion	4:0:0
13AE210	ANSYS Laboratory	0:0:2
13AE211	Experimental Stress Analysis	4:0:0
13AE212	Materials in Aerospace Applications	3:0:0
13AE213	Aeroelasticity	3:0:0
13AE214	Advanced space dynamics	3:0:0
13AE215	Introduction to Hypersonic Flows	4:0:0
13AE216	Aircraft and Engine Systems	4:0:0
13AE217	Operation Research	3:0:0
14AE2001	Introduction to Aerospace Engineering	3:0:0
14AE2002	Aerospace Components Drawing	0:0:1
14AE2003	Materials in Aerospace Application	3:0:0
14AE2004	Elements of Avionics	3:0:0
14AE2005	Strength of Aerospace Materials	3:1:0
14AE2006	Aerodynamics	3:0:0
14AE2007	Aerodynamics Laboratory - 1	0:0:2
14AE2008	Aerodynamics Laboratory – 2	0:0:2
14AE2009	CAD Laboratory	0:0:2
14AE2010	Aircraft Instrumentation	3:0:0
14AE2011	Instrumentation and Avionics Laboratory	0:0:2
14AE2012	Aircraft Structures	3:0:0
14AE2013	Aircraft Structures Laboratory	0:0:2
14AE2014	Aircraft Performance	3:1:0
14AE2015	Aircraft Stability and Control	3:0:0
14AE2016	Space Dynamics	3:0:0
14AE2017	Aircraft Propulsion	3:0:0
14AE2018	Propulsion Laboratory	0:0:2
14AE2019	Computational Fluid Dynamics	3:0:0
14AE2020	CFD Laboratory	0:0:2
14AE2021	Gas Dynamics	3:0:0
14AE2022	Rocket Propulsion	3:0:0
14AE2023	Aircraft/Spacecraft Design Project	0:0:2
14AE2024	Computational Structural Analysis Laboratory	0:0:2
14AE2025	Thermal Engineering for Aerospace	3:0:0
14AE2026	Wind Tunnel Techniques	3:0:0
14AE2027	Navigation, Guidance and Control of Aerospace Vehicles	3:0:0
14AE2028	Experimental Stress Analysis	3:0:0
14AE2029	Air Traffic Control and Aerodrome details	3:0:0

14AE2030	Basics of Aerospace Engineering	3:0:0
14AE2031	Introduction to Non Destructive Testing	3:0:0
14AE2032	Aero-elasticity	3:0:0
14AE2033	Advanced space dynamics	3:0:0
14AE2034	Introduction to Hypersonic Flows	3:0:0
14AE2035	Aircraft Systems	3:0:0
14AE3001	Advanced Solid Mechanics	3:0:0
14AE3002	Advanced Computational Fluid Dynamics	3:0:0
14AE3003	Thermodynamics & Heat Transfer	3:0:0
14AE3004	Flight Performance and Dynamics	3:0:0
14AE3005	Orbital Space Dynamics	3:0:0
14AE3006	Advanced Aerodynamics	3:0:0
14AE3007	Advanced Propulsion	3:0:0
14AE3008	Aerospace Structural Analysis	3:0:0
14AE3009	Advanced Avionics	3:0:0
14AE3010	Advanced Computational Fluid Dynamics Lab	0:0:1
14AE3011	Advanced Aerodynamics Lab	0:0:2
14AE3012	Structural Analysis Lab	0:0:2
14AE3013	Aircraft Modelling Lab	0:0:1
14AE3014	Aero Propulsion Lab	0:0:2
14AE3015	Elements of Aerospace Engineering	3:0:0
14AE4001	Basic Celestial Mechanics	4:0:0
14AE4002	Orbital Mechanics	4:0:0
14AE4003	Hypersonic Flow Theory	4:0:0
14AE4004	Hypersonic Aerothermodynamics	4:0:0

13AE201 FLUID MECHANICS

Credits: 4:0:0

Objective

- The purpose of this course is to learn the fluid properties and fundamentals of fluid statics and fluid flow
- To introduce the concepts of flow measurements and flow losses in pipes
- To impart the knowledge on pumps and turbines

Outcome:

- Understanding the requirement of flow measurements and flow losses in pipes
- Knowledge in maintenance and operation of the pumps and turbines

Unit I
FLUID PROPERTIES
Density – Specific weight - Specific gravity – Viscosity – surface tension – Capillarity – Compressibility – Vapour pressure.
Fluid Statics: Pressure relation – Pascal's law –Measurement of pressure – Manometers, gauges and pressure transducers, Forces on plane and curved surfaces – Total pressure and centre of pressure.

Unit II
EQUATIONS OF FLUID FLOW
Types of flow – Stream line – Stream tube – Control volume – Continuity equation – One dimensional and three dimensional flow – Velocity potential and stream function, rotation and circulation, Free and forced vortex flow.
Kinematics of fluid flow: Energy equation – Euler's equation in one dimensional form – Bernoulli's equation. Applications of Bernoulli's equation: Orifices - Venturi meter – Orifice meter – Pitot tube.

Unit III

DIMENSIONAL ANALYSIS AND SIMILITUDE

Dimensions and Units, Dimensional analysis, Buckingham's theorem, Non-dimensional numbers and their significance, geometric, Kinematic and dynamic similarity, Application of Non-dimensional numbers.

Flow Through Pipes: Darcy – Weisbach equation. Friction factor and Moody diagram. Loss of energy in pipes – Flow through pipes in series and parallel – power transmission through pipes – Syphon – Water hammer (Definition).

Unit IV

HYDRAULIC PUMPS AND TURBINES

Impulse momentum equation- Impact of Jets-plane and curved- stationary and moving plates - Positive displacement pumps. Centrifugal pumps - operating principles -slip-indicator diagram, air vessels - operation - velocity triangles - performance curves - Cavitation - Multi staging - Selection of pumps.

Turbine classification - Working principles - Pelton wheel, Francis, Kaplan turbines – Velocity triangles.

Unit V

BOUNDARY LAYER AND APPLICATIONS: Concepts of boundary layer- Flow over a flat plate, Boundary layer thickness – displacement, momentum and energy thickness. The momentum equation for the boundary layer. Laminar and turbulent boundary layer- Blasius solution.

Text Books:

1. Rajput, R.K., "A Text book of Fluid Mechanics and Hydraulic Machines" , S.Chand and Co., New Delhi, 1998.
2. John F.Douglas, Janusz M.Gasiorek and J.A.Swaffield., Fluid Mechanics, Pearson Education Limited, 2004.

Reference books:

1. Bansal, R.K., "Fluid Mechanics and Hydraulic Machines", Laxmi Publications, New Delhi, 2005.
2. Streeter. V. L., and Wylie, E.B., Fluid Mechanics, McGraw Hill, 1983.
3. Som,S.R, & Biswas, "Introduction to Fluid Mechanics and Fluid Machines", Tata McGraw Hill, 1998.
4. Agarwal, S.K., "Fluid Mechanics and Machinery", Tata Mc Graw Hill Co., 1997.

13AE202FLUID MECHANICS LABORATORY

Credit: 0:0:2

Objective:

- To give hands on training on Flow measurement, Losses due to friction in pipes.
- To give hands on training on working of different types of Pumps and turbine

Outcome:

- Knowledge to carry out flow measurements
- An understanding of performance of pumps.

LIST OF EXPERIMENTS

1. Determination of Darcy's Friction Factor.
2. Calibration of Flow Meters.
3. Flow through Mouth piece / orifice.
4. Determination of Minor Losses in pipes
5. Calibration of manometer.
6. Calibration of pressure Gauges.
7. Impact of jet on vanes.
8. Reynolds' Experiment.
9. Performance of Centrifugal Pump.
10. Performance of reciprocating pump.
11. Load Test on Pelton Wheel.

12. Load Test on Francis Turbine
13. Load Test on Kaplan Turbine

(Any 12 experiments can be offered)

13AE203 THERMODYNAMICS

Credit: 4:0:0

Objective:

- To achieve an understanding of principles of thermodynamics and to apply it for simple physical systems
- To provide in-depth study of thermodynamic principles, thermodynamics of state, Principle of Psychometric & Properties of pure substances

Outcome:

- Knowledge of thermodynamics laws and principles and their applications

Unit I

BASIC CONCEPTS AND FIRST LAW OF THERMODYNAMICS

Energy and Thermodynamics – Applications of Thermodynamics – Systems and Control volumes - Property, state – Path, Process and cycle - quasi-static process - work and modes of work - Zeroth law of thermodynamics – Energy transfer by heat and work. First law of thermodynamics – application to closed and open systems, Energy conversion efficiencies – Energy and Environment

Unit II

PROPERTIES OF PURE SUBSTANCE AND ENERGY ANALYSIS

Properties of pure substances – Thermodynamic properties of pure substances in solid, liquid and vapour phases, phase rule, Phase change process with T-v, p-v, p-T diagrams, p-v-T surface

Energy balance for closed systems – conservation of mass – Energy analysis of steady flow and unsteady flow process

Unit III

SECOND LAW OF THERMODYNAMICS AND ENTROPY

Thermal Energy reservoirs – Heat Engines – Second law of thermodynamics – Kelvin and Clausius statements of second law - Reversibility and irreversibility – Perpetual Motion Machine Type- I - Carnot cycle & reversed Carnot cycle – efficiency and COP. Concept of entropy, entropy of ideal gas, principle of increase of entropy – Carnot theorem, absolute entropy, availability – Isentropic efficiencies of steady flow devices – Entropy balance

Unit IV

GAS MIXTURES AND CHEMICAL REACTIONS

Gas mixtures – Properties of ideal and real gases - Equation of state- Avogadro's law - Van der Waal's equation of states, compressibility, compressibility chart. Dalton's law of partial pressure – Properties of gas mixtures – Gibbs function

Fuels and combustion – Theoretical and actual combustion process

Unit V

PSYCHROMETRY

Psychrometry and Psychrometric charts- property calculations of air vapour mixtures - Psychrometric process – Sensible heat exchange processes - Latent heat exchange processes. Adiabatic mixing- Evaporative cooling- simple problems

Text Books:

1. Nag.P.K., "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi, Fourth Edition, 2008.
2. Yunus A Cengel and Michael A Boles, "Thermodynamics : An Engineering approach", Tata McGraw Hill, New Delhi, Sixth Edition, 2008.

Reference books:

1. Holman.J.P., "Thermodynamics", 3rd Ed. McGraw-Hill, 1995.

13AE204 THERMAL ENGINEERING

Credits: 3:0:0

Objective:

- To integrate the concepts, laws and methodologies of Thermodynamics into analysis of cyclic processes
- To apply the thermodynamic concepts into various thermal application like IC engines, Steam Turbines, Compressors and Refrigeration and Air conditioning system

Outcome:

- Understanding the working of various gas power cycles and its thermodynamic basics.
- Knowledge on the operation of Engines, turbines, Refrigeration and Air-conditioning.

Unit I

INTERNAL COMBUSTION ENGINES

Classification - Components and their function – Parts of IC Engine - Two stroke engine – Four stroke Engine - Comparison of two stroke and four stroke engines - Carburetor system, Fuel Injection system - Lubrication system - Battery and Magneto Ignition System – Combustion in SI and CI engines

Unit II

AIR STANDARD CYCLES

Air standard cycle – Air standard Efficiency – Carnot cycle – Otto Cycle- Diesel cycle – Dual cycle – Comparison of cycles – Brayton cycle

Unit III

STEAM NOZZLES AND TURBINES

Steam flow through nozzles - Nozzle efficiency – Supersaturated and metastable expansion – general relationship between area, velocity and pressure – Steam injector

Classification of steam turbines - Impulse and Reaction principles - compounding - velocity diagram – Turbine efficiencies

Unit IV

AIR COMPRESSORS

Classification - Working principle of reciprocating compressors, work of compression with and without clearance, volumetric efficiency, Isothermal efficiency and isentropic efficiency of reciprocating compressors, Multi-stage air compressor and inter cooling – Rotary compressors – classification

Unit V

REFRIGERATION AND AIR CONDITIONING

Fundamentals of Refrigeration – Air refrigeration system – simple Vapour compression refrigeration cycle - working principle of vapour absorption system

Aircraft air conditioning system - Introduction and need, Ram air cooling, Air cycle refrigeration system, Turbo fan cooling system, Vapor cycle system, Expandable heat sinks, Humidity control system

Text Books :

1. Rudramoorthy, R, "Thermal Engineering ",Tata McGraw-Hill, New Delhi,2003
2. Rajput. R. K., "Thermal Engineering" S. Chand Publishers , 2000
3. Ion Moir and Allan Seabridge, Aircraft Systems, John Wiley & Sons Ltd, England, Third edition, 2008

Reference Books :

1. Kothandaraman.C.P., Domkundwar.S,Domkundwar. A.V., "A course in thermal engineering,"Dhanpat Rai &sons , Fifth edition, 2002

13AE205 INTRODUCTION TO AEROSPACE ENGINEERING

Credits: 4:0:0

Objective:

- To introduce the basic concepts of aircrafts, rockets, satellites and their application
- To familiarize with the basic parts and their function and construction details
- To familiarize with the national and international aeronautical and aerospace agencies

Outcome:

- Understanding the nature of aerospace technologies,
- Knowledge in various types of aerospace vehicles, satellites and their applications,
- Familiarize with various national and international aerospace agencies

Unit I

HISTORICAL EVOLUTION AND MAJOR AIRCRAFT COMPONENTS

History of air vehicles and space vehicles- Historical developments of Aerodynamics, Structures and Propulsion system throughout the years - Different types of flight vehicles and its classification - Major components of an airplane and their functions - Conventional flight control surfaces

Unit II

BASIC THEORY OF FLIGHT

Atmospheric layers - Basic atmospheric properties and its variation in altitude - International standard atmosphere (ISA) – Basic knowledge on Meteorology – Forces acting on a flight vehicle - Airfoil – its nomenclature and classification - Evolution of lift, drag and moment - wing configuration – monoplane, biplane – High, mid, low – aspect ratio – swept back, swept forward.

Unit III

INTRODUCTION TO STRUCTURES: General types of aircraft construction and structural layout, Fuselage construction - monocoque, semi-monocoque, and geodesic construction, Wing structure , aerospace materials - metallic and nonmetallic materials, use of aluminum alloy, titanium, stainless steel, composite materials.

Unit IV

PROPULSION SYSTEMS: Basic ideas about piston, turboprop and jet engines, Principles of Thrust generation-propeller and jets, comparative merits.

ROCKETS AND SATELLITES: Principles of operation of rocket, types of rockets and typical applications, Exploration into space, Satellites –types and applications.

