DIVISION OF BIOMEDICAL ENGINEERING

LIST OF NEW COURSES

Sl. No	Course Code	Course Title	Credits
1	24BM2001	Sensory and Motor Rehabilitation	3:0:0:3
2	24BM2002	Biomedical Optics	3:0:0:3
3	24BM2003	Biometric Systems	3:0:0:3
4	24BM2004	Nuclear Medicine	3:0:0:3
5	24BM2005	Machine Learning and Artificial Intelligence	3:0:0:3
6	24BM2006	Telemedicine	3:0:0:3
7	24BM2007	Patient and Device Safety	3:0:0:3
8	24BM2008	Robots in Healthcare	3:0:0:3
9	24BM2009	Radiological Imaging Techniques	3:0:0:3
10	24BM2010	Biomechanics	3:0:0:3
11	24BM2011	Data Analytics for Biomedical Engineering	3:0:0:3
12	24BM2012	Block Chain Technology	3:0:0:3
13	24BM2013	Augmented/Virtual Reality Applications in Biomedical Engineering	3:0:0:3
14	24BM2014	Deep Learning for Biomedical Applications	3:0:0:3
15	24BM2015	BioMEMS Technology	3:0:0:3
16	24BM2016	Assistive Devices for Healthcare	3:0:0:3
17	24BM2020	Embedded Systems for Biomedical Applications	3:0:0:3
18	24BM2021	Medical Internet of Things	3:0:0:3
19	24BM2022	Speech Signal Processing	3:0:0:3

Course code	**Sensory and Motor Rehabilitation**	**L**	**T**	**P**	**C**
24BM2001		**2**	**0**	**0**	**2**

Course Objective:

To impart knowledge on

1. Basics of Rehabilitation Engineering
2. The recent developments in the field of Rehabilitation Engineering legal and ethical principles and application of these principles in health care settings
3. Various Assistive Technology for vision & hearing

Course Outcomes:

The students will be able to:

1. Identify the models of Rehabilitation
2. Interpret the techniques for wheel chair design
3. Compare various components of orthotic and prosthetic devices
4. Summarize the various categories of visual impairment
5. Recommend the Assistive Technology for hearing
6. Develop an assistive device to solve critical problems related to patient with disability

Module: 1	**Introduction to Rehabilitation Engineering**	**7 Hours**

Introduction to Rehabilitation Engineering - PHAATE model - Clinical practice of Rehabilitation Engineering - Low technology tools - Service delivery – Universal design - Design based on human ability - Standards for Assistive Technology - Test for best design, Current state and conceptual framework of Rehabilitation Engineering

Module: 2	**Wheel Chair**	**8 Hours**

Seating Assessment - Interventions in seating system - Biological aspects of tissue health - Support surface classification - Manual wheelchairs – Electric power wheelchairs - Power assisted wheelchairs - Wheel chair standards & tests - Wheel chair transportation and design consideration

Module: 3	**Orthotic & Prosthetic Devices**	**7 Hours**

Classification of amputation types - Prosthesis prescription - Components of upper limb prosthesis - Fabrication of prosthesis - Components of lower limb prosthesis – Orthoses: Its need and types - Lower extremity- and upper extremity- orthoses - Splints – materials used. Typical examples of Orthotic & Prosthetic Devices: application with case study

Module: 4	**Visual Impairment**	**8 Hours**

Anatomy of eye, Categories of visual impairment - Psycho social impact of visual impairment - Physical Medicine and Eye Diseases - Cortical & retinal implants - Auditory Information Display - Blind mobility aids – Reading, Writing & Graphics Access - Orientation & navigation Aids - Technologies for prevention - Early detection and Learning of the Visually Impaired: Case study		
Module: 5	**Assistive Technology for Hearing**	**7 Hours**
Anatomy of Ear – hearing functional assessment - Management of deafness in children - Syndromes related to persons with Hearing Impairment - Cochlear Implantation and management in deaf children - Surgical and non-surgical hearing aids - Assistive Technology solutions for hearing -Tactile Information Display - Typical application design of hearing devices: Case Study		
Module: 6	**Advanced Applications**	**8 Hours**
Functional Electrical Stimulation - Robots in Rehabilitation - Rehabilitation in sports -Daily living aids - Assistive Technology for learning disorders - Computer and Internet access for challenged people - Rehabilitation engineering for Neural applications: Case study		
	Total Lectures	**45 Hours**

Text Books

1.	Rory A, Cooper, Hisaichi Ohnabe, Douglas A, Hodson, "An Introduction to Rehabilitation Engineering", CRC Press, First edition, 2006, ISBN: 9780429146589.
2.	Dejan Popovic, Thomas Sinkjaer, "Control of Movement for the Physically Disabled: Control for Rehabilitation Technology" Springer Science & Business Media, 2012, ISBN: 1852332794.
3.	Marion A Hersh, Michael A, Johnson, "Assistive Technology for Visually impaired and blind people", Springer Publications, First edition, 2008, ISBN: 978-1-84628-867-8.
4.	Dario Farina, Winnie Jensen, Metin Akay, "Introduction to Neural Engineering for Motor Rehabilitation" John Wiley & Sons, 2013, ISBN: 9780470916735.

Reference Books

1.	Suzanne Robitaille, "The illustrated guide to Assistive technology and devices–Tools and gadgets for living independently", Demos Health New York, First edition, 2010, ISBN: 1935281712.
2.	Terri M. Skirven, A. Lee Osterman, Jane Fedorczyk, Peter C. Amadio, "Rehabilitation of the Hand and Upper Extremity", 2-Volume Set E-Book: Expert Consult Elsevier Health Sciences, 2011, ISBN: 9780323509138.
3.	Alenjandro Hernanadz – Arieta, Konstantanious Dermitzakis, Dana Damina, Max Lungarella, and Rolf Pfeifer, "Sensory- Motor Coupling in Rehabilitation Robotics", Intech Open limited, August 2008, ISBN: 978-953-7619-00-8.
4.	Punani .B. and Rawal N, "Visual Impairment Handbook", 2nd Edition, Ahmedabad; Blind People's Association (India), 2000, ISBN: 9780367670597.

Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	**Biomedical Optics**	**L**	**T**	**P**	**C**
24BM2002		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Characteristics of light and its effect on tissues
2. Instrumentation in photonics
3. Application of laser in the field of healthcare

Course Outcomes:

The students will be able to:

1. Comprehend the optical properties of laser
2. Relate the different measurement techniques in medical optics
3. Illustrate the concept of biomedical optics in various real life applications
4. Analyze the instrumentation involved in biomedical optics
5. Apply laser instrumentation in medical diagnosis and therapy
6. Determine the therapeutic applications in the field of medicine

Module: 1	**Optical Properties of the Tissues**	**8 Hours**

Optical properties of the tissues: Refraction, Scattering, Absorption, Light transport inside the tissue, Tissue properties - Laser Characteristics as applied to medicine and biology - Laser tissue Interaction- Chemical- Thermal- Electromechanical – Photoabalative processes		
Module: 2	**Instrumentation in Photonics**	**8 Hours**
Instrumentation in photonics: Instrumentation for absorption, Scattering and emission measurements, excitation light sources, high pressure arc lamp, LEDs, Lasers, Optical filters, - optical detectors – Time resolved and phase resolved detectors		
Module: 3	**Laser Applications**	**7 Hours**
Laser applications: Lasers in ophthalmology- Dermatology –Dentistry-Urology-Otolaryngology - Tissue welding		
Module: 4	**Imaging System Fundamentals**	**7 Hours**
Endoscopic imaging system fundamentals, Angioscope, Videoscopy, Fluorescence endoscopy, Fluorescent probes in biomedical applications		
Module: 5	**Non Thermal Diagnostic Applications**	**8 Hours**
Optical coherence tomography, Elastography, Laser Induced Fluorescence (LIF)-Imaging, FLIM Raman Spectroscopy and Imaging, FLIM – Holographic and speckle application of lasers in biology and medicine		
Module: 6	**Therapeutic Applications**	**7 Hours**
Therapeutic applications: Phototherapy, Photodynamic therapy (PDT) - Principle and mechanism - Oncological and non-oncological applications of PDT - Bio stimulation effect – applications-Laser Safety Procedures		
	Total Lectures	**45 Hours**

Text Books	
1.	Tuan Vo Dinh, Biomedicla Photonics Handbook, CRC Press, Newyork, 2003, ISBN: 978849311161.
2.	Lasers and Current Optical Techniques in Biology, Royal Society of Chemistry, 2004, ISBN: 9780854043217.
3.	David A. Boas, Constantions Pitris, Nimmi Ramanujam, “Handbook of Biomedical optics”, CRC Press, 2020, ISBN: 9781420090369.
Reference Books	
1.	MarkolfH.Niemz, “Laser-Tissue Interaction Fundamentals and Applications”, Springer, 2007, ISBN: 9783030119195.
2.	Abraham Katzir, “Lasers and Optical Fibers in Medicine”, Academic press Inc,1993, ISBN: 978-0-12-401940-9.
3.	Maini, Anil, “Lasers and Optoelectronics: Fundamentals, Devices and Applications”, John Wiley & Sons, Incorporated, 2013, ISBN: 9781118458877.
4.	Elias Greenbaum, “Radiation physics for medical physicists (Biological and Medcial physics, biomedical engineering)”, Springer, 2014, ISBN: 9783642008740.
5.	Mark Csele, “Fundamentals of Light source and Lasers” Wiley Inderscience Publishers, 2004, ISBN: 9780471476603.
6.	Caroline Boudoux, “Fundamentals of Biomedical Optics: From light interactions with cells to complex imaging systems”, Blurb, 2022, ISBN: 9781366446190.
Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	**Biometric Systems**	**L**	**T**	**P**	**C**
24BM2003		**3**	**0**	**0**	**3**
Course Objective:					
To impart knowledge on 1. Basic concepts of fingerprint, iris, face and speech recognition 2. Design of biometric systems 3. Personal privacy and security implications of biometrics					
Course Outcomes:					
The students will be able to: 1. Infer the technologies of fingerprint, iris, face and speech recognition 2. Comprehend the general principles of design of biometric systems and the underlying trade-offs					

3. Relate the physiological and behavioral characteristics for specific applications in biometric system
4. Identify the appropriate interfacing technologies for real time biometric applications
5. Evaluate personal privacy and security implications of Biometrics based identification technology
6. Develop biometric based applications

Module: 1	**Biometric Fundamentals**	**8 Hours**
Biometrics versus traditional techniques – Characteristics - Key biometric processes - Verification – Image processing/pattern recognition- filtering - edge detection- smoothening- enhancement- Biometric matching - Performance measures in biometric systems – Assessing the privacy risks of biometrics.		
Module: 2	**Physiological Biometrics Characteristics**	**8 Hours**
Facial scan - Ear scan, Retina scan -Iris scan - Finger scan - automated fingerprint identification system - Palm print - Hand vascular geometry analysis - DNA - Dental.		
Module: 3	**Behavioral Biometrics Characteristic**	**7 Hours**
Signature scan - Keystroke scan - Voice scan, Gait recognition - Gesture recognition – Video face - mapping the body technology.		
Module: 4	**Biometric Interfaces**	**7 Hours**
Human machine interface - BHMI structure, Human side interface: Iris image interface – Hand geometry and fingerprint sensor - Machine side interface - Parallel port - Serial port – Network topologies.		
Module: 5	**Multibiometric System**	**8 Hours**
Introduction to Multibiometric - Information Fusion in Biometrics - Issues in Designing a Multibiometric System - Sources of Multiple Evidence - Levels of Fusion in Biometrics - Sensor level, Feature level, Rank level, Decision level fusion - Score level Fusion. Examples – biopotential and gait based biometric systems.		
Module: 6	**Biometric Applications**	**7 Hours**
Categorizing biometric applications, Application areas: Criminal and citizen identification – Surveillance - PC/network access - E-commerce and retail/ATM - Costs to deploy - Issues in deployment - Biometrics in medicine - cancellable biometrics.		
	Total Lectures	**45 Hours**

Text Books

1. Ruud M. Bolle et al, “Guide to Biometrics”, Springer, USA, 2003, ISBN: 978387400891.
2. Richard O Duda, David G. Strok, Peter E hart, “Pattern Classification”, Wiley 2007. ISBN: 9780471056690.
3. Rafael C. Gonzalez, Richard Eugene Woods, “Digital Image Processing using MATLAB”, Mc-Graw Hill 2010, ISBN: 9780070702622.

Reference Books

1. Anil K. Jain, Arun Ross, and KarthikNandakumar, “Introduction to biometrcis”, 2011, ISBN: 978-0-387-77325-4.
2. James Wayman, Anil Jain, DavideMaltoni, Dario Maio, “Biometric Systems, Technology Design and Performance Evaluation”, Springer, 2005, ISBN: 9781852335960.
3. S.Y. Kung, S.H. Lin, M.W.Mak, “Biometric Authentication: A Machine Learning Approach” Prentice Hall, 2005, ISBN: 9780137074839.
4. Nalini K Ratha, Ruud Bolle, “Automatic fingerprint Recognition System”, Springer, 2003, ISBN: 978-0-387-95593-3.
5. L C Jain, I Hayashi, S B Lee, U Halici, “Intelligent Biometric Techniques in Fingerprint and Face Recognition” CRC Press, 1999, ISBN: 9780849367465.
6. David D Zhang, “Automated Biometrics: Technologies and Systems”, Kluwer Academic Publishers, New Delhi, 2005, ISBN: 9780792378563.

Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course Code	Nuclear Medicine	L	T	P	C
24BM2004		3	0	0	3

Course Objective:

To impart knowledge on

1. Principle of operation of various nuclear medicine instruments
2. Characteristics and mechanisms of radio pharmaceuticals
3. Applications of nuclear medicine and radiation safety procedures and regulations

Course Outcomes:

The students will be able to:

1. Acquire knowledge about radiation activity in the living cells
2. Identify the key principles of nuclear medicine and radioactivity
3. Analyze the working principle of advanced nuclear medicine imaging systems
4. Interpret the effects of ionizing and non-ionizing radiations
5. Analyze the effect of microwave on human organs and systems
6. Suggest suitable therapeutic radiation for diseases without any side effects

Module: 1	**Basics of Nuclear Medicine**	**7 Hours**

Radioactivity and interaction of radiation; Alpha, Beta and Gamma emission - Laws of radioactive decay - Mechanisms of radioactive delay - Radiation intensity and exposure - Decay schemes and energy levels - Compton scattering - Pair productions - Particle interactions

Module: 2	**Radiopharmaceuticals**	**8 Hours**

Radionuclide production - 99Mo/99mTc generator - Mechanism of localization - Types of radiopharmaceuticals - characteristics of radio pharmaceuticals - Radiopharmaceuticals for diagnosis and treatments in human - Dispensing of radio pharmaceuticals - RIA radiopharmaceuticals and kits production

Module: 3	**Nuclear Medicine Instrumentation**	**7 Hours**

Construction and principle operation of Gamma camera - Rectilinear scanner - Basic principles of pulse height analyser - Radiation detectors - Ionization chamber, Geiger Muller counter, Semiconductor detectors, Scintillation detectors - Electronic Instrumentation for radiation detection system

Module: 4	**Diagnostic and Therapeutic Applications of Radionuclide**	**8 Hours**

PET-CT - Single photon emission computed tomography (SPECT) - Radio iodine therapy for Thyrotoxicosis , Differentiated thyroid cancers, Palliative treatment for bone metastasis - 32P and 89 Strontium Dosage, Intravascular particulate radio nuclide Therapy, Receptor targeted therapy, 131I-MIBG Therapy, Targeted internal radiation in HCC: 90 Y, Radio-synovectomy using Yttrium

Module: 5	**Recent Developments in Nuclear Medicine**	**7 Hours**

Personalized Medicine - Artificial Intelligence Techniques Support Nuclear Medicine Modalities - 3D Printing Of Radioactive Phantoms - Nuclear Envelope And Nuclear Pore Complexes In Neurodegenerative Diseases - Archaic Mitochondrial Dna Inserts In Modern Day Nuclear Genomes.

Module: 6	**Radiation Safety**	**8 Hours**

Radiation protection indifferent nuclear isotope therapy procedures - Management of radiation accidents - Radiation effect on pregnancy and fertility - Diagnosis, evaluation and treatment of radiation overexposure - Instruments used in radiation survey & monitoring - Handling of radioactive patients - Role of national and international bodies in radiation safety - ICRP recommendations - BARC regulations regarding limits of radiation exposure

	Total Lectures	**45 Hours**

Text Books

1.	Simon Cherry, James Sorenson, Michael Phelps, “Physics in Nuclear Medicine”, Elsevier Saunders, 4th Edition, 2012, ISBN: 9781416051985.
2.	Jennifer Prekeges, “Nuclear Medicine Instrumentation”, Jones and Barlett publishers, 1st edition, 2011, ISBN: 9781449652883.

Reference Books

1.	Max.H.Lombardi, “Radiation safety in Nuclear Medicine”, CRC Press, Florida, USA, 2nd edition 1999, ISBN: 978084938183.
2.	Fred A Mettler, Milton J Guiberteau, “Essentials of nuclear Medicine and molecular imaging” 7th Edition, Elseiver, 2018, ISBN: 9780323483193.
3.	Harvey Ziessman, Janis O Malley, James Thrall, “Nuclear Medicine”, Fourth Edition, Elseiver, 2013, ISBN: 9781423209492.

4.	Pete, Shackett, “Nuclear Medicine technology”, Second Edition, LipkottWilliamnsndWilkkins, USA 2008, ISBN: 9781975119836.
5.	Jennifer Prekeges, “Nuclear Medicine Instrumentation”, Second revised Edition, John and Barelett Publishers, Inc USA, 2012, ISBN: 9781449652883.
Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	**Machine Learning and Artificial Intelligence**	**L**	**T**	**P**	**C**
24BM2005		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Concepts of machine learning
2. Supervised and unsupervised learning paradigms
3. Fundamentals of artificial intelligence

Course Outcomes:

The students will be able to:

1. Describe features for machine learning approach
2. Discriminate various machine learning techniques
3. Comprehend the artificial neural network approaches
4. Interpret the types of neural networks in healthcare
5. Relate the concepts of artificial intelligence
6. Apply AI in healthcare applications

Module: 1	**Introduction to Machine Learning**	**8 Hours**

Learning – Types of Machine Learning – The Brain and the Neuron – Design a Learning System – Perspectives and Issues in Machine Learning – Concept Learning Task – Finding a Maximally Specific Hypothesis – Version Spaces and the Candidate Elimination Algorithm – Linear Discriminants.

Module: 2	**Supervised and Unsupervised Learning**	**8 Hours**

Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Nearest Neighbor Methods – Naive Bayes Linear models: Linear Regression, Logistic Regression – Data Clustering Algorithms – K means Algorithms – Fuzzy C means clustering – mountain clustering – subtractive clustering

Module: 3	**Introduction to Artificial Neural Networks**	**7 Hours**

Characteristics- learning methods – taxonomy – Evolution of neural networks- McCulloch-Pitts neuron - linear separability - Hebb network - supervised learning network: perceptron networks - adaptive linear neuron, multiple adaptive linear neuron.

Module: 4	**Types of Neural Network**	**7 Hours**

BPN, associative memory network: auto-associative memory network, hetero - associative memory network, BAM, Hopfield networks, Kohonen self-organizing, ART network. Case studies on biomedical applications

Module: 5	**Artificial Intelligence**	**8 Hours**

Introduction, Problems; spaces & search - Heuristic search techniques - Predicate Logic – Representing knowledge using Rules - Concept Learning-Symbolic and Statistical reasoning

Module: 6	**AI for Healthcare**	**7 Hours**

AI tools used: Healthcare – Soft Tissue Characterization - Disease Prediction Models – Genomic Medicine – Advantages of Artificial Intelligence – AI Limitation – Real life examples of Artificial Intelligence - Challenges.

Total Lectures	**45 Hours**

Text Books

1.	Tom M Mitchell, “Machine Learning”, First Edition, McGraw Hill Education India Ltd, 2013, ISBN: 0070428077.
2.	Jang J.S.R., Sun C.T and Mizutani E, “Neuro Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence”, Prentice Hall, 2008, ISBN: 978132619667.
3.	Shalev-Shwartz, Ben-David, “Understanding Machine Learning: From Theory to Algorithms”. In Cambridge University Press. Cambridge University Press, 2014, ISBN: 9781107057135.
4.	Tom Taulli, “Artificial Intelligence Basics”, Apress, 2019, ISBN: 9781484250273.

Reference Books	
1.	Stephen Marsland, “Machine Learning: An Algorithmic Perspective”, CRC Press, 2015, ISBN: 9781466583283.
2.	LaureneFausett, “Fundamentals of Neural Networks: Architectures, Algorithms and Applications”, Pearson Education India, 2006, ISBN: 9780133341867.
3.	TimothyJ Ross, “Fuzzy logic with Engineering Applications”, John Wiley and Sons, 2009, ISBN: 9781119235866.
4.	Ton J. Cleophas, Aeilko H. Zwinderman, “Machine Learning in Medicine”, Springer, Revised Edition 2, 2015, ISBN: 9783030339692.
5.	S.Rajasekaran and G A VijayalakshmiPai, “Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications”, Prentice Hall, India, 2003, ISBN: 9780070111899.
6.	Elaine Rich, Kevin Knight, Shivashankar B. Nair, “Artificial Intelligence”, Third Edition, McGraw-Hill, 2009, ISBN: 9781250758040.
7.	Stuart Russell, Peter Norvig, “Artificial Intelligence: A Modern Approach”, Third Edition, Prentice Hall, 2010, ISBN: 9781292401133.
Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	**Telemedicine**	**L**	**T**	**P**	**C**
24BM2006		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Key principles of telemedicine
2. Telemedical technology
3. Telemedical standards and its application

Course Outcomes:

The students will be able to:

1. Interpret the concepts of Telemedicine
2. Summarize the legal aspects of Telemedicine
3. Illustrate the technologies for data transmission in telemedicine
4. Analyse the protocols of secured data transmission
5. Explain the data acquisition and data storage systems
6. Apply telehealth technology in medical applications

Module: 1	**Introduction to Telemedicine**	**7 Hours**

History and Evolution of telemedicine, Functional diagram of telemedicine system, Essential Parameters for Telemedicine, Types of Information in Telemedicine, Types of Telemedicine services, Delivery Modes in Telemedicine, Benefits and Limitations of Telemedicine

Module: 2	**Ethical , Security And Legal Aspects of Telemedicine**	**8 Hours**

Confidentiality, patient rights and consent: confidentiality and the law, the patient, doctor relationship, access to medical records, consent treatment, Telemedical Malpractice, data protection & security, jurisdictional issues, intellectual property rights, Security in Telemedicine systems, Access control, Fire wall, Encryption, Authentication, Digital certificate, Digital Timestamp

Module: 3	**Telemedical Technology**	**8 Hours**

Data Transmission, Electronic Medical Record, Personal Health Record, Communication Technologies for Telemedicine: PSTN, POTS, ANT, ISDN, Internet, Wireless Communication, GSM satellite, and Microwave, Modulation techniques, Types of Antenna, Satellite communication, Mobile hand-held devices and mobile communication, Internet technology, Wireless Body Area Network, Video and audio conferencing

Module: 4	**Data Acquisition And Storage System**	**7 Hours**

Acquisition System, Camera, Scanners, Display Systems, Analogue Devices, LCD, Laser Displays, Holographic Representation, Virtual Screen devices, Storage System, Magnetic System, Optical System, Solid State Disk

Module: 5	**Data Security and Standards**	**8 Hours**

Cryptography, Symmetric and Asymmetric, Protocols: ISO-OSI, TCP/IP, Standards - DICOM, HL7, H. 320 series (Video phone-based ISBN) T. 120, H.324 (Video phone based PSTN)

Module: 6	Applications	7 Hours
Teleradiology, Telepathology, Telesurgery, Telemedicine access to health care services – health education and self-care, Medical Emergency and Disaster relief, Telerehabilitation.		
	Total Lectures	**45 Hours**

Text Books	
1.	Olga Ferrer Roca, M.SosaIudicissa , "Hand book of Telemedicine", IOS press, 2002, ISBN: 9789051994131.
2.	Norris.A.C, "Essentials of Telemedicine and Telecare", John Sons & Ltd, 2002, ISBN: 9780471531517.
Reference Books	
1.	R.S.Khandpur "Telemedicine Technology and Applications (mhealth, Telehealth and ehealth)", PHI Learning Pvt.Ltd, Delhi 2017, ISBN: 9780471531517.
2.	Wootton, R., Craig, J., Patterson, V., "Introduction to Telemedicine", Royal Society of Medicine Press Ltd, CRC Press 2017, ISBN: 9781853154256.
3.	Latifi, R. "Current Principles and Practices of Telemedicine and e-Health" IOHS Press, Washington DC, 2008, ISBN: 97815863869.
4.	Bashshur, R.L., Shannon G.W. "History of Telemedicine", New Rochelle NY: Mary Ann Liebert Publishers, 2009, ISBN: 9781934854112.
5.	Victor Lyuboslavsky, "Telemedicine and Telehealth 2.0: A Practical Guide for Medical Providers and Patients", CreateSpace Independent Publishing Platform, 2015, ISBN: 9781515135708.
6.	Choudhury, "Telemedicine: The Computer Transformation of Healthcare", Switzerland: Springer International Publishing, 2022, ISBN: 9783030994563.
7.	Bernard Fong, A.C.M Fong, C.K.Li "Telemedicine Technologies – Information Technologies in Medicine and Telehealth", Wiley Publishers, 2020, ISBN: 9780470745694.

Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	Patient and Device Safety	L	T	P	C
24BM2007		3	0	0	3

Course Objective:

To impart knowledge on

1. The ideas, concepts, and techniques for mitigating unacceptable errors, mistakes, or shortcomings in medical device performance, fostering a culture of continuous improvement
2. Principles of safety and risk management
3. Diverse medical device standards and regulations.

Course Outcomes:

The students will be able to:

1. Recall the principles of reliability testing and failure analysis in medical devices
2. Analyze the process of failure assessment and risk management in medical device safety
3. Evaluate the impact of medical devices on the environment and propose measures for mitigating ecological risks
4. Analyze the principles of mechanical and electrical safety in medical device design and operation
5. Apply knowledge of regulatory compliance to the development, testing, and marketing of medical devices
6. Analyze the requirements and implications of medical devices directives in ensuring product safety and market access

Module: 1	Basics of Reliability and Concept of Failure	8 Hours
Reliability and Safety Testing: Reliability – Types of reliability – Reliability optimization & assurance – Reliability's effect on medical devices – The concept of failure – Causes of failure – Types of Failures in Medical devices – Safety testing – Device specific safety goals		
Module: 2	**Safety and Risk Management**	**8 Hours**
Failure assessment and Documentation – Visual inspection: External & Internal visual inspection – Measurement – Safety parameters, Function test - Risk Management: Safety and risk management – Risk,		

Deciding on acceptable risk, Factors important to medical device risk assessment – Risk management – Tools for risk estimation – Liability – Manufacturer's and physician's responsibilities		
Module: 3	**Environmental & Ecological Safety**	**7 Hours**
Devices Handling, Environmental & Ecological Safety: Safe medical devices – Handling and operation – Medical Application safety – Usability – Clinical assessment – Environmental safety – Interference with the environment – Environmental conditions, Impact on the environment – Ecological safety- Design Principles for Next-Generation Medical Devices		
Module: 4	**Mechanical and Electrical Safety**	**7 Hours**
Mechanical and Electrical Safety: Safety Mechanics – Electrical Safety – Biological aspect – Limitation of Voltages - Macroshock and Microshock – Earth and Protection – Leakage currents – Magnetic fields and compatibility – Basic assumptions in safety technology – Safety classes		
Module: 5	**Medical Devices Standards, Regulations**	**8 Hours**
Medical Standards and Regulations –Classification of Medical Devices – Registration and listing – Declaration of conformance to a recognized standard – Investigational Device Exemptions (IDEs) – Institutional Review Boards (IRBs) – IDE format – Good laboratory practices (GLPs) – Good manufacturing practices (GMPs) – Human factors – Design control		
Module: 6	**Medical Devices Directives**	**7 Hours**
The Medical Devices Directives (MDD) – Definition, Process and choosing the appropriate directive – Active Implantable Medical Devices Directive (AIMDD) – In Vitro Diagnostic Medical Devices Directive (IVDMDD). European Union Regulations for Medical Devices - Key Concepts in Medical Device Legislation		
	Total Lectures	**45 Hours**

Text Books

1. Richard Fries, "Reliable Design of Medical Devices", CRC Press, Taylor & FrancisGroup, 2006, ISBN: 9781138075191.
2. Norbert Leitgeb "Safety of Electromedical Devices Law – Risks – Opportunities" Springer Verlog/Wein, 2010, ISBN: 9783211996829.

Reference Books

1. Bertil Jacobson and Alan Murray, "Medical Devices Use and Safety", Elsevier Limited, 2007, ISBN: 9780443102592.
2. Gordon R Higson, "Medical Device Safety – The regulation of Medical Devices for Public Health and Safety", IOP Publishing Limited, Bristol and Philadelphia, 2002, ISBN: 978750307680.
3. Shayne Cox Gad, "Safety Evaluation of Medical Devices" Second Edition, Marcel Dekker Inc., 2002, ISBN: 9781439866818.
4. Michael Wiklund, Jonathan Kendler, Alison Strochlic, "Usability Testing of Medical Devices", Second edition, CRC Press, Taylor and Francis Group, 2015, ISBN: 9781466595880.

Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	Robots in Healthcare	L	T	P	C
24BM2008		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Robots, manipulators, actuators and grippers
2. Types of sensors and power sources
3. Applications of robot in the medical field

Course Outcomes:

The students will be able to:

1. Identify the concepts of robotic motions and its dynamics
2. Summarize the principles of sensors and actuators for robots
3. Apply software tools for analysis of robotic motion
4. Comprehend Kinematics of robotic arm movement
5. Evaluate the path planning algorithms for mobile robots
6. Create simple robots for surgical applications.

Module: 1	**Introduction of Robotics**	**8 Hours**
Introduction to Robotics and its history, Overview of robot subsystems, Degrees of freedom, configurations and concept of workspace, Automation, Mechanisms and movements, Dynamic stabilization- Applications of robotics in medicine		
Module: 2	**Actuators and Grippers**	**8 Hours**
Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors, Various types of Grippers, Design consideration in vacuum and other methods of gripping, PD and PID feedback actuator models		
Module: 3	**Manipulators**	**7 Hours**
Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and pneumatic manipulator		
Module: 4	**Basic Kinematics**	**6 Hours**
Forward Kinematic Problems, Inverse Kinematic Problems, Solutions of Inverse Kinematic problems		
Module: 5	**Power Sources and Sensors**	**8 Hours**
Sensors and controllers, Internal and external sensors, position, velocity and acceleration sensors, Proximity sensors, force sensors, laser range finder, variable speed arrangements, Path determination - Machinery vision, Ranging – Laser- Acoustic, Magnetic fiber optic and Tactile sensor		
Module: 6	**Robotics In Medicine**	**8 Hours**
Da Vinci Surgical System, Image guided robotic systems, Biologically Inspired Robots, Neural Engineering, Application in Rehabilitation – Interactive Therapy - Bionic Arm - Clinical and Surgical – Gynaecology, Orthopaedics, Neurosurgery		
	Total Lectures	**45 Hours**

Text Books

1.	Nagrath and Mittal, “Robotics and Control”, Tata McGraw-Hill, First edition, 2003, ISBN: 9780070482937.
2.	Spong and Vidhyasagar, “Robot Dynamics and Control”, John Wiley and Sons, First edition, 2008, ISBN: 9780471612438.

Reference Books

1.	Barbara Webb and Thomas Consi. R, “BioRobotics: Methods & Applications”, AAAI Press/MIT Press, First Edition, 2001, ISBN: 9780894486616.
2.	ConstantinosMavroidis, Antoine Ferreira, “Nanorobotics: Current approaches and Techniques”, Springer 2011, ISBN: 9781489986153.
3.	Fu.K.S, Gonzalez.R.C. Lee, C.S.G, “Robotics, control, sensing, Vision and Intelligence”, Tata McGraw Hill International, First edition, 2008, ISBN: 9780070226258.

Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	**Radiological Imaging Techniques**	**L**	**T**	**P**	**C**
24BM2009		**2**	**0**	**0**	**2**

Course Objective:

To impart knowledge on

1. Radiographic methods of recording sectional images
2. MRI image acquisition and reconstruction
3. Ultrasonic and Infrared imaging techniques

Course Outcomes:

The students will be able to:

1. Comprehend the medical imaging techniques
2. Explain the difference between PET and SPECT Scan
3. Interpret the working of MRI machine
4. Identify the suitable medical imaging techniques using Ultrasound
5. Summarize the principle of Infra red imaging
6. Justify the need for Picture Archiving Techniques

Module: 1	**X-Ray and CT Imaging**	**7 Hours**
Principles and production of soft X-rays and hard X-rays- Details of radiographic and fluoroscopic images in X-Ray systems- Screen-film and image intensifier systems - Evolution of CT machines - CT		

image formation- Conversion of X-ray data into scan image, Mathematical details of various algorithms- spiral CT, Transverse tomography- CT Angiography		
Module: 2	**PET and SPECT Imaging**	**8 Hours**
Introduction to emission tomography, basic physics of radioisotope imaging- Compton cameras for nuclear Imaging - PET scanner principles - SPECT - Computer techniques in fast acquisition - Analytic image reconstruction techniques - Attenuation, scatter compensation in SPECT spatial compensation in SPECT		
Module: 3	**Magnetic Resonance Imaging (MRI)**	**7 Hours**
Principles of MRI pulse sequence – image acquisition and reconstruction techniques – MRI instrumentation magnetic gradient system RF coils – receiver system functional MRI – MRI artifacts- Various types of pulse sequences for fast acquisition of imaging, NMR spectroscopy - Application of MRI		
Module: 4	**Ultrasonic Imaging**	**8 Hours**
Transducers: principle design and types -Electronics - Matching Layers -Image acquisition and display; A-mode, M-mode, B-mode, Linear and Curvilinear Arrays, Phased Arrays, Annular Arrays, The Near Field, the Far Field, Focused Transducers-Production of ultrasound – properties and principles of image formation -Doppler ultra sound and color flow mapping – applications of diagnostic ultra sound		
Module: 5	**Infra-Red Imaging**	**7 Hours**
Physics of thermography – imaging systems – pyroelectric Videocon camera - clinical thermography – liquid crystal thermography		
Module: 6	**Other Imaging Techniques**	**8 Hours**
Optical coherence tomography (OCT): Introduction and its medical applications - Advances in image resolutions - Speed in Picture Archiving and Communication Systems (PACS) in medical imaging		
	Total Lectures	**45 Hours**

Text Books	
1	Khandpur.R.S. "Handbook of Biomedical Instrumentation". Second edition Tata McGraw Hill Pub.Co. Ltd., 2003, ISBN: 9789339205430.
2	John Ball and Tony Price Chesney's, "Radiographic Imaging". Blackwell Science Limited, U.K. 2006, ISBN: 9780632039012.
3	Penelope, Jerry Williams, "Farr's Physics of Medical Imaging", Elsevier, 2007, ISBN: 9780702083648.
4	Joseph Bronzino. "The Physics of Medical Imaging". Second edition, 2005, ISBN: 9780367805838.
Reference Books	
1.	M. Analoui, J.D. Bronzino, D.R.Peterson, "Medical Imaging: Principles and Practices", CRC Press, 2012, ISBN: 9781439871027.
2.	S. Webb, "Physics of Medical Imaging", Taylor & Francis, 2010, ISBN: 9780852743492.
3.	T. Farncombe, K. Iniewski, "Medical Imaging: Technology & Applications", CRC Press, 2013, ISBN: 9781138072282.
4.	J.S. Benseler, "The Radiology Handbook: A pocket guide to medical imaging", Ohio University Press, 2006, ISBN: 9780821417089.
5.	R.R.Carlton, A.M.Adler, "Principles of Radiographic Imaging: An Art and a Science", Delmar Cengage Learning; Fifth Eddition, 2012, ISBN: 9781337711067.
6.	N.B.Smith, A. Webb, "Introduction to Medical Imaging Physics, Engineering and Clinical Applications", CRC Press, 2010, ISBN: 97805211957.
Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	**Biomechanics**	**L**	**T**	**P**	**C**
24BM2010		**3**	**0**	**0**	**3**
Course Objective:					
To impart knowledge on 1. The principles of mechanics to analyse human movement 2. Structure and functions of soft and hard tissue skeletal muscle 3. Fluid mechanics to human body					
Course Outcomes:					

The students will be able to:

1. Recognize the concepts of mechanics and kinematics for human movements
2. Comprehend the basics of kinematics and instrumentation techniques
3. Apply the engineering techniques for modelling and analysis of bone
4. Review the characteristics of biofluids
5. Assess the mechanical properties of musculoskeletal elements
6. Develop devices for biomechanical applications

Module: 1	**Fundamentals of Mechanics**	**8 Hours**
Newton's law- mechanical behavior of bodies in contact, work, power and energy relationship – Linear and angular kinematics - Angular kinematics of human movement-measuring angles		
Module: 2	**Fundamentals of Kinematics**	**8 Hours**
Angular kinetics of human movement- center of gravity, stability and balance – Kinematic concepts for human motion- Joint movement terminology – Kinetic concepts for human motion- mechanical loads on the human body- Instrumentation for muscle, wrist and toe strength- Hand grip dynamometer		
Module: 3	**Bone and Cartilage**	**7 Hours**
Bone structure & composition, blood circulation in bone, mechanical properties of bone, viscoelastic properties of bone - Maxwell &Voight models - viscoelastic properties of cartilage - Bone growth - Elasticity and strength of bone. Load on Bone - stress and strain – Osteoporosis–Bone Implants		
Module: 4	**Biofluid Mechanics**	**7 Hours**
Newtonian viscous fluid, non-viscous fluid – Rheological properties of blood –Structure and composition of blood vessel –Nature of fluids, fluid properties - Mechanical properties of arterioles, capillary vessels and veins –Measurement techniques		
Module: 5	**Mechanics of Skeletal Muscle**	**8 Hours**
Structure of skeletal muscle –muscle fibers, motor units – Structure of skeletal muscle-fiber types, Sliding element theory of skeletal muscle-Skeletal muscle function – Contraction of skeletal muscle and Hill's model, Factors affecting muscular force generation – Muscular strength, power and endurance – Muscle injuries- spasm- Pain and gate control theory		
Module: 6	**Applications of Biomechanics**	**7 Hours**
Human Gait- analysis- modelling- Gait measurements- applications in rehabilitation- injury prevention – Occupational Health and Safety Assessment and standards. Case study on applications in biomechanics		
	Total Lectures	**45 Hours**

Text Books

1. Susan J Hall, "Basic Biomechanics", Tata McGraw Hill, 6th edition, 2004, ISBN: 9781260085549.
2. Fung Y C, "Biomechanics: Mechanical Properties of Living Tissues", Springer, 2nd edition, 1993, ISBN: 9780387979472.

Reference Books

1. Dhanjoo N Ghista, "Applied Biomedical Engineering Mechanics", CRC Press, Taylor and Francis, 2008, ISBN: 9780824758318.
2. Ronald L Huston, "Principles of Biomechanics", CRC Press, Taylor and Francis, 2009, ISBN: 9780367452469.
3. Webster J G, "Medical Instrumentation –Application & Design", John Wiley and sons 3rd edition, 2003, ISBN: 9780471676003.
4. Donald R Peterson and Bronzino J D, "Biomechanics- Principles and Applications", CRC Press, 2nd Edition, 2007, ISBN: 9780849314926.
5. Duane Knudson, "Fundamentals of Biomechanics", Springer, 2nd edition, 2007, ISBN: 9783030518370.

Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	**Data Analytics for Biomedical Engineering**	**L**	**T**	**P**	**C**
24BM2011		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Fundamental concepts and methods of Big data analysis
2. Data exploration, visualization and statistical analysis for given dataset

3. Performing big data analytics for Biological dataset		
Course Outcomes:		
The students will be able to: 1. Interpret the fundamental knowledge of Big data analytics 2. Compare different types of data from different sources 3. Create R script to analyse data from data interface 4. Generate different types of charts and graphs 5. Analyze statistical methods using R packages for given dataset 6. Apply big data analytics for medical applications		
Module: 1	**Introduction**	**8 Hours**
Big data analytics overview - Data life cycle - Traditional Data mining Life cycle – CRISP - Big Data life cycle methodologies - Machine learning implementation - Recommender system – Dashboard - Ad-Hoc analysis		
Module: 2	**Data Exploration and Visualization**	**8 Hours**
Problem Definition - Data Collection - Data Pre-processing - Data Cleaning – Homogenization – Heterogenization - Summarizing data - Data Exploration and Visualization		
Module: 3	**Big Data Methods**	**6 Hours**
Introduction to R programming, - Data Frames - Atomic vectors – Factors - Data types – Variables – Functions - working with excel files - Data interface		
Module: 4	**Charts and Graphs**	**8 Hours**
Develop pie chart - 3D pie chart – Histograms - Bar chart - Group bar chart - Stacked Bar chart - Line graph - Multiline graph and Box plot		
Module: 5	**Statistical Methods**	**7 Hours**
Regression models - Linear Regression - Multiple regression - Logistic regression – Mean – Median – Mode - Chi-Square test - T-Test		
Module: 6	**Big Data Analytics for Health care**	**8 Hours**
Big data analytics in diagnostics - challenges and opportunities - Machine Learning techniques - Medical Imaging - case study		
	Total Lectures	**45 Hours**
Text Books		
1.	Venkat Ankam, “Big Data analytics”, Packt publishing, 2016, ISBN: 9781785884696.	
2.	Parag Kulkarni, Sarang Joshi, ”Big Data analytics“, PHI learning, 2016, ISBN:9788120351165.	
3.	Bharat Bhushan, Om Prakash Jena, Utku Kose, “Machine Learning and Deep Learning in Medical Data Analytics and Healthcare Applications, CRC Press, 2022, ISBN: 9781032126876.	
Reference Books		
1.	Wang, Baoying, “Big Data Analytics in Bioinformatics and Health”, 2014, ISBN: 9781466666115.	
2.	Rehman, Saeeda and Imran Razzak, “Leveraging big data analytics in healthcare enhancement: trends, challenges and opportunities”, Multimedia Systems, 2022.	
3.	Suganya, Rajaram, Sheik Abdullah, “Big Data in Medical Image Processing, CRC Press, 2018, ISBN: 9781138557246.	
4.	Piyush Kumar, Rishi Chauhan, Radhika Goyal, Nishi Bhati, Shubham Garg, Shuchi Mala, “Skin cancer prediction using big data analytics and AI techniques”, Academic Press, 2022.	
Recommended by Board of Studies	16.04.2024	
Approved by Academic Council	11.05.2024	

Course code	**Block Chain Technology**	**L**	**T**	**P**	**C**
24BM2012		**2**	**0**	**0**	**2**
Course Objective:					
To impart knowledge on 1. Concepts of block chain technology 2. Operations of Block Chain Technology 3. Applications of Block Chain Technology					
Course Outcomes:					
The students will be able to: 1. Comprehend the fundamentals of Block Chain Technology					

2. Relate the concepts of Crypto currency
3. Compare various bitcoin networks
4. Interpret the concepts of block chain technology
5. Deploy Block chain application for enterprises
6. Develop Block chain application environment

Module: 1	**Introduction**	**8 Hours**

History of Blockchain - Public Ledgers - Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Public vs Private Blockchain, Decentralization using Blockchain, Understanding Cryptocurrency to Blockchain, Permissioned Model of Blockchain - Overview of Security Aspects of Blockchain

Module: 2	**Block Chain and Crypto Currency**	**8 Hours**

Basic Crypto Primitives: Cryptographic Hash Function - Hash Pointer and Merklwe tree, Digital Signature, Public Key Cryptography, Symmetric & Asymmetric Key Cryptography, A basic cryptocurrency. Bitcoin and Blockchain: Creation of Coins, Payments and Double Spending - Bitcoin P2P Network - Transaction in Bitcoin Network - Block Mining - Block Propagation and Block Relay

Module: 3	**Consensus in Bitcoin**	**6 Hours**

Distributed Consensus in Open Environments - Consensus in a Bitcoin Network, Proof of Work (PoW) – Basic Introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the Monopoly Problem, Proof of Stake, Proof of Burn and Proof of Elapsed Time, Bitcoin Mining, Mining Difficulty, Mining Pool

Module: 4	**Block Chain for Enterprises**	**8 Hours**

Permissioned Blockchain: Permissioned Model and Use Cases, Design Issues for Permissioned Blockchains - State Machine Replication - Overview of Consensus Models for Permissioned Blockchain - Distributed Consensus in Closed Environment - Paxos, RAFT Consensus, Byzantine General Problem, Byzantine Fault Tolerant System, Lamport-Shostak - Pease BFT Algorithm, BFT over Asynchronous Systems.

Module: 5	**Enterprise Application of Block Chain**	**7 Hours**

Cross Border Payments, Know Your Customer (KYC), Food Security, Mortgage Over Blockchain, Blockchain Enabled Trade, We Trade – Trade Finance Network, Supply Chain Financing, Patient record Management.

Module: 6	**Block Chain Application Development**	**8 Hours**

Hyperledger Fabric- Non-Fungible Tokens, Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing Smart Contract using Hyperledger Fabric, Writing Smart Contract using Ethereum, Overview of Ripple and Corda.

	Total Lectures	**45 Hours**

Text Books

1. Melanie Swan, “Block Chain: Blueprint for a New Economy”, O’Reilly, 2015, ISBN: 9781491920497.
2. Josh Thompsons, “Block Chain: The Block Chain for Beginners- Guide to Block chain Technology and Leveraging Block Chain Programming”, 2015, ISBN: 9781546772804.

Reference Books

1. Daniel Drescher, “Block Chain Basics”, Apress; 1st edition, 2017, ISBN: 9781484226032.
2. Imran Bashir, “Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained”, Packt Publishing, 2018, ISBN: 9781788838672.
3. Anshul Kaushik, “Block Chain and Crypto Currencies”, Khanna Publishing House, Delhi, 2018, ISBN: 978986173720.
4. Ritesh Modi, “Solidity Programming Essentials: A Beginner’s Guide to Build Smart Contracts for Ethereum and Block Chain”, Packt Publishing, 2018, ISBN: 9781788831383.
5. Salman Baset, Luc Desrosiers, Nitin Gaur, Petr Novotny, Anthony O’Dowd, Venkatraman Ramakrishna, “Hands-On Block Chain with Hyperledger: Building Decentralized Applications with Hyperledger Fabric and Composer”, Import, 2018, ISBN: 9781788996044.
6. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder, “Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction”, Packt Publishing, 2016, ISBN: 9780691171692.
7. Saifedean Ammous, “The Bitcoin Standard: The Decentralized Alternative to Central Banking Hardcover”, Wiley, 2018, ISBN: 9781119473862.

Recommended by Board of Studies	16.04.2024

Approved by Academic Council	11.05.2024

Course code	Augumented/ Virtual Reality Applications in Biomedical Engineering	L	T	P	C
24BM2013		3	0	0	3

Course Objective:

To impart knowledge on

1. The underlying concepts and principles of virtual and augmented reality to understand their potential impact on Biomedical Engineering
2. The various VR and AR environments and software to determine their suitability for specific applications in Biomedical Engineering

Course Outcomes:

The students will be able to:

1. Understand the foundational principles of augmented and virtual reality and their historical development within the context of biomedical engineering
2. Apply geometric modeling techniques to create three-dimensional representations and transformations relevant to augmented and virtual reality
3. Analyze the components and functionalities of virtual environment and augmented reality systems to enhance their application in biomedical scenarios
4. Evaluate the integration of VR hardware and software tools to optimize the user experience in biomedical simulations
5. Create innovative augmented and virtual reality applications that address real-world challenges in engineering, entertainment, science, and training
6. Synthesize knowledge of AR/VR technologies to develop advanced solutions for specific biomedical applications, such as dental care and rehabilitation

Module: 1	Introduction to Augmented Reality and Virtual Reality	8 Hours

Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark. Augmented Reality Concepts: History of Augmented Reality, Multimodal displays: Haptic, Tactile and Tangible Displays, Visual Perception

Module: 2	Geometric Modelling	6 Hours

Geometric Modelling: Introduction, From 2D to 3D, 3D space curves, 3D boundary representation. Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection

Module: 3	Virtual Environment and Augmented Reality Systems	8 Hours

Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system. Augmented Reality Systems – Types, Taxonomy of Augmented Reality, Helmet, Headup display, Smart Glasses, Projection

Module: 4	VR Hardware and Software	8 Hours

Human Factors: Introduction, the eye, the ear, the somatic senses. VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems. VR Software: Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML, Khronos Group – AR Toolkit – Augmented Reality Operating System – Role of Augmented Reality interfaces – Players and Platforms

Module: 5	AV/VR Applications	8 Hours

Introduction, Engineering, Entertainment, Science, Training. The Future: Virtual environment, modes of interaction. Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft

Module: 6	AR/VR for Biomedical Applications	8 Hours

Augmenting Dental Care – Virtual Reality for Rehabilitation – Medical Model Generation - Enhancing Surgical Precision with AR/VR – AR/VR in Medical Training and Education

	Total Lectures	45 Hours

Text Books

1. John Vince, “Virtual Reality Systems”, Pearson Education Asia, 2007, ISBN: 9788131708446.
2. Dieter Schmalstieg, Tobias Hollerer, “Augmented Reality: Principles and Practice”, Addison-Wesley Professional, 2016, ISBN: 9780321883575.