Unit V

FLIGHT TESTING: Introduction to flight-testing, Purpose and Scope of Flight Testing, Basic instruments for flying.

AEROSPACE INDUSTRIES AND INSTITUTIONS: Introduction to aerospace industries – Research and Development organizations and Academic institutions in India and worldwide

Text Book

1. Anderson, J. D., "Introduction to Flight", McGraw-Hill, 2006.

Reference Books

1. Kermode, A. C., "Flight without Formulae", Pitman, 2002.
2. Sutton, G.P., et al., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 2004

13AE206 INSTRUMENTATION AND AVIONICS LABORATORY

Credit: 0:0:2

Objectives:

- To introduce different types of Instruments and control systems
- To train students to measure parameters accurately and their importance in different applications in the field of Avionics

Outcome:

- Working with the avionics systems on an aircraft
- Understand the Design concept of new control systems
- Familiarize the methods of troubleshoot and rectification of faulty Instruments.

List of Experiments

1. Study on basic electronics and radio wave principles.
2. Temperature measurement using different thermocouple
3. Temperature measurement using RTD
4. Temperature measurement pyrometer.
5. Steady Pressure measurements using pressure transducer
6. Unsteady Pressure measurements using pressure transducer
7. Force measurements using load cells
8. Flow measurements using hot wire anemometer.
9. Heat Flux measurements
10. Instrumentation study of the cockpit.
11. Controls in weather radar systems.
12. Controls in airborne ATC transponder.
13. Controls in Mems gyroscope.
14. Controls in Mems accelerometer.
15. Study on air navigation systems.
16. Study on avionic systems/aids/simulation software.

(Any 12 experiments can be offered)

13AE207 GAS DYNAMICS

Credits: 4:0:0

Objective:

- To familiarize with behavior of compressible gas flow
- To understand the difference between subsonic and supersonic flow
- To familiarize with effect of transonic and supersonic flow over flying vehicles

Outcome:

- Knowledge of design and configuration of the flying vehicles for transonic and supersonic flights
- Understanding the effect of shock wave on aircraft/engine performance
- Knowledge of the flow behavior and consequent loads

Unit I:

EQUATIONS OF MOTION FOR COMPRESSIBLE FLOWS:

Introduction to gas dynamics, Energy equation, Continuity equation, Gas momentum and momentum equation, Velocity of sound, Stream tube area-velocity relationship, Isentropic flow equations for convergent, divergent and C-D nozzle, Rayleigh flow, Fanno flow

Unit II:
INTRODUCTION TO SHOCK AND EXPANSION WAVES:
Line of disturbance, Flow in convex and concave corners, Formation of normal & oblique shock and expansion wave, Methods of supersonic C-D nozzle design, C-D nozzle performance under various back pressures
NORMAL SHOCKS
Normal shock equation (Prandtl equation), Rankine – Hugoniot relations, Pitot static tube and correction factors for subsonic & supersonic flows

Unit III:
OBLIQUE SHOCKS AND EXPANSION WAVES
Oblique shocks and corresponding equations, Relationship between flow turning and shock angle, Hodograph and shock polar, Flow over wedges, Strong, weak and detached shocks, Expansion polar, Reflection and intersection of shocks & expansion waves

Unit IV:
HIGH SPEED FLOW OVER AIRFOIL
Small perturbation potential flow theory, Prandtl-Glauert affine transformation for subsonic flows, Supersonic flow over thin plate, Lift, drag, pitching moment and center of pressure for supersonic profiles, Lower and upper critical Mach numbers, Lift and drag divergence Mach number, Shock induced flow separation

Unit V:
HIGH SPEED FLOW OVER FINITE WING
Finite wing, Tip effects, Characteristics of swept wings, Effects of thickness, camber and aspect ratio of wings, Transonic area rule

Text Books:

1. Rathakrishnan, E., "Gas Dynamics", Third Edition, Prentice Hall of India, 2010
2. Shapiro, A.H., "The Dynamics and Thermodynamics of Compressible Fluid Flow", Volume-I, John Wiley & Sons

Reference Books:

1. Liepmann H W and Roshko A, "Elements of Gasdynamics", John Willey & Sons .
2. Zucrow, M.J. and Anderson, J.D., "Elements of Gas Dynamics", McGraw-Hill Book Co., NY, 1989.
3. Mc Cornick. W.,"Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, NY, 1979

13AE208 AIRCRAFT PROPULSION

Credits:4:0:0

Objective:
- To familiarize with working principles of Gas Turbine Engine (**GTE**)
- To familiarize with working principle of GTE individual modules and matching of all modules
- To familiarize with performance characteristic of GTE

Outcome:
- Evaluation of the performance at component level and matching all to achieve the system level performance requirement
- Understanding the design concept of the GTE for aircraft/helicopter application

Unit I
INTRODUCTION
Classification of propulsion system and Gas Turbine Engine (**GTE**), Review of thermodynamic laws and processes, GTE working cycle, parameters, losses and efficiencies, Elements & operating principles of GTE, Standard atmospheres and operational envelope

Unit II
COMPRESSORS
Centrifugal Compressor: Basic concepts and principles of operation, Work done, Velocity triangle and blade design, Impeller channel, Compressibility effect, Compressor characteristics
Axial Flow Compressor: Basic operation, Elementary theory, Blade design, Factors affecting stage pressure ratio, Degree of reaction, Off-design performance, Compressor characteristics

Unit III
COMBUSTION AND TURBINES
Combustion Systems: Design/operational requirements, Factors affecting combustion process, Types of combustion systems, Combustion process
Axial Flow Turbines: Basic operation & elementary theory, Impulse and reaction turbine blade, Vortex theory, Choice of blade profiles and pitch & chord, Limiting factor in turbine design, Overall performance, Methods of blade cooling

Unit IV
INLETS AND NOZZLES
AFTER BURNERS: Purpose and operational requirements, Design parameters, After burner components and operation (Fuel injection, Atomization & vaporization, Ignition, Flame stabilization, Combustion)
INLETS: Introduction and requirement parameters, subsonic inlet and operations, Supersonic inlets and operations with internal & external compression
Exhaust Nozzle: Types of exhaust nozzle and its operation

Unit V
ENGINE PERFORMANCE
Performance Prediction of Simple GTE: Introduction, Component characteristics, Off design operation of single shaft GTE, Equilibrium running of a gas generator, Off design operation of free turbine GTE, Off design operation of turbo jet engine
Performance Prediction of Turbo-Fan GTE: Introduction and purpose of twin spool GTE, Matching of turbo-fan engine, Some Notes on behavior of twin spool GTE
Performance Characteristics of Single Shaft GTE: Transient behavior of GTE, Principles of control systems, Jet engine performance characteristics (Altitude, Mach number and Shaft speed)

Text Books:

1. V. Ganesan, Gas Turbines, Second Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2009
2. H. Cohen, G.F.C. Rogers and H.I.H. Saravanmuttoo, Gas Turbine Theory, Fifth Edition, Pearson Education Ltd, 2009

Reference Books:

1. Jack .D Mattingly, Elements of Gas Turbine Propulsion, Tata McGraw Hill Publishing Co. 2005
2. Rolls Royce Plc, The Jet Engine, 1996, ISBN 090212235
3. E. Irwin Treager, Aircraft Gas Turbine Engine Technology, 3rd Edition 1995 'ISBN-00201828

13AE209 ROCKET PROPULSION

Credits: 4:0:0

Objective:
- To introduce the concepts of Rocket Propulsion
- To introduce the concept of combustion in RAM Jet and SCRAM Jet
- To familiarize with Advanced propulsion Techniques

Outcome:
Students will be able to
- Knowledge of the performance of rocket propulsion system

- Understanding the need for different propulsion systems and their usage

Unit I
FUNDAMENTALS OF ROCKET PROPULSION
Operating principle – Specific impulse of a rocket – internal ballistics- Rocket nozzle classification – Rocket performance considerations – Numerical Problems.

Unit II
CHEMICAL ROCKETS
Solid propellant rockets – Selection criteria of solid propellants – Important hardware components of solid rockets – Propellant grain design considerations – Liquid propellant rockets – Selection of liquid propellants – Thrust control in liquid rockets – Cooling in liquid rockets – Limitations of hybrid rockets – Relative advantages of liquid rockets over solid rockets- Numerical Problems.

Unit III
RAMJET PROPULSION
Operating principle – Sub critical, critical and supercritical operation – Combustion in ramjet engine – Ramjet performance – Sample ramjet design calculations – Introduction to scramjet – Preliminary concepts in supersonic combustion – Integral ram- rocket- Numerical problems.

Unit IV
ADVANCED PROPULSION TECHNIQUES
Electric rocket propulsion – Ion propulsion techniques – Nuclear rocket – Types – Solar sail- Preliminary Concepts in nozzle-less propulsion.

Unit V
ROCKET TESTING
Types of tests- Test facilities and safeguards –Monitoring the environment and control toxic material – Instrumentation and data management- measurement system terminology –Test measurements- Health monitoring system- Flight testing- post accident procedures.

Text Books

1. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 5th Edn., 1993.
2. Hill P.G. & Peterson, C.R. “Mechanics & Thermodynamics of Propulsion” Addison – Wesley Longman INC, 1999.

Reference Books:

1. Cohen, H., Rogers, G.F.C. and Saravanamuttoo, H.I.H., “Gas Turbine Theory”, Longman Co., ELBS Ed., 1989.
2. Gorden, C.V., “Aero thermodynamics of Gas Turbine and Rocket Propulsion”, AIAA Education Series, New York, 1989.
3. Mathur, M., and Sharma, R.P., “Gas Turbines and Jet and Rocket Propulsion”, Standard Publishers, New Delhi, 1988

13AE210 ANSYS LABORATORY

Credit 0:0:2

Objective:
- To understand the load and stress analysis of different types of structural components
- To evaluate and find deflection calculations so as to estimate the performance of the software.

Outcome:
- Understand the basics of ANSYS Software
- Analyze and design various structural elements using the software

LIST OF EXPERIMENTS:

1. Static structural analysis of 2D truss
2. Static structural analysis of tensile bar
3. Deflection of cantilever Beam
4. Deflection of SSB (Simply Supported Beam)
5. Deflection of rectangular wing
6. Stress analysis of rectangular plate with hole.
7. Buckling of plates.
8. Buckling of columns.
9. 2D steady heat conduction problem
10. Thermal stresses in bar
11. 3D conduction problem
12. Transient heat conduction problem

13AE211 EXPERIMENTAL STRESS ANALYSIS

Credits: 4:0:0

Objective:

- To understand experimental method of finding the response of the structure to different types of load.

Outcome:

- Knowledge of the general aspects of strain measurements
- Understanding the principle of operation of different type of strain gauges, circuits
- Familiarize with the optical methods of stress analysis and Nondestructive techniques

Unit I
INTRODUCTION AND STRAIN MEASUREMENTS METHODS AND RELATED INSTRUMENTATIONS

Principle of measurements-Accuracy, sensitivity and range- Definition of strain and its relation to experimental determinations, Properties of strain gauge systems, Types of strain gauge systems- Mechanical, Optical, Acoustical and Electrical extensometers.

Unit II
ELECTRICAL-RESISTANCE STRAIN GAUGES AND CIRCUITS

Principle of operation and requirements - Types and their uses-Materials for strain gauge-Calibration and temperature compensation-Cross sensitivity-Rosette analysis- Wheatstone bridge-Potentiometer circuits for static and dynamic strain measurements-Strain indicators, Transducer applications- Load cells- Diaphragm pressure transducers.

Unit III
PRINCIPLES OF PHOTOELASTICITY

Two dimensional photo elasticity-Concepts of photoelastic effects-Photoelastic materials-Stress optic law-Plane polariscope–Circular polariscope-Transmission and Reflection type-Effect of stressed model in Plane and Circular polariscope. Interpretation of fringe pattern Isoclinics and Isochromatics.-Fringe sharpening and Fringe multiplication techniques-Compensation and separation techniques-Introduction to three dimensional photoelasticity.

Unit IV
PHOTOELASTICITY AND INTERFEROMETRY TECHNIQUES

Fringe sharpening and Fringe multiplication techniques - Compensation and separation techniques-Calibration methods – Photo elastic materials. Introduction to three dimensional photoelasticity. Moire fringes – Laser holography – Grid methods-Stress coat

Unit V

NON DESTRUCTIVE TECHNIQUES

Radiography- Ultrasonics- Magnetic particle inspection- Fluorescent penetrant technique-Eddy current testing-Acoustic emission technique.

Text Books:

1. J.W. Dally and M.F. Riley, "Experimental Stress Analysis", McGraw-Hill Book Co., New.York, 1988.
2. Srinath,L.S., Raghava,M.R., Lingaiah,K. Gargesha,G.,Pant B. and Ramachandra,K. – Experimental Stress Analysis, Tata McGraw Hill, New Delhi, 1984
3. P. Fordham, "Non-Destructive Testing Techniques" Business Publications, London, 1988

Reference books:

1. M. Hetenyi, "Handbook of Experimental Stress Analysis", John Wiley & Sons Inc., New York, 1980.
2. G.S. Holister, "Experimental Stress Analysis, Principles and Methods", Cambridge University Press, 1987.
3. A.J. Durelli and V.J. Parks, "Moire Analysis of Strain", Prentice Hall Inc., Englewood Cliffs, New Jersey, 1980.

13AE212 MATERIALS IN AEROSPACE APPLICATIONS

Credits: 3:0:0

Objective:

- To understand various materials used in Aerospace industry,
- To help the students in various Mechanical behavior of the materials and its testing methods

Outcome:

- Knowledge of the mechanical behavior of various Aerospace Materials and its heat treatment process.
- Familiarize with the application of ferrous and nonferrous alloys in Aerospace Engineering.
- Understanding the non-metallic materials and adhesives used and its properties

Unit I:

MECHANICAL BEHAVIOUR OF ENGINEERING MATERIALS

Knowledge of various types of hardness testing machines and various types of hardness numbers Linear and non-linear elastic properties - Stress and Strain Curves – Yielding and strain Hardening ,Toughness – Modules of resilience - Bauchinger's effect – Effect of notches – Testing and flaw detection of materials and components .

Unit II :

NON-FERROUS MATERIALS

Aluminum and its alloys: Types and identification, Properties, Castings, Heat treatment processes, Surface treatments.

Magnesium and its alloys: Cast and Wrought alloys, Aircraft application, features specification, fabrication problems, Special treatments.

Titanium and its alloys: Applications, machining, forming, welding and heat treatment.

Copper Alloys:- Monel, K-Monel

Unit III:

FERROUS MATERIALS

Steel:- Plain and low carbon steels , various low alloy steels , aircraft steel specifications, corrosion and heat resistant steels , structural applications.

Maraging Steels:- Properties and Applications,

Super Alloys:- Application, Nickel base, Cobalt base, Iron base, Forging and Casting of Super alloys, Welding, Heat treatment.

Unit IV:
NON METALLIC MATERIALS
Wood and fabric in aircraft construction and specifications –Glues, Use of glass, plastics and rubber in aircraft, Introduction to composite materials

Unit V:
ADHESIVE AND SEALANTS
Advantages of Bonded structure in airframes, Crack arresting, Weight saving, Technology of adhesive Bonding Structural adhesive materials, Typical bonded joints & nondestructive tests for bonded joint
Bonded Sandwich structures, Methods of construction of honeycombs

Text Books:

1. Aircraft General Engineering by Lalith Gupta, Himalaya Book House, Delhi 2003
2. Aircraft Material & Process by Titterton 2004

Reference Books:

1. Workshop Technology – Vol 1 & 2 by Hajira Chowdhry, Nedia Promoters, Mumbai
2. Advanced Composite Materials by Lalith Gupta 2006, Himalaya Book House, Delhi

13AE213 AEROELASTICITY

Credits: 3:0:0

Objective:

- To understand the basic concepts of Aeroelasticity
- To acquire knowledge about the Static and dynamic Aeroelastic phenomena
- To understand about Aeroelasticity phenomena in Turbomachines

Outcome:

- Understanding the Aero-elastic phenomena's and learning how to predict the Aeroelasticity phenomena's
- Knowledge of how to prevent body (i.e Aircrafts, Turbomachines and etc.) from Aeroelastic instability.

Unit I
INTRODUCTION AEROELASTIC PHENOMENA
History of Aeroelasticity, Stability versus response problems – The aero-elastic triangle of forces – Aeroelasticity in Aircraft Design – Prevention of aeroelastic instabilities. Influence and stiffness co-efficients. Coupled oscillations.

Unit II
STATIC AEROELASTICITY- DIVERGENCE OF A LIFTING SURFACE
Simple two dimensional idealisations -Strip theory – Integral equation of the second kind – Exact solutions for simple rectangular wings – 'Semirigid' assumption and approximate solutions

Unit III
STATIC AEROELASTICITY- STEADY STATE AEROELASTIC PROBLEM
Loss and reversal of aileron control – Critical aileron reversal speed – Aileron efficiency – Semi rigid theory– Lift distribution – Rigid and elastic wings. Tail efficiency. Effect of elastic deformation on static longitudinal stability.

Unit IV
DYNAMIC AEROELASTICITY- FLUTTER AND BUFFETING
Non-dimensional parameters – Stiffness criteria – Dynamic mass balancing – Dimensional similarity. Flutter analysis – Galerkin method for critical flutter speed– Methods of determining the critical flutter speeds – Flutter prevention and control, Introduction to buffeting phenomena.

Unit V

AEROELASTICITY IN TURBOMACHINES

Aero elastic Environment in Turbomachines - Stall and chocking Flutter in Turbine blades - Aero elastic Eigen values - Recent Trends in Aeroelasticity.

Text books:

1. Y.C. Fung, "An Introduction to the Theory of Aeroelasticity", John Wiley & Sons Inc., New York, 2008.
2. Earl H. Dowell, Robert Clark, David Cox, H.C. Curtiss, Jr, John W. Edwards, Kenneth C. Hall, David A. Peters, Robert Scanlan, Emil Simiu, Fernando Sisto and Thomas W. Strganac, "A Modern Course in Aeroelasticity", Fourth Revised and Enlarged Edition, 2004.

Reference Books:

1. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 1996.
2. R.H. Scanlan and R.Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.
3. E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd., 1986.

13AE214 ADVANCED SPACE DYNAMICS

Credit 3:0:0

Objective:

- To understand two-body and restricted three-body problem and its modifications

Outcome:

- Knowledge of the trajectory and performance of the space vehicle
- Understanding the advanced design of inter-planetary trajectory

Unit I

TWO-BODY PROBLEM

The motion of the center of mass, relative motion, two-point boundary value problem- application to Lambert's Theorem, some expansions of elliptic motion.

Unit II

RESTRICTED THREE-BODY PROBLEM

Equations of motion, Jacobi integral, Tisserand's criterion for the identification of comets, reduction, regularization.

Unit III

TOTALITY OF SOLUTIONS

Location of equilibrium points, Motion near the collinear and equilateral points, non-linear phenomenon around the equilibrium points.

Unit IV

HAMILTONIAN DYNAMICS

Equations of motion, canonical transformation in the phase space, extended phase space, Examples of Hamiltonian dynamics in the extended phase space, canonical transformation of the restricted three-body problem.

Unit V

MODIFICATIONS OF RESTRICTED THREE-BODY PROBLEM

Three-dimensional restricted three-body problem, elliptic restricted three-body problem, Hill's problem, other modifications.

Text books:

1. J.M.A.Danby, "Fundamentals of Celestial Mechanics", Willmann-Bell, Inc.,USA, 2nd Edition, Third printing, 1992.
2. V.G.Szebehely, "Theory of Orbits- The restricted problem of three bodies", Academic Press, USA, 1967.

Reference Books:

1. V.A.Chobotov, "Orbital Mechanics", IIIrd Edition, AIAA Education series, 2002.
2. C.D. Murray and S.F.Dermott, Solar system dynamics, Cambridge University Press, 1999.

13AE215 INTRODUCTION TO HYPERSONIC FLOWS

Credits: 4:0:0

Objective:

- To introduce the basics of hypersonic air flow
- To familiarize with the inviscid and the viscous hypersonic flow on an object

Outcome:

- Understanding the hypersonic flow behavior on an object
- Familiarize with the Hypersonic Interaction Parameter, Shock Wave-Boundary layer Interaction

Unit I
INTRODUCTION
Thin shock layer, Entropy layer, Viscous Interaction, High Temperature effects, Low Density Effects

Unit II
INVISCID HYPERSONIC FLOWS
Hypersonic Shock relations, Hypersonic Similarity Parameters and Shock relations, Hypersonic Expansion Wave relation, Newtonian Flows, Modified Newtonian Laws, Centrifugal Force Correction, Tangent wedge Method, Tangent Cone Method, Shock Expansion Method

Unit III
HYPERSONIC INVISCID FLOW FIELD
Governing Equations, Mach number independence Principle, Hypersonic Small Disturbance Theory, Blast wave Theory, Exact methods – Method of Characteristics, Hypersonic Blunt Body Problem, Hypersonic Shock wave shapes

Unit IV
VISCOUS FLOWS
Governing Equations – Navier-Stokes equations, Similarity Parameters, Boundary Conditions, Hypersonic Boundary Layer Theory, Self similar Solution – Flat Plate and Stagnation Point, Non-similar Boundary Layer, Local similarity Method, Hypersonic Transition, Turbulent Boundary layer,

Unit V
HYPERSONIC AERODYNAMIC HEATING AND VISCOUS-INVISCID INTERACTION
Hypersonic Aerodynamic Heating, Approximate Methods, Entropy Layer Effects, Interaction – Strong and Weak, Hypersonic Interaction Parameter, Shock Wave-Boundary layer Interaction

Text Books:

1. Anderson – Hypersonic and High Temperature Gas dynamics, 2006

Reference Books:

1. Hayes & Probstien – Hypersonic Flow Theory,

13AE216 AIRCRAFT AND ENGINE SYSTEMS

Credits: 4:0:0

Objective:

- To familiarize the importance and the operating principles of aircraft systems
- To familiarize the various flight and ambient conditions for which aircraft systems should be designed
- To familiarize modern trend in designing aircraft systems

Objective:

- Understanding the aircraft systems requirements
- Knowledge of design concepts of the systems for the various aircraft category
- Familiarize with the methods to diagnose the aircraft systems for its performance

Unit I
AIRCRAFT FLIGHT CONTROL SYSTEMS
Introduction and types of aircraft control systems, Conventional system, Hydro-mechanical system, Hydro-electro-mechanical system (fly by wire system), Fly by wire system with electro-hydro-static actuator, High lift devices systems, Smart actuator system

Unit II
AIRCRAFT HYDRAULIC SYSTEMS
Introduction, importance and types of hydraulic systems, Application and design requirements for hydraulic system, Conventional hydraulic systems, Modern hydraulic system, Design features and operating principles of hydraulic system components – pumps, motors, servo valves, accumulators, pressure reducing valve, pressure relief valve

Unit III
AIRCRAFT FUEL SYSTEMS
Introduction to fuel system and its importance, Design requirements and features of sub systems - feed, refueling, transfer, venting, Factors affecting the fuel system, Design features and operating principles of fuel system components- pumps, fuel no air valve, air no fuel valve, fuel gauging, transfer valve, refueling valve

Unit IV
AIRCRAFT AUXILLIARY SYSTEMS
Introduction, operating principle and design requirements of following systems- Environmental control system, Oxygen systems, Fire protection systems, Deicing & anti icing system, Pilot life supporting and ejection system

Unit V
ENGINE SYSTEMS
Introduction, operating principle, design requirements of following systems- Engine secondary power & starting system, Conventional fuel control system (hydro-mechanical fuel control system), Electro-hydro-mechanical fuel control system (FADEC system)

Text Books:

1. Ion Moir and Allan Seabridge, Aircraft Systems, John Wiley & Sons Ltd, England, Third edition, 2008
2. Roy Langton, Chuck Clark, Martin Hewitt and Lonnie Richards, Aircraft Fuel Systems, Wiley & Sons Ltd, England, 2009
3. General Hand Books of Airframe and Power plant Mechanics", U.S. Dept. of Transportation, Federal Aviation Administration, The English Book Store, New Delhi1995

Reference Books:

1. Mekinley, J.L. and Bent, R.D., "Aircraft Power Plants", McGraw-Hill, 1993.
2. Pallet, E.H.J., "Aircraft Instruments & Principles", Pitman & Co., 1993.
3. Treager, S., "Gas Turbine Technology", McGraw-Hill, 1997.

13AE217 OPERATIONS RESEARCH

Credit: 3: 0: 0

Objective:

- To introduce students various optimization techniques used in industrial practice.
- The subject also aims at imparting knowledge on Quality and Quality Management Systems.

Outcome:

- Model a physical problem in to a mathematical model and find optimal solutions for real situations.
- Contribute to the industry's quality policy in which they are placed

Unit I:
LINEAR MODELS
The phases of operations research study – Linear programming – Graphical method – Simplex algorithm – Duality – Transportation problems – Assignment problems.

Unit II:
NETWORK MODELS
Network models - Shortest route – Minimal spanning tree – Maximum flow models – Project network – CPM and PERT networks – Critical path scheduling – Sequencing models-n jobs through two machines, n jobs through m machines

Unit III:
INVENTORY MODELS
Inventory models – Economic order quantity models – Techniques in inventory Management –ABC Analysis – formation of ABC graph from the data – Two Bin Methods.

Unit IV:
QUEUING MODELS
Queuing models (No derivation) – Queuing systems and structures – Notation – parameter – Single server and multi server models – Poisson input – Exponential service – Constant rate service – Infinite population – Simulation – Monte Carlo Technique – inventory and queuing application.

Unit V:
DECISION MODELS
Decision models – Game theory – Two person zero sum games – Graphical solution – Algebraic solution – Linear programming solution – Replacement models – Models based on service life – Economic life – Single / Multivariable search technique.

Text Books:

1. H.A. Taha, "Operations Research", Prentice Hall of India, 1999 6th Edn.
2. S. Bhaskar, "Operations Research", Anuradha Pub., Tamil Nadu 1999.
3. Gupta and Hira, "Operations Research", Dhanpat Rai and Co.

Reference Books:

1. Shenoy, Srivastava, "Operations Research for Management", Wiley Eastern, 1994
2. M.J. Bazara, Jarvis H. Sherali, "Linear Programming and Network Flows", John Wiley, 1990
3. Philip and Ravindran, "Operations Research" , John Wiley, 1992
4. Hiller and Lieberman, "Operations Research", Holden Day , 1986

14AE2001 INTRODUCTION TO AEROSPACE ENGINEERING

Credits: 3:0:0

Course Objectives:

- To introduce the basic concepts of aircrafts, rockets, satellites and their applications.
- To provide knowledge about the basic parts and their function and construction details of aerospace vehicles.
- To provide knowledge about the national and international aerospace agencies.

Course Outcome:

- An understanding the nature of aerospace technologies,
- Knowledge in various types of aerospace vehicles, satellites and their applications.

History of aviation, history of spaceflight; Classification of Flight Vehicles**;** Components of an airplane and their functions; Standard atmosphere; Principles of flight - Lift generation**;** General types of aircraft construction and structural layout, Fuselage construction, Wing structure, Empennage structure, Landing gears; Honeycomb and Sandwich structure; Principles of Thrust generation; Working Principle of Aircraft engines; Types of Rockets; Satellites –types and applications; Basic Aircraft instruments; Aerospace industries and institutions worldwide

References:

1. Anderson, J. D., "Introduction to Flight", McGraw-Hill, 2nd ed, 2009.
2. Anderson. David, Wand Scott Eberhardt. "Understanding Flight". 2nd ed. McGraw-Hill Professional, 2009.
3. Newman Dava. "Interactive Aerospace Engineering and Design". Mc Graw Hill, 2002
4. Kermode, A. C., "Flight without Formulae", Pitman, 2002.
5. Sutton, G.P., et al., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 8th edition, 2010

14AE2002 AEROSPACE COMPONENT DRAWING

Credits: 0:0:1

Co-requisites: 14AE2001 Introduction to Aerospace Engineering

Course Objectives:

- To impart understanding about drawing and develop capacity to represent graphically any component of an Aircraft.
- To develop primary knowledge of standard drawing practices.
- To impart an understanding of the orthographic drawing of different parts.

Course Outcome:

- Ability to draw and develop the Aerospace component with the help of picture.
- An Understanding of the standard procedures in developing the component drawing.

The faculty conducting the Laboratory will prepare a list of 6 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE2003 MATERIALS IN AEROSPACE APPLICATIONS

Credits: 3:0:0

Course Objectives:

- To provide an understanding in various materials used in Aerospace industry,
- To impart the knowledge in various Mechanical behavior of the material and its testing methods

Course Outcome:

- Knowledge of the mechanical behavior of various Aerospace Material, its properties and heat treatment process.
- Familiarity with the application of metallic, nonmetallic and adhesives in Aerospace Engineering.