3.	Kamal Kant Hiran, “Applications of Virtual and Augmented Reality for Health and Wellbeing”, IGI Global publishers, 2024, ISBN: 9798369311233.
Reference Books	
1.	Anand R., “Augmented and Virtual Reality”, Khanna Publishing House, Delhi, 2022, ISBN: 9781119481348.
2.	Adams, “Visualizations and Virtual Reality”, Tata McGraw Hill, 1994, ISBN: 9780830641246.
3.	Grigore C. Burdea, Philippe Coiffet, “Virtual Reality Technology”, Wiley Inter Science, 2nd Edition, 2006, ISBN: 9780471086321.
4.	William R. Sherman, Alan B. Craig, “Understanding Virtual Reality: Interface, Application and Design”, Morgan Kaufmann, 2008, ISBN: 9780128183991.
5.	Jon Peddie, “Augmented Reality – Where We Will All Live”, Springer International Publishing AG, 2017, ISBN: 9783319545011.
Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	**Deep Learning for Biomedical**	**L**	**T**	**P**	**C**
24BM2014	**Applications**	**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Basics of deep learning
2. Concepts of deep reinforcement learning
3. Trends in deep learning

Course Outcomes:

The students will be able to:

1. Comprehend the fundamentals of deep learning
2. Compare the various models of deep learning
3. Describe the concepts of deep unsupervised learning
4. Analyze the significance of reinforcement techniques in deep learning
5. Develop applications of deep learning in computer vision
6. Analyze the latest trends in deep learning

Module: 1	**Introduction to Deep Learning**	**8 Hours**

History and Rise of Deep Learning, Impact of Deep Learning, Motivation of Deep Architecture, Challenges and Applications, Deep learning Hardware and software frameworks, Activation functions: Linear – sigmoid – rectified linear and SoftMax, Loss functions, Regularization, Optimization for Training Deep Models

Module: 2	**Deep Learning Models**	**7 Hours**

Convolutional Neural Networks - Restricted Boltzmann Machines - Recurrent Neural Networks, Practical Examples

Module: 3	**Deep Unsupervised Learning**	**7 Hours**

Autoencoders (standard, sparse, denoising, contractive, etc) - Variational Autoencoders - Adversarial Generative Networks - Autoencoder and DBM Attention and memory models - Dynamic memory networks

Module: 4	**Deep Reinforcement Learning**	**8 Hours**

Value learning based algorithms - Policy search based algorithms - Actor critic based algorithm - Deep Q Network - Implementing Deep Reinforcement Learning

Module: 5	**Deep Learning in Computer Vision**	**7 Hours**

Origin of CNN, Data Transformations, Network Layers and regularization - Popular CNN Architecture: Alexnet, Googlenet, Visual Geometry, Resnet

Module: 6	**Trends in Deep Learning**	**8 Hours**

Recent Models of Deep Learning, Genomics, Predictive Medicine - Clinical Imaging, Lip Reading, Visual Reasoning

	Total Lectures	**45 Hours**

Text Books

1.	Wei Di, Anuragh Bharadwaj, “Deep Learning Essentials”, Jianing Wei, Packt Publishers, 2018, ISBN: 9780262537551.

2.	Nikhil Buduma, Nicholas, "Fundamentals of Deep Learning", O Reilly Media, 2017, ISBN: 9781491925614.
3.	Ragav Venkatesan, Baoxin Li, "Convolutional Neural Networks in Visual Computing", CRC Press, 2018, ISBN: 9781138747951.
4.	Francois Chollet, "Deep Learning with Python", Second Edition, Manning Publications, 2021, ISBN: 9781617296864.
Reference Books	
1.	Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning",MIT Press, 2016, ISBN: 9780262035613.
2.	Gopal, "Deep Learning", Pearson Education, 2022, ISBN: 978935661972.
3.	Josh Patterson, Adam Gibson, "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017, ISBN: 9781491914250.

Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	**Bio-MEMS Technology**	**L**	**T**	**P**	**C**
24BM2015		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Evolution of MEMS and acquaint with the various modern micromachining techniques
2. Materials used and the micro manufacturing of devices
3. Microsystems and their applications in medical field

Course Outcomes:

The students will be able to:

1. Identify the principles of sensors and actuators
2. Summarize the optical devices and applications
3. Classify the performance of microfluidic devices to the environment
4. Use the software tools for designing and analyzing the sensors
5. Recommend the suitable principles of testing for biomedical conditions
6. Create simple systems for medical applications

Module: 1	**MEMS In Healthcare**	**8 Hours**

MEMS and Microsystems- Introduction - Typical MEMS and Microsystem Products - Application of Micro- system in Healthcare Industry – Working Principles of Microsystems Micro-sensors – Micro-actuation - Micro accelerator – Micropump – Microgripper – Micropressure Sensor

Module: 2	**Fundamentals of MOEMS**	**7 Hours**

Micro-Opto Electromechanical Systems: Fundamental principle of MOEMS Technology, Advantages - Light Modulators, Beam splitter – Micro-lens, Micro-mirrors - Digital Micro-mirror Device, Grating Light Valve, Optical Switch, Waveguide and Tuning

Module: 3	**Microfluidic Systems**	**8 Hours**

Microfluidics- Introduction and Fluid Properties, Applications of MFS- Fluid Actuation Methods- Electrophoresis, Dielectrophoresis, Electrowetting, Optoelectrowetting, Electroosmosis Flow, Electrothermal Flow, Thermocapillary Effect- Microfluidic Channel- Microdispenser- Microneedle- Microfilter

Module: 4	**BioMEMS**	**7 Hours**

Introduction to BioMEMS, BioMEMS for Clinical Monitoring, Lab on a chip, DNA Sensors, E-Nose, E- Tongue. Microsystem approaches to PCR, MEMS based Implantable Drug Delivery System, Emerging BioMEMS Technology

Module: 5	**Micromachining Techniques and software tools**	**7 Hours**

Microsystem technology-photolithography-X-ray lithography-etching-deposition-Material properties-Thin film process-Clean room-Laser deposition-Thin film diode-transistor- FET-ISFET. Software tools for design, analysis and testing

Module: 6	**Testing Tools and Applications**	**8 Hours**

Introduction to nanoscale phenomena, Nanoparticles- Nanomaterial characterization – XRD, TEM, SEM, Scanning Tunneling microscopy, AFM, Biomolecular sensing for cancer diagnostics using carbon

nanotubes, Carbon nanotube biosensors, Magnetic nanoparticles for MR Imaging, Nano-devices in biomedical applications	
Total Lectures	**45 Hours**
Text Books	
1.	Tai-Ran Hsu, "MEMS & Microsystems - Design, Manufacture and Nanoscale Engineering", John Wiley & Sons, 2nd Edition, 2008, ISBN: 9780470083017.
2.	Nitaigour Premchand Mahalik, "MEMS", Tata McGraw Hill, 2nd Reprint, 2008, ISBN: 978070142947.
Reference Books	
1.	Albert Folch, "Introduction to Bio Mems", CRC Press, First Edition, 2012, ISBN: 9780367864965.
2.	N.P.Mahalik, "Micro manufacturing & Nanotechnology", Springer, 2006, ISBN: 9780380037141.
3.	Sergey Edward Lysherski, "Nano and Micro-electromechanical systems", Second Edition, CRCPress, 2005, ISBN: 9780849328381.
4.	Wanjun Wang, Steven A. Soper, "BioMEMS Technologies and Applications", CRC Press, 2006, ISBN: 9780849335327.
5.	Abraham P. Lee, James L. Lee, "BioMEMS and Biomedical Nano technology", Vol.I, Springer, 2006, ISBN: 9781489977458.
6.	Saliterman S.S., "Fundamentals Of Biomems And Medical Micro devices" John Wiley (Original), 2007, ISBN: 9780819459770.
Recommended by Board of Studies	16.04.2024
Approved by Academic Council	11.05.2024

Course code	**Assistive Devices for Healthcare**	**L**	**T**	**P**	**C**
24BM2016		**3**	**0**	**0**	**3**
Course Objectives:					
To impart knowledge on: 1. The fundamental terms and concepts of human assist devices 2. Various assist device functions and its classification 3. Design tools for modelling and analysis of AI based assist devices					
Course Outcomes:					
The students will be able to: 1. Describe the concept of assistive devices 2. Discriminate the materials used in assistive devices 3. Analyse the types of assistive devices 4. Demonstrate the importance of assistive devices in vision 5. Observe the importance of assistive device in hearing aid 6. Summarize the features of assistive device based on artificial intelligence					
Module: 1	**Introduction to Assistive Devices**				**7 Hours**
Classification and Function – Benefits of Assistive Technology-Levels of Assistive Technology-Assistive Technology Products-Rehabilitation-Barriers in Assistive Devices					
Module: 2	**Materials used in Assistive Devices**				**8 Hours**
Smart Materials- Biodegradable Materials – 3D Printing- Bionic Devices – Smart Prosthetics – Soft Exoskeletons – Smart Glasses					
Module: 3	**Types of Assistive devices**				**8 Hours**
Mobility devices – Positioning devices – Prosthetics and Orthotics devices – Daily living devices – Vision devices – Hearing devices					
Module: 4	**Assistive Devices – Braille**				**8 Hours**
Braille Technology - Braille Displays – Braille Printer – Braille Translation Software – e -braille Notetaker – Braille Clock – Haptic Technology					
Module: 5	**Assistive Devices – Hearing Aid**				**7 Hours**
Assistive Listening Devices- Augmentative and Alternative Communication (AAC) Device-Alerting Devices -Text Based Services-Audio/Video Transcriptions					
Module: 6	**AI based Assistive Devices**				**7 Hours**
Advanced Environmental Guidance – Mobility Aids – Smart Assistance – Robotic Movement - User Created Assistive Technology					

	Total Lectures	**45 Hours**
Text Books		
1.	Albert M. Cook, Janice Miller Polgar, "Assistive Technologies: Principles and Practice" 5th edition, Elsevier, 2020, ISBN: 9780323523387.	
2.	Marion. A. Hersh, Michael A. Johnson, "Assistive Technology for visually impaired and blind", Springer Science & Business Media, 1st edition, 2010, ISBN: 9781846288661.	
Reference Books		
1.	Matthew Dipaola, "3D Printing in Orthopaedic Surgery", , Elsevier, 2019, ISBN: 9783030918996.	
2.	Muzumdar A., "Powered Upper Limb Prostheses: Control, Implementation and Clinical Application", Springer, 2004, ISBN: 97835404064.	
3.	Rory A Cooper, "An Introduction to Rehabilitation Engineering", Taylor & Francis, CRC Press, UK. 2006, ISBN: 9780429146589.	
Recommended by Board of Studies	16.04.2024	
Approved by Academic Council	11.05.2024	

Course code	**Embedded Systems for Biomedical Applications**	**L**	**T**	**P**	**C**
24BM2020		**3**	**0**	**0**	**3**

Course Objective

To impart knowledge on

1. Concepts of Embedded Systems
2. Interfacing I/O devices
3. Design Real Time Embedded Systems

Course Outcome

The student will be able to

1. Comprehend the architecture of embedded systems
2. Identify the various tools and development process of embedded system
3. Develop programs for embedded system applications
4. Demonstrate the various I/O interfacing techniques with microcontroller
5. Summarize the real time models, languages and operating systems
6. Design real time embedded systems for biomedical applications

Module: 1	**System Design**	**7 Hours**

Introduction to Embedded system, Processor embedded into a system, Embedded hardware units and devices in a system, Embedded software in a system – Process of converting embedded C into machine code, Embedded system architecture, Classifications, Skills required for an embedded system designer, Typical application scenario of embedded systems

Module: 2	**Embedded Systems Design, Development Process and Tools**	**8 Hours**

Complex systems and microprocessor, Design process and metrics in embedded system, Design challenges, Optimising the design metrics, Issues related to embedded software development, Embedded software development process and tools, Host and Target machine, Linking and Locating Software, Getting embedded software into the target system, Design process

Module: 3	**Programming Concepts**	**7 Hours**

Programming in assembly language and high-level language, C program elements, Embedded C programming- Python programming - Simple programs, High level language descriptions of software for embedded system, Java based embedded system design

Module: 4	**Microcontroller Interfacing**	**8 Hours**

Study of microcontroller, Processor and memory organization, Switch, Keypad and LED, LCD interfacing, Seven segment display interfacing, Data Acquisition system, A/D, D/A converters, Timers, Counters, Actuators. Sensor Interfacing

Module: 5	**Techniques for Embedded Systems**	**8 Hours**

State Machine and State Tables, Embedded system design using state diagram approach, Simulation and Emulation of embedded systems. Real time models, Language and Operating Systems-Tasks and task states, operating system services, Real Time Kernel, Kernel services, RTOS functions, Interrupt routine in RTOS environment

Module: 6	**Biomedical Applications**	**7 Hrs**

Design of Body temperature measurement system, Stepper motor control, Embedded system for portable devices - design and implementation- Wireless sensor technologies, Body sensor network, Patient monitoring system, Case study	
Total Lectures	**45**
Text Books	
1.	RajKamal, "Embedded Systems Architecture, Programming and Design", Tata McGrawHill,Second Edition, 2008, ISBN: 0070667640
2.	Tim Wilhurst, "An Introduction to the Design of Small Scale Embedded Systems", Palgrave, 2004, ISBN: 0333929942
Reference Books	
1.	Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2005. ISBN: 9780750677929
2.	Frank Vahid, Tony Givargis, "Embedded Systems Design", Wiley India, 2006. ISBN: 812650837X
3.	Khandpur R.S, "Hand-book of Biomedical Instrumentation", Tata McGraw Hill, 2nd Edition, 2003. ISBN: 9780070473553
Recommended by Board of Studies	16/07/2024
Approved by Academic Council	

Course code	**Medical Internet of Things**	**L**	**T**	**P**	**C**
24BM2021		**2**	**0**	**0**	**2**

Course Objective

To impart knowledge on

1. Components of Internet of Things
2. Technologies involved in IoT
3. Concepts of Cloud Computing

Course Outcome

The student will be able to

1. Summarize Internet of Things and its hardware and software components
2. Interface I/O devices, sensors & communication modules
3. Analyze the communication Technologies in IoT
4. Interpret the concepts of Cloud Computing
5. Summarize the challenges in IoT
6. Apply IoT in real life biomedical applications

Module: 1	**Introduction to IoT Architecture**	**7 Hours**
History of IoT, Layers of IoT, M2M – Machine to Machine, Web of Things, Data transfer referred with OSI Model, IP Addressing, Data transfer & Network Topologies		
Module: 2	**Engineering IoT Device Smart Objects**	**8 Hours**
The "Things" in IoT, Sensors, Actuators, and Smart Objects, Sensor Networks, Wireless Sensor Networks, Connecting Smart Objects, Communications Criteria, Range, Frequency Bands, Power Consumption, Constrained- Node Networks, Data Rate and Throughput, Latency and Determinism, Overhead and Payload		
Module: 3	**IoT Access Technologies**	**7 Hours**
Types of Protocols - Wi-Fi, Wi-Fi direct, Zigbee, Z wave, BACNet, BLE, Modbus, SPI , I2C, IIOT protocols –COAP, MQTT, 6lowpan, LWM2M, AMPQ. Hardwire the sensors with different protocols such as HART, MODBUS-Serial & Parallel, Ethernet, BACNet. IEEE 802.15.4, LoRaWAN, LTE-M, NB-IoT		
Module: 4	**Cloud Computing**	**8 Hours**
Overview of Cloud Computing, Characteristics of Cloud, Benefits, limitations, Cloud Deployment Models, Cloud service models-Infrastructure as a service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Anything as a Service (XaaS) - Edge computing		
Module: 5	**Challenges in IoT**	**7 Hours**
Design challenges, Development challenges, Security challenges – identity and access management. Prevention of attacks and network security		
Module: 6	**Case Study/Health Care**	**8 Hrs**

IOT in Emergency and Healthcare services, Components of IoT healthcare, Remote health care, Real time monitoring, Preventive care, Preventive Cardiological Monitoring, Health care systems- Activity Monitoring	
Total Lectures	**45**
Text Books	
1	Bălaş, V.E., Solanki, V.K., Kumar, R., Ahad, "A Handbook of Internet of Things in Biomedical and Cyber Physical System", 2019. ISBN 978-3-030-23983-1
2	Arshdeep Bahga, Vijay Madisetti, "Internet of Things: A Hands-on Approach", Universities Press, 2015. ISBN: 8173719543
3	Harry Fairhead, Raspberry Pi Iot in C, 1st edition, I/O Press, 2016. ISBN-13: 978-1871962468
Reference Books	
1.	Vijay Madisetti, Arshdeep Bahga, Ïnternet of Things, "A Hands on Approach", University Press, 2014. ISBN: 8173719543
2.	Lu Yan, Yan Zhang, Laurence T. Yang, Huansheng Ning, "The Internet of Things: From RFID to the Next-Generation Pervasive Networked", 2008. ISBN: 978-0367852771
3.	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "loT Fundamentals: Networking Technologies, Protocols and Use Cases for lnternet of Things, Cisco Press, 2017. ISBN: 9386873745
Recommended by Board of Studies	16/07/2024
Approved by Academic Council	

Course code	**Speech Signal Processing**	**L**	**T**	**P**	**C**
24BM2022		**3**	**0**	**0**	**3**

Course Objective

To impart knowledge on

1. Fundamental Concepts and Techniques in Speech Processing
2. Advanced Audio and Speech Processing Methods
3. Practical Applications and Implications

Course Outcome

The student will be able to

1. Understand the basic properties of the speech signal and the principles underlying its digital representation and processing
2. Apply techniques to interpret dynamic characteristics of speech signals.
3. Analyse techniques to assess auditory perception.
4. Demonstrate the principles and techniques of both audio coders
5. Evaluate the use of recurrent neural networks (RNNs) in ASR, including their application as language models and the Encoder-Decoder model.
6. Analyze the impact of speech processing technologies across various applications.

Module: 1	**Digital models of the Speech Signal**	**7 Hours**

Speech Signal, Convolution Theorem and the Mechanism of Speech Production-Phonetics and Linguistics, Classification of Speech Units- Voiced, Unvoiced sounds Classification of Phonemes, Understanding Speech production, modelling the vocal tract-Basics of audio processing

Module: 2	**Short time analysis of speech signals**	**8 Hours**

Window Functions, Frame Length and Frame rate –Short time energy, Short time zero crossing rate-Homomorphic Processing of Speech Signal- Pitch Estimation and Tracking-ACF, AMDF, Pre-processing for pitch estimation-Pitch Estimation using Cepstrum , HPS, Pitch Tracking Voiced & Unvoiced classification-Short time Fourier Transform , MFCC

Module: 3	**LPC and Speech perception**	**7 Hours**

LPC analysis using Autocorrelation, Levinson Recursion-Lattice Formulations and solutions , Choice of LPC order and Window length Frequency Domain Detection of Thresholds of Hearing-Demonstration of Masking of Tone by white Noise

Module: 4	**Audio Coding And Transform Coders**	**8 Hours**

Lossless Audio Coding– Lossy Audio Coding– ISO–MPEG–1A–Dolby Audio Coding Standards– DolbyAC-2,AC-2A– Optimum Coding in the Frequency Domain – Perceptual Transform Coder – Brandenburg-Johnston Hybrid Coder – CNET Coders – Adaptive Spectral Entropy Coding –Differential

Perceptual AudioCoder–DFT Noise Substitution –DCT with Vector Quantization–MDCT with Vector Quantization.		
Module: 5	**Speech Recognition and TTS**	**8 Hours**
Speech Recognition Architecture, Automatic Speech Recognition Task, and Recurrent Neural Networks, The Encoder-Decoder Model with RNNs- RNNs as Language Models, LSTM, Feature Extraction for ASR: Log Mel Spectrum, CTC- ASR Evaluation: Word Error Rate, TTS Transformer model – Self attention, Multi-head attention, Transformer blocks		
Module: 6	**Speech processing and its applications**	**7 Hrs**
Voice Assistants and Smart Speakers-Speech Recognition Systems-Telecommunications -Hearing Aids Music and Audio Production Language –Translation- Security and Surveillance Healthcare Entertainment-Automotive -Education -Customer Service –Accessibility- Gaming		
	Total Lectures	**45**

Text Books	
1.	Jayan, A. R," Speech and Audio Signal Processing", PHI Learning Pvt. Ltd., 2017. ISBN: 9788120352568
2.	Jurafsky, D., & Martin, J. H, "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition", Prentice Hall, 2008. ISBN: 0130950696
Reference Books	
1.	Christensen, M. G, "Introduction to audio processing", Springer, 2019. ISBN: 9783030117801
2.	Gold, B., Morgan, N., & Ellis, D, "Speech and audio signal processing: processing and perception of speech and music", John Wiley & Sons, 2011. ISBN: 9780470195369
3.	Uday Kamath, John Liu, James Whitaker, "Deep Learning for NLP and Speech Recognition", Speech International Publishing, 2019. ISBN: 3030145956

Recommended by Board of Studies	16/07/2024
Approved by Academic Council	

DIVISION OF BIOMEDICAL ENGINEERING

LIST OF NEW COURSES

Sl. No	Course Code	Course Title	Credits [L:T:P:C]
1.	22BM2032	Biosignal Processing Laboratory	0:0:3:1.5
2.	23BM2001	Medical Equipment Troubleshooting Laboratory	0:0:4:2
3.	23BM2002	Medical IoT Laboratory	0:0:2:1
4.	23BM2003	NEMS in Healthcare	3:0:0:3
5.	23BM2004	ICU and OT Equipment	3:0:0:3
6.	23BM2005	Medical Optics and Photonics	3:0:0:3
7.	23BM2006	Medical Device Regulations	3:0:0:3
8.	23BM2007	Biostatistics	3:0:0:3
9.	23BM2008	Cybersecurity for Medical Systems	3:0:0:3
10.	23BM2009	Cancer Biology	3:0:0:3
11.	23BM2010	Medical Informatics	3:0:0:3
12.	23BM2011	Electron Devices and Circuits Laboratory	0:0:2:1
13.	23BM2012	Engineering Practices and Graphics Laboratory	0:0:4:2
14.	23BM3001	Medical Instrumentation Design	3:0:0:3
15.	23BM3002	Wearable Devices for Medical Applications	3:0:0:3
16.	23BM3003	Advanced Biomedical Engineering Laboratory	0:0:4:2
17.	23BM3004	Medical Image Processing Laboratory	0:0:4:2
18.	23BM3005	Advanced Embedded System Design Laboratory	0:0:4:2
19.	23BM3006	Cognitive Technology for Biomedical Engineers	3:0:0:3
20.	23BM3007	Hospital Supply Chain Management	3:0:0:3
21.	23BM3008	Biomedical Engineering Entrepreneurship	3:0:0:3
22.	23BM3009	Deep Learning for Healthcare	3:0:0:3
23.	23BM3010	3D Printing for Biomedical Engineering	3:0:0:3

Course code	BIOSIGNAL PROCESSING LABORATORY	L	T	P	C
22BM2032		0	0	3	1.5

Course Objectives:

Enable the student to

1. Analyze various biosignals.
2. Apply Matlab/LabVIEW for processing biosignals.
3. Process biosignals using various signal processing algorithms.

Course Outcomes:

The student will be able to:

1. Apply Fourier transformations on a given data.
2. Design IIR and FIR filters for the given specification.
3. Assess the characteristics of given ECG signal.
4. Examine the given EMG signal for specific analysis.
5. Analyse the reason for changes in respiratory signals.
6. Demonstrate the usage of software tools for biosignal analysis.

List of Experiments:

1. DFT and FFT computation
2. IIR filters design-digital Butterworth filter
3. IIR filters design-digital Chebyshev filter
4. FIR filter design using windowing techniques
5. Adaptive filter design
6. Analysis of PPG signals
7. Detection of QRS complex in ECG
8. Analysis of EMG

9. Analysis of heart rate variability 10. Analysis of respiratory signal 11. Measurement of Oxygen saturation using Raspberry Pi 12. Measurement & Analysis of ECG signal using Raspberry Pi	
Recommended by Board of Studies	04.05.2023
Approved by Academic Council	03 June 2023

Course code	**MEDICAL EQUIPMENT TROUBLESHOOTING LABORATORY**	**L**	**T**	**P**	**C**
23BM2001		**0**	**0**	**4**	**2**

Course Objectives:

Enable the student to:

1. Comprehend various Medical Equipment.
2. Assess the functionality of the Equipment.
3. Troubleshoot the medical equipment.

Course Outcomes:

The student will be able to:

1. Demonstrate the functions of medical equipment.
2. Differentiate the working of various equipment.
3. Assess the functioning of circuits.
4. Examine the performance of the equipment.
5. Report the errors in the equipment.
6. Test the medical equipment.

List of Experiments:

1. Study on creating flow chart for work flow process in medical equipment.
2. Calibration of basic medical equipment.
3. Fault identification in medical Equipment.
4. Troubleshooting of weighing machine.
5. Troubleshooting Pulse Oximeter.
6. Troubleshooting Suction Pump.
7. Troubleshooting Nebulizer.
8. Troubleshooting Defibrillator.
9. Troubleshooting Portable Ultrasound.
10. Troubleshooting ECG machine.

Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**MEDICAL IOT LABORATORY**	**L**	**T**	**P**	**C**
23BM2002		**0**	**0**	**2**	**1**

Course Objectives:

Enable the student to:

1. Distinguish Embedded Processors and Microcontrollers to monitor and control data remotely.
2. Develop embedded programming for Medical IoT.
3. Interface IoT communication protocol using various wireless modules.

Course Outcomes:

The student will be able to:

1. Configure wireless devices using embedded software.
2. Demonstrate the hardware configuration of IoT devices with embedded hardware.
3. Assess the characteristics of communication protocols.
4. Develop programs for implementation in Raspberry pi processor.
5. Illustrate the interfacing of IoT devices and access cloud platforms.
6. Recommend the usage of software tools for vital parameter monitoring.