Atomic and Crystal Structure and its characterization of the material; Crystal defects – point, line and the surface defects; Mechanical behavior of Aerospace materials; Linear and non-linear elastic properties; Toughness; Modules of resilience; Testing and flaw detection of materials and components; Non-ferrous Materialsproperties and structural application - Aluminum and its alloys, Copper Alloys; Magnesium and its alloys, Titanium and its alloys; Super Alloys; Ferrous Materials properties and structural application –Steel,Maraging Steels,; Non Metallic Materials applications – Wood, fabric, glass, plastics and rubber; Composite materials and applications; Adhesives and Sealants, Anti- corrosion coating materials.

References*:*

1. Eric J Mittemeijer, "Fundamentals of Material Sciences", Springer Heidelverg, London 2010
2. Lalit Gupta," Aircraft General Engineering", Himalaya Book House, Delhi 2003
3. Titterton, "Aircraft Material & Process" 2004
4. HajiraChowdhry, "Workshop Technology – Vol 1 & 2", Nedia Promoters, Mumbai
5. Lalit Gupta," Advanced Composite Materials" Himalaya Book House, Delhi, 2006

14AE2004 ELEMENTS OF AVIONICS

Credits: 3:0:0

Course Objectives:

- To impart knowledge about basic concepts of micro-processors and controllers, their significance and functioning.
- To provide understanding of the basic concepts and functioning of the avionic system data buses.

Course Outcome:

- An understanding of and ability to analyze the functioning of the digital systems.
- Exposure to the working of the air data buses and the trends in display technology.
- An understanding of the basic Avionics systems in Civil and Military Aircrafts.

Introduction to Avionics - Role for Avionics in Civil and Military Aircraft systems, Avionic systems, - Civil and Military Electrical Power requirement standards and its comparison. Data Buses - MIL standard and its elements; Avionics System/subsystem and its requirement and design, Various Avionic architecture.
Trends in display technology, Alphanumeric displays, character displays etc., MFDs, MFK, HUD, HDD, HMD, DVI, HOTAS, Synthetic and enhanced vision, situation awareness, Panoramic/big picture display, virtual cockpit

References:

1. Collinson R.P.G. "Introduction to Avionics Systems", Springer Science Business Media B.V, 2011.
2. Middleton, D.H. "Avionics Systems", Longman Scientific and Technical, Longman Group UK Ltd., England, 1989.
3. Spitzer, C.R. "Avionics- Elements, Software and Functions", CRC Press, Taylor & Francis group LLC, 2007
4. Jim Curren, "Trend in Advanced Avionics", IOWA State University, 1992.

14AE2005 STRENGTH OF AEROSPACE MATERIALS

Credits: 3:1:0

Course Objectives:

- To provide an understanding regarding the concepts of stress and strain, Shear force and Bending moment
- To provide knowledge in the methods of determining the deflections of beams

Course Outcome:

- An understanding of material properties like elasticity, plasticity etc
- Knowledge in various methods of analysis of aerospace structural members and the failure theories of the materials

Stresses and strain due to axial and impact force; Property of elasticity and plasticity; Thermal and Hoop stresses, Strain Energy; Shear force and bending moment for different types of beam in different load conditions; Theory of bending and torsion – simple equation; Strain energy due to bending moment, deformation in circular solid, hollow and composite shafts; stress due to combined bending and Torsion; Deformations and Stresses in Springs; Deflection of beamsusing double integration method, Macaulay's method, area moment method; Column buckling - Euler's and Rankine's formulae; Principal stresses and their planes - Mohr's circle of stresses; Theories of Elastic Failure

References:

1. Bansal R K, "Strength of Materials", Laxmi Publishing co, New Delhi, 2007
2. G Lakshmi Narasaiah "Aircraft Structures", BS Publications.,2010
3. Ramamurtham .S "Strength of Materials", DhanpatRai Publishing co, New Delhi, 2008.
4. Rajput R K, "Strength of Materials", 2006
5. Sun C T, " Mechanics of Aircraft Structures", Wiley India,2010

14AE2006 AERODYNAMICS

Credits: 3:0:0

Pre-requisites: 14CE2003 - Mechanics of Fluid

Course Objectives:

- To impart knowledge of basics of air flow
- To provide details regarding the airfoils, wings and the flow over these

Course Outcome:

- An understanding of the flow behaviour over aircraft wings
- Ability to assess the forces and moments due to flow

Aerodynamic forces and moments. Centre of pressure. Types of flow.Continuity equation.Momentum equation and drag of a two dimensional body.Energy equation. Path lines, Stream lines and Streak lines. Angular velocity, Vorticity and Strain.Circulation.Stream function, Velocity potential and their relationship. Euler's and Bernoulli's equations. Elementary flows and its combination: non-lifting and lifting flow over cylinders. Kutta – joukowski theorem and generation of lift. Airfoil characteristics.Vortex sheet.Kutta condition.Kelvins circulation theorem. Classical thin airfoil theory, Helmholtz theorems. Introduction to Prandtl's lifting line theory and lift distribution.

References:

1. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010
2. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012.
3. L.M Milne Thomson, "Theoretical Aerodynamics", 1996
4. Rathakrishnan, E, Theoretical Aerodynamics, John Wiley & Sons, 2013
5. Jan Roskam, Chuan-Tau Edward Lan, Airplane Aerodynamics and Performance, DAR Corporation, 1997
6. Theodore A. Talay, Introduction to the Aerodynamics of Flight, National Aeronautics and Space Administration, 1975

14AE2007 AERODYNAMICS LABORATORY - I

Credits: 0:0:2

Pre-requisites: 14CE2003 - Mechanics of Fluid
Co requisites: 14AE2006 **-** Aerodynamics

Course Objectives:

- To impart knowledge about various experimental facilities
- To provide the knowledge of different sensors, measurement techniques and their use for conducting the test, acquiring the data and their analysis

Course Outcome:

Ability to

- choose proper experimental facilities
- configure the experiment and conduct the test
- visualize the flow and pressure distribution over 2D and 3D bodies by tuft & smoke methods

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE2008 AERODYNAMICS LABORATORY - II

Credits: 0:0:2

Pre-requisites: 14AE2007 - Aerodynamics Laboratory - 1

Course Objectives:

- To provide details of various experimental facilities
- To provide the knowledge of different sensors, measurement techniques and their use for conducting the test, acquiring the data and their analysis

Course Outcome:

- Ability to choose proper experimental facilities
- Ability to configure the experiment and conduct the test
- An understanding of the methods to draw inferences from acquired data

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE2009 CAD LABORATORY

Credits: 0:0:2

Pre-requisites: 14AE2002 - Aerospace Component Drawing

Course Objectives:

- To impart the skills on 2D and 3D modeling using CAD packages.
- To enable the knowledge in modelling different parts of Aircraft and Launch vehicles.

Course Outcome:

- Ability to understand the CAD packages.
- An understanding of the modeling of different components of aircraft
- Familiarity with basic aircraft assembly

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE2010 AIRCRAFT INSTRUMENTATION

Credits: 3:0:0

Pre-requisites: 14AE2004 - Elements of Avionics

Course Objectives:
- To provide the knowledge regarding basic concepts of flight instruments, their significance and operation.
- To impart the information about the concepts of measurements using air data sensor, Gyroscope and engine data.
- To impart the basic concepts regarding Avionics systems and also the necessary knowledge on working of avionics system in aircraft.

Course Outcome:
- An understanding of and ability to analyze the instrumentation methods in avionics engineering.
- An understanding of the importance and need for avionics systems.

Instrumentation brief review-Concept of measurement, Errors, Functional elements of an instrument system; Transducers; Civil and Military aircraft cockpits; Classification of aircraft instruments; Air data instruments; Gyroscope and its properties; Principles of accelerometer; Pressure measurement, temperature measurement, fuel quantity measurement, engine power and control instruments-measurement of RPM, manifold pressure, torque, exhaust gas temperature, EPR, fuel flow, engine vibration, monitoring;

References:

1. Pallet, E.H.J. “Aircraft Instruments & Integrated systems”, Longman Scientific and Technical, McGraw-Hill, 1992.
2. Murthy, D.V.S., “Transducers and Measurements”, McGraw-Hill, 1995.
3. Doeblin.E.O, “Measurement Systems Application and Design”, McGraw-Hill, New York, 1999.
4. Harry L.Stilz, “Aerospace Telemetry”, Vol. I to IV, Prentice-Hall Space Technology Series.
5. Spitzer, C.R. “Avionics- Elements, Software and Functions”, CRC Press, Taylor & Francis group LLC, 2007
6. Cary R .Spitzer, “The Avionics Handbook”, CRC Press, 2000.
7. Collinson R.P.G. “Introduction to Avionics Systems”, Springer Science + Business Media B.V, 2011.

14AE2011 INSTRUMENTATION AND AVIONICS LABORATORY

Credit: 0:0:2

Pre-requisites: 14AE2004 - Elements of Avionics
Co-requisites: 14AE2010 - Aircraft Instrumentation

Course Objectives:
- To impart the knowledge about different types of Instruments and control systems
- To train students to measure parameters accurately and their importance in different applications in the field of Avionics

Course Outcome:
- Ability to work with the avionics systems on an aircraft
- An Understanding of the design concept of new control systems
- Familiarity with methods of troubleshoot and rectification of faulty instruments.

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE2012 AIRCRAFT STRUCTURES

Credits: 3:0:0

Pre-requisites: 14AE2005 - Strength of Aerospace Materials

Course Objective:

- To impart the knowledge on the structural behavior of aircraft components under different types of loads
- To provide the understanding in structural design methods for aerospace vehicles

Course Outcome:

- Knowledge in various methods of analysis of aerospace structural members.
- Familiarity with the buckling property of plates and the concepts of shear flow
- Ability to understand the basic structures in Composite materials

Structural materials and stress-strain characteristics: Structural analysis methods- Method of joints, Clapeyron's three Moment Equation, Castigliano's theorem, Maxwell's Reciprocal theorem, Unit load method and Moment Distribution Method; Shear centre of different sections; Unsymmetrical bending; Flexural shear flow in thin walled sections; Bending, shear and torsion of thin-walled members. Bending and buckling of thin plates and stiffened plates. Stress analysis of wing, control surfaces and their structural members, Stress analysis of fuselage and its structural members; Composite Materials- Introduction and its application

References:

1. Megson, T.M.G., "Aircraft Structures for Engineering Students", 2007.
2. G Lakshmi Narasaiah "Aircraft Structures", BS Publications.,2010
3. Sun C T, " Mechanics of Aircraft Structures", Wiley India,2010
4. Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.
5. Donaldson B K, "Analysis of Aircraft Structures" Cambridge Aerospace Series, 2008

14AE2013 AIRCRAFT STRUCTURES LABORATORY

Credits: 0:0:2

Pre-requisites: 14AE2005 - Strength of Aerospace Materials
Co-requisites: 14AE2012 **-** Aircraft Structures

Course Objective:

- To provide the basic knowledge on the testing equipment for various structural components.
- To impart the practical exposure with the measuring equipment and sensors.

Course Outcome:

- Ability to select test equipment for different types of static loading ,
- Ability to conduct tests, analyze results, document and compare with analytical/theoretical results

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE2014 AIRCRAFT PERFORMANCE

Credits: 3:1:0

Pre-requisites: 14ME2001 - Engineering Mechanics

Course Objectives:

- To impart knowledge about the concepts of Flight performance
- To introduce the various parameters effecting the performance
- To introduce the various theories of propeller analysis and design

Course Outcome:

- Ability to make preliminary performance estimation
- An understanding of various design parameters of propeller
- Ability to assess various aircraft parameters and their effect of performance

Streamlined and Bluff bodies, Aerofoil characteristics, Pressure Distribution around circular cylinder and aerofoils, NACA Nomenclature, Types of Drags; Induced Drag equation: Drag Polar; Equation of Aircraft Motion - Steady Level Flight; Thrust/Power available and required with altitudes; Estimation of Maximum level flight speed; Range and Endurance for reciprocating and turbine engine Aircraft; Climb flight performances; Glide flight; Hodograph; Estimation of take-off and landing distances, High Lift Devices, use of thrust augmentation and reverse thrust; Load Factor; Vertical and Horizontal turn; V-n diagram; Blade element theory, propeller coefficients, Fixed and variable pitch propellers.

References:

1. Roskam, Jan and Lan, Chuan-tau E, "Airplane Aerodynamics and Performance", DAR Corporation, Lawrence, Kansas, USA, 1997.
2. Perkins, C D and Hage, R E; "Airplane Performance Stability and Control", Willey Toppan, 2010.
3. J D Anderson, "Aircraft performance and Design", McGraw-Hill, New York, 2000.
4. Houghton, E L and Carruthers, N B; "Aerodynamics for Engineering Students", Edward Arnold Publishers, 1988.
5. Filippone, A, "Advanced Aircraft Flight Performance, Cambridge University Press, 2012.

14AE2015 AIRCRAFT STABILITY AND CONTROL

Credit: 3:0:0

Pre-requisites: 14ME2001 - Engineering Mechanics

Course Objectives:

- To introduce the concept of Stability and control of Aircraft
- To impart knowledge about various Aircraft motions and related stability
- To introduce the concept of dynamic stability of Aircraft

Course Outcome:

- Ability to perform the dynamic analysis in the stability of aircraft
- An understanding of the requirement of control force and power plant
- An understanding of the motion of unstable aircraft and related modes of instability

Degrees of Freedom of a system; Static Longitudinal Stability – Basic equations of equilibrium; Stability criterion; Wing and tail contribution; Effects of Fuselage and nacelles; Stick Fixed Static Longitudinal Stability; Stick Free Longitudinal Stability – Elevator hinge moment; Neutral point and Static Margin; Stick Force gradients and Stick force per g load, Aerodynamic balancing; Static Lateral Stability – Dihedral Effect, Adverse yaw, Aileron power, Aileron reversal; Static Directional Stability – Weather cocking Effect, Rudder Requirements, One engine In-operative Conditions, Rudder Lock; Dynamic Longitudinal Stability – Equations of motion, stability Derivatives, Routh's discriminant, Dutch roll and Spiral instability, Auto rotation and Spin.

References:
1. Perkins, C D and Hage, R E; " Airplane Performance Stability and Control", Willey Toppan, 2010
2. J D Anderson, "Aircraft performance and Design", McGraw-Hill, , New York, 2000.
3. Etkin, B., "Dynamics of Flight Stability and Control", Edn. 2, John Wiley, New York, 1995.
4. Roskam Jan, "Airplane Flight Dynamics and Automatic Flight Controls". Design, Analysis and research Corporation. 3rd Printing 2003
5. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 1991

14AE2016 SPACE DYNAMICS

Credits: 3:0:0

Pre-requisites: 14ME2001 - Engineering Mechanics

Course Objectives:
- To impart the knowledge related to the performance and stability of rockets, solar system and basics of orbital mechanics.
- To impart the knowledge of various factors affecting the satellite orbits and generation of interplanetary trajectories.