List of Experiments:

1. Configuring embedded/LabVIEW software setup and GPIO configuration

2. Study the characteristics of bluetooth modules and their interfacing complying with IEEE standards.
3. Interfacing of WiFi device for data communication.
4. Web publishing method for monitoring sensor data.
5. Wireless transmission of ECG signal using TCP/IP protocol
6. Mobile phone-based monitoring of respiration rate
7. Configuring Raspberry Pi software setup and GPIO configuration
8. Cloud based monitoring of biomedical signals using Raspberry Pi Processor
9. Interfacing PPG sensor and Monitoring of SpO_2 using Raspberry Pi
10. Interfacing Long Range Communication Protocol for wireless transmission
11. Biosensor interfacing with LoRA Protocol
12. Development of Medical IoT system for wireless transmission of ECG and PPG signals using MAX86150.

Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**NEMS in Healthcare**	**L**	**T**	**P**	**C**
23BM2003		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Comprehend NEMS Technology.
2. Apply the concepts of nanomaterials in development of medical devices.
3. Analyse Nano based health systems.

Course Outcomes:

The student will be able to:

1. Comprehend the basic concepts of NEMS.
2. Perceive the use of different types of sensors in healthcare industry
3. Analyse the use of Nanomaterials for healthcare domain.
4. Examine the importance of NEMS in Implants.
5. Apply the nanotechnology methods used in drug delivery systems.
6. Survey the features of NEMS in healthcare.

Module: 1	**Introduction to NEMS**	**7 Hours**

Overview of NEMS- Difference between NEMS and MEMS- Design of NEMS – NEMS device and structures – Atomic structures – Quantum mechanics – Nanostructure dynamics.

Module: 2	**NEMS Transducer and Sensor**	**8 Hours**

Gas sensor – Piezoelectric sensor – Electromechanical heterostructure – Biosensor – Acoustic sensor – Gyroscope and their uses in Biofield.

Module: 3	**Nanomaterials used in healthcare**	**8 Hours**

Materials and properties used in Implantable Medical devices-Graphene - Materials and properties used in Imaging Techniques - Perfluorocarbon - Materials and properties used for Dentistry- Hydroxyapetite - Materials and properties used in cellular imaging-Quantum clots - Application of Silicon in healthcare fields.

Module: 4	**NEMS in Implantable Medical Devices**	**8 Hours**

NEMS based components for Implantable Medical Devices: NEMS switch for IMDs-NEMS Amplifier-NEMS Filter-NEMS Microcontroller-NEMS based dental implants- NEMS based pacemaker.

Module: 5	**Nanotechnology in Drug delivery**	**7 Hours**

Fundamentals of nanotechnology based techniques in designing of drug - Drug designing and drug delivery process and mechanism - Nanoparticles used in drug delivery system - Natural product based nanotechnology and drug delivery - Future of nanomedicine and drug delivery system.

Module: 6	**NEMS application in healthcare**	**7 Hours**

Nanorobots-NEMS Wearable Medical Devices – NEMS Diagnostic device-NEMS Therapeutic devices-Nanomedicine – Case study.

Total Lectures	**45 Hours**

Text Books

1.	Marc J Madou, "From MEMS to Bio-MEMS and Bio-NEMS: Manufacturing Techniques and Applications (Fundamentals of Microfabrication and Nanotechnology Book 3)", CRC Press, 3rd Edition, 2011.
2.	Aviru Kumar Basu, "Adreeja Basu; Sagnik Ghosh; Shantanu Bhattacharya," MEMS Applications in Biology and Healthcare"AIPP Books, 2021.
Reference Books	
1.	Atul Tiwari, Baldev Raj," Materials and Failures in MEMS and NEMS" Wiley press, 2015.
2.	Sergey Edward Lyshevski, "MEMS and NEMS Systems, Devices, and Structures", CRC Press, October 2018.
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**ICU AND OT EQUIPMENT**	**L**	**T**	**P**	**C**
23BM2004		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to :

1. Differentiate the functioning of various intensive care equipment.
2. Assess the necessity of different operation theatre equipment.
3. Evaluate the significance of patient safety in hospital environment.

Course Outcomes:

The student will be able to:

1. Choose suitable surgical materials, decontamination method and management.
2. Design new monitoring devices for ICU.
3. Assess the importance of critical care equipment based on their applications.
4. Analyse the merits of the operation theatre equipment based on its applications.
5. Compare the various techniques and trends used in clinical diagnosis, therapy and surgery.
6. Apply the knowledge acquired on patient safety in hospital premises.

Module: 1	**Introduction to Surgeries**	**7 Hours**

Wounds and Abscess, Suture Materials, Instruments for Surgery, Robotic surgery system.

Module: 2	**Sterilization Techniques**	**8 Hours**

Suction apparatus, Different types of Sterilizers, Sterilization aspects, Chemical, Radiation, Steam for small and larger units, CSSD, ABG Machine, Dry heat sterilization, Methods of decontaminations, Biomedical waste management.

Module: 3	**Critical Care Equipment**	**8 Hours**

Classifications of medical devices based on risk, ICU, ICCU, ICMU, CCU, Haemodialysis Machine, Different types of Dialyzers, Membranes, Machine controls and measurements, Incubators, Multipara Monitors, Intracranial pressure monitor.

Module: 4	**Operation Theatre Equipment**	**8 Hours**

Surgical diathermy, Heart Lung Machine, different types of oxygenators, peristaltic pumps, Boyle's apparatus, Pulmonary artery catheter, Defibrillators, Intra-aortic balloon pump, Cryosurgical unit.

Module: 5	**Centralized Systems**	**7 Hours**

Centralized Oxygen, Nitrogen, Air supply & Suction. Centralized Air Conditioning, Operation Theatre table & Lighting.

Module: 6	**Patient Safety**	**7 Hours**

Patient electrical safety, Types of hazards, Natural protective mechanisms against electricity, Leakage current, Inspection of grounding and patient isolation, Hazards in operation rooms, ICCU and IMCUs, Optocouplers and Pulse transformers.

	Total Lectures	**45 Hours**

Text Books	
1.	Khandpur,R.S, "Handbook of Biomedical Instrumentation ",Third Edition. Tata Mc Graw Hill Pub. Co., Ltd. 2014
2.	John, G. Webster, "Medical Instrumentation, Application and Design", Fourth Edition. John Wiley & sons, NewYork. 2010.
Reference Books	

1.	Myer Kutz, “Biomedical Engineering Fundamentals”, Mc Graw Hill Co.2021.
2.	Azzam Taktak, “A Handbook for Clinical and Biomedical Engineers”, Academic Press,2014.
3.	Raghbir Singh Khandpur, “Compendium of Biomedical Instrumentation”, John Wiley & sons, NewYork,2020.
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**MEDICAL OPTICS AND PHOTONICS**	**L**	**T**	**P**	**C**
23BM2005		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to :

1. Review geometrical optics- wave optics- digital imaging concepts relevant to biomedical applications.
2. Learn optical imaging technologies used in life science research.
3. Understand optical imaging technologies used in medical applications.

Course Outcomes:

The student will be able to:

1. Acquire adequate knowledge on the working principles of biomedical optical instruments.
2. Identify key performance specifications of biomedical optical instruments.
3. Apply biomedical concepts in Optics.
4. Enumerate the performance requirements of the Biomedical Applications.
5. Create adequate optics solutions.
6. Correlate the principles and applications of Medical Optics.

Module: 1	**Optics-Introduction**	**8Hours**
Geometrical optics- Reflection- Refraction- Thin Lenses- Lens Aberrations- Prism- Fermat's Principle- Optical Phenomena - Wave optics- Huygens' Principle- Interference- Diffraction- Polarization- Dispersion- Fraunhofer Diffraction- Fresnel Diffraction- Waveguides- Coherence.		
Module: 2	**Microscopy-Introduction**	**8 Hours**
Digital imaging- Image Formation- Image Sampling and Quantization- Image Enhancement- Image Registration-Optical Microscopy - Principles of light microscopy- bright field microscopy- darkfield microscopy- phase contrast microscopy- and fluorescence microscopy.		
Module: 3	**Microscopy Techniques**	**7 Hours**
Light Microscopy- Electron Microscopy- Confocal Microscopy- Super-resolution Microscopy- Structured illumination microscopy- Multi-photon microscopy		
Module: 4	**Optical Imaging and Spectroscopy Techniques**	**8 Hours**
Optical Coherence Tomography (OCT)- Fluorescence Lifetime Imaging Microscopy (FLIM)- Raman Spectroscopy- Optical Manipulation Techniques- STORM		
Module: 5	**Optics in Medical Diagnosis**	**7 Hours**
Tissue optics - In vivo confocal microscopy - Laser speckle imaging- Photo acoustic imaging- Diffuse optical imaging		
Module: 6	**Clinical Applications**	**7 Hours**
Dermatology- Gastroenterology- Cardiology- Ophthalmology- Ex vivo fresh tissue imaging		
	Total Lectures	**45 Hours**

Text Books

1.	Fischer.Robert, Biljana Tadic-Galeb, Paul. Yoder, “Optical system design”. McGraw-Hill Education, 2008.
2.	Hecht- Eugene, “Optics”, Pearson Education India, 2012.

Reference Books

1.	Goodman- Joseph W, “Introduction to Fourier optics”, Roberts and Company publishers, 2005.
2.	Tuan Vo Dinh, “Biomedical Photonics-Handbook”, CRC Press, Bocaraton, 2014.
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**MEDICAL DEVICE REGULATIONS**	**L**	**T**	**P**	**C**
23BM2006		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Identify importance of medical device regulations across countries.
2. Learn different regulatory schemes adopted in countries.
3. Analyse the challenges in regulatory aspects of AI based medical devices.

Course Outcomes:

The student will be able to:

1. Identify various medical device regulatory norms.
2. Interpret the difference between various clinical practices.
3. Outline the FDA regulations of medical devices.
4. Examine the regulations of medical devices in Europe.
5. Apply the medical device regulation policies of India for make in India products.
6. Solve various challenges that arise in cyber world in AI based medical devices.

Module: 1	**Introduction to Medical Devices**	**7 Hours**

Classifications of medical devices on the basis of risk- History of medical device regulations globally- Product life cycle of medical device- The five stages of the medicinal product life cycle- International Medical Device Regulators Forum-IMDRF Management Committee- Global Harmonization Task Force (GHTF)

Module: 2	**Ethics of Clinical trials of Medical Devices**	**8 Hours**

Clinical investigational plan for medical devices- Clinical investigation conduct- ISO 14155:2011- International Council on Harmonization of Good Clinical Practice- ISO 13485:2016: quality management system of medical devices requirements for regulatory purposes- ISO 14971:2019 medical device risk management applications- Risk management application throughout the lifecycle of the device

Module: 3	**Regulations for Medical Devices in the United States**	**8 Hours**

US Food & Drug Administration (FDA)- Classification of medical devices (I- II- and III)- Regulatory approval process for medical device- Premarket notification 510 (k) —21 CFR Part 807 E- Premarket approval- Approval process of medical devices in the USA- Investigational device exemption- Quality system requirements-21 CFR part 820- Labelling requirements-21 CFR Part 80- Post-marketing surveillance of medical device- Unique device identification of medical device

Module: 4	**European Union Medical Devices Regulations**	**8 Hours**

Medical devices' laws in Europe- The new approach for regulating products- Regulatory approval process of medical device- Notified bodies in Europe- CE Marking in Europe for medical devices- Medical device labelling: EU Regulation MDR 2017/745- Product labelling and QMS—EU MDR

Module: 5	**Regulations for Medical Devices in India**	**7 Hours**

Classification of medical device in India- Regulations in India- Central Drugs Standard Control Organization (CDSCO)- Medical device definition as per CDSCO- Medical device registration process- The documents needed for registration- Approval process of medical device in India- Manufacture of medical devices for sale or for distribution- Class A-B-C and D; import of medical devices

Module: 6	**Regulations for AI based medical devices**	**7 Hours**

Lifecycle Regulation and Evaluation of Artificial Intelligence and Machine Learning-Based Medical Devices- Cyber security of Medical Devices: Regulatory Challenges- Regulation of Digital Health Technologies- IP and FDA Regulation of De Novo Medical Devices

	Total Lectures	**45 Hours**

Text Books

1.	Aakash Deep, "Medical Device Regulations A Complete Guide", Elsevier Academic Press, 2022
2.	I. Glenn Cohen,Timo Minssen, W. Nicholson Price II, "The Future of medical Device regulation-innovation and protection" - Cambridge University Press, 2022

Reference Books

1.	Lingling Tian- Charlene Wang- Susan Liao- "Medical devices : regulations- standards and practices", Elsevier Academic Press,2015.
2.	Beth Ann Fiedler- "Managing Medical Devices Within a Regulatory Framework"- Elsevier Academic Press,2016.
3.	G.R Higson-" Medical Device Safety-The Regulation of Medical Devices for Public Health and Safety", CRC Press,2001.

Recommended by Board of Studies	03 Aug 2023

Approved by Academic Council	25 Aug 2023

Course code	BIOSTATISTICS	L	T	P	C
23BM2007		3	0	0	3

Course Objectives:

Enable the student to :

1. Correlate the concepts and methods in statistics relevant to biomedical data.
2. Interpret biomedical data using statistical techniques.
3. Analyse data using the principles of experimental design.

Course Outcome

The student will be able to :

1. Interpret the statistical concepts in biomedical engineering.
2. Demonstrate probability theory to model healthcare data.
3. Implement estimation methods and hypothesis test in biostatistical investigations.
4. Apply statistical methods to design and conduct experiments in biomedical research.
5. Illustrate the principles and properties of chi-square distribution.
6. Apply ethical principles in the use of statistical methods and the reporting of statistical findings.

Module: 1	Introduction to Biostatistics and Descriptive Statistics	7 Hours

Measurement and Measurement Scales - Sampling and Statistical Inference - Scientific Method and the Design of Experiments - Computers and Biostatistical Analysis. Descriptive Statistics - Ordered Array - Grouped Data: The Frequency Distribution - Measures of Central Tendency - Measures of Dispersion

Module: 2	Probability Concepts and Distribution	8 Hours

Overview of Probability Concepts - Calculating the Probability of an Event - Bayes' Theorem, Screening Tests. Probability Distributions of Discrete Variables: The Binomial Distribution - The Poisson Distribution - Continuous Probability Distributions - The Normal Distribution - Normal Distribution Applications

Module: 3	Estimation and Hypothesis testing	7 Hours

Probability concepts and rules - Random variables and probability distributions - Estimation and hypothesis testing - Confidence intervals Parametric and non-parametric tests - Power and sample size calculations. Hypothesis Testing - Paired Comparisons - A Single Population Proportion - Difference Between Two Population Proportions

Module: 4	Experimental Design	8 Hours

Analysis of variance (ANOVA) and its applications - Completely Randomized Design - Randomized Complete Block Design - Repeated Measures Design - Factorial Experiment - Regression Model - Sample Regression Equation - Evaluating the Regression Equation - Correlation Model - Correlation Coefficient

Module: 5	Chi-square Distribution and Analysis of Frequencies	8 Hours

The Mathematical Properties of the Chi-Square Distribution - Tests of Goodness-of-Fit - Tests of Independence - Tests of Homogeneity - The Fisher Exact Test - Relative Risk, Odds Ratio, and the Mantel–Haenszel Statistic. Case Studies on Chi-square distribution in healthcare applications: Patient Treatment Outcome, Assessing the Association between Smoking & Lung Cancer – Case Study on the analysis of frequencies in healthcare applications: Disease Distribution in a Population

Module: 6	Survival Analysis and Vital Statistics	7 Hrs

Time-to-Event Data and Censoring - Kaplan–Meier Procedure - Comparing Survival Curves - Cox Regression: The Proportional Hazards Model. Vital Statistics: Death Rates and Ratios – Measures of Fertility- Measures of Morbidity. Case Studies on Survival Analysis: Cancer Survival Analysis, Analysis of Time-to-Recovery from specific disease. Case Studies on Vital Statistics: Infant Mortality Rate (IMR) Analysis – Maternal Mortality & Socioeconomic Disparities

	Total Lectures	45

Text Books

1. Daniel, W. W, Cross, C. L, " Biostatistics: Basic Concepts and Methodology for the Health Sciences. India", Wiley, 2018.
2. Streiner, D. L., Norman, G. R.. "Biostatistics: The Bare Essentials", United States: People's Medical Publishing House, 2014.

Reference Books

1.	Roy, J. A., Triola, M. F, Triola, M. M, "Biostatistics for the Biological and Health Sciences". United Kingdom: Pearson, 2018.
2.	Berry, G, Armitage, P, Matthews, J. N. S, "Statistical Methods in Medical Research", Germany: Wiley, 2013.
2.	Thomas D. Cook, David L. DeMets, "Introduction to Statistical Methods for Clinical Trials", United Kingdom: Taylor & Francis, 2008.
3.	Lee, E. T, "Statistical Methods for Survival Data Analysis". United Kingdom: Wiley, (1992).

Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	CYBERSECURITY FOR MEDICAL SYSTEMS	L	T	P	C
23BM2008		3	0	0	3

Course Objectives:

Enable the student to :

1. Comprehend the fundamentals of cyber security in medical system.
2. Design secured and trustable Medical IoT systems.
3. Analyze the threats and risks within context of the cyber security.

Course Outcomes:

The student will be able to:

1. Identify cyber security regulations and policies.
2. Design a security architecture for medical system.
3. Distinguish fundamental concepts of data privacy attacks.
4. Solve network security problems in various networks.
5. Develop trustable cloud based IoT systems.
6. Analyze the cyber security needs of a medical organization.

Module: 1	**Introduction to Cyber Security**	**7 Hours**

Basic Cyber Security Concepts, layers of security, Vulnerability, threat, Harmful acts, Internet Governance – Challenges and Constraints, Computer Criminals, CIA Triad, Assets and Threat, motive of attackers, active attacks, passive attacks, Software attacks, hardware attacks, Cyber Threats-Cyber Warfare, Cyber Crime, Cyber terrorism, Cyber Espionage, etc., Comprehensive Cyber Security Policy.

Module: 2	**Cyber Security Policies**	**8 Hours**

Introduction, Cyber Security Regulations, National Cyber Security Policy, writing security policies, Internet and email security policies, Compliance and Enforcement of policies, Review.

Module: 3	**Building Security architecture**	**8 Hours**

Introduction, Proliferation of Mobile and Wireless medical Devices, Trends in Mobility, Credit card Frauds in Mobile and Wireless Computing Era for medical system, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication service Security, Attacks on Mobile/Cell Phones, Organizational security Policies and Measures in Mobile Computing Era, Laptops.

Module: 4	**Implications**	**8 Hours**

Introduction, cost of cybercrimes and IPR issues, Web threats for medical organizations, security and privacy implications, social media marketing: Security risks and perils for organizations, social computing and the associated challenges for organizations.

Module: 5	**Privacy Issues**	**7 Hours**

Basic Data Privacy Concepts: Fundamental Concepts, Data Privacy Attacks, Data linking and profiling, privacy policies and their specifications, privacy policy languages, Privacy in different domains- medical, financial, etc.

Module: 6	**Case Studies**	**7 Hours**

Medical organization website hacking, Hospital database hacking, Case of Intellectual Property Crime, Financial Frauds in Cyber Domain.

Total Lectures	**45 Hours**

Text Books

1.	Nina Godbole and Sunit Belpure, "Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives", Wiley, 2014.
2.	B.B. Gupta, D.P. Agrawal, Haoxiang Wang, "Computer and Cyber Security: Principles, Algorithm, Applications, and Perspectives", CRC Press, 2018.

Reference Books	
1.	James Graham, Richard Howard and Ryan Otson," Cyber Security Essentials", CRC Press, 2013.
2.	William Stallings, "Cryptography and Network security", Pearson Education, 7th Edition, 2016.
3.	Scott Barman, "Writing Information Security Policies", New Riders Publications, 2002.
4.	Behrouz A. Forouzan , Debdeep Mukhopadhyay, "Cryptography and Network security", Mcgraw Hill Education, 2nd Edition, 2011.
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	CANCER BIOLOGY	L	T	P	C
23BM2009		3	0	0	3

Course Objectives:

Enable the student to:

1. Understand the basics of cancer biology.
2. Analyse the concept of oncogenes.
3. Learn the types of therapy preferred for treating cancer.

Course Outcomes:

The student will be able to:

1. Describe the molecular and cellular mechanisms that lead to cancer.
2. Analyze the primarily focus on the role of growth factors that leads to cancer.
3. Evaluate the role of gene mutation in the development of cancer.
4. Discuss on oncogenes- tumor suppressor genes- angiogenesis and signal transduction mechanisms in tumor formation.
5. Articulate the fundamental principles behind cancer diagnosis and prevention.
6. Explain the various therapeutic management system for cancer biology.

Module: 1	**Fundamentals of Cancer Biology**	**9 Hours**

Regulation of cell cycle-mutations that cause changes in signal molecules-effects on receptor-signal switches-tumour suppressor genes-modulation of cell cycle in cancer-different forms of cancers- diet and cancer. Cancer screening and early detection-Detection using biochemical assays-tumor markers-molecular tools for early diagnosis of cancer.

Module: 2	**Principles of Carcinogenesis**	**9 Hours**

Theory of carcinogenesis-Chemical carcinogenesis-metabolism of carcinogenesis-principles of physical carcinogenesis-x-ray radiation-mechanisms of radiation carcinogenesis.

Module: 3	**Principles of Molecular Cell Biology Of Cancer**	**9 Hours**

Signal targets and cancer-activation of kinases-Oncogenes-identification of oncogenes-retroviruses and oncogenes-detection of oncogenes. Oncogenes/proto oncogene activity-Growth factors related to transformation-Telomerases.

Module: 4	**Principles of Cancer Metastasis**	**9 Hours**

Clinical significances of invasion-heterogeneity of metastatic phenotype-metastatic cascade- basement membrane disruption-three step theory of invasion-proteinases and tumour cell invasion.

Module: 5	**Cancer Prevention and Diagnosis**	**4 Hours**

Carcinogens and DNA damage-Epidemology and cancer-Genomic screening-Infectious agents that cause cancer-Cancer nanotechnology.

Module: 6	**New Molecules for Cancer Therapy**	**4 Hours**

Different forms of therapy-chemotherapy-radiation therapy-detection of cancers-prediction of aggressiveness of cancer-advances in cancer detection,Use of signal targets towards therapy of cancer,Gene therapy.

	Total Lectures	**45 Hours**

Text Books	
1.	Robin Hesketh, "Introduction to Cancer Biology: A Concise Journey from Epidemiology Through Cell and Molecular Biology to Treatment and Prospects", Cambridge University Press, 2012.
2.	Devita V T, " Devita Hellman and Rosenbergs Cancer Principles and Practice of Oncology", LWW, 2019.
Reference Books	

1.	Govindan, “Devita, Cancer, Principles and Practice of Oncology: Review”, Wolters Klumer India Pvt. Ltd, 2018.
2.	Margaret Knowles, Peter Selby, “Introduction to the Cellular and Molecular Biology of Cancer”, OUP Oxford, 2005.
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course Code	**MEDICAL INFORMATICS**	**L**	**T**	**P**	**C**
23BM2010		3	0	0	3

Course Objectives:

Enable the student to:

1. Study the applications of information technology in health care management.
2. Provide knowledge on resources, devices, and methods.
3. Optimize the acquisition, storage, retrieval of information in healthcare.

Course Outcomes:

The student will be able to:

1. Explain the structure and functional capabilities of Hospital Information System.
2. Describe the need of computers in Medical Imaging.
3. Articulate information storage and retrieval in computerized patient record system.
4. Apply the suitable decision support system for automated clinical diagnosis.
5. Discuss the application of virtual reality.
6. Analyze telehealth technology in medical industry.

Module: 1	**Hospital and Medical Informatics**	**7 Hours**

Introduction - Structure of Medical Informatics – Internet and Medicine - Security issues , Computer based medical information retrieval, Hospital management and information system, Functional capabilities of a computerized HIS, Health Informatics – Medical Informatics, Bioinformatics

Module: 2	**Computers in Clinical Laboratory And Radiology**	**7 Hours**

Automated clinical laboratories-Automated methods in hematology, cytology and histology, Intelligent Laboratory Information System - Computerized ECG, EEG and EMG, Computer assisted medical imaging- nuclear medicine, ultrasound imaging, computed X- ray tomography, Radiation therapy and planning, Nuclear Magnetic Resonance.

Module: 3	**Digital Health Record**	**7 Hours**

Introduction - History taking by computer, Dialogue with the computer, Components and functionality of CPR, Development tools, Intranet, CPR in Radiology- Application server provider, Clinical information system, Computerized prescriptions for patients.

Module: 4	**Computer Assisted Medical Decision-Making**	**8 Hours**

Neurocomputers and Artificial Neural Networks application, Expert system-General model of CMD, Computer–assisted decision support system-production rule system cognitive model, semantic networks, decisions analysis in clinical medicine-computers in the care of critically ill patients, Computer aids for the handicapped.

Module: 5	**Recent Trends in Medical Informatics**	**8 Hours**

Virtual Reality Applications in medicine- Virtual Endoscopy-Computer Assisted Surgery-Surgical Simulation.

Module: 6	**Telemedicine - Tele Surgery**	**8 Hours**

Computer assisted patient education and health- Medical education and healthcare information, Computer assisted instruction in medicine.

Total Lectures	**45 Hours**

Text Books

1.	Mohan Bansal, “Medical Informatics”, Tata McGraw Hill Publishing Ltd, 2003.
2.	R.D.Lele, “Computers in Medicine Progress in Medical Informatics”, Tata Mcgraw Hill, 2005.

Reference Books

1.	Kathryn J. Hannah, Marion J Ball, “Health Informatics”, 3rd Edition, Springer, 2006.
2.	Edward H. Shortliffe, Edward H. Shortliffe, James J. Cimino, “Biomedical Informatics: Computer Applications in Health Care and Biomedicine”, Springer International Publishing, 5th edition, Switzerland, 2021.

3.	Naresh Babu Muppalaneni, Vinit Kumar Gunjan, "Computational Intelligence in Medical Informatics", Springer Nature, Singapore,2014.
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**ELECTRON DEVICES AND CIRCUIT LABORATORY**	**L**	**T**	**P**	**C**
23BM2011		**0**	**0**	**2**	**1**

Course Objectives:

Enable the student to:

1. Learn about active and passive circuit elements.
2. Impart practical knowledge on the behaviour of semiconductor device.
3. Learn about the characteristics of amplifier gain and frequency response.

Course Outcomes:

The student will be able to:

1. Describe the characteristics of electronic circuit components.
2. Analyze the characteristics of semiconductor devices.
3. Examine the characteristics of device used for power switching.
4. Design circuits using diodes.
5. Construct transistor-based application circuits.
6. Classify the characteristics of sensor interfacing.

List of Experiments:

1. Study of Circuit Components and Equipment
2. Characteristics of transistor under Common Base Configuration
3. Characteristics of transistor under Common Emitter Configuration
4. Characteristics of JFET
5. Characteristics of UJT
6. VI Characteristics of SCR
7. Wave Shaping Circuits – Clipper and Clamper
8. Transistor as a Switch
9. Transistor as an Amplifier
10. Interfacing of Light Sensor Circuit using LDR

Recommended by Board of Studies	03 Aug 2023
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Course code		**L**	**T**	**P**	**C**
23BM2012	**ENGINEERING PRACTICES AND GRAPHICS LABORATORY**	**0**	**0**	**4**	**2**

Course Objectives:

Enable the student to

1. Design and fabricate printed circuit boards.
2. Understand the fundamentals of DC sources and components.
3. Apply computer software for the preparation of engineering drawing.

Course Outcomes:

The student will be able to:

1. Operate the measuring instruments.
2. Design and fabricate the printed circuit board.
3. Analyze DC Sources and components.
4. Create engineering drawings using CAD software.
5. Evaluate the parts according to standard practice.
6. Sketch the orthographic and isometric views of objects in CAD environment.

List of Experiments:

1. Study of Measuring Instruments (Voltmeter, Ammeter, Oscilloscopes, Multimeter)
2. Design of printed circuit board
3. Fabrication of printed circuit board
4. Study of DC Power Sources

5. Troubleshooting of DC Motors 6. Study of Mechanical components of Medical Equipment. 7. Drawing aids: snap, grid, limits and Osnap. 8. Application of modifying commands. 9. Methods of drawing lines, circles and arcs. 10. Application of lines, arcs and circles to draw simple geometries. 11. Dimensioning, hatching methods to show different materials, title block and layers. 12. Isometric view of primitive solids and combination of primitive solids.	
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code		**L**	**T**	**P**	**C**
23BM3001	**MEDICAL INSTRUMENTATION DESIGN**	**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:
1. Understand the fundamentals of human physiology system and its functions.
2. Learn the fundamental concepts of physiological parameters measurement.
3. Apply the concepts of various instrumentation techniques for biomedical applications.

Course Outcomes:

The student will be able to:
1. Identify the basic functions of various human physiological systems.
2. Analyze the features of electrodes and the interfacing of circuits.
3. Categorize the design procedures involved in neurological signal analysis.
4. Analyze working of various measurement instruments related to cardiac activity.
5. Design an suitable Instrumentation system for respirating analysis.
6. Assess the medical device safety and testing of devices.

Module: 1	**Introduction to Human Physiology**	**8 Hours**

Circulatory system – cardiovascular system-central nervous system – respiratory system – muscular skeletal system – digestive system – excretory system – sensory organs – voluntary and involuntary action.

Module: 2	**Biopotential and Measurements**	**7 Hours**

Cell and its structure – resting potentials – action potentials – bioelectric potentials – measurement of potentials and their recording – Electrode theory – bipolar and Unipolar electrode-surface electrode – electrode impedance –equivalent circuit for extra cellular electrodes- micro electrodes. basic principles of ECG, EEG, EMG.

Module: 3	**Neurological Instrumentation System**	**7 Hours**

Neurophysiology, design of EEG amplifiers, wireless EEG, Bispectral Index EEG measurements for depth of anesthesia monitoring. Deep learning in neurocomputing. Case study.

Module: 4	**Cardiovascular System and Instrumentation**	**8 Hours**

Design of instrumentation system for Blood pressure measurement -selection of sensors -design specifications - blood flow measurements - phonocardiography–Cardiac pacemakers – heart lung machine, Tread mill test – Design of interface system –Artificial intelligence in cardiovascular system – Case study.

Module: 5	**Respiratory System and Instrumentation**	**7 Hours**

Mechanics of breathing –regulation of respiration, design of instrumentation system for respiratory system – selection of transducers – artificial respiration therapy – artificial mechanical ventilation – troubleshooting and maintenance of ventilators. Case study –Machine Learning in diagnosis.

Module: 6	**Electrical Safety**	**8 Hours**

Definition-Scope-Responsibilities of Hospital Personnel- Legal and Insurance Requirements-Physiological Effects- Leakage Current-Line Isolation Systems- Equipotential Grounding System-Ground Fault Interrupters-Power Wiring and Distribution- Specialized Electrical Safety Test Equipment.

Total Lectures	**45 Hours**

Text Books

1. Joseph J Carr, John M Brown, “Introduction to medical equipment technology”, Pearson education publisher, New Delhi, 2013.

2.	Steven Schreiner, Joseph D. Bronzino, Donald R. Peterson, **"**Medical Instruments and Devices: Principles and Practices**",** CRC Press, 2017.
Reference Books	
1.	John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, New York, 2009.
2.	Joseph D. Bronzino, "The Biomedical engineering handbook", Vol I, CRC press, 2000.
3.	Myer Kutz, "Standard Handbook of Biomedical Engineering & Design", McGraw Hill Publisher, UK, 2003.
4.	Leslie Cromwell, "Biomedical Instrumentation and measurement", Prentice hall of India, New Delhi, 2007.
5.	Khandpur, R.S," Handbook of Biomedical Instrumentation", Second Edition. Tata Mc Graw Hill Pub. Co., Ltd. 2003
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

23BM3002	**WEARABLE DEVICES FOR MEDICAL APPLICATIONS**	**3**	**0**	**0**	**3**
Course Objectives:					
Enable the student to: 1. Identify basic concepts of embedded systems. 2. Distinguish various techniques used for designing an embedded system. 3. Develop wearable devices and its applications.					
Course Outcomes:					
The student will be able to: 1. Discuss the basics of embedded systems and its hardware units. 2. Identify the various tools and development process of embedded system. 3. Create the programming for embedded system design. 4. Demonstrate the various peripherals interfacing with microcontroller. 5. Summarize the characteristics of wearable devices. 6. Develop a real time embedded system for biomedical applications.					
Module: 1	**System Design**				**8 Hours**
Definitions-Characteristics -Architecture of an embedded system-Overview of micro-controllers and microprocessors- Classifications of an embedded system - Embedded processor architectural definitions-Embedded hardware units and devices in a system, Design Process, Design process and metrics in embedded system, Design challenges, Optimising the design metrics, Skills required for an embedded system designer.					
Module: 2	**Embedded Software Tools for Programming**				**7 Hours**
Embedded software development Process, Host and Target machine, Linking and Locating Software, Getting embedded software into the target system, Converting embedded C programming into Machine codes, Embedded Software IDE for programming, Embedded Software Tools.					
Module: 3	**Course in Embedded C**				**7 Hours**
Review of embedded C programming Language, Programming in assembly language and high-level language, C program elements, Embedded C programming- Simple programs, High level language descriptions of software for embedded system, Basics of Python programming.					
Module: 4	**Medical Device peripherals interfacing**				**8 Hours**
Study of microcontroller, Interfacing and Programming – Switch, Keypad, LED, seven segment displays, Data Acquisition system, A/D, D/A converters, Timers and Counters. Interrupt concept.					
Module: 5	**Techniques for Wearable devices**				**7 Hours**
Wearable system design, Clinical problems and engineering approaches, Wearable technologies, Wearable biosensors, Health and Fitness wearables, Security and privacy risks. Smart wearable device, Biosensors and IoT in smart health care applications: challenges and opportunities, Low power integrated circuit design for wearable biopotential sensing.					
Module: 6	**Real Time Applications**				**8 Hours**

Body temperature measurement, Stepper motor control, Wireless sensor technologies, Wireless body area network, Patient monitoring system. Case studies on designing embedded system for biomedical application, Case studies on designing wearable sensors for biomedical applications.	
Total Lectures	**45 Hours**
Text Books	
1.	RajKamal, "Embedded Systems Architecture, Programming and Design", Tata McGrawHill ,Second Edition, 2008
2.	Edward Sazonov, "Wearable Sensors: Fundamentals, Implementation and Applications", Elsevier, Technology & Engineering, 2014.
Reference Books	
1.	Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2005.
2.	Frank Vahid, Tony Givargis, "Embedded Systems Design", Wiley India, 2006
3.	Khandpur R.S, "Hand-book of Biomedical Instrumentation", Tata McGraw Hill, 2nd Edition, 2003.
4.	Tim Wilhurst, "An Introduction to the Design of Small Scale Embedded Systems,Palgrave, 2004.
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**ADVANCED BIOMEDICAL ENGINEERING LABORATORY**	**L**	**T**	**P**	**C**
23BM3003		**0**	**0**	**4**	**2**

Course Objectives:

Enable the student to:
1. Illustrate biosignal acquisition and analysis.
2. Develop Interfacing of medical equipments.
3. Simulate medical sensors using software tools.

Course Outcomes:

The student will be able to:
1. Illustrate the acquisition of bio signals.
2. Discuss the principle of physiological sensors.
3. Assess the characteristics of given bio signal.
4. Develop algorithms for the signal analysis.
5. Construct the interfacing circuits for biomedical applications.
6. Simulate MEMS based sensors.

LIST OF EXPERIMENTS
1. Detection of QRS complex in ECG signal
2. Acquisition and analysis of EMG, EEG signals.
3. Acquisition and analysis of respiratory signal.
4. Calculation of flow rate in infusion and syringe pump.
5. Analysis of PPG signals using biokit.
6. Measurement of Oxygen saturation using Raspberry Pi
7. Robot Programming for medical applications
8. Acquisition of physiological signal using Force Plate.
9. Monitoring of Gait parameters using Polyrite.
10. Design and Analysis of MEMS accelerometer and pressure sensor using COMSOL.
11. BiPAP, CPAP, Neonatal Incubator
12. Development of Implants using 3D Printing

Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**MEDICAL IMAGE PROCESSING LABORATORY**	**L**	**T**	**P**	**C**
23BM3004		**0**	**0**	**4**	**2**

Course Objectives:

Enable the student to:
1. Differentiate with various medical image data.

2. Develop Programs for image processing using MATLAB.
3. Simulate medical images using various methods.

Course Outcomes:

The student will be able to:

1. Demonstrate the manipulation of images for the specified requirement.
2. Identify the region of interest using segmentation and morphological operations.
3. Modify the image geometry for specific purpose.
4. Show the effect of rending on given image.
5. Indicate the results of fusion and registration of images.
6. Demonstrate image reconstruction using the given data.

LIST OF EXPERIMENTS

1. Basic operations on medical images
2. Enhancement of medical images
3. Image segmentation using thresholding and region based methods
4. Morphological operations on medical images
5. Translation and rotation of medical images
6. Image reformatting and tracking
7. Volume rendering and Surface rendering
8. Methods for medical image fusion using artificial intelligence
9. Image registration methods using deep learning
10. Image reconstruction using machine learning
11. Object Detection using deep learning.
12. Decomposition and reconstruction of medical images using wavelets.
13. Mini Project

Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**ADVANCED EMBEDDED SYSTEM DESIGN LABORATORY**	**L**	**T**	**P**	**C**
23BM3005		**0**	**0**	**4**	**2**

Course Objectives:

Enable the student to:

1. Discover the concepts of Embedded system and its peripherals.
2. Design various programming techniques in real time applications.
3. Solve interfacing issues related to embedded system design in healthcare.

Course Outcomes:

The student will be able to:

1. Develop an embedded C program for various I/O interfacing in medical devices.
2. Illustrate the hardware timer concepts for providing delay.
3. Develop real time embedded systems for biomedical applications.
4. Apply internet protocols for data transmission.
5. Design interfacing circuits to acquire real time data and process it using software.
6. Experiment integration the sensor with embedded processor for online monitoring.

LIST OF EXPERIMENTS

1. Port Programming
2. Input and Output device Interfacing
3. Concept of timer for generating hardware delay
4. PWM generation
5. Biosensor Interfacing
6. ON/OFF Relay control
7. Low Power wireless transmission of biosignals
8. Analysis of biosignals and image with Raspberry Pi using python
9. Configuring Raspberry Pi processor for cloud storage and interfacing of biosignals
10. Design of Online Patient monitoring system –IoT implementation
11. Mobile phone-based design of medical devices for continuous monitoring system
12. Web server-based monitoring and control

Recommended by Board of Studies	03 Aug 2023
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Course code	**COGNITIVE TECHNOLOGY FOR BIOMEDICAL ENGINEERS**	**L**	**T**	**P**	**C**
23BM3006		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Discover the various soft computing frame works.
2. Describe the with design of various neural networks and fuzzy logic.
3. Discuss genetic programming and hybrid systems.

Course Outcomes:

The student should be able to:

1. Discover the concepts of various Artificial neural networks.
2. Explain various neural networks for modelling and control.
3. Apply appropriate fuzzy logic methods.
4. Relate genetic programming and hybrid soft computing.
5. Select computing techniques for biomedical applications.
6. Assess hybrid techniques.

Module: 1	**Introduction to Artificial Neural Networks**	**7 Hours**

Review of fundamentals – Biological neuron, artificial neuron, activation function, single layer perceptron – Limitation – Multi layer perceptron – Back Propagation Algorithm (BPA) – Recurrent Neural Network (RNN) – Adaptive Resonance Theory (ART) based network – Radial basis function network – online learning algorithms, BP through time – RTRL algorithms – Reinforcement learning Applications of ANNs to solve some real-life problems

Module: 2	**Neural Networks for Modeling And Control**	**8 Hours**

Modelling of non-linear systems using ANN – Generation of training data – Optimal architecture– Model validation – Control of non-linear systems using ANN – Direct and indirect neuro control schemes – Adaptive neuro controller. Applications of Neural network in biomedical field

Module: 3	**Fuzzy Logic**	**7 Hours**

Membership functions: features, fuzzification, methods of membership value assignments- Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - formation of rules-decomposition of rules, fuzzy inference systems- Fuzzy Logic in Databases-Information Retrieval with Fuzzy Logic 10. Fuzzy Intelligent Agents, Fuzzy Decision Trees- Case studies on biomedical applications.

Module: 4	**Genetic Algorithm**	**8 Hours**

Genetic algorithm and search space - general genetic algorithm, operators - Generational cycle, stopping condition, constraints. Classification, genetic programming, multilevel optimization, real life problem, Advances in GA. Applications of GA in engineering problems, job-shop scheduling and routing problems

Module: 5	**Hybrid Soft Computing Techniques**	**7 Hours**

Neuro-fuzzy hybrid systems - genetic neuro hybrid systems - genetic fuzzy hybrid and fuzzy genetic hybrid systems - simplified fuzzy ARTMAP. Case studies on biomedical applications.

Module: 6	**Soft Computing Applications**	**8 Hours**

A fusion approach of multispectral images with SAR, optimization of traveling salesman problem using genetic algorithm approach, soft computing based hybrid fuzzy controllers. Case studies on biomedical applications.

Total Lectures	**45 Hours**

Text Books

1.	Laurene V. Fausett, “Fundamentals of Neural Networks: Architectures, Algorithms and Applications” Pearson Education, 2010.
2.	S.N.Sivanandam and S.N.Deepa, “Principles of Soft Computing”, Wiley India Pvt Ltd, 2011.

Reference Books

1.	J.S.R.Jang, C.T. Sun and E.Mizutani, “Neuro-Fuzzy and Soft Computing”, Pearson Education, 2004.

2.	S.Rajasekaran and G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd., 2006.
3.	George J. Klir, Ute St. Clair, Bo Yuan, "Fuzzy Set Theory: Foundations and Applications", Prentice Hall, New Delhi,1997.
4.	Simon Haykin, "Neural Networks Comprehensive Foundation", Second Edition, Pearson Education, 2005.

Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**HOSPITAL SUPPLY CHAIN MANAGEMENT**	**L**	**T**	**P**	**C**
23BM3007		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:
1. Interpret the fundamentals of health care delivery services.
2. Learn the procedures in maintenance of equipment.
3. Summarize Hospital support systems.

Course Outcomes:

The Student will be able to:
1. Comprehend the principle of supply chain management in healthcare.
2. Classify the types of hospitals and functions.
3. Modify the design to develop support systems.
4. Infer the most challenges in environment and market trends.
5. Evaluate the systems based on the safety criteria to environment.
6. Create the methodology for medical equipment maintenance.

Module: 1	**Introduction to Supply Chain Management**	**7 Hours**

Goals-importance – Drivers for supply chain – customer service – monetary value –integrating healthcare-demand planning – supply chain process.

Module: 2	**Healthcare Supply Chain Management**	**8 Hours**

Essentials of healthcare supply chain management, designing sustainable health care supply chain, performance metrics, emerging trends in healthcare supply chain management. Data analytics in supply chain management.

Module: 3	**Health and Hospital Management**	**7 Hours**

Health organisation of the country, the State, the Cities and the Region, Management of Hospital Organisation, Nursing Sector, Medical Sector, Central Services, Technical Department, Definition and Practice of Management by Objective, Transactional Analysis Human Relation in Hospital, Importance of Team Work, Legal aspect in Hospital Management. Case study: Health survey.

Module: 4	**Hospital Support System**	**8 Hours**

Maintenance of Hospital support system, surveillance network, electric power management, Medical gas production, waste disposal, inventory control. Case study: RF ID tag for inventory. IoT in inventory management.

Module: 5	**Safety Equipment**	**7 Hours**

Operation of safety devices, personnel safety equipment, Gas mask, Radiation measurements, equipment safety systems, Safety codes-elements of basic first aid, fire fighting, Case study: Safety Awareness.

Module: 6	**Hospital Equipment Maintenance Management**	**8 Hours**

Organizing the maintenance operation, equipment life cycle - biomedical equipment procurement procedure, proper selection, compatibility, testing and installation, purchase and contract procedure, training for medical staff, on proper use of equipment and operating instructions. Maintenance of job planning, preventive maintenance, maintenance budgeting, maintenance contract.

Total Lectures	**45 Hours**

Text Books

1.	Hokey Min, "Healthcare Supply Chain Management: Basic Concepts and principles", Business expert press, NewYork, 2014.
2.	Keith Willson, Keith Ison, SlavikTabakov, "Medical Equipment Management", CRC Press, 2013.

Reference Books

1.	Webster.J.G. and Albert M.Cook, "Clinical Engineering Principles and Practices Prentice Hall Inc., Englewood Cliffs, New Jersey, 1979.
2.	Robin Guenther, Gail Vittori, "Sustainable Healthcare Architecture", Wiley, 2013.
3.	Sharma D K, R.C.Goyal, "Hospital administration and human Resource Management in Hospital", Prentice Hall of India, New Delhi, 2017.
4.	Syed Amin Tabish "Hospital and Health services Administration Principles and Practices" Oxford Press, New Delhi, 2001.

Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**BIOMEDICAL ENGINEERING ENTREPRENEURSHIP**	**L**	**T**	**P**	**C**
23BM3008		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Learn fundamentals of entrepreneurship.
2. Apply the methods of entrepreneurship in medical field.
3. Evaluate the medical devices and market trends.

Course Outcomes:

The student will be able to:

1. Describe the role of biomedical engineers in entrepreneurship.
2. Acquire the skills and techniques required towards market analysis.
3. Develop business plan.
4. Categorize the resources and funding schemes.
5. Judge the right product based on market needs.
6. Create awareness on environmental safety and protection.

Module: 1	**Scope for Biomedical Engineering Entrepreneurship**	**7 Hours**

Innovations in Biomedical Engineering - Entrepreneurship and Vision –Team building- Development phase- Advancements in biomedical field, Supporting societies and professional activities. Impact of innovation in medical devices. Case study. Artificial intelligence in innovation of medical devices.

Module: 2	**Market & Venture**	**8 Hours**

Assessing the venture, Organizational Structure -Establish venture- Types of Entrepreneurs -Evaluate the invention, - market research, case study. Data analytics in market research – Customer segment - Value proposition Canvas, Market Estimation-TAM, SAM, SOM, Competitive analysis. Case study.

Module: 3	**Business Plan**	**7 Hours**

Identify problem worth solving, define the problem using Design thinking principles. Overview to Product Development, Minimum viable product (MVP): Build - Measure - Learn, validate MVP- Achieve a Product – Market fit - Development of the Value Proposition for the StartUp - Introduction to Business model, Business plan and lean approach, Lean canvas model,

Module: 4	**Identifying the Grants**	**8 Hours**

Identify and organize support for product development, funding agencies, collaborative initiatives, and angel investors – NSTEBD- Financial assistance and subsidies offered by government.

Module: 5	**Impact of Globalization**	**7 Hours**

Medical product manufacturing, Patent-digital marketing, leadership, quality management. Case study: Machine learning techniques in product design.

Module: 6	**Regulations & Environmental Concern**	**8 Hours**

Certification, ISI, CE, UL, NABL and FDA regulations, ISO: 13485, ISO: 14791, risk management, Environmental regulation. Case study on risk management. Case study. Safety, safe disposal, preventing pollution, preventing health hazards.

Total Lectures	**45 Hours**

Text Books

1.	Jen-Shih Lee "Biomedical Engineering Entrepreneurship", World Scientific Publishing, USA. 2010.
2.	Brant Cooper, Patrick Vlaskovits, "The Lean Entrepreneur", Wiley, 2nd edition, New Jersy, 2016.

Reference Books

1.	Nathan Furr, Jeff Dyer, "The Innovator's Method: Bringing the Lean Start-up into Your Organization", Harvard Business Press, Boston, 2014.

2.	Jen-Shih Lee, “Being a Biomedical Entrepreneur: Growth of the Biomedical Industry”, World Scientific Publishing, Singapore. 2019
3.	Stephen Roper, “Entrepreneurship :A Global Perspective”, Routledge Publisher, Taylor & Francis Group, USA. 2013.
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**DEEP LEARNING FOR HEALTH CARE**	**L**	**T**	**P**	**C**
23BM3009		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:
1. Learn deep Learning techniques.
2. Analyze advanced neural networks in deep learning.
3. Apply Deep learning techniques in medical field.

Course Outcomes:

The student will be able to:
1. Comprehend the concept of deep learning.
2. Review the concepts of advanced neural networks.
3. Analyse the deep learning techniques in computational medicine.
4. Examine the importance of digital deep learning biomarkers.
5. Compute the challenges in applying medical deep learning techniques.
6. Summarize the features of deep learning in diagnostic and therapeutic devices.

Module: 1	**Introduction to Deep Learning**	**7 Hours**

History of deep learning – Back propagation network- BPN Algorithm- Regularization- Parameter regularization- Normalization – Batch normalization – Shallow networks.

Module: 2	**Advanced Neural Networks**	**8 Hours**

Fully connected neural network – Convolutional neural networks – Recurrent neural networks – Deep belief network – Autoencoder – Generative adversal network – Artificial neural network- Case study.

Module: 3	**Deep Learning in computational medicine**	**8 Hours**

Medical image – Electronic health record – Genomics – Drug development – Biomedical research by deep learning – case study.

Module: 4	**Digital Deep Learning Biomarkers**	**8 Hours**

Models for health related outcome – Minimize device discrepancy - Sensitive implementation strategies – Monitoring – clinical decision support – Digital therapeutics.

Module: 5	**Challenges in applying Deep Learning in medical field**	**7 Hours**

Overfitting – Small dataset – Class imbalance – Data augmentation – Redesign the loss function – Generate synthetic data.

Module: 6	**Healthcare Applications**	**7 Hours**

Diagnostic devices – Deep learning techniques in CT, MRI, Ultrasound, Fluroscopy -Therapeutic devices – Radiotherapy, Bed side monitoring, Drug delivery applications.

	Total Lectures	**45 Hours**

Text Books

1.	Charru C Aggarwal, “Neural Networks and Deep Learning”, Springer Publications 2018.
2.	Lakhmi C. Jain, Yen-Wei Chen, “Deep Learning in Healthcare, Springer Publications 2019.