Course Outcome:
- Ability to estimate the trajectory and performance of the rockets.
- Ability to use proper reference coordinate system for space vehicle analysis, to compute the orbits of the satellites under perturbing forces and to generate preliminary design of inter-planetary trajectories.

Rocket performance, Thrust equation, Static and dynamic stability of rockets; Solar system, Kepler's laws, Reference frames, Coordinate Systems, Earth's atmosphere, The ecliptic, Motion of vernal equinox, Position, velocity and orbital elements, Solution of Kepler's equation, Orbit Perturbations, Special and General Perturbation methods, Lagrange planetary equations, Single Impulse Maneuvers, Hohmann transfers, Rendezvous opportunities, Sphere of influence, Departure and arrival, Two-dimensional interplanetary trajectories.

References:
1. Vladimir A. Chobotov, "Orbital Mechanics", AIAA Education Series, AIAA Education Series, Published by AIAA, 2002.
2. Howard D. Curtis, "Orbital Mechanics for Engineering Students", Elsevier Butterworth-Heinemann, Third Edition, 2010.
3. J.W.Cornelisse, H.F.R. Schoyer, and K.F. Wakker,"Rocket Propulsion and Spaceflight Dynamics", Pitman, 2001.
4. William E.Wiesel,"Spaceflight Dynamics", Aphelion Press, USA, Third Edition, 2010.
5. David.A. Vellado,"Fundamentals of Astrodynamics and Applications", Microcosm and Kluwer , Second Edition,2004.
6. Sutton, G.P. "Rocket Propulsion Elements", John Wiley, 2009.
7. Anderson,Jr, John D., Introduction to Flight, Tata McGraw Hill Education Private Limited, Sixth Edition, 2010.

14AE2017 AIRCRAFT PROPULSION

Credits: 3:0:0

Pre-requisites: 14ME2014 - Engineering Thermodynamics

Course Objectives:
- To impart knowledge on working principles of Gas Turbine Engine (GTE)
- To impart knowledge on characteristics of GTE modules and its matching

Course Outcome:

- Ability to design GTE for aircraft/helicopter
- Ability to evaluate GTE performance at component and system level

Classification of propulsion systems and its components, work cycle, operation, performance and limitations.Types of aviation fuels and its properties. Centrifugal & Axial flow compressor and its elementary theory, performance and characteristics. Axial flow turbine and its elementary theory, performance and characteristics. Vortex theory and 3-D design of axial flow compressor & turbine. Combustion chamber &After burner types, operation, process and its characteristics. Air-intake & Exhaust nozzle operation, characteristics and performance. Off design operation and matching of various GTE. Thrust characteristics of GTE (Altitude, Mach number).

References:

1. Ganesan. V, Gas Turbines, Second Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2009
2. H. Cohen, G.F.C. Rogers and H.I.H. Saravanmuttoo, Gas Turbine Theory, Fifth Edition, Pearson Education Ltd, 2009
3. Philip P. Walsh and Paul Fletcher, Gas Turbine Performance, Blackwell Publishing company, 2004
4. Jack .D Mattingly, Elements of Gas Turbine Propulsion, Tata McGraw Hill Publishing Co. 2005
5. E. Irwin Treager, Aircraft Gas Turbine Engine Technology, 3rd Edition 1995 'ISBN-00201828
6. KlauseHunecke, Jet Engines Fundamentals of Theory, Design and Operation, Motors book international publishers & Wholesalers, 6^{th} edition, 1997

14AE2018 PROPULSION LABORATORY

Credits: 0:0:2

Prerequisites: 14ME2014 - Engineering Thermodynamics
Co-requisites: 14AE2017 **-** Aircraft Propulsion

Course Objective:

- To impart knowledge on basic concepts and operation of various propulsion systems
- To provide practical exposure to the operation of various propulsion systems

Course Outcome:

- Ability to understand the design features of various propulsion systems
- Ability to evaluate the performance of various propulsion systems

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE2019 COMPUTATIONAL FLUID DYNAMICS

Credits: 3:0:0

Prerequisites: 14CE2003 - Mechanics of Fluid

Course Objectives:

- To provide knowledge on governing equations of fluid dynamics.
- To provide an understanding of the solution methodologies of discretised equations, turbulence and combustion models.

Course Outcome:

- Knowledge of performing CFD Analysis.
- Ability to apply the boundary conditions and solve CFD problems using turbulence and combustion models.

Introduction to CFD. Governing equations of fluid flow and heat transfer, Navier Stoke's equations, Conservative, differential and integral form of transport equations. Classifications PDEs. Solution methodology- Direct, Relaxation, TDMA. Turbulence and zero equation, two equation and Reynolds stress models.
FVM for steady and unsteady convection diffusion problems. Solution algorithms for pressure velocity couplings. Implementation of boundary conditions.

References:

1. Versteeg, H.K, and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method",Prentice Hall, 2nd Edition, 2007
2. Ghoshdastidar, P.S., "Computer simulation of flow and heat transfer", Tata McGraw – Hill publishing Company Ltd., 1998.
3. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", McGraw-Hill, 1980. Ane-Books2004 Indian Edition.
4. R H Pletcher, J C Tannehill, Dale Anderson, Computational Fluid Mechanics and Heat Transfer, Third Edition, Taylor & Francis; 2011
5. Muralidhar, K and Sundarajan .T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2nd Ed, 2011
6. Wendt, John, Computational Fluid Dynamics, Springer, 3rd ed. 2009

14AE2020 CFD LABORATORY

Credits: 0:0:2

Pre-requisites: 14CE2003 - Mechanics of Fluid
Co-requisite: 14AE2019 **-** Computational Fluid Dynamics

Course Objectives:

- To provide the understanding in the students with the working of CFD codes
- To impart the knowledge on actual setting up of the problem and solution procedure
- To impart the knowledge on deriving aerodynamic quantities from computed data

Course Outcome:

- Knowledge in performing CFD Analysis.
- Ability to apply the boundary conditions and solve CFD problems.
- Ability to solve problems using turbulence and combustion models.

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE2021 GAS DYNAMICS

Credits: 3:0:0

Pre-requisites: 14AE2006 - Aerodynamics

Course Objectives:

- To provide information regarding the behavior of compressible fluid flow
- To impart knowledge regarding the difference between subsonic and supersonic flow; estimation of flow over flying vehicles at subsonic and supersonic speeds

Course Outcome:

- Ability to design flying vehicles for transonic and supersonic flights
- Ability to understand the effect of shock wave on aircraft/engine performance
- Ability to assess the flow behavior and consequent loads

Equations of motions for compressible fluid flow. Theory of Mach wave, shock wave and expansion wave.Normal shock and its governing equations. Pitot tube and its correction factors for subsonic and supersonic flow.Oblique shock and its governing equations and relationship with wedge angle.Expansion waves and its governing equations. Flow characteristics and performance of C-D nozzle, Rayleigh flow, Fanno flow. Reflection and intersection of shocks.High speed flow over aerofoil and its governing equations and characteristics. High speed flow over a finite wing and its characteristics

References:

3. Rathakrishnan, E., "Gas Dynamics", Third Edition, Prentice Hall of India, 2010
4. Anderson Jr., D., – "Modern compressible flows", McGraw-Hill Book Co., New York 1999
5. Robert D Zucker, Oscar Biblarz, Fundamental of Gas Dynamics, Second Edition, John Willey & Sons, 2002
6. Shapiro, A.H., "The Dynamics and Thermodynamics of Compressible Fluid Flow", Volume-I, John Wiley & Sons, 1953
7. Liepmann H W and Roshko A, "Elements of Gasdynamics", John Willey & Sons, 1957

14AE2022 ROCKET PROPULSION

Credits: 3:0:0

Pre-requisites: 14ME2014 - Engineering Thermodynamics

Course Objectives:

- To impart knowledge on concepts of Rocket Propulsion
- To impart knowledge on concept of Ramjet and Scramjet engine

Course Outcome:

- Ability to evaluate the performance of propulsion system
- Ability to select and design a suitable rocket propulsion

Operating principle of solid propellant rockets.Selection criteria of solid propellants.Propellant grain design considerations. Liquid propellant rockets. Selection of liquid propellants.Cooling in liquid rockets.Rocket nozzle classification.Electric rocket propulsion.Ion propulsion techniques.Nuclear rocket.Operating principle of ramjet engine and combustion in ramjet engine.Introduction to scramjet.Preliminary concepts in supersonic combustion.Integral ram- rocket. Types of tests Test facilities and safeguards Instrumentation and data management

References:

1. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5th Edn., 1993.
2. Hill P.G. & Peterson, C.R. "Mechanics & Thermodynamics of Propulsion" Addison – Wesley Longman INC, 1999.
3. Cohen, H., Rogers, G.F.C. and Saravanamuttoo, H.I.H., "Gas Turbine Theory", Longman Co., ELBS Ed., 1989.
4. Gorden, C.V., "Aero thermodynamics of Gas Turbine and Rocket Propulsion", AIAA Education Series, New York, 1989.
5. Mathur, M., and Sharma, R.P., "Gas Turbines and Jet and Rocket Propulsion", Standard Publishers, New Delhi, 1988

14AE2023 AIRCRAFT/SPACECRAFT DESIGN PROJECT

Credits: 0:0:2

Pre-requisites: 14AE2006 - Aerodynamics, 14AE2012 - Aircraft Structures, 14AE2014 - Aircraft Performance

Course Objectives:

- To impart knowledge about inputs required for Aircraft design

- To introduce methodology for aerodynamic design of aircraft
- To introduce power plant selection to meet performance requirements
- To introduce the methodology for structural design of aircraft

Course Outcome:
- Ability to design an aircraft/Spacecraft with given configuration
- Estimating the design parameters required for its better performance

Works to be carried out:
1. Comparative study of the different type of the aircrafts / spacecraft and their specifications and performance details.
2. Preliminary weight estimations, selection of main parameters, Power plant selection, In case of Aircraft: Aerofoil selection for Wing, Tail and Control surfaces
3. Preparation of lay out of balance diagram and three view drawings
4. Detailed performance calculation and Stability Estimates, V-n diagram

14AE2024 COMPUTATIONAL STRUCTURAL ANALYSIS LABORATORY

Credit 0:0:2

Pre-requisites: 14AE2012 - Aircraft Structures

Course Objectives:
- To provide the knowledge on various structural analysis software packages.
- To impart the understanding of the stress analysis of different types of structural components

Course Outcome:
- An understanding of the basics Software packages.
- Ability to analyze and design various structural elements using the software.

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE2025 THERMAL ENGINEERING FOR AEROSPACE

Credits: 3:0:0

Pre-requisites: 14ME2014 **-** Engineering Thermodynamics

Course Objectives:
- To impart knowledge on behavior of compressible fluid flow
- To impart knowledge on effect of transonic and supersonic flow over flying vehicles

Course Outcome:
- Ability to design flying vehicles for transonic and supersonic flights
- Ability to understand the effect of shock wave on aircraft/engine performance

Internal Combustion Engines – Classification, Components and their function, Working and comparison of Two stroke and Four stroke Engines, Fuel Injection system and Lubrication system in SI and CI engines, Air standard cycles and Efficiency, Comparison of cycles**,** Steam flow through nozzles and Nozzle efficiency, Supersaturated and meta-stable expansion, Classification of steam turbines, compounding - Working principle of reciprocating compressors, Multi-stage air compressor andRotary compressors, simple Vapour compression refrigeration, Aircraft air conditioning system , Air cycle refrigeration system, Humidity control system

References:

1. Rudramoorthy, R, “Thermal Engineering “,Tata McGraw-Hill, New Delhi,2003
2. Rajput. R. K., “Thermal Engineering” S. Chand Publishers , 2000
3. Kothandaraman.C.P.,Domkundwar.S, Domkundwar. A.V., “A course in Thermal Engineering”, DhanpatRai& sons, Fifth edition, 2002
4. Ion Moir and Allan Seabridge, Aircraft Systems, John Wiley & Sons Ltd, England, Third edition, 2008
5. Yunus A Cengel, ‘Thermodynamics An Engineering Approach’, The McGraw Hill Companies, 6th Edition, 2008.

14AE2026 WIND TUNNEL TECHNIQUES

Credits: 3:0:0

Course Objectives:

- To provide knowledge of various types of wind tunnel and test techniques.
- To introduce the basic concepts of measurement of forces and moments on models during the wind tunnel testing.

Course Outcome:

- An understanding of the various types of wind tunnel and test techniques.
- Familiarity with the application of different types of wind tunnel for various test requirements.
- Knowledge in the flow visualization and measurement techniques

Low Speed Wind Tunnel - layouts and nomenclature - Types - Closed jet and open jet test section. Special purpose tunnels - Flow similarity. Supersonic Wind Tunnels - Classification - Runtime – Air storage Charging Times - Nozzle mass flows - Starting Loads - Calibration. Hypersonic Wind Tunnels- Classification – Runtime – Vacuum system sizing – Evacuation Times. Shock Tube: Driver – driven – Vacuum Pumps – Diaphragm – Type of operation – Shock Speed and Initial Diaphragm Pressure Ratio. Model sizing - Flow visualization techniques - Pressure measurements - Velocity Measurements - Force and moment measurements - Calibration of test section for various Tunnels.

References:

1. Rae, W.H. and Pope, A. “Low Speed Wind Tunnel Testing”, John Wiley Publication, 1999
2. Pope, A., and Goin, L., “High Speed wind Tunnel Testing”, John WileyPublication, 1999
3. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010
4. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012.
5. L.M Milne Thomson, “Theoretical Aerodynamics”, 1996
6. J Lukosiewitz, M Dekkar, “Experimental Methods of Hypersonic”, 1973
7. Rathakrishnan E, Gas Dynamics. PHI Learning Pvt Ltd, 2011

14AE2027 NAVIGATION, GUIDANCE AND CONTROL OF AEROSPACE VEHICLES

Credits: 3:0:0

Pre-requisites: 14AE2010 - Aircraft Instrumentation

Course Objectives:

- To provide the information regarding the concepts of navigation, guidance and control of an aircraft.
- To provide necessary mathematical knowledge required for modeling the guidance and control methods.

Course Outcome:

- To deploy the skills effectively in design of control for aerospace vehicle systems and in understanding the functioning of navigation methods.
- Exposure to various topics such as 6-DOF equations of motions, autopilots and augmentation systems and missile guidance systems.

Introduction to navigation systems- Types Different co-ordinate systems - Transformation Techniques; Different types of radio navigation; - Introduction to Inertial Sensors; INS components; Introduction to GPS - system description - basic principles - position and velocity determination.
Introduction to Guidance and control; Need for automatic flight control systems; Displacement Autopilot - Pitch Orientation Control system; Methods of Obtaining Coordination, Yaw Orientation Control system. Introduction to Fly-by-wire flight control systems, Lateral Autopilot; Operating principles and design of guidance laws, homing guidance laws.