Reference Books

1.	Cao Xiao, Jimeng Sun, Introduction to Deep Learning for Healthcare, Springer International Publishing, 2021.
2.	Fadi Al-Turjman, Ishaani Priyadarshini, Jyotir Moy Chatterjee, Vishal Jain, Deep Learning for Healthcare Decision Making, CRC Press, UK. 2023.
3.	Jyotir Moy Chatterjee, Vishal Jain, Machine Learning and Healthcare, Springer International Publishing, 2020.
Recommended by Board of Studies	03 Aug 2023
Approved by Academic Council	25 Aug 2023

Course code	**3D PRINTING FOR BIOMEDICAL APPLICATIONS**	**L**	**T**	**P**	**C**

23BM3010		3	0	0	3
Course Objectives:					
Enable the student to: 1. Learn 3D printing in Manufacturing. 2. Recommend the appropriate use of 3D printing technology. 3. Comprehend the need of 3D Printing in Bio-medical field.					
Course Outcomes:					
The student will be able to: 1. Summarize the 3D printing in manufacturing. 2. Interpret the design process. 3. Identify materials for 3D printing. 4. Paraphrase the advantages and limitations of each 3D printing technology. 5. Design and print objects for human implants. 6. Evaluate the advantages of 3D printing for medical applications.					
Module: 1	**Introduction to 3D Printing**	**8 Hours**			
Introduction, Process, Classification, Advantages, Additive, Conventional Manufacturing Processes, Applications, Research achievements in printing deposition, Technical challenges in printing, Applications of Printing Processes.					
Module: 2	**Development of 3D Printing Technology**	**7 Hours**			
3D Printing: Principle, basic process, types of printing, process capabilities, material system. Solid based, Liquid based and powder based 3DP systems, Shape Deposition Manufacturing (SDM): Introduction, basic process, shape decomposition, mold SDM and applications. Selective Laser Melting, Electron Beam melting – Rapid manufacturing.					
Module: 3	**3D Printing Materials**	**8 Hours**			
Polymers, Metals, Non-Metals, Ceramics; Various forms of raw material- Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their properties, Support Materials.					
Module: 4	**CAD Modelling**				
Basic concept- Digitization techniques – Model Reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data Requirements – geometric modelling techniques-Wire frame, surface and solid modelling – data formats – Data interfacing, Part orientation and support generation, Support structure design, Model Slicing and contour data organization, direct and adaptive slicing, Tool path generation.					
Module: 5	**Orthopaedic Implants**	**7 Hours**			
Introduction, Medical Imaging: from Medical Scanner to 3D Model, Computer Approach in body Implant- BioBuild Paradigm – Importing a dataset, Volume reduction, Anatomical orientation confirmation, Volume editing, Image processing, Build orientation optimization, 3D visualization. Case study.					
Module: 6	**3D Printing for Medical Applications**	**8 Hours**			
Medical Applications for 3D Printing – Software Support for Medical Applications, Limitations of 3D Printing for Medical Applications –Case study.					
Total Lectures		**45 Hours**			
Text Books					
1. Ian Gibson, Advanced Manufacturing Technology for Medical Applications, John Wiley, 2005.					
2. Paulo Bartolo and Bopaya Bidanda, Bio-materials and Prototyping Applications in Medicine, Springer, 2008.					
Reference Books					
1.Ian Gibson, David Rosen and Brent Stucker, “Additive Manufacturing Technologies: 3D printing, Rapid prototyping and Direct Digital Manufacturing”, Springer, 2014.					
2.Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, 2016.					
Recommended by Board of Studies	03 Aug 2023				
Approved by Academic Council	25 Aug 2023				

DEPARTMENT OF BIOMEDICAL ENGINEERING

LIST OF NEW COURSES

Sl. No.	Course Code	Programme Code / Course Title	Credits L:T:P	Credits C
1	21BM3031	Advanced Medical Image Processing	3:0:0	3
2	22BM2001	Biosignal Processing	3:0:0	3
3	22BM2002	Medical Ethics and Standards	2:0:0	2
4	22BM2003	Hospital Management	3:0:0	3
5	22BM2004	Modelling of Physiological Systems	3:0:0	3
6	22BM2005	Biomedical Instrumentation Laboratory	0:0:3	1.5
7	22BM2006	Biomaterials and Artificial Organs	3:0:0	3
8	22BM2007	Control System for Biomedical Engineers	3:0:0	3
9	22BM2008	Introduction to Biomedical Engineering	3:0:0	3
10	22BM2009	Fundamentals of Electrical and Electronics Engineering Laboratory	0:0:2	1
11	22BM2010	Embedded System Laboratory for Biomedical Applications	0:0:3	1.5
12	22BM2011	Signal Conditioning Circuits	3:0:0	3
13	22BM2012	Microprocessor and Microcontroller	3:0:0	3
14	22BM2013	Electron Devices and Circuits	3:0:0	3
15	22BM2014	Signals and Systems for Biomedical Engineers	3:0:0	3
16	22BM2015	Medical Imaging Techniques	3:0:0	3
17	22BM2016	Electrical Circuit Analysis	3:1:0	4
18	22BM2017	Image Processing for Medical Applications	3:0:0	3
19	22BM2018	Image Processing Laboratory for Medical Applications	0:0:3	1.5
20	22BM2019	Human Anatomy and Physiology	3:0:0	3
21	22BM2020	Biology for Engineers	3:0:0	3
22	22BM2021	Biomedical Sensors	3:0:0	3
23	22BM2022	Medical Internet of Things	3:0:0	3
24	22BM2023	Signals Conditioning Circuits Laboratory	0:0:2	1
25	22BM2024	Biomedical Sensors and Transducers Laboratory	0:0:2	1
26	22BM2025	Digital Electronics	3:0:0	3
27	22BM2026	Medical Diagnostics and Therapeutic Equipment I	3:0:0	3
28	22BM2027	Medical Diagnostics and Therapeutic Equipment II	3:0:0	3
29	22BM2028	Virtual Instrumentation for Biomedical Engineers	3:0:2	4
30	22BM2029	Electrical and Electronics for Biomedical Engineers	3:1:0	4
31	22BM2030	Ergonomics and Sports Mechanics	3:0:0	3
32	22BM2031	3D Printing	3:0:0	3

Course code	ADVANCED MEDICAL IMAGE PROCESSING	L	T	P	C
21BM3031		3	0	0	3

Course Objective:

Enable the student to:

1. Know the concepts of medical image processing and filtering techniques
2. Learn about the Segmentation techniques used in Medical image processing
3. Understand the applications of medical image processing for Diagnosis.

Course Outcomes:

The student will be able to:

1. Summarize the concepts of digital image processing techniques.
2. Identify the noise and apply filters for medical image applications
3. Determine the restoration for medical images.
4. Implement segmentation and evaluation techniques.
5. Apply the Featuring engineering on medical images.
6. Develop systems for medical image processing and analysis for diagnosis

MODULE: 1	**IMAGING FUNDAMENTALS**	**8 Hours**
Components of Digital Image Processing, Sampling and Quantisation, CAD System, Various Modalities of Medical Imaging, Image Enhancement, Other Modalities of Medical Imaging		
MODULE: 2	**NOISE REDUCTION FILTERS FOR MEDICAL IMAGES**	**7 Hours**
Sources of Noise and Filters used for Noise Reduction, Spatial Domain Filters, Frequency Domain Filters, Practical Results with case studies.		
MODULE: 3	**MEDICAL IMAGE RESTORATION**	**8 Hours**
Image Restoration, Degradation Model, Estimation of Degradation Function, Blur Model, Medical Image Restoration, Blur Identification, Super – Resolution Method, Application of Image Restoration.		
MODULE: 4	**BIOMEDICAL IMAGE SEGMENTATION**	**7 Hours**
Image Segmentation: Broad Classification and Applications, Points Detection, Line Detection, Edge Detection Methods, Thresholding and Edge Thinning, Histogram – Based Image Segmentation, Segmentation using Split and Merge Method, Region Growing Method, Watershed Method, k- Means Clustering Method, Self – similar Fractal Method, Topological Derivate- Based segmentation, Comparison of Segmentation Methods. Systematic Evaluation and Validation.		
MODULE: 5	**FEATURE EXTRACTION AND STATISTICAL MEASUREMENT**	**7 Hours**
Selection of Features, Shape Related Features, Fourier Descriptors, Texture analysis, Breast Tissue Detection, Analysis of Tissue Structure.		
Module: 6	**Applications of AI in Medical Imaging**	**8 Hours**
MR brain image classification, Mammogram image segmentation, Image enhancement in retinal images, Medical image compression, Histopathological blood cell image analysis, Nodule detection in lung images, Cancer detection in skin images.		
	Total Lectures	**45 Hours**

Text Books

1. Sinha G. R, Patel, B. C.(2014).*Medical Image Processing: Concepts and Applications(1st ed.).* Prentice Hall.
2. Rangayyan R M.(2005).*Biomedical Image Analysis(5th ed.).*CRC Press.

Reference Books

1. Gonzalez R C, Woods R E.(2018).*Digital Image Processing (4th ed.).* Pearson.
2. Kayvan Najarian, Robert Splinter.(2014).*Biomedical Signal and Image Processing (2nd ed.).*CRC Press.
3. Thomas Martin Deserno (2014). *Biomedical Image Processing.* Springer.
4. Guorong Wu, Dinggang Shen, Mert Sabuncu.(2016). *Machine Learning and Medical Imaging (1st ed.).*Elsevier .

	Recommended by Board of Studies	
	Approved by Academic Council	18th December 2021

Course Code	**BIOSIGNAL PROCESSING**	**L**	**T**	**P**	**C**
22BM2001		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on
1. Signal processing fundamentals.
2. Filter design and its applications.
3. Analyzing biosignals using biosignal processing methods

Course Outcomes:

At the end of this course, students will be able to:
1. Describe the fundamentals of signal processing
2. Identify the effect of IIR Digital filter design
3. Illustrate the various applications of IIR filter
4. Discuss about the FIR Filter design and applications

5. Interpret the various methods to analyze biosignals 6. Explain the biosignal processing concepts for real time applications		
Module: 1	**Fundamentals of Signal Processing**	**7 Hours**
Sampling and aliasing, simple signal conversion systems,Spectral analysis, FFT -decimation in time algorithm, Decimation in Frequency algorithm, Different types of bioelectric signals and its basic characteristics.		
Module: 2	**IIR Digital Filter Design**	**8 Hours**
Impulse invariant method, Bilinear transformation method, Design of bilinear transformation method using Butterworth and Chebyshev techniques, Design of impulse invariant method using Butterworth and Chebyshev techniques		
Module: 3	**IIR Digital Filter Applications**	**7 Hours**
Warping and pre-warping effect, frequency transformation, Frequency domain filters- Introduction to adaptive filters – Removal of Artifacts in ECG, Maternal – Fetal ECG		
Module: 4	**FIR Digital Filter Design and Its Applications**	**8 Hours**
Characteristics of FIR filter, FIR filter design using windowing techniques- Rectangular, Hamming, Hanning and Blackmann windows, Time domain filters- synchronized averaging, moving average filters		
Module: 5	**Analysis of Biosignals**	**7 Hours**
P-wave detection, QRS complex detection-derivative based method, Pan Tompkins algorithm, Template matching method, Signal averaged ECG, Analysis of heart rate variability-time domain method and frequency domain methods, Synchronized averaging of PCG envelopes, Envelogram, analysis of PCG signal, EMG signal analysis.		
Module: 6	**Case studies in BSP**	**8 Hours**
ECG rhythm analysis, normal and ectopic ECG beats, analysis of exercise ECG, Analysis of respiration, spectral analysis of EEG signals, Case studies- in ECG and PCG, PCG and carotid pulse, ECG and Atrial Electrogram, Cardio respiratory interaction, EMG and Vibromyogram (VMG).		
	Total Lectures	**45 Hours**

Text Books	
1.	Rangaraj.M.Rangayyan, “Biomedical signal processing”, Wiley-IEEE press, 2nd Edition, 2015.
2.	S.Salivahnan, C.Gnanapriya, “Digital signal processing”, Tata McGraw-Hill, New Delhi, 2nd Edition, 2011.
Reference Books	
1.	John G. Proakis and DimitrisG.Manolakis, “Digital signal processing, algorithms and applications”, PHI of India Ltd., New Delhi, 4th Edition, 2007.
2.	Reddy D.C, “Biomedical signal processing: Principles and techniques”, Tata McGraw-Hill, New Delhi, 2nd Edition, 2005.
3.	Eugene N. Bruce, “Biomedical Signal Processing and Signal Modeling” 1st Edition, 2001.
4.	Anke Meyer-Baese, Fabian J. Theis, “Biomedical Signal Analysis: Contemporary Methods and Applications” The MIT Press Cambridge, 2010.
5.	Varun Bajaj, G.R.Sinha, Chinmay Chakraborty “Biomedical Signal Processing for Healthcare Applications” CRC Press Taylor & Francis Group 2022.
6.	Jose Maria Giron-Sierra “Digital Signal Processing with MATLAB Examples” Springer Nature Singapore, 2017.
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**MEDICAL ETHICS AND STANDARDS**	**L**	**T**	**P**	**C**
22BM2002		**2**	**0**	**0**	**2**
Course Objective:					
To impart knowledge on 1. Achieve familiarity with some basic ethical framework& understand how these ethical frameworks can be helpful in medical ethics.					

2. Know about the legal and ethical principles and application of these principles in health care settings
3. Gain knowledge about the medical standards followed in hospitals.

Course Outcomes:

After completion of course, students will be able to:

1. Identify the scope of medical ethics
2. Illustrate the concepts of ethical theories and moral principles for the healthcare providers.
3. Paraphrase the purpose of medical standards
4. Acquire knowledge about hospital accreditation standards
5. Summarize the importance of hospital safety standards
6. Recommend the suitable principles of medical equipment safety standards in hospitals

Module: 1	**Introduction to Medical Ethics**	**7 Hours**

Definition of Medical ethics, Medical Ethics Vs Bioethics, Scope of ethics in medicine, American medical Association code of ethics, CMA code of ethics- Fundamental Responsibilities, The Doctor and the Patient, The Doctorand the Profession, Professional Independence, The Doctor and Society.

Module: 2	**Ethical Theories and Moral Principles**	**8 Hours**

Theories-Deontology & Utilitarianism, Casuist theory, Virtue theory, The Right Theory. Principles Non-Maleficence, Beneficence, Autonomy, Veracity, Justice. Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research, Bioethical issues in Human Genetics & Reproductive Medicine

Module: 3	**Medical Standards**	**7 Hours**

Evolution of Medical Standards – IEEE 11073 - HL7 – DICOM – IRMA - LOINC – HIPPA –Electronics Patient Records – Healthcare Standard Organizations - Evidence Based Medicine

Module: 4	**Hospital Accreditation Standards**	**8 Hours**

Accreditation - JCI Accreditation & its Policies – JCAHO (Join Commission on Accreditation of Healthcare Organization) - JCIA (Joint Commission International Accreditation) , Patient centered standards, Healthcare Organization management standards

Module: 5	**Hospital Safety Standards**	**7 Hours**

Life Safety Standards- Protecting Occupants, Protecting the Hospital From Fire, Smoke, and Heat, Protecting Individuals From Fire and Smoke, Providing and Maintaining Fire Alarm Systems, Systems for Extinguishing Fires Environment of Care Standards-Minimizing EC Risks, Smoking Prohibitions, Managing Hazardous Material and Waste, Maintaining Fire Safety Equipment, Features, Testing, Maintaining, and Inspecting Medical Equipment.

Module: 6	**Medical Equipment Safety Standards**	**8 Hours**

General requirements for basic safety & essential performance of medical equipment. IEC 60601standards-Base Standard-general requirement of electrical medical devices, Collateral Standards EMC radiation protection &programmable medical device system, Particular Standards-type of medical device

	Total Lectures	**45 Hours**

Text Books

1.	Olinda Timms, “Biomedical Ethics”, Elsevier Pub, 2019
2.	JohnnaFisher, “Biomedical Ethics: A Canadian Focus.” Oxford University Press Canada 2009.
3.	Ben Mepham,”Bioethics-—An Introduction for the biosciences”,Oxford, 2008.
4.	Domiel A Vallero, “Biomedical Ethics for Engineers”, Elsevier Pub.1st edition, 2007.

Reference Books

1.	Joint Commission Accreditation Standards for Hospitals, 2nd edition 2003.
2.	NilsHoppe and JoseMiola, “Medical law and Medical Ethics”, Cambridge University Press 2014.
3.	R.S.Khandpur “Telemedicine Technology and Applications (mhealth, Telehealth and ehealth)”, PHI Learning Pvt.Ltd, Delhi 2017.
4.	Peter.A.Singer, A.M.Veins, “"The Cambridge Textbook of Bioethics”, Cambridge University Press, United Kingdom, 2008
5.	Mohan Bansal, “Medical informatics”, Tata Mc Graw Hill Publishing Ltd, 2003

6.	Richard Edmund Ashcroft, Angus Dawson, Heather Draper , John McMillan "Principles of Health Care Ethics" 2nd Edition, Wiley, 2015.
7.	Norbert Leitgeb "Safety of Electro-medical Devices Law – Risks – Opportunities" Springer Verlog, 2010.
8.	Physical Environment Online: A Guide to The Joint Commissions Safety Standards, HCPro, Inc.2010
9.	Robert M Veatch," Basics of Bio Ethics", Second Edition. Prentice- Hall,Inc, 2003
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**HOSPITAL MANAGEMENT**	**L**	**T**	**P**	**C**
22BM2003		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. The need and significance of Clinical Engineering and Health Policies.
2. The training strategies, human resources and hospital design.
3. The information technology and needs of medical records.

Course Outcomes:

At the end of this course, students will be able to:

1. Identify the need for clinical engineering in healthcare system.
2. Summarize the use of various health policies.
3. Demonstrate how high quality training is delivered for technical staff.
4. Evaluate the hospital designing and disposal of medical waste.
5. Debate the needs of hospital information system
6. Apply the use of computer and information technology in medical data

Module: 1	**Clinical Engineering**	**8 Hours**
Clinical engineering program, Educational responsibilities, Role to be performed by them in hospital, Staff structure in hospital. Classifications of hospital, scope of hospital.		
Module: 2	**National Health Policies**	**7 Hours**
National health policy, Five year plans, Health organization in country, state, Projects, schemes, Health education, Health insurance..		
Module: 3	**Training and Management of Human resources**	**8 Hours**
Difference between hospital and industrial organization, Levels of training, Steps of training, Developing Training program, Evaluation of training, Wages and salary, Employee appraisal method. Human resource management in hospital.		
Module: 4	**Hospital Design**	**7 Hours**
Pilot study, Hospital committee, selection of location, survey, hospital consultant, funds, policies, license, scope for expansion, commissioning the hospital, waste disposal.		
Module: 5	**Hospital Information System**	**8 Hours**
Structure, benefits, selection of software, modules in Hospital information system, Computer integration, case study: IoT applications.		
Module: 6	**Computers and Information Technology**	**7 Hours**
Computer application in ICU, Picture Archival System for Radiological images department, Clinical laboratory administration, Patient data and medical records, communication.		
	Total Lectures	**45 Hours**

Text Books

1.	R.C. Goyal, D.K. Sharma, "Hospital Administration and Human Resource Management", 6th edition, Prentice Hall of India, 2013.
2.	Joseph. F. Dyro, "Clinical Engineering Handbook", 1st Edition, 2004. eBook ISBN: 9780080476575.

Reference Books

1.	Antony Kelly, "Strategic Maintenance planning Elsevier/Butterworth-Heinemann, 2006. ISBN: 0750669950.

2.	Azzam Taktak (Editor), Paul Ganney (Editor), David Long, Clinical Engineering: A Handbook for Clinical and Biomedical Engineers 2nd Edition, 2019. ISBN: 0081026943.
3.	Webster, J.G. and Albert M. Cook, "Clinical Engineering Principles and Practices", Prentice HallInc. Englewood Cliffs, 1979.
4	Cesar A. Caceres and Albert Zara, "The Practice of Clinical Engineering", Academic Press, 1977.
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**MODELLING OF PHYSIOLOGICAL SYSTEMS**	**L**	**T**	**P**	**C**
22BM2004		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Basic ideas related to modeling.
2. Different modelling techniques of physiological systems.
3. Various regulatory systems of the human body.

Course Outcomes:

At the end of this course, students will be able to

1. Analyze the concepts of modelling
2. Differentiate the dynamics and static characteristics of physiological systems
3. Assemble the various concepts in modelling of circulatory system
4. Design and perform the modelling for physio thermo regulatory systems
5. Create various models for human filtration system
6. Evaluate the mass-balance concept for biological system

Module: 1	**Basics of physiological control systems**	**7 Hours**

Systems Analysis, examples of physiological control systems, differences between engineering and physiological control systems. Generalized system properties, mathematical approach, electrical analogs, linear models, lung mechanics, muscle mechanics, distributed parameter versus lumped parameter models

Module: 2	**Analysis of Physiological Models**	**8 Hours**

Static and dynamic analysis of physiological systems: regulation of cardiac output, blood glucose regulation, chemical regulation of ventilation, electrical model of neural control mechanism

Module: 3	**Modelling of Circulatory System**	**8 Hours**

Circulatory System: Physical, chemical and rheological properties of blood, problems associated with extra corporeal blood flow, dynamics of circulatory system.

Module: 4	**Modelling of Regulatory System**	**8 Hours**

Thermal Regulatory System: Parameters involved, Control system model etc. Biochemistry of digestion, types of heat loss from body, models of heat transfer between subsystem of human body like skin core, etc. and systems like within body, body, environment, etc.

Module: 5	**Modelling of Filtration In Human Body**	**7 Hours**

Ultra-Filtration System: Transport through cells and tubules, diffusion, facilitated diffusion and active transport, methods of waste removal, counter current model of urine formation in nephron, Modeling Henle's loop.

Module: 6	**Modelling and Regulation of Respiration**	**7 Hours**

Respiratory System: Modelling oxygen uptake by RBC and pulmonary capillaries, Mass balancing by lungs, Gas transport mechanisms of lungs, oxygen and carbon dioxide transport in blood and tissues.

	Total Lectures	**45 Hours**

Text Books

1.	Physiological Control Systems: Analysis , Simulation and Estimation -IEEE Press Series on Biomedical Engineering, 2018.
2.	David O Cooney, Biomedical Engineering Principles, Marcel Decker Pub. Co 2002.

Reference Books

1.	John Enderly, Joseph Bronzino. Introduction to Biomedical Engineering. Third Edition, Academic Press Series in Biomedical Engineering, 2012
2.	Willian B.Blesser, "A System Approach to Biomedicine", McGraw Hill Book Co., New York, 2009
3.	Manfreo Clynes and John H.Milsum, "Biomedical Engineering System", McGraw Hill and Co., New York , 2001
4.	Richard Skalak and ShuChien, "Hand Book of Biomedical Engineering", McGraw Hill and Co. New York, 1998
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**BIOMEDICAL INSTRUMENTATION LABORATORY**	**L**	**T**	**P**	**C**
22BM2005		**0**	**0**	**3**	**1.5**

Course Objective:

To impart knowledge on

1. Measurements and monitoring of physiological parameters.
2. Recording of bio signals.
3. Analysis of various physiological parameters

Course Outcomes:

At the end of this course, students will be able to:

1. Illustrate the working procedure of medical instruments.
2. Identify the suitability of diagnostic and therapeutic equipment for specific applications.
3. Analyze the performance of various biomedical equipment and infer their safety aspects.
4. Apply appropriate measurement techniques.
5. Design portable instruments capable of recording bio signals.
6. Evaluate the performance of medical instruments.

List of Experiments:

1. Real time acquisition of ECG and its analysis
2. Analysis of EEG signal using 10-20 electrode system
3. EMG signal acquisition and Analysis
4. Audiometer
5. Dialyzer and Heart lung machine
6. Spirometer
7. TENS
8. Real time patient monitoring system
9. Defibrillator – Study
10. Calculation of flow rate using Infusion and Syringe Pump
11. Analysis of multi physiological parameters using Polyrite
12. Pacemaker Simulator
13. Electrical Safety Analyzer

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

Course code	**BIOMATERIALS AND ARTIFICIAL ORGANS**	**L**	**T**	**P**	**C**
22BM2006		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Learn the Concepts, Classification, Properties, and Structural variations in biomaterials.
2. Understand the testing of implants and cell-interfacing materials.
3. Know the applications of biomaterials in Artificial Organs and their development.

Course Outcomes:

At the end of the course, the student will be able to:

1. Identify the structural variations in biomaterials.
2. Determine the various properties of biomaterials.
3. Analyse the methods for testing implants
4. Recall the cell-biomaterial interactions for constructing artificial organs.
5. Assess the Interfacing materials and ethical implications.
6. Apply the biomaterials in healthcare sectors.

Module: 1	**Structural Variations in Biomaterials**	**7 Hours**

Definition, classification and properties of bio-materials, Surface, bulk, mechanical and biological. Types of biomaterials; Biological response to biomaterials; Crystal structure of metals; Crystal structure of ceramics; Carbon based materials; General structure of polymers; Synthesis of polymers. Bending properties; Time dependent properties – creep properties of polymers; Influence of porosity and the degradation of mechanical properties; Introduction to fatigue.