References:

1. Myron Kyton, Walfred Fried, ‘Avionics Navigation Systems’, John Wiley & Sons, 2nd edition, 1997
2. Nagaraja, N.S. “Elements of Electronic Navigation”, Tata McGraw-Hill Pub. Co., 15th reprint, 2006.
3. Blake Lock, J.H ‘Automatic control of Aircraft and missiles’, John Wiley Sons, Second Edition, 1991.
4. Stevens B.L & Lewis F.L, ‘Aircraft control & simulation’, John Wiley Sons, Second Edition, 2003.
5. Collinson R.P.G. “Introduction to Avionics Systems”, Springer Science + Business Media B.V, 2011.
6. Garnel.P. & East.D.J, ‘Guided Weapon control systems’, Pergamon Press; 2nd edition, 1980.
7. Nelson R.C ‘Flight stability & Automatic Control’, McGraw Hill, Second Edition, 2007.
8. Bernad Etikin,’Dynamic of flight stability and control’, Revised, John Wiley, 1995.

14AE2028 EXPERIMENTAL STRESS ANALYSIS

Credits: 3:0:0

Pre-requisites: 14AE2005 - Strength of Aerospace Materials

Course Objectives:

- To impart the knowledge in experimental method of finding the response of the structure to different types of load.

Course Outcome:

- Knowledge of the general aspects of strain measurements
- Ability to understand the principle of operation of different type of strain gauges, circuits

Stress-strain relationships, plane stress and plane strain approaches, Airy’s stress function. Introduction of Measurements, strain measurements methods. Electrical-Resistance strain gauges and circuits, Strain indicator, load cells. Optical method of stress analysis – polariscope – interferometer - shadow caustics. Moiré Methods, Holography. Principle of photoelasticity--stress optic law-Effect of a stressed model in a plane polariscope and circular polariscope - photoelastic photography- Photoelastic stress analysis, Materials for photoelasticity. Coating Methods.

References:

1. J.W. Dally and M.F. Riley, “Experimental Stress Analysis”, McGraw-Hill Book Co., New.York, 1988.
2. Srinath,L.S., Raghava,M.R., Lingaiah,K. Gargesha,G.,Pant B. and Ramachandra,K. – Experimental Stress Analysis, Tata McGraw Hill, New Delhi, 1984
3. Hetenyi, “Handbook of Experimental Stress Analysis”, John Wiley & Sons Inc., New York, 1980.
4. G.S. Holister, “Experimental Stress Analysis, Principles and Methods”, Cambridge University Press, 1987.
5. A.J. Durelli and V.J. Parks, “Moire Analysis of Strain”, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1980.

14AE2029 AIR TRAFFIC CONTROL AND AERODROME DETAILS

Credits: 3:0:0

Course Objectives:

- To impart knowledge on the procedures of aerodrome formation and the functioning of air traffic control.
- To provide information regarding the physical characteristics of the aerodrome.

Course Outcome:

- An understanding of the functioning of the air traffic services and its units.
- An understanding of the concepts of radar services and the visual aids for navigation.

Objectives of ATS - Parts of ATC service - Scope and Provision of ATCs, VFR & IFR operations, Classification of ATS air spaces, Altimeter setting procedures, Division of responsibility of control; Area control service, Assignment of cruising levels minimum flight altitude ATS routes and significant points, RNAV and RNP - Vertical, lateral and longitudinal separations based on time / distance, ATC clearances, Flight plans, Position report; Radar service, Basic radar terminology - Identification procedures using primary/ secondary radar, Alerting service, Rules of the air; Aerodrome data - Basic terminology; Instrument runway, Physical characteristics of runway - Markings, Lightings; Visual aids for navigation Wind direction indicator, Landing direction indicator, Aerodrome beacon, Identification beacon – Simple approach lighting system, VASI & PAPI

References:

1. AIP (India) Vol. I & II, "The English Book Store", 17-1, Connaught Circus, New Delhi.
2. "Aircraft Manual (India) Volume I", latest Edition – The English Book Store, 17-1,Connaught Circus, New Delhi.
3. "PANS – RAC – ICAO DOC 4444", Latest Edition, the English Book Store, 17-1,Connaught Circus, New Delhi.

14AE2030 BASICS OF AEROSPACE ENGINEERING

Credits: 3:0:0

NOTE: This course is offered to other dept/school students

Course Objectives:

- To introduce the basic concepts of aircrafts, rockets, satellites and their application
- To impart knowledge about the basic parts and their function and construction

Course Outcome:

- An understanding the nature of aerospace technologies
- Knowledge in principles of flight, power plants used and fundamentals of structures.

Historical evolution**;** Developments in aerodynamics, materials, structures and propulsion over the years; Components of an airplane and their functions; Different types of flight vehicles, classifications; Basic instruments for flying; Principles of flight**-** Evolution of lift, drag and moment; General types of Aircraft construction, Fuselage and Wing Structure; Aerospace materials, metallic and non-metallic materials;Basic ideas about piston, turboprop and jet engines, Basic Propeller theory; Principles of operation of rocket, types of rockets and typical applications, Exploration into space.

References:

1. John D Anderson Jr, "Introduction to Flight",Tata McGraw Hill Education Private Limited, NewDelhi, 5th Edition, 2009.
2. Anderson. David, Wand Scott Eberhardt. "Understanding Flight". 2nd ed. McGraw-Hill Professional, 2009.
3. Newman Dava. "Interactive Aerospace Engineering and Design". Mc Graw Hill, 2002.
4. A.C Kermode, "Flight without Formulae" , Pearson Education,5th Edition, 2008.
5. Course material of Faculty Enablement Program on "Introduction to Aircraft Industry", conducted by Infosys, Mysore through Campus connect Program.

14AE2031 INTRODUCTION TO NON - DESTRUCTIVE TESTING

Credits: 3:0:0

Course Objectives:

- To provide the knowledge in various processes involved in non-destructive testing.
- To impart knowledge in NDT application in Aerospace maintenance field.

Course Outcomes:

- Knowledge in non – destructive testing, its scope and purpose.
- An understanding of the different NDT processes.

Introduction to NDT, concern in NDT, History, NDT vs. Destructive, Conditions for NDT, Personal Considerations, Certification, Primary production of metal, castings, cracks, welding discontinuities, corrosion induced discontinuities, fatigue cracking, creep, brittle fracture, geometric discontinues.Visual Testing**:** Visual Inspection, Liquid Penetrant Testing- Procedure- Materials, Penetrant Testing Methods, Sensitivity, Penetrant Testing Applications and Limitations, Quality Control Considerations, Magnetic Particle Testing, Radiographic Test,Ultrasonic Testing, Eddy Current Testing, Electromagnetic Testing, Thermal Infrared Testing, Acoustic Emission Testing - Equipments, Techniques, Variables, Evaluation, Applications, Advantages and Limitations. Standards for NDT.

References:

1. P. E. Mix, "Introduction to non-destructive testing", Wiley Interscience,, John Wiley & Sons, Inc, Publ., 2005
2. Lalith Gupta," Aircraft General Engineering", Himalaya Book House, Delhi 2003
3. Baldev Raj, T. Jayakumar, M. Thavasimuthu, "Practical Non-destructive Testing", Woodhead Publishing, 2002
4. Louis Cartz, "Nondestructive Testing: Radiography, Ultrasonics, Liquid Penetrant, Magnetic Particle, Eddy Current", Asm International, 1995
5. C. Hellier, "Handbook of Nondestructive Evaluation", McGraw-Hill, 1994.

14AE2032 AERO-ELASTICITY

Credits: 3:0:0

Pre-requisites: 14AE2012 - Aircraft Structures, 14AE2015Aircraft Stability and Control

Course Objectives:

- To impart the basic concepts of Aeroelasticity
- To provide knowledge about the Static and dynamic Aeroelastic phenomena

Course Outcome:

- An understanding of the Aero-elastic phenomena
- Ability to predict the Aeroelastic behavior
- Knowledge in preventing body (i.e. Aircrafts) from Aeroelastic instability.

Introduction to Aeroelasticity, Stability versus response problems – The aero-elastic triangle of forces – Prevention of Aeroelastic instabilities. Influence and stiffness coefficients. Coupled oscillations. Static Aeroelasticity-Divergence of a Lifting Surface: Simple two dimensional idealisations -Strip theory – 'Semirigid' assumption. Steady State Aeroelastic Problem: Loss and reversal of aileron control – Critical aileron reversal speed – Aileron efficiency – Semi rigid theory– Lift distribution – Rigid and elastic wings. Tail efficiency. Effect of elastic deformation on static longitudinal stability. Dynamic Aeroelasticity- Flutter and Buffeting. Flutter prevention and control.

References:

1. Y.C. Fung, "An Introduction to the Theory of Aeroelasticity", John Wiley & Sons Inc., New York, 2008.

2. Earl H. Dowell, Robert Clark, David Cox, H.C. Curtiss, Jr, John W. Edwards, Kenneth C. Hall, David A. Peters, Robert Scanlan, Emil Simiu, Fernando Sisto and Thomas W. Strganac, "A Modern Course in Aeroelasticity", Fourth Revised and Enlarged Edition, 2004.
3. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 1996.
4. R.H. Scanlan and R.Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.
5. E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd., 1986.

14AE2033 ADVANCED SPACE DYNAMICS

Credits: 3:0:0

Pre-requisites: 14AE2016 - Space Dynamics

Course Objectives:
- To impart the knowledge related to the basics of celestial mechanics, Hamiltonian dynamics and analytical methods.
- To impart the knowledge related to the orbits in restricted three-body problem.

Course Outcome:
- Ability to compute the orbits of satellites with Hamiltonian dynamics and perturbation theory.
- Ability to understand different type of orbits in the restricted three-body problem.

Fundamental principles and definitions, central orbits, the problem of two bodies, Lambert's theorem, force model, fundamentals of perturbation theory, perturbation in the elements, Lagrange's and Hamilton's equations, the method of canonical transformations, the general integrals of the problem of n-bodies, the problem of three bodies, restricted three-body problem, periodic and quasi-periodic orbits, perturbations - geometrical considerations, analytical methods.

References:
1. J.M.A.Danby, Willman-Bell, "Fundamental of Celestial Mechanics" ,Inc., 2nd Edition, USA,1992.
2. Victor G. Szebehely Hans Mark, "Adventures in celestial mechanics", Wiley-VCH, Second Edition, 2004.
3. Franz T. Geyling H. Robert Westerman "Introduction to orbital mechanics", Addison-Wesley Publishing Company, London, 1971.
4. O. Montenbruck, E. Gill "Satellite orbits, models, methods and applications", Springer, Berlin, 2001.
5. Vladimir A. Chobotov, "Orbital Mechanics", AIAA Education Series, AIAA Education Series, Published by AIAA, 2002.
6. Howard D. Curtis, Orbital Mechanics for Engineering Students, Elsevier Butterworth-Heinemann, 2005.
7. William E.Wiesel,"ModernAstrodynamics", Aphelion Press, USA, Second Edition, 2010.
8. Valtonen, M. and Karttunen, H., The "Three-Body Problem", Cambridge University Press. 2006.
9. Henon, M, "Generating Families in the Restricted Three-Body Problem", Springer, 1997.

14AE2034 INTRODUCTION TO HYPERSONIC FLOWS

Credits: 3:0:0

Pre-requisites: 14AE2021 - Gas Dynamics

Course Objectives:
- To introduce the features of in-viscid hypersonic flows, viscous hypersonic flows and high temperature effects
- To provide knowledge regarding estimation of flow over bodies under hypersonic conditions

Course Outcome:

- Ability to solve problems involving in-viscid and viscous hypersonic flows
- An understanding of high temperature effects in hypersonic aerodynamics.
- An understanding of the design issues for hypersonic wings
- Ability to use computational tools to evaluate hypersonic flows.

Features of Hypersonic Flows -- Thin Shock Layers, Entropy Layer. High Temperature Gases, Low Density Flow; Hypersonic Shock and Expansion Waves; Methods for Calculating Surface Pressures-- Newtonian and Modified Newtonian Laws, Centrifugal Force Corrections, Tangent Wedge/Tangent Cone Methods, Shock Expansion Method; Approximate Methods for Inviscid Hypersonic Flows -- Mach number independence Principle, Hypersonic Slender Body Theory for All Angles of Attack, Hypersonic Similarity Laws, Thin Shock Layer Theory; Viscous Hypersonic Flow -- Boundary Layer Equations, Self-Similar Solutions, Non-Similar Boundary Layers, Reference Temperature Method, Turbulent Boundary Layer, Aerodynamic Heating, Axisymmetric Analogue for Three-Dimensional Bodies; Hypersonic Viscous Interactions

References:

1. John D. Anderson Jr , Hypersonic and High Temperature Gas Dynamics, AIAA; 2 edition (2006)
2. John J Bertin, Hypersonic Aerothermodynamics, AIAA Education Series., Washington DC, 1994
3. Wallace D. Hayes and Ronald F. Probstein , Hypersonic Flow theory, Dover Publications (January 19, 2004)
4. Ernst Heinrich Hirschel, Basics of Aerothermodynamics, Springer Verlag Berlin, 2005
5. Wilbur L. Hankey (1988), Re-entry Aerodynamics, AIAA Education series, Washington DC
6. Vladimir V. Lunev, Real Gas Flows with High Velocities, CRC Press, 2009
7. Maurice Rasmussen, Hypersonic Flow, John Wiley & Sons (4 Oct 1994)

14AE2035 AIRCRAFT SYSTEMS

Credits: 3:0:0

Pre-requisites: 14CE2003 **-** Fluid Mechanics

Course Objective:

- To impart knowledge on importance and operating principles of aircraft systems
- To impart knowledge on aircraft environmental and flight conditions

Course Objective:

- Ability to design systems for different category of aircraft
- Ability to diagnose aircraft systems performance

Types of flight control systems and its importance, design features and components. Types of hydraulic systems and its importance, design features, application and components. Fuel system & subsystem design features and its importance and components. Importance and design features of environmental control system, oxygen systems, fire protection systems, deicing & anti icing system, pilot life supporting and Ejection system. Importance, design features and components of Gas Turbine Engine lubrication, fuel and FADEC system. Secondary power and Engine starting system and its design features and operation. Current trends in aircraft systems design.