Module: 2	**Properties of Biomaterials**	**8 Hours**

Wound-healing and blood compatibility. Surface modification of biomaterials – plasma treatment, radiation grafting, self-assembled monolayers (SAMs), Langmuir – Blogett films and covalent biological coatings; Protein properties that affect biomaterial surface interaction; biomaterial surface interaction that affect interactions with proteins; Protein adsorption kinetics; DLVO model for cell adhesion; Assays to determine the effects of cell-material interactions – agar diffusion assay, adhesion assays and migration assays.

Module: 3	**Biocompatibility**	**8 Hours**

Biocompatibility–Toxicology, Biocompatibility, Mechanical and Performance Requirements, Regulation. Biomaterials associated infection. Cytocompatibility evaluation laboratory, Tissue compatibility evaluation laboratory, Hemocompatibility evaluation laboratory, Sterility evaluation laboratory, Histopathology evaluation laboratory, Physiochemical evaluation laboratory.

Module: 4	**Implantation**	**8 Hours**

In vitro assays for inflammatory response due to biomaterial implantation; Fibrous encapsulation of healing process; Ideal features of soft tissue implants; Metallic Implant materials, Polymeric Implant materials, Tissue replacement materials-soft, hard and blood interfacing materials.

Module: 5	**Oxygenators &Audiometer**	**7 Hours**

Heart, heart valves, oxygenators - bubble, film oxygenators and membrane oxygenators. Gas flow rate and area for membrane oxygenators -air conduction, bone conduction, masking, functional diagram of an audiometer.

Module: 6	**Dialysers& Lung Devices**	**7 Hours**

Dialysers - Haemodialysis: flat plate type, coil type and hollow fiber. Haemodialysis Machine, Portable kidney machine - Brief of lungs gaseous exchange / transport, artificial heart - Lung devices,

	Total Lectures	**45 Hours**

Text Books

1. John B.Park Joseph D. Bronzino, “Biomaterials - Principles and Applications” CRC Press, 4th edition, 2003.

Reference Books

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons. An Introduction to Materials in Medicine. Academic Press. USA, 2012.
2. L Hench J. Jones, “Biomaterials, Artificial Organs and Tissue Engineering”, Woodhead Publishing, 2005.
3. Michael Lysaght and Thomas Webster, “Biomaterials for Artificial Organs”, Woodhead Publishing series , 2010
4. Rajendran V. and Marikani A., Materials Science, Tata McGraw Hill Pub. Company Ltd., New Delhi, 2004

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

Course code	CONTROL SYSTEM FOR BIOMEDICAL ENGINEERS	L	T	P	C
22BM2007		3	0	0	3

Course Objective:

To impart knowledge on
1. Bio control systems modelling technique.
2. Time response analysis and frequency response analysis.
3. Analyze biological control systems.

Course Outcomes:

At the end of this course, students will be able to:
1. Represent the system in various forms.
2. Interpret the response of the system in time domain.
3. Analyze the frequency response of any system
4. Examine the stability of the system.
5. Compute the mathematical model of physiological systems.
6. Summarize the features of physiological system.

Module: 1	**Engineering Control Systems**	**7 Hours**
Basic structure of control system, Positive and Negative Feedback, transfer functions, modeling of electrical systems, block diagram and signal flow graph representation of systems- MatLab Programs		
Module: 2	**Time Domain Analysis**	**8 Hours**
Introduction to simulation, Step response of first order and second order systems, determination of time domain specifications of first and second order systems. Definition of steady state error constants and its computation- MatLab Programs		
Module: 3	**Frequency Domain Analysis**	**8 Hours**
Frequency response, determination of gain margin and phase margin using Bode plot, use of Nichol's chart to compute resonant frequency and band width- MatLab Programs		
Module: 4	**Stability Analysis**	**8 Hours**
Definition of stability, Routh-Hurwitz criteria of stability, construction of root locus, Nyquist stability criterion, Nyquist plot and determination of closed loop stability- MatLab Programs		
Module: 5	**Physiological Control Systems**	**7 Hours**
Difference between engineering and physiological control systems, generalized system properties, models with combination of system elements. Physiological system modeling, linear model of respiratory mechanics.		
Module: 6	**Modelling of Physiological systems**	**7 Hours**
Mathematical Model of chemical regulation of ventilation, linear model of muscle mechanics, model of regulation of cardiac output, model of Neuromuscular reflex motion.		
	Total Lectures	**45 Hours**

Text Books

1. Michael. C. K. Khoo, "Physiological control systems- Analysis, Simulation and Estimation", IEEE press, Prentice –Hall of India, 2018
2. Benjamin C. Kuo, "Automatic control systems" McGraw-Hill Education, 10th edition 2017

Reference Books

1. M. Gopal "Control Systems Principles and design", Tata McGraw Hill ,2002, 2009
2. John Enderle, Susan Blanchard, Joseph Bronzino, "Introduction to Biomedical Engineering", Third Edition, Academic Press, 2005.
3. Richard C. Dorf, Robert H. Bishop," Modern control systems", Pearson, 2011.

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

Course code	INTRODUCTION TO BIOMEDICAL ENGINEERING	L	T	P	C
22BM2008		3	0	0	3

Course Objective:

To impart knowledge on

1. The field of biomedical engineering and role of biomedical engineers in society.
2. The principles of various diagnostic, therapeutic equipment.
3. The some basic ethical framework and medical standards to be followed in hospitals.

Course Outcomes:

The Student will be able to

1. Interpret the role of biomedical engineering in society
2. Demonstrate the principles of various diagnostic devices.
3. Identify the various techniques used in diagnosis though imaging.
4. Describe the working principles of various therapeutic and assist devices.
5. Outline device specific safety goals and standards.
6. Illustrate the concepts of ethical theories and moral principles for the health professions.

Module: 1	Introduction	7 Hours

Historical Perspective-Evolution of modern healthcare system-Modern Healthcare system-Role of Biomedical engineers in various domain -Recent advances in Biomedical Engineering-Professional status of biomedical engineering-Professional Societies for Biomedical Engineering.

Module: 2	Fundamentals of Medical Instrumentation	8 Hours

Anatomy and Physiology – Sources of biomedical signals- basic medical instrumentation system-Performance requirements –Intelligent Medical Instrumentation Systems - PC based Medical Instruments - General constraints in design of medical instruments.

Module: 3	Diagnostic Imaging	8 Hours

X-rays, Nuclear Medical Imaging-Positron Emission Tomography-Magnetic Resonance Imaging Scanners-Diagnostic Ultrasound- Thermal imaging systems.

Module: 4	Introduction to Biomedical Equipment	8 Hours

ECG – EEG - Cardiac Pacemakers - Cardiac Defibrillators – Haemodialysis Machines-Artificial Kidney-Dialyzers- Ventilators-Humidifiers, Nebulizers and Aspirators- Anaesthesia Machine.

Module: 5	Medical Safety Standards	7 Hours

Medical standards and regulations – Institutional Review Boards – Good Laboratory Practices -Good Manufacturing Practices -Human factors.

Module: 6	Ethical Practices in Health Care	7 Hours

Morality and Ethics-A Definition of terms,Human Experimentation-Ethical issues in feasibility studies, Ethical issues in emergency use, Ethical issues in treatment use-Codes of ethics for bio engineers.

	Total Lectures	45 Hours

Text Books

1. Enderle, John D, Bronzino, Joseph D, Blanchard, Susan M- Introduction to Biomedical Engineering-Elsevier Inc 3rdedition,2012
2. R. S. Khandpur, Handbook of Biomedical Instrumentation, McGraw-Hill Publishing Company Limited 3rd edition , 2014.

Reference Books

1. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurement, Prentice Hall of India, New Delhi,2nd edition, 2011.
2. John G Webster, Medical Instrumentation: Application and Design, John Wiley and sons, New York,4thedition,2010.
3. Joseph. J Carr, John M Brown, Introduction to Biomedical Equipment Technology, John Wiley& Sons, New York,4th edition, 2001.
4. Norbert Leitgeb "Safety of Electro-medical Devices –Risks Opportunities" Springer/Wein, 2010.
5. Michael Domach-"Introduction to Biomedical Engineering", Pearson, 2004.
6. Daniel A Vallero, Biomedical ethics for Engineers, Elsevier publication, 1st edition,2011

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

Course code	**FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY**	**L**	**T**	**P**	**C**
22BM2009		**0**	**0**	**2**	**1**

Course Objective:

The student should be made to:

1. To impart practical knowledge on basics of Electrical Engineering
2. To impart practical knowledge on basics of Electronics Engineering
3. To impart knowledge on testing of electrical and electronics components

Course Outcomes:

At the end of this course, students will be able to

1. Test the electric circuit components
2. Study of electronic measuring instruments
3. Perform domestic wiring
4. Analyse the characteristics of basic diodes.
5. Test the electrical equipment
6. Design simple equivalent circuit.

LIST OF EXPERIMENTS

1. Testing of active and passive components
2. Study of electrical safety, protection devices, gadgets.
3. Domestic wiring
4. Verification of KVL, KCL for DC circuits
5. Use of tester and test lamp to ascertain the healthy status of mains
6. Testing of electric equipment, short circuit, open circuit
7. Test the working of different types of rotary switches, limit switches
8. Test the working of different types of relays, contactor
9. Demonstration of fuse and MCB separately by creating a fault.
10. Characteristics of PN diode and Zener diode.
11. Zener diode as a voltage regulator.
12. Characteristics of halfwave and full wave rectifier.
13. Regulation of single phase transformer

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

Course code	**EMBEDDED SYSTEM LABORATORY FOR BIOMEDICAL APPLICATIONS**	**L**	**T**	**P**	**C**
22BM2010		**0**	**0**	**3**	**1.5**

Course Objective:

To impart knowledge on

1. The integration of hardware circuits with software
2. The concepts of programming in an IDE and download it into a processor
3. The practical aspects of data acquisition and analysis

Course Outcomes:

The Student will be able to

1. Design interfacing circuits to acquire real time data and process it using software
2. Develop real time embedded systems for biomedical applications
3. Apply communication protocols for data transmission
4. Create an embedded C program for various I/O interfacing

5. Implement timer concept for providing real time delay
6. Integrate the sensor with microcontroller for embedded system design

List of Experiments:

8085 Processors

1. Arithmetic Operations: Addition of 8 Bit Numbers Using 8085
2. Arithmetic Operations: Subtraction of 8 Bit Numbers Using 8085
3. Multiplication and Division of Two Numbers Using 8085
4. Sorting of Numbers in an Array
5. Block Transfer Using 8085

Atmega 328P Microcontroller

6. Activation of LED
7. Temperature Sensor Interfacing
8. Distance Measurement Using Ultrasonic Sensor
9. ECG sensor Interfacing
10. PWM Signal Generation
11. DC Motor Interfacing
12. Stepper Motor Control

Keil µVision : 8051 & ARM Microcontroller

13. Study the concept of Timer
14. LED Display
15. Relay Control
16. Seven Segment Display Interfacing

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

Course code	SIGNAL CONDITIONING CIRCUITS	L	T	P	C
22BM2011		3	0	0	3

Course Objective:

To impart knowledge on

1. Biopotential measurement techniques
2. Bioelectric amplifiers, filters and isolation circuits
3. Application of signal conditioning in biomedical field

Course Outcomes:

After completion of course, students will be able to:

1. Identify the origin and characteristics of various biosignals and its acquisition.
2. Apply the signal conditioning circuits using operational amplifiers for biomedical field.
3. Analyze and design bio filters and isolation circuits used in medical signal conditioning.
4. Paraphrase the elements of data acquisition system with analog and digital circuits
5. Create the various circuits for designing medical equipments using different ICs
6. Recommend the various safety standards and circuit design for biomedical applications.

Module: 1	**Biopotential Measurement**	**7 Hours**

Biopotentials and bioelectric currents, Nature of Bio Electricity: Bioelectric Currents, Nernst Potential, Diffusion Potential, Action potential, Detection of Bio electric events, bio-electrode and electrode-skin interface, Need for bioamplifiers and biosignal Conditioning.

Module: 2	**Operational Amplifiers and Its Biomedical Applications**	**8 Hours**

Operational Amplifiers Basic opamps parameters, Ideal and practical opamp, Op amp ICs with datasheet, application of opamp for biosignals conditioning - Adder, subtractor, analog integrator, differentiator, preamplifiers, Transimpedance amplifier.

Module: 3	**Basic Filters and Isolation Circuits**	**8 Hours**

Fundamentals of filtering, Active filters – Low pass filter, High pass filter, Band pass filter, Band stop filter, First order and second order active filters, Instrumentation amplifier, Types of isolation amplifiers and optocouplers.

Module: 4	**Biosignal Data Acquisition Systems and Circuit Elements**	**7 Hours**
Data Acquisition system, Aliasing and sampling, Analog to Digital, Digital to Analog conversion, Comparators, Comparator applications, Multivibrators, 555 timers, Astable and monostable, Pacemaker circuits, Practical applications.		
Module: 5	**Special Analog Circuits**	**7 Hours**
Special analog circuits and systems used in biomedical transmission, Phase Detectors-Analog and Digital, Voltage Controlled Oscillators, Various VCO ICS, Phase locked loops.		
Module: 6	**Circuit Design and Applications**	**8 Hours**
Study of software for designing circuit, PCB fabrication, circuit design for biomedical applications, Electrical Interface problems and Safety Standards in Bio Potential Measurements, Advanced biomedical instrumentation systems.		
	Total Lectures	**45 Hours**

Text Books	
1.	Robert B. Northrop, "Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation", CRC Press, II Edition, New York, 2017
2.	Sergio Franco, "Design with Operational Amplifier and Analog Integrated Circuits", TMH, 3rd Edition, 2009.
Reference Books	
1.	Myer Kutz, "Biomedical Engineering and Design Handbook", II Edition, Volume 1, McGraw Hill Professional,2011
2.	Robert F. Coughlin, Frederick F. Driscoll, "Operational Amplifiers & Linear Integrated Circuits", Prentice-Hall, 6th Edition,2004.
3.	Milman&Hallkias, "Integrated Electronics-Analog and Digital Circuit", McGraw Hill, II Edition,2011
4.	Roy Choudhury and Shail Jain, "Linear integrated circuits", Wiley Eastern Ltd,2002
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**MICROPROCESSOR AND MICROCONTROLLER**	**L**	**T**	**P**	**C**
22BM2012		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. The basic knowledge about architecture of processor & controller.
2. The interfaces in processors and instruction sets in controller.
3. The necessity of controller in real time applications.

Course Outcomes:

After completion of course, students will be able to:

1. Summarize the microprocessor organization and its evolution.
2. Interpret the various instruction sets and programming language of 8085.
3. Analyze their knowledge in designing a system using 8051
4. Compare controller / processor architecture and features.
5. Interface the peripheral devices with controller.
6. Simulate the real time system using integrated development environment.

Module: 1	**Introduction to Microprocessor**	**7 Hours**
Introduction about digital computer, System architecture- Von Neumann and Harvard architecture, CISC and RISC processor, Fundamentals of Microprocessor, Hardware Architecture, Functional building blocks of 8085 microprocessor, 8085 pin configurations and functions, Definition of embedded system and its characteristics.		
Module: 2	**Instruction set and assembly language programming of 8085**	**8 Hours**
Instruction formats, addressing modes, instruction set- Data transfer, data manipulation & control instructions, Assembly language format, Simple programs.		
Module: 3	**8051 microcontrollers**	**8 Hours**

8051 Architecture, Internal Block Diagram - CPU - ALU - address - data and control bus - working registers - SFRs - Clock and RESET circuits - Stack and Stack Pointer - Program Counter - I/O ports - Memory Structures - Data and Program Memory - Timing diagrams and Execution Cycles.		
Module: 4	**Programming 8051 Microcontroller**	**7 Hours**
Addressing modes: Introduction, Immediate addressing - Register addressing - Direct addressing - Indirect addressing - Relative addressing - Indexed addressing - Bit inherent addressing - bit direct addressing. 8051 Instruction set - Instruction timings. Data transfer instructions - Arithmetic instructions - Logical instructions - Branch instructions - Subroutine instructions - Bit manipulation instruction. Assembly language programs - C language programs. Assemblers and compilers. Programming and debugging tools, Study of Integrated development environment, Software installation and downloading procedure.		
Module: 5	**Interfacing of peripheral devices**	**7 Hours**
Memory and I/O expansion buses - control signals - memory wait states. Interfacing of peripheral devices, General Purpose I/O - ADC - DAC - timers - counters, Synchronous and Asynchronous Communication, RS232 - SPI - I2C		
Module: 6	**Applications**	**8 Hours**
Port access, LED interfacing, Switch and Keyboard interfacing, Timer programming, Stepper motor control - DC Motor interfacing - Sensor interfacing.		
	Total Lectures	**45 Hours**
Text Books		
1.	M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, " The8051 Microcontroller and Embedded Systems: Using Assembly and C" ,Pearson Education, 2007.	
2.	R. S. Gaonkar, ", Microprocessor Architecture: Programming and Applications with the 8085" , Penram International Publishing, 2002	
Reference Books		
1.	K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning,2005.	
2.	R. Kamal, "Embedded System", McGraw Hill Education,2009.	
3.	D. A. Patterson and J. H. Hennessy, "Computer Organization and Design: The Hardware/Software interface", Morgan Kaufman Publishers, 2013.	
Recommended by Board of Studies		
Approved by Academic Council	24th September 2022	

Course code	**ELECTRON DEVICES AND CIRCUITS**	**L**	**T**	**P**	**C**
22BM2013		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. The basic introduction and an understanding of Semiconductor devices.
2. The transistor and biasing circuits.
3. The design of amplifier and oscillator circuits.

Course Outcomes:

After completion of course, students will be able to:

1. Paraphrase the basic properties of solid state devices like diode, transistor and FET.
2. Identify and differentiate rectifiers, amplifiers and oscillators.
3. Analyze the amplitude and frequency response of general amplifier circuits.
4. Sketch the types of power amplifiers and their transfer characteristics.
5. Classify the power amplifiers to meet certain specifications.
6. Distinguish between amplifiers and oscillators.

Module: 1	**Theory of Semiconductor**	**7 Hours**
Energy band structure of conductors, insulators and semiconductors – Comparison of Germanium, Silicon and gallium arsenide – Electron hole generation and recombination –Intrinsic and extrinsic semiconductors – Conductivity – Temperature dependence – Hall effect – drift and diffusion in semiconductors.		
Module: 2	**Semiconductor Diodes**	**8 Hours**

PN junction -depletion region – barrier potential – diode equation – Forward and Reverse characteristics. Zener diodes – Schotky Barrier Diode – Tunnel diodes – DIAC – TRIAC – Photodiodes-Photo transistors – LCD- LED-Gunn diodes -Varactor diode. Introduction, Load –line Analysis, Series Diode configuration, Parallel and series-parallel configurations, Practical Applications of diode circuits		
Module: 3	**BJT**	**8 Hours**
Introduction, Transistor construction, Operation, Common-base configuration & characteristics, Common-Emitter configuration & characteristics, Common collector configuration & characteristics, Limits of operation, Emitter-bias configuration, Voltage divider bias configuration, Emitter follower configuration, Design operations, Practical Applications, study of Transistor data sheet		
Module: 4	**Rectifiers and Filters**	**7 Hours**
PN Junction as Rectifiers, Half wave rectifier – Full wave rectifier – ripple factors – DC and AC components in rectifiers. Bridge rectifiers, Full wave rectifier with Capacitor and inductor filters. Voltage regulators-Transistorized series pass regulator, Practical Applications.		
Module: 5	**Amplifiers**	**7 Hours**
Single stage- RC coupled amplifiers- Power amplifiers: Class A, AB, B power amplifiers, Push Pull amplifiers- Feedback amplifier – Differential amplifier, Practical Applications.		
Module: 6	**Oscillators**	**8 Hours**
RC Phase shift-Hartley Oscillator-Crystal Oscillator, Colpitts Oscillator – single tuned amplifier - Double tuned amplifier, Practical Applications.		
	Total Lectures	**45 Hours**
Text Books		
1.	Robert Boylestad and Louis Nashelsky, “Electronic Devices & Circuit Theory”, 9th Pearson Education Edition, 2016.	
2.	Millman &Halkias, "Electronic Devices & Circuits", Tata McGraw Hill, 3rd Edition, 2013.	
Reference Books		
1.	V.K.Metha,“Principles of Electronics”, Chand Publications,2015.	
2.	Malvino.A P, “Electronic Principles”, McGraw Hill International, 7th Edition 2016.	
3.	David .A .Bell, "Electronic Devices & Circuits ", Oxford University Press, 5th Edition 2010.	
Recommended by Board of Studies		
Approved by Academic Council	24th September 2022	

Course code	**Signals and Systems for Biomedical Engineers**	**L**	**T**	**P**	**C**
22BM2014		**3**	**0**	**0**	**3**
Course Objective:					
To impart knowledge on 1. The basic concepts of bio signals and its importance. 2. The time and frequency domain techniques. 3. The analysis of bio signals.					
Course Outcomes:					
At the end of this course, students will be able to: 1. Identify the nature of biomedical signals. 2. Analyze the spectral characteristics of continuous-time periodic and aperiodic signals using Fourier analysis. 3. Classify systems based on their properties and determine the response of LTI system using Laplace transform. 4. Apply Laplace transform and Z- transform to analyze continuous-time and discrete-time signals and systems. 5. Summarize system properties based on impulse response by FIR, IIR filtering techniques. 6. Demonstrate mathematical tools in characterization of physiological system.					
Module: 1	**Introduction to Signals**				**7 Hours**

Basics of Biomedical Signals and systems- representation –Sampling and quantization-Periodic, aperiodic and transient, stationary and non- stationary signals. Two- dimensional signals-Images. Linear and Non Linear systems-Linear System theory- Stability of systems		
Module: 2	**Fourier Transform**	**8 Hours**
Time and frequency -domain signal representatives, Fourier series analysis, Symmetry, Frequency and Complex representation, The continuous Fourier transform, The discrete Fourier series and discrete Fourier transform, The Fourier transform and power spectrum: Implications and applications. Spectral averaging, Stationarity and time-frequency Analysis		
Module: 3	**Joint Time-Frequency Analysis of Biomedical Signals**	**7 Hours**
The Short- Term Fourier Transform. The Gabor and Adaptive Gabor Transforms, The Wigner-Ville and Pseudo-Wigner Transforms, Cohen's General Class of JTF Distributions JTFA Using Wavelets, Applications of JTFA to Physiological Signals		
Module: 4	**Linear Systems is the Frequency Domain**	**8 Hours**
The transfer function. The response of system elements to sinusoidal inputs-phasor analysis. The transfer function spectral plots. Linear systems analysis in the complex frequency domain: The Laplace transform and the Analysis of Transients - The Laplace transform, The inverse Laplace transform, Laplace analysis - the Laplace transfer function, Nonzero initial conditions- initial and final value theorems, The Laplace domain and the frequency domain, Application of Laplace Transform		
Module: 5	**Linear Systems In The Time Domain**	**7 Hours**
Convolution and simulation, Linear system analysis: Applications, Linear filters, filter types, Filter attenuation slope-filter order, Filter initial sharpness, Basics of Z Transform. The digital transfer function and the Z-transform, The digital transfer function		
Module: 6	**Biomedical Signals And Systems Analysis**	**8 Hours**
Concurrent, coupled and correlated processes, filtering for removal of artifacts, event detection, wave shape and wave form complexity, analysis of non-stationary signals. Mathematical Tools Used in the characterization of Physiological Systems. Complex systems in biology and medicine - properties and examples		
	Total Lectures	**45 Hours**

Text Books	
1.	JohnSemmlow,"SignalsandSystemsforBioengineers"ElsevierIndiaPrivateLimited,2012.
2.	RangarajM.Rangayyan,BiomedicalSignalAnalysis:ACase-StudyApproach,2nd,Wiley,2012
3	RobertB.Northrop,SignalsandSystemsAnalysisinBiomedicalEngineering,2ndEdition,CRCPress,Taylor& Francis Group,2012
Reference Books	
1	SureshR.Devasahayam,"Signals and Systems in Biomedical Engineering: Signal Processing and Physiological Systems Modeling", Academic/PlenumPublishers,2000.
2	Lathi. B. P, "Linear Systems and Signals", Oxford University Press,2nd Edition,2005.
3	J. Proakis and D. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", 4th Edition, Prentice-Hall, 2006.
4	LiTan,"Digital Signal Processing: Fundamentals and Applications",Elsevier,2008.
5	Mrinal Mandal, Amir Asif, "Continuous and Discrete Time Signals and Systems", Cambridge University Press, 2008
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**Medical Imaging Techniques**	**L**	**T**	**P**	**C**
22BM2015		**3**	**0**	**0**	**3**
Course Objective:					
To impart knowledge on 1. The scattered radiations and different types of radio diagnostic unit 2. The techniques to visualize opaque, transparent organs. 3. The special techniques adopted to visualize different sections of any organ.					