References:

1. Ion Moir and Allan Seabridge, Aircraft Systems, John Wiley & Sons Ltd, England, Third edition, 2008
2. Roy Langton, Chuck Clark, Martin Hewitt and Lonnie Richards, Aircraft Fuel Systems, Wiley & Sons Ltd, England, 2009
3. General Hand Books of Airframe and Power plant Mechanics", U.S. Dept. of Transportation, Federal Aviation Administration, The English Book Store, New Delhi1995
4. Mekinley, J.L. and Bent, R.D., "Aircraft Power Plants", McGraw-Hill, 1993
5. Pallet, E.H.J., "Aircraft Instruments & Principles", Pitman & Co., 1993
6. Treager, S., "Gas Turbine Technology", McGraw-Hill, 1997

7. McKinley, J.L., and Bent, R.D., “Aircraft Maintenance & Repair”, McGraw-Hill, 1993

14AE3001 ADVANCED SOLID MECHANICS

Credits: 3:0:0

Course Objectives:

- To impart an understanding of the basic concepts of stress, strain, displacement and transformations.
- To provide the in-depth knowledge in various stresses in plates, shells, thick circular cylinders and discs.

Course Outcomes:

- Ability to analyze the strength, predict failure and incorporate design considerations in solids.
- Ability to apply and use energy methods to find force, stress and displacement in simple structures.

Principal stresses and strains; Mohr’s circle representation of triaxial stresses and strains; Shear centre, stress and deflection of beams subjected to unsymmetrical bending; Bending of rectangular and circular plates; Contact stresses -Point and line contact; Buckling of columns; Stress concentration in tension and compression members; Stresses in a plate with a circular hole, elliptical hole and small semi circular grooves; Beam on Elastic Foundations and supports

References:

1. R.C. Ugural, S.K. Fenster .Advanced strength and applied elasticity, Elsevier, 2003
2. S.Timoshenko Strength of material part-2, East-West press pvt.Ltd, .N. Delhi, 1991
3. Egor P. Popov, “ Engineering Mechanics Of Solids”, 2 Edition, Prentice-Hall, 2002
4. James M. Gere, Stephen Timoshenko, “Mechanics of Materials” 2 Edition CBS Publisher 2004
5. Richard G. Budynas, “Advanced Strength and Applied Stress Analysis” (2nd Edition) by, McGraw-Hill International Editions, 1999.
6. L.S. Srinath, “Advanced mechanics of solids”, (2nd Edition) by Tata McGraw-Hill, 2003
7. S.Timoshenko and SW Krieger ., “Theory of plates and shells” , by, McGraw - Hill International Edition 1999, Engineering mechanics series

14AE3002 ADVANCED COMPUTATIONAL FLUID DYNAMICS

Credits: 3:0:0

Course Objectives:

- To provide knowledge on governing equations of fluid dynamics.
- To provide an understanding of the solution methodologies of discretised equations, turbulence and combustion models.

Course Outcome:

- Knowledge of performing CFD Analysis.
- Ability to apply the boundary conditions and solve CFD problems using turbulence and combustion models.

Introduction to CFD. Governing equations of fluid flow and heat transfer, Navier Stoke’s equations, conservative, differential and integral form of transport equations. Classifications PDEs, Solution methodology- Direct, Relaxation, TDMA. . Turbulence and two equation model. Combustion modeling- SCRS and two step reaction model.

FDM for steady and unsteady convection diffusion problems, ADI technique. Quasi 1-D nozzle flow. Two-D supersonic flow, Prandtl-Meyer expansion. Supersonic flow over a flat plate.

References:

1. Anderson, J.D., “Computational fluid dynamics – the basics with applications”, McGraw Hill Publication, 2010

2. Versteeg, H.K, and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”,Prentice Hall, 2nd Edition, 2007
3. Ghoshdastidar, P.S., “Computer simulation of flow and heat transfer”, Tata McGraw – Hill publishing Compony Ltd., 1998.
4. Patankar, S.V., “Numerical Heat Transfer and Fluid Flow”, McGraw-Hill, 1980. Ane-Books2004 Indian Edition.
5. R H Pletcher, J C Tannehill, Dale Anderson, Computational Fluid Mechanics and Heat Transfer, Third Edition, Taylor & Francis; 2011
6. Muralidhar, K and Sundarajan .T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 2nd Ed, 2011
7. Wendt, John, Computational Fluid Dynamics, Springer, 3rd ed. 2009

14AE3003 THERMODYNAMICS AND HEAT TRANSFER

Credits: 3:0:0

Course Objectives:

- To impart an understanding of the principles of thermodynamics.
- To provide in-depth knowledge of the principles of heat transfer and its relevance in engineering applications

Course Outcome:

- Knowledge of thermodynamics laws, principles and their applications.
- Ability to apply heat transfer principles to real-time problems

First law and Second law analysis – concept of entropy – principle of increase of entropy – entropy generation – Availability – concept of exergy. Helm Holtz function – Gibb’s function. Thermodynamic relations, Maxwell’s relations, T-ds equation.Thermodynamics probability, Maxwell statistics, Entropy and probability, Degeneracy of energy levels.

Introduction to heat Transfer, Transient conduction – the lumped capacitance method Forced convection – laminar flow over a flat plate, introduction to boundary layer. Energy equation of thermal boundary layer over a flat plate, integral energy equation. Radiation heat transfer- Radiative heat exchange between surfaces Radiation shields.

References

1. KalyanAnnamali&IshwarK.Puri, “Advance thermodynamics engineering”, ,crc press
2. Yunus A Cengel, ‘Thermodynamics An Engineering Approach’, The McGraw Hill Companies, 6th Edition, 2008.
3. P.K. Nag., ‘Engineering Thermodynamics’, 3rd Edition., McGraw Hill, 2005.
4. Holman J.P., ‘Heat andMass Transfer’, Tata McGraw Hill, 8th Ed., 1989.
5. Frank P. Incropera and David P. Dewit T., ‘Fundamentals of Heat and Mass Transfer’, 4th Ed., JohnWiley& Sons, 1998.

14AE3004 FLIGHT PERFORMANCE AND DYNAMICS

Credits: 3:0:0

Course Objectives:

- To introduce the parameters effecting the Flight performance
- To impart knowledge about the concept of Stability and control of Aircraft
- To introduce with the concept of dynamic stability of Aircraft

Course Outcome:

- Ability to make preliminary performance estimation
- Ability to analyse the stability of aircraft using dynamical analysis

- Ability to assess the requirement of control force

Atmospheric Structure and its significance: Performance characteristics of aircraft steady level flight, climb, gliding and turn flight; Basic Propeller Theory; Definition of stability, static stability, longitudinal, directional and lateral; stick free stability: stick fixed stability; Neutral Point; Dynamic Longitudinal Stability – Equations of motion, stability Derivatives, Routh's discriminant, Dutch roll and Spiral instability, Auto rotation and Spin, Two control airplane; stability criterion and stability diagrams; Analysis of unsteady flight, trajectory optimization, automatic control and guidance.

References:

1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley & Son:,Inc, New York, 2000.
2. M Cook, "Flight Dynamics Principles", 3rd Edition ,Butterworth-Heinemann, 2012
3. Pamadi, Bandu N, "Performance, stability, dynamics, and control of airplanes", Reston, VA : American Institute of Aeronautics and Astronautics, 2004
4. J D Anderson, "Aircraft performance and Design", McGraw-Hill, , New York, 2000.
5. Etkin, B., "Dynamics of Flight Stability and Control", Edn. 2, John Wiley, New York, 1995.
6. Roskam Jan, "Airplane Flight Dynamics and Automatic Flight Controls". Design, Analysis and research Corporation. 3rd Printing 2003
7. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 1991

14AE3005 ORBITAL SPACE DYNAMICS

Credits: 3:0:0

Course Objectives:

- To impart the knowledge in two-body, restricted three-body and n-body problem, Hamiltonian dynamics, canonical transformations, Poincare surface sections.
- To provide necessary knowledge to study the satellite and interplanetary trajectories.

Course outcome:

- Ability to solve the orbital problems related to Earth satellite orbits using Hamiltians.
- Ability to generate interplanetary orbits in the frame work of restricted three-body problem.

Fundamental principles and definitions, central orbits, problem of two bodies, Kepler's equation and Lambert's theorem, force model, fundamentals of perturbation theory, perturbation in the elements, Lagrange's and Hamilton's equations, the method of canonical transformations, the general integrals of the problem of n-bodies, the problem of three bodies, restricted three-body problem, periodic and quasi-periodic orbits, Poincare surface sections.

References:

1. J.M.A.Danby, Willman-Bell "Fundamental of Celestial Mechanics", ,Inc., 2nd Edition, USA,1992.
2. Victor G. Szebehely Hans Mark "Adventures in celestial mechanics", Wiley-VCH, Second Edition, 2004.
3. Montenbruck, O and E. Gill "Satellite orbits, models, methods and applications", Springer, Berlin, 2001.
4. William E.Wiesel,"ModernAstrodynamics", Aphelion Press, USA, Second Edition, 2010.
5. David. A. Vellado,"Fundamentals of Astrodynamics and Applications", Microcosm and Kluwer , Second Edition,2004.
6. Valtonen, M. and Karttunen, H., The "Three-Body Problem", Cambridge University Press. 2006.
7. Henon, M, "Generating Families in the Restricted Three-Body Problem", Springer, 1997.
8. Szebehely, V G"Theory of Orbits- The restricted problem of three bodies", Academic Press, USA, 1967.
9. Morbidelli, A"Modern Celestial Mechanics- Aspects of solar system dynamics", Taylor & Francis, 2010.

14 AE3006 ADVANCED AERODYNAMICS

Credits: 3:0:0

Course Objectives:

- To introduce the basics of air flow
- To familiarize student with the airfoils and wings and the flow over them

Course Outcome:

- An understanding of the flow behavior various body shapes
- Ability to assess the forces and moments due to flow

Aerodynamic forces and moments. Centre of pressure. Rotation, deformation, vortex theorems, Conservation laws: integral and differential formulations- mass, momentum and energy equation, Potential flows,Elementary flows and its combination: non-lifting and lifting flow over cylinders. Kutta – Joukowski theorem and generation of lift. Kutta condition, Thin airfoil theory, Vortex filament, Helmholtz theorems. Introduction to Prandtl's lifting line theory and lift distribution. Introduction to compressible flows- Normal shock equations- Oblique shock and expansion waves. Elements of hypersonic flow.

References:

1. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010
2. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012.
3. Ernst Heinrich Hirschel, Basics of Aerothermodynamics, Springer Verlag Berlin, 2005
4. L.M Milne Thomson, "Theoretical Aerodynamics", 1996
5. Rathakrishnan, E, Theoretical Aerodynamics, John Wiley & Sons, 2013
6. Jan Roskam, Chuan-Tau Edward Lan, Airplane Aerodynamics and Performance, DAR Corporation, 1997
7. Theodore A. Talay, Introduction to the Aerodynamics of Flight, National Aeronautics and Space Administration, 1975

14AE3007 ADVANCED PROPULSION

Credits: 3:0:0

Pre-requisites: 14AE3003 -Thermodynamics and Heat Transfer

Course Objectives:

- To impart knowledge on working principles, operation and performance of Gas Turbine Engine (GTE), Ramjet, Scramjet and Rocket engines
- To impart knowledge on characteristics of GTE modules and its matching

Course Outcome:

- Ability to design an engine for aerospace application
- Ability to evaluate GTE performance at component and system level

Classification of propulsion systems and its components, work cycle, operation, and limitations. Axial flow compressor and turbine and its elementary theory, performance and characteristics. Vortex theory and 3-D design of axial flow compressor & turbine. Combustion chamber & after burner types, operation, process and its characteristics. Air-intake & exhaust nozzle operation, characteristics and performance. Off design operation and matching of various GTE. Thrust characteristics of GTE (Altitude, Mach number). Principles of GTE control system. Ramjet and Scramjet operations and characteristics.Rocket propulsion classification and its operation and characteristics.

References :

3. V. Ganesan, Gas Turbines, Second Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2009

4. H. Cohen, G.F.C. Rogers and H.I.H. Saravanmuttoo, Gas Turbine Theory, Fifth Edition, Pearson Education Ltd, 2009
5. Philip P. Walsh and Paul Fletcher, Gas Turbine Performance, Blackwell Publishing company, 2004
6. Jack .D Mattingly, Elements of Gas Turbine Propulsion, Tata McGraw Hill Publishing Co. 2005
7. Sutton G.P., Rocket Propulsion Elements, Eight Edition, John Wiley & Sons Inc.,New Jersey, 2010
8. E. Irwin Treager, Aircraft Gas Turbine Engine Technology, 3rd Edition 1995 'ISBN-00201828
9. KlauseHunecke, Jet Engines Fundamentals of Theory, Design and Operation, Motors book international publishers & Wholesalers, 6th edition, 1997

14AE3008 AEROSPACE STRUCTURAL ANALYSIS

Credits: 3:0:0

Pre-requisites: 14AE3001 - Advanced Solid Mechanics

Course Objectives:
- To impart the knowledge on the structural behavior of aircraft components under different types of loads
- To provide the understanding in structural design methods for aerospace vehicles

Course Outcome:
- Knowledge in various methods of analysis of aerospace structural members.
- Familiarity with the buckling property of plates and the concepts of shear flow
- Ability to understand the basic structural members of an Aircraft and launch vehicle.

Brief historical review of development of the Aerospace structural systems. Design aspects of Aerospace structures; Structural materials and stress-strain characteristics. Structural analysis methods-analytical and numerical; Virtual work, Energy method in Structural Analysis; Bending, shear and torsion of thin-walled members. Bending and buckling of thin plates and stiffened plates. Stress analysis of wing, control surfaces and their structural members, Stress analysis of fuselage and its structural members, Failure modes. Introduction to FEM.

References:
1. Megson, T.H.G., “Aircraft Structures for Engineering Students”, 2007.
2. T. H. G. Megson “An Introduction to Aircraft Structural Analysis” Butterworth-Heinemann, 2010
3. G Lakshmi Narasaiah “Aircraft Structures”, BS Publications.,2010
4. Sun C T, “ Mechanics of Aircraft Structures”, Wiley India,2010
5. Peery, D.J., “Aircraft Structures”, McGraw–Hill, N.Y., 2011.
6. Donaldson B K, “Analysis of Aircraft Structures” Cambridge Aerospace, 2008
7. G F Titterton, Aircraft Materials and Processes, Himalayan Books, New Delhi, 1956

14AE3009 ADVANCED AVIONICS

Credits: 3:0:0

Course Objectives:
- To impart the understanding in basic principles, theory and operation of flight instruments and modern avionics systems
- To familiarize the student with the concepts of guidance and control of an aircraft and to provide the necessary mathematical knowledge that are needed in modeling the guidance and control methods.
- To familiarize the student with the advanced concepts of remote sensing and image processing for aerospace applications.

Course Outcomes:
- An understanding of the theory of transmission and reception of radio waves and functioning of radar systems.

- An understanding of autopilots and missile guidance systems and ability to deploy these skills effectively in the design of control of aerospace systems.
- An understanding of vision based navigation and control and modeling physical process.

Principle and operation of ; NAVAIDS, Transponder, Airborne Weather Radar, Radar Altimeter & TCAS, Introduction to navigation and guidance and control, Flight Control Systems, Longitudinal Autopilot, Lateral Autopilot, Fundamentals of UAV, Electronic warfare, Principles of aerial photography; Sensors for aerial photography; Case studies - vision based navigation and control.

References:

1. Collinson, R.P.G., Introduction to Avionics Systems, 2nd Ed., Kluwer, 2003
2. Middleton, D.H., Avionic Systems, Longman Scientific and Technical, 1989
3. IAP. Avionics Fundamentals, IAP., 1987
4. Blake Lock, J.H ‘Automatic control of Aircraft and missiles’, John Wiley Sons, New York, 1990
5. Garnell.P. & East. D.J, ’Guided Weapon Control Systems’, Pergamon Press, Oxford, 1977
6. Rafael C.Gonzalez and Richard E. Woods, “Digital Image Processing’, Third Edition, Pearson Education, 2008
7. Ron Graham, Alexander Koh, “Digital Aerial Survey: Theory and Practice”, Whittles Publishing; First Edition,2002

14AE3010 ADVANCED COMPUTATIONAL FLUID DYNAMICS LAB

Credits: 0:0:1

Co-requisites: 14AE3002 **-** Advanced Computational Fluid Dynamics

Course Objective:

- To familiarize with the working of CFD codes
- To familiarize the students with actual setting up of the problem and solution procedure
- To extract the required data, post process and compare with available data

Course Outcome:

- Knowledge in performing CFD Analysis.
- Ability to apply the boundary conditions and solve CFD problems.
- Ability to solve problems using turbulence and combustion models.

The faculty conducting the Laboratory will prepare a list of 6 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE3011ADVANCED AERODYNAMICS LAB

Credits: 0:0:2

Co-requisites: 14AE3006 - Advanced Aerodynamics

Course Objectives:

- To introduce various experimental facilities
- To provide the knowledge of different sensors, measurement techniques and their use for conducting the test, acquiring the data and their analysis

Course Outcome:

Ability to

- choose proper experimental facilities
- configure the experiment and conduct the test
- visualize the flow and pressure distribution over 2D and 3D bodies by tuft & smoke methods

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE3012 STRUCTURAL ANALYSIS LAB

Credits: 0:0:2

Pre-requisites: 14AE3001 - Advanced Solid Mechanics
Co-requisites: 14AE3008 **-** Aerospace Structural Analysis

Course Objective:

- To provide the basic knowledge on the testing equipment for various structural components.
- To impart the practical exposure with the measuring equipment and sensors.

Course Outcome:

- Ability to select test equipment for different types of static loading ,
- Ability to conduct tests, analyze results, document and compare with analytical/theoretical results

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE3013 AIRCRAFT MODELING LAB

Credits 0:0:1

Course Objectives:

- To provide the role of Computer Modeling on Aerospace Engineering studies.
- To introduce the components of Computer aided design (CAD), basic concepts of Geometric modeling systems – wireframe, surface and solid modeling systems.
- To develop the modeling skills of student for simple mechanical, hydraulic, thermal and structural systems.

Course Outcome:

- Gaining the hands on experience in latest software packages.
- Knowledge in the design and modeling of aircraft structures.

The faculty conducting the Laboratory will prepare a list of 6 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE3014 AERO PROPULSION LAB

Credits: 0:0:2

Prerequisites: 14AE3003 **-** Thermodynamics and Heat Transfer
Co-requisites: 14AE3007 - Advanced Propulsion.

Course Objective:

- To impart knowledge on basic concepts and operation of various propulsion systems
- To provide practical exposure to the operation of various propulsion systems

Course Outcome:

- Ability to understand the design features of various propulsion systems
- Ability to evaluate the performance of various propulsion systems

The faculty conducting the Laboratory will prepare a list of 12 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

14AE3015 ELEMENTS OF AEROSPACE ENGINEERING

Credits: 3:0:0

Course objectives:

- To introduce the basic concepts of aircrafts, rockets, satellites and their application
- To impart knowledge about basic parts and their function and construction details
- To introduce the orbital mechanics

Course Outcome:

- Understanding the nature of aerospace technologies,
- Knowledge in various types of aerospace vehicles, satellites and their applications

History of aviation- Types of flying machines, Anatomy of an aircraft. Fundamental aerodynamic variables- Aerodynamic forces, Lift generation, Airfoils and wings, Aerodynamic Moments, Concept of Static stability, control surfaces. Mechanism of thrust production- Propellers, Jet engines and their operation, Elements of rocket propulsion. Loads acting on an aircraft- Load factor for simple maneuvers, V-n diagrams. Aerospace Materials, Aircraft and launch vehicle structural elements. Basic orbital mechanics, Satellite orbits, Launch vehicles and Re-entry bodies.

References:

1. Anderson. David, Wand Scott Eberhardt. “Understanding Flight”. 2nd ed. McGraw-Hill Professional, 2009.
2. Anderson.J.D.” Introduction to flight”. 6th ed. Mc Graw Hill, 2009.
3. Zebehely.V.G and Mark.H. “Adventures in celestial mechanics”. 4th ed. WILEY-VCH Verlag GmbH Co, 2004.
4. Turner.M.J. “Rocket and Spacecraft Propulsion”. 3rd ed. Springer, 2009.
5. Newman Dava. “Interactive Aerospace Engineering and Design”. Mc Graw Hill, 2002.
6. Sutton G.P., Rocket Propulsion Elements, Eight Edition, John Wiley & Sons Inc.,New Jersey, 2010
7. E. Irwin Treager, Aircraft Gas Turbine Engine Technology, 3rd Edition 1995 'ISBN-00201828

14AE4001 BASIC CELESTIAL MECHANICS

Credits: 4:0:0

Course Objectives:

- To impart the knowledge of the modern celestial mechanics through Hamiltonian dynamics. Lie series.
- To impart the knowledge of interpreting the results of numerical simulations carried out with different methods.

Course Outcome:

- Ability to apply the knowledge of Hamiltonian dynamics, Lie series to various real systems.
- Ability to understand the properties of KAM tori, and be able to detect periodic, quasi-periodic orbits and chaotic zones.

Hamiltonian of the 2-body problem, Perturbations in Hamiltonian form, Canonical transformations, Properties of Hamiltonian flow, Integrable Hamiltonian, Delaunay variables, Hamilton equations of motion for restricted three-body problem, Integrable dynamics, Introduction to perturbation theory, Lie series approach, The small divisor problem, Normal forms, Averaging over the mean motions, Secular normal form. Kolmogorov’s theorem, Properties of KAM tori, Periodic and quasi-periodic orbits. Perturbed resonant dynamics, Resonant invariant tori, Splitting of separatrices, Size of chaotic region. Monitoring the time evolution in phase space, Lyapunov exponents, Frequency analysis, Fast Lyapunov indicator, Poincare surface of section, Numerical computations.

References:
1. Morbidelli, A"Modern Celestial Mechanics- Aspects of solar system dynamics", Taylor & Francis, 2010.
2. Szebehely, V G "Theory of Orbits- The restricted problem of three bodies", Academic Press, USA, 1967.
3. C.D. Murray and S.F.Dermott, Solar system dynamics, Cambridge University Press, 1999.
4. William E.Wiesel,"ModernAstrodynamics", Aphelion Press, USA, Second Edition, 2010.
5. Valtonen, M. and Karttunen, H., The "Three-Body Problem", Cambridge University Press. 2006.
6. Henon, M, "Generating Families in the Restricted Three-Body Problem", Springer, 1997.

14AE4002 ORBITAL MECHANICS

Credits: 4:0:0

Course Objectives:
- To impart the knowledge of basics of two-body, restricted three-body problem, elliptic restricted three-body problem etc and regular variables.
- To impart the knowledge on solar system, basics of orbital mechanics and various factors affecting the satellite orbits.

Course Outcome:
- Ability to estimate the trajectory and performance and carry out the analysis of the space vehicle with the use of proper reference coordinate system.
- Ability to generate preliminary design of inter-planetary trajectory.

.

The motion of the centre of mass, relative motion, Lambert's Theorem, some expansions of elliptic motion, Solution of Kepler's equation.Equations of motion, Jacobi integral, Tisserand's criterion for the identification of comets, reduction, regularization, Numerical integration- Fourth-order Runge-Kutta method. Location of equilibrium points, Motion near the collinear and equilateral points, non-linear phenomenon around the equilibrium points.Three-dimensional restricted three-body problem, elliptic restricted three-body problem, Hill's problem.
Levi-Civita transformation, KS transformation, Equations of motion of RTBP in KS variables

References:
1. Danby, J M A "Fundamentals of Celestial Mechanics", Willmann-Bell, Inc.,USA, 2nd Edition, Third printing, 1992.
2. Szebehely, V G "Theory of Orbits- The restricted problem of three bodies", Academic Press, USA, 1967.
3. V.A.Chobotov, "Orbital Mechanics", IIIrd Edition, AIAA Education series, 2002.
4. C.D. Murray and S.F.Dermott, Solar system dynamics, Cambridge University Press, 1999.
5. E.L.Stiefel and G.Scheifele,"Linear and Regular Celestial mechanics", Springer-Verlag, Berlin Heidelberg New York 1971.
6. William E.Wiesel,"ModernAstrodynamics", Aphelion Press, USA, Second Edition, 2010.
7. Valtonen, M. and Karttunen, H., The "Three-Body Problem", Cambridge University Press. 2006.
8. Henon, M, "Generating Families in the Restricted Three-Body Problem", Springer, 1997.
9. Morbidelli, A"Modern Celestial Mechanics- Aspects of solar system dynamics", Taylor & Francis, 2010.

14AE4003 HYPERSONIC FLOW THEORY

Credits: 4:0:0

Course Objectives:
- To introduce the features of inviscid hypersonic flows, viscous hypersonic flows and high temperature effects
- To impart knowledge regarding Testing facilities and Instrumentation for Hypersonic flows.
- To provide understanding of the numerical methods for hypersonic flows.

Course Outcome:

- Ability to solve in-viscid hypersonic flows problems
- Ability to solve problems involving viscous hypersonic flows
- An understanding of high temperature effects in hypersonic aerodynamics.
- Ability to use computational tools to evaluate hypersonic flows.
- Knowledge of recent developments in hypersonic aerodynamics with application to aerospace systems

Characteristic features of hypersonic flow, basic equations boundary conditions for inviscid flow, shock shapes over bodies, flow over flat plate, flow over a wedge, hypersonic approximations, Prandtl-Meyer flow, axisymmetric flow over a cone, Hypersonic small disturbance theory, applications to flow over a wedge and cone, blast wave analogy, Newtonian impact theory, Busemann centrifugal correction and shock expansion method, tangent wedge methods , introduction to viscous flows, hypersonic boundary layers, and non-equilibrium high enthalpy flow, introduction to high enthalpy impulse test facilities and instrumentation. Introduction to computational fluid mechanics techniques for hypersonic flows and methods of generating experimental data for numerical code validation at hypersonic Mach numbers in hypervelocity facilities.

References:

1. John D. Anderson Jr , Hypersonic and High Temperature Gas Dynamics, AIAA; 2 edition (2006)
2. John J Bertin, Hypersonic Aerothermodynamics, AIAA Education Series., Washington DC, 1994
3. Wallace D. Hayes and Ronald F. Probstein , Hypersonic Flow theory, Dover Publications (January 19, 2004)
4. Ernst Heinrich Hirschel, Basics of Aerothermodynamics, Springer Verlag Berlin, 2005
5. Wilbur L. Hankey (1988), Re-entry Aerodynamics, AIAA Education series, Washington DC
6. Vladimir V. Lunev, Real Gas Flows with High Velocities, CRC Press, 2009
7. Maurice Rasmussen, Hypersonic Flow, John Wiley & Sons (4 Oct 1994)
8. Chernii G.G. Introduction to Hypersonic flow Academic Press 1961
9. Cox.R.N. and Crabtree L.P.Elements of Hypersonic Aerodynamics London 1965

14AE4004 HYPERSONIC AEROTHERMODYNAMICS

Credits 4:0:0

Course Objectives:

- To introduce the features of viscous hypersonic flows and high temperature effects as they apply to hypersonic aerodynamics.
- To provide an understanding of Testing facilities and Instrumentation for Hypersonic flows
- To impart the knowledge regarding Numerical methods for hypersonic flows

Course Outcome:

- Ability to solve problems involving high temperature inviscid hypersonic flows
- Ability to solve problems involving high temperature viscous hypersonic flows.
- Ability to use computational tools to evaluate hypersonic flows.
- Knowledge of experimental methods and Instrumentation for Hypersonic flows
- Knowledge of recent developments in hypersonic aerodynamics with application to aerospace systems

Introduction to hypersonic aerodynamics, shock waves and basic properties of gases, characteristic features of hypersonic flows, equations of motion equilibrium and non-equilibrium flows, introduction to transport properties of gases, definition and techniques of estimation of aerothermodynamics environments including CFD, ground based test facilities for hypersonic flow field measurements including heat transfer and aerodynamic forces, analysis of stagnation region flow filed and pressure distribution over hypersonic flight vehicles. Viscous Inviscid interactions, aerodynamics and design consideration of hypersonic reentry vehicles.

References:

1. John. J Bertin Hypersonic Aerothermodynamics AIAA Education Series 1994
2. T J Chung – Computational Fluid Dynamics, Cambridge University Press, 2002
3. Ernst Heinrich Hirschel, Basics of Aerothermodynamics, Springer Verlag Berlin, 2005

4. Chul Park, Nonequilibruim Hypersonic Aerothermodynamics John Wiley & Sons (18 April 1990)
5. Joshua E. Johnson, Aerothermodynamic Optimization of Earth Entry Blunt Body Heat Shields for Lunar and Mars Return, ProQuest, 2009
6. Jacques Periaux, Jean-Antoine Desideri, Roland GlowinskiEds, Hypersonic Flows for Reentry Problems: Survey Lectures and Test Cases Analysis Proceedings of Workshop, Volume I, Springer-Verlag Berlin and Heidelberg GmbH & Co. KG, 2011
7. Vladimir V. Lunev, Real Gas Flows with High Velocities, CRC Press, 2009
8. Maurice Rasmussen, "Hypersonic Flow", John Wiley & Sons 1994