Course Outcomes:

At the end of this course, students will be able to

1. Outline the various medical imaging techniques.
2. Paraphrase the principle of specific medical imaging techniques.
3. Interpret the imaging outputs.
4. Identify the suitable medical imaging techniques for specific pathology.
5. Sketch new ideas to solve certain issues in medical imaging.
6. Justify the impact of medical imaging system for diagnosis

Module: 1	**Medical X-Ray Equipment and Digital Imaging**	**8 Hours**

Nature of X-Rays - X- ray Absorption - Tissue Contrast . X-Ray Equipment – X- ray Tube, collimator , Bucky Grid, power supply. Digital Radiography - discrete digital detectors, storage phosphor and film Scanning. X-Ray Image intensifier tubes –Dual Imaging-Fluoroscopy – Digital Fluoroscopy. Angiography, Cine angiography. Digital Subtraction Angiography. Mammography

Module: 2	**CT Imaging**	**7 Hours**

Principles of Tomography - First to Fifth generation scanners – Image reconstruction Technique - Back projection and Iterative method. Spiral CT Scanning - Ultra fast CT Scanners - X-Ray Sources – Collimation – X-Ray Detectors – Viewing System

Module: 3	**Magnetic Resonance Imaging (MRI)**	**7 Hours**

Fundamentals of Magnetic Resonance -Principles of MRI pulse sequence – image acquisition and reconstruction techniques – MRI instrumentation magnetic gradient system RF coils – receiver system functional MRI Rotat ion and Precession – induct ion of a magnetic resonance signal – bulk Magnetization – Relaxation Processes T1 and T2. – MRI artifacts- Various types of pulse sequences for fast acquisition of imaging, NMR spectroscopy - Application of MRI

Module: 4	**Ultrasonic and Infrared Imaging**	**8 Hours**

Production of ultrasound – properties and principles of image formation, capture and display – principles of A-mode, B-mode and M-mode display – Doppler ultra sound and color flow mapping – applications of diagnostic ultra sound. Physics of thermography – imaging systems – pyroelectric Videocon camera clinical thermography – liquid crystal thermography- Microwave Imaging- Properties- Applications

Module: 5	**PET and SPECT Imaging**	**7 Hours**

Introduction to emission tomography, basic physics of radioisotope imaging Compton cameras for nuclear imaging, pet scanner principles, SPECT, computer techniques in fast acquisition analytic image reconstruction techniques, attenuation, scatter compensation in SPET spatial compensation in SPECT

Module: 6	**Other Imaging Techniques**	**8 Hours**

Optical coherence tomography (OCT): Introduction and its medical applications - Advances in image resolutions-Magnetoencephalography- Applications- POCUS- Point of care Ultrasonography-Speed in Picture Archiving and Communication Systems (PACS) in medical imaging, Safety aspects in Radio diagnosis

	Total Lectures	**45 Hours**

Text Books

1. Gopal B Saha , “Physics and Radiobiology of Nuclear Medicine”, Third Edition, Springer 2013
2. Myer Kutz, “Standard handbook of Biomedical Engineering and Design,” Mc Graw Hill 2003
3. John Ball and Tony Price Chesney’s, “Radiographic Imaging”. Blackwell Science Limited, U.K. 2006.
4. Farr, “The Physics of Medical Imaging”, Adem Hilger, Bristol & Philadelphia, 2007.

Reference Books

1. M. Analoui, J.D. Bronzino, D.R.Peterson, “Medical Imaging: Principles and Practices”, CRC Press, 2012.
2. S. Webb, “Physics of Medical Imaging”, Taylor & Francis, 2010.
3. T. Farncombe, K. Iniewski, “Medical Imaging: Technology & Applications”, CRC Press, 2013.
4. J.S. Benseler, “The Radiology Handbook: A pocket guide to medical imaging”, Ohio University Press, 2006.
5. R.R.Carlton, A.M.Adler, “Principles of Radiographic Imaging: An Art and a Science”, Delmar Cengage Learning; Fifth Eddition, 2012.

6. N.B.Smith, A. Webb, "Introduction to Medical Imaging Physics, Engineering and Clinical Applications", CRC Press, 2010.	
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**ELECTRICAL CIRCUIT ANALYSIS**	**L**	**T**	**P**	**C**
22BM2016		**3**	**1**	**0**	**4**

Course Objective:

To impart knowledge on

1. electric circuits and network to students
2. To develop the ability to analyse the various types of electrical circuits and networks in students.
3. To make the students understand the various network theorems and its usage in analysing the circuits and networks.

Course Outcomes:

At the end of the course the students will be able to

1. Comprehend and design ac/dc circuits.
2. Develop and understand ac/dc circuits.
3. Evaluate ac/dc circuits.
4. Interpret electrical circuits.
5. Apply circuit theorems in real time.
6. Analyze with network theorems on DC circuits

Module: 1	**MESH AND NODAL ANALYSIS**	**7 Hours**
Analysis with dependent and independent voltage source and current source, Current Division, Voltage Division, Node Analysis, Mesh Analysis, Concept of Duality and dual networks		
Module: 2	**NETWORK THEOREMS**	**10 Hours**
Superposition Theorem, Thevenin Theorem, Norton Theorem, Maximum Power Transfer Theorem Reciprocity Theorem, Compensation Theorem, Tellegen's Theorem, Millman's Theorem, Star Delta Transformation,		
Module: 3	**SOLUTION OF FIRST ORDER AND SECOND ORDER NETWORKS**	**8 Hours**
Series RL, RC Network, Series RLC Network, Parallel RL, RC Network Parallel RLC Network, Initial and Final Conditions, Forced and Free Response, Time constants, steady state and transient responses,,Complex Impedance		
Module: 4	**SINUSOIDAL STEADY STATE ANALYSIS**	**11 Hours**
Representation of sine function as rotating phasor, phasor diagrams , Impedances and Admittances , AC Circuit Analysis, Effective or RMS Value, Average Power and Complex Power, Three Phase Circuits Coupled Circuits, Dot Convention in coupled circuits Ideal Transformer		
Module: 5	**ELECTRIC CIRCUIT ANALYSIS USING LAPLACE TRANSFORM**	**9 Hours**
Review of Laplace Transform, Analysis of Electric Circuits using Laplace Transform for standard inputs, Convolution Integral, Inverse Laplace Transform, Transformed Network with initial condition, Transfer Function Representation, Poles and Zeros, Frequency Response, Series and parallel resonance		
Module: 6	**TWO PORT NETWORKS AND NETWORK FUNCTIONS**	**15 Hours**
Two port networks, Terminal Pairs, Relationship of two port variables, Impedance Parameters, Admittance Parameters, Transmission Parameters, Hybrid Parameters, Interconnection of two port networks, Image Parameters		
	Total Lectures	**45 Hours**

Text Books

1. William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, "Engineering Circuits Analysis", Tata McGraw Hill Publishing Company Limited, New Delhi, 8 th Edition, 2013.

2. Sudhakar A., Shyammohan S Palli, "Circuits & Networks: Analysis and Synthesis", Tata McGraw Hill Publishing Company Limited, New Delhi, 4th Edition, 2010.

Reference Books

1. Joseph A. Edminister, Mahmood Nahri, "Electric Circuits", Schaum's series, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2010.
2. Van Valkenburg M.E., "Network Analysis", Pearson Education India, 3rd Edition, 2015.
3. Roy Choudhuri D., "Networks and Systems", New Age International Private Limited, 2nd Edition,2013.
4. Alexander C.K., SadikuM.N.O., "Fundamentals of Electric Circuits", McGraw Hill Education Series, New York, 5thEdition, 2013
5. Murthy K.V.V., Kamath M.S., "Basic Circuit Analysis", Jaico Publications, 1st Edition, 2002.
6. Arumugam. M , Premakumaran.N,"Electric Circuit Theory", Khanna Publishers, Fifth Edition,2000.

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

Course code	IMAGE PROCESSING FOR MEDICAL APPLICATIONS	L	T	P	C
22BM2017		3	0	0	3

Course Objective:

To impart knowledge on

1. Digital image fundamentals.
2. Low level image processing techniques.
3. Segment, compress and analyze images

Course Outcomes:

At the end of this course, students will be able to:

1. Paraphrase the digital image fundamentals for a given condition
2. Illustrate the effect of image enhancement techniques on images
3. Distinguish between image restoration filters
4. Summarize about the image segmentation procedure
5. Compute the level of compression achieved for the given image data
6. Evaluate the features useful for image representation and recognition

Module: 1	**Digital Image Fundamentals**	**7 Hours**

Introduction – Origin – Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels - color models, Medical imaging applications

Module: 2	**Image Enhancement**	**8 Hours**

Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering– Smoothing and Sharpening Spatial Filtering – Frequency Domain: Introduction to Fourier Transform – Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters., Application of filtering in medical images.

Module: 3	**Image Restoration**	**8 Hours**

Noise models– Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering.Application of Image Restoration in medical images

Module: 4	**Image Segmentation**	**7 Hours**

Detection of Discontinuities–Edge Linking and Boundary detection – Region based segmentation-Morphological processing- erosion and dilation, Application of edge detection in medical images.

Module: 5	**Wavelets and Image Compression**	**8 Hours**

Wavelets – Sub band coding - Multiresolution expansions - Compression: Fundamentals – Image Compression models – Error Free Compression – Variable Length Coding – Bit-Plane Coding –Lossless Predictive Coding – Lossy Compression – Lossy Predictive Coding – Compression Standards, Case study

Module: 6	Image Representation and Recognition	7 Hours
Boundary representation – Chain Code – Polygonal approximation, signature, boundary segments –Boundary description – Shape number – Fourier Descriptor, moments- Regional Descriptors –Topological feature, Texture - Patterns and Pattern classes - Recognition based on matching.		
	Total Lectures	**45 Hours**

Text Books	
1.	Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", Fourth Edition, Pearson Education, 2010.
2.	Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd., 2011.
Reference Books	
1.	Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata McGraw Hill Pvt. Ltd., 2011
2.	Willliam K Pratt, "Digital Image Processing", John Willey, 2002.
3	Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", First Edition, PHI LearningPvt. Ltd., 2011.
4	Chris Solomon, Toby Breckon, "Fundamentals of Digital Image Processing – A practical approach with examples in Matlab", Wiley-Blackwell, 2010.
5	Jayaraman, "Digital Image Processing", Tata McGraw Hill Education, 2011
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	IMAGE PROCESSING LABORATORY FOR MEDICAL APPLICATIONS	L	T	P	C
22BM2018		0	0	3	1.5

Course Objective:

To impart knowledge on

1. Working with various medical image data
2. Usage of Simulation tools for image processing
3. Process medical images using various methods

Course Outcomes:

At the end of this course, students will be able to:

1. Demonstrate basic operations on a given image to obtain specific output
2. Produce enhanced images using spatial and frequency domain filters
3. Assess the performance of image restoration techniques under given condition
4. Identify the object in a given image through segmentation
5. Analyze the effect of image compression on given image data
6. Compute the features useful for image analysis

LIST OF EXPERIMENTS

1. Basic operations on images
2. Color conversion of images
3. Image enhancement using point operations & filters
4. Image restoration in the presence of noise and degradation
5. Image segmentation using edge and region based methods
6. Morphological operations on images
7. Multiresolution analysis of images using wavelets
8. Image compression using lossless and lossy methods
9. Histogram processing of Images
10. Extraction of shape and texture features from an image
11. Image pseudo coloring
12. Image capturing and display using thermal camera.

Recommended by Board of Studies	

Approved by Academic Council	24th September 2022

Course code	HUMAN ANATOMY AND PHYSIOLOGY	L	T	P	C
22BM2019		3	0	0	3

Course Objective:

To impart knowledge on

1. Basic structural and functional elements of human body.
2. Organs and structures involving in system formation and functions.
3. Understand all systems in the human body.

Course Outcomes:

At the end of this course, students will be able to:

1. Recall the basic elements of human body.
2. Compare the major bones and their processes as they relate to each region of the body.
3. Interpret the major organs and components of the respiratory system and understand their functions.
4. Recognize the major organs and vessels of the cardiovascular system and understand their functions.
5. Summarize the basic components and functions of urinary and special sensing systems.
6. Demonstrate the structure and functions of nervous systems.

Module: 1	Basic Elements of Human Body	9 Hours

Cell: Structure and organelles - Functions of each component in the cell. Cell membrane – transport across membrane – origin of cell membrane potential – Action potential Tissue: Types – Specialized tissues – functions, Types of glands.

Module: 2	Skeletal and Respiratory System	7 Hours

Skeletal system: Bone types and functions – Joint - Types of Joint - Cartilage and functions

Module: 3	Respiratory System	7 Hours

Respiratory System: Components of respiratory system – Respiratory Mechanism. Types of respiration - Oxygen and carbon dioxide transport and acid base regulation.

Module: 4	Circulatory System	8 Hours

Blood composition - functions of blood – functions of RBC.WBC types and their functions Blood groups – importance of blood groups – identification of blood groups. Blood vessels - Structure of heart – Properties of Cardiac muscle – Conducting system of heart -Cardiac cycle – ECG - Heart sound - Volume and pressure changes and regulation of heart rate –Coronary Circulation. Factors regulating Blood flow

Module: 5	Urinary and Special Sensory System	7 Hours

Urinary system: Structure of Kidney and Nephron. Mechanism of Urine formation and acid base regulation – Urinary reflex – Homeostasis and blood pressure regulation by urinary system. Special senses: Eye and Ear.

Module: 6	Nervous System	7 Hours

Structure of a Neuron – Types of Neuron. Synapses and types. Conduction of action potential in neuron Brain – Divisions of brain lobes - Cortical localizations and functions - EEG. Spinal cord – Tracts of spinal cord - Reflex mechanism – Types of reflex, Autonomic nervous system and its functions.

	Total Lectures	45 Hours

Text Books

1. Ross & Wilson “Anatomy & Physiology in Health & Illness” 13th Edition. Print Book & E-Book. ISBN 9780702072765, 9780702072840.
2. Elaine.N. Marieb,“Essential of Human Anatomy and Physiology”, Eight edition, Pearson Education NewDelhi, 2007.
3. Gillian Pocock, Christopher D. Richards, "The Human Body- An introduction for Biomedical and Health Sciences", Oxford University Press, USA, 2009.

Reference Books

1. William F. Ganong,"Review of Medical Physiology, 22nd edition, McGraw Hill New Delhi, 2005
2. Eldra Pearl Solomon."Introduction to Human Anatomy and Physiology", W.B.Saunders Company, 2003.
3. Arthur C. Guyton, "Text book of Medical Physiology", 11 th Edition, Elsevier Saunders, 2006

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

Course code	**BIOLOGY FOR ENGINEERS**	**L**	**T**	**P**	**C**
22BM2020		**3**	**0**	**0**	**3**

Course Objective:

1. To comprehend the fundamental principles of Life and Life forms
2. To impart knowledge on biodiversity and genetic theory.
3. To transfer knowledge in applications of biology in Industries.

Course Outcomes:

The Student will be able to

1. Illustrate the fundamentals of living things, their classification, cell structure and biochemical constituents
2. Assess the significance of biodiversity in world.
3. Comprehend genetics and the immune system
4. Outline cause, symptoms, diagnosis and treatment of common diseases.
5. Comprehend nervous system and mechanochemistry.
6. Apply future trends in biology.

Module: 1	**Introduction To Life And Biomolecules**	**8 Hours**

Classification of life forms - Characteristics of living organisms--cell theory-structure of prokaryotic and eukaryotic cell-Introduction to biomolecules: definition-general classification and important functions of carbohydrates-lipids-proteins-nucleic acids vitamins and enzymes.

Module: 2	**Health and Well-Being and Stress Management**	**8 Hours**

The Human Body during Health and Disease – Circulatory and Digestive. Stress and Depression- Symptoms, Types, Causes and Treatment. Alcohol Abuse and Drug Abuse - Symptoms, Types, Causes and Treatment. Case Study – Substance Abuse and Social Responsibility.

Module: 3	**Evolution, Genetics And Immune System**	**8 Hours**

Evolution: theories of evolution-Mendel's cell division–mitosis and meiosis-evidence of e laws of inheritance- nucleic acids as a genetic material-central dogma immunity antigens-antibody-immune response.

Module: 4	**Human Diseases**	**7 Hours**

Lifestyle diseases -diabetes, obesity, blood pressure, heart disease, stroke, tuberculosis and diseases associated with drug abuse-Definition- causes, symptoms, diagnosis, treatment and prevention of cancer.

Module: 5	**Nervous System, Cell Signaling And Mechanochemistry**	**8 Hours**

Basics of nervous system and neural networks- General principles of cell signaling - ATP synthase structure - The bacterial flagellar motor - Cytoskeleton -Bioremediation.

Module: 6	**Biology For Industrial Applications**	**6 Hours**

Stem cell and tissue engineering - bioreactors - biopharming - recombinant vaccines-drugdiscovery-biofertilizer-biofilters-biosensors-biopolymers-bioenergy-biomaterials-biochips.

	Total Lectures	**45 Hours**

Text Books

1. A Text book of Biotechnology, R. C. Dubey, S. Chand Higher Academic Publications, 2013
2. Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011.

Reference Books

1. ThyagaRajan. S., Selvamurugan. N., Rajesh.M.P., Nazeer.R.A., Richard W. Thilagaraj, Barathi.S., and Jaganthan.M.K., "Biology for Engineers", Tata McGraw-Hill, New Delhi, 2012
2. Cell Biology and Genetics (Biology: The unity and diversity of life Volume I), Cecie Starr, Ralph Taggart, Christine Evers and Lisa Starr, Cengage Learning, 2008
3. Biotechnology Expanding horizon, B.D. Singh, Kalyani Publishers, 2012
4. Jon Cooper, "Biosensors A Practical Approach", Bellwether Books, 2004.
5. Diseases of the Human Body, Carol D. Tamparo and Marcia A. Lewis, F.A. Davis Company, 2011.
6. Martin Alexander, "Biodegradation and Bioremediation", Academic Press, 1994.

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

Course Code	**BIOMEDICAL SENSORS**	**L**	**T**	**P**	**C**
22BM2021		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on :

1. The basic of sensors and its applications in healthcare.
2. The principle and operation of different medical transducers.
3. The concept of bio sensors and comprehend the function of various receptors in human body.

Course Outcomes:

After completion of course, students will be able to:

1. Identify the need of a closed loop system with feedback and appreciate the use of sensors.
2. Interpret the errors in measurement by analyzing the performance characteristics of the sensors.
3. Develop advanced medical sensors based on the basic transduction principles.
4. Demonstrate the advanced sensor approach based on light and sound
5. Apply the suitable design criteria for developing a medical sensor for a particular application.
6. Summarize the use of electrodes in measuring electrical potential in human body

Module: 1	**Introduction to Measurement**	**8 Hours**

Generalized Instrumentation System, General properties of input transducer. Static Characteristics: Accuracy, Precision, Resolution, Reproducibility, Sensitivity, Drift, Hysteresis, Linearity, Input Impedance and Output Impedance. Dynamic Characteristics.

Module: 2	**Sensors Based on Transduction Principle**	**8 Hours**

Potentiometers, Strain gauges, Resistive Temperature Detectors (RTD), Thermistors, light-dependent resistors, Capacitive sensors, Inductive sensors, Electromagnetic sensors.

Module: 3	**Self-Generating Sensors**	**8 Hours**

Thermoelectric sensors, Piezoelectric sensors, Electrochemical sensors, Signal conditioning for self-generating sensors.

Module: 4	**Optical and Ultrasound Sensors**	**8 Hours**

N Optical techniques, General principles of optical sensing, Fiber-optic basics, Fiber-optic sensor technologies and applications. Fundamentals of ultrasonic-based sensors, Ultrasonic-based sensing methods and applications.

Module: 5	**Biological sensors and Biosensors**	**7 Hours**

Study of Various corpuscles like Pacinian, functions and modelling, Chemoreceptor, hot and cold receptors, baro- receptors, sensors for smell, sound, vision, osmolality and test. Biosensors Operating principle, biological elements in biosensors, Immobilization of the biological component, applications and signal conditioning .

Module: 6	**Bio potential electrodes**	**8 Hours**

Electrodes Electrolyte Interface, Half Cell Potential, Polarization, Polarizable and Non Polarizable, Electrodes, Calomel Electrode, Electrode Circuit Model, Electrode Skin-Interface and Motion Artifact. Body Surface Electrodes.

Total Lectures	**45 Hours**

Text Books

1.	Medical Instrumentation-Application and Design by John G. Webster, 2013
2.	Transducers for Biomedical Measurements: Principles and Applications, Richard S.C. Cobbold, John Wiley & Sons, 2004.

Reference Books

1.	Electronics in Medicine and Biomedical Instrumentation by Nandini K. Jog PHI Second Edition 2013.
2.	Instrument Transducer – An Introduction to their performance and design, Hermann K P. Neubert.
3.	Biomedical sensors – Fundamentals and application by Harry N, Norton.
4.	Biomedical Transducers and Instruments, Tatsuo Togawa, Toshiyo Tamma and P. Akeoberg.

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

Course Code	**MEDICAL INTERNET OF THINGS**	**L**	**T**	**P**	**C**
22BM2022		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on :

1. The necessary and practical knowledge of components of Internet of Things
2. The Knowledge on IoT protocols
3. The case studies related to healthcare applications of IoT.

Course Outcomes:

After completion of course, students will be able to:

1. Summarize internet of Things and its hardware and software components
2. Interface I/O devices, sensors & communication modules
3. Paraphrase the data and control devices
4. Interpret the data analytics and supporting devices
5. Analyze the Case studies on IoT applications in health care
6. Simulate real life IoT based medical applications

Module: 1	**Introduction IoT Architecture**	**7 Hours**
History of IoT, Layers of IoT, M2M – Machine to Machine, Web of Things, Data transfer referred with OSI Model, IP Addressing, Data transfer & Network Topologies.		
Module: 2	**Engineering IoT Device Smart Objects**	**8 Hours**
The "Things" in IoT, Sensors, Actuators, and Smart Objects, Sensor Networks, Wireless Sensor Networks, Connecting Smart Objects, Communications Criteria, Range, Frequency Bands, Power Consumption, Constrained- Node Networks, Data Rate and Throughput, Latency and Determinism, Overhead and Payload		
Module: 3	**IoT Access Technologies**	**7 Hours**
IEEE 802.15.4, IEEE 802.15.4g and 802.15.4e, IEEE 1901.2a, IEEE 802.11ah, Physical Layer, MAC Layer, Topology, Security, LoRaWAN, LTE-M, NB-IoT		
Module: 4	**Cloud Computing**	**8 Hours**
Overview of Cloud Computing, Characteristics of Cloud, Benefits, limitations, Cloud Deployment Models, Cloud service models-Infrastructure as a service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Anything as a Service (XaaS). Edge computing.		
Module: 5	**Challenges in IoT**	**8 Hours**
Design challenges, Development challenges, Security challenges – identity and access management. Prevention of attacks and network security.		
Module: 6	**Case Study/Health Care**	**7 Hours**
IOT in Emergency and Healthcare services,, Components of IoT healthcare, Remote health care, Real time monitoring, Preventive care, Preventive Cardiological Monitoring, Health care systems- Activity Monitoring		
	Total Lectures	**45 Hours**

Text Books

1.	A Handbook of Internet of Things in Biomedical and Cyber Physical System, Bălaş, V.E., Solanki, V.K., Kumar, R., Ahad, ISBN 978-3-030-23983-1, 2019
2.	Medical Internet of Things, Hamed Farhadi, Intech Open, 2019.
3	"The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press)
4	"Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)
5	Raspberry Pi Iot in C, Harry Fairhead , 1st edition, 2016, I/O Press;, ISBN-13: 978-1871962468.

Reference Books

1.	"Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)

2.	Bălaş, V.E., Solanki, V.K., Kumar, R., Ahad, "A Handbook of Internet of Things in Biomedical and Cyber Physical System" , ISBN 978-3-030-23983-1, 2019
3.	Vijay Madisetti, Arshdeep Bahga, İnternet of Things, "A Hands on Approach", University Press, 201
4.	. Lu Yan, Yan Zhang, Laurence T. Yang, Huansheng Ning, "The Internet of Things: From RFID to the Next-Generation Pervasive Networked", 2008.
5	Vijay Madisetti , Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 2014.

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

Course Code	SIGNALS CONDITIONING CIRCUITS LABORATORY	L	T	P	C
22BM2023		0	0	2	1

Course Objective:

To impart knowledge on

1. Design of filters and amplifier circuits for bioelectric amplifiers.
2. Different preamplifiers used for amplifying the bio signals.
3. Application of signal conditioning in biomedical field.

Course Outcomes:

At the end of this course, students will be able to

1. Summaries the principles of various digital ICs
2. Identify and apply the amplifiers and various signal conditioning circuits for biosignals acquisition.
3. Demonstrate the basic concepts for filtering of bio signals
4. Design and build various analog and digital interfaces for signal conversion
5. Select suitable circuits to design various biomedical devices
6. Analyze the front end analogue circuit design for ECG, EMG, EEG, etc.

LIST OF EXPERIMENTS

1. Study of basic digital logic used in bio-signal conditioning
2. Study of different data storage flip-flops used in medical hardware's
3. Design of ADC and DAC circuits
4. Design of basic op-amp circuits for bio-signal processing
5. Design of wave shaping circuits
6. Instrumentation amplifier for ECG amplification
7. Design of constant current source and trans impedance circuits.
8. Design of pre-amplifier circuit
9. Design of medical isolation amplifier
10. Biosignal data acquisition system
11. Design of pacemaker circuit
12. Design of active filters for biosignal acquisition (PPG Signal Acquisition)

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

Course Code	BIOMEDICAL SENSORS AND TRANSDUCERS LABORATORY	L	T	P	C
22BM2024		0	0	2	1

Course Objective:

To impart knowledge on

1. To introduce the practical aspects of various medical transducers and their characteristics.
2. To impart knowledge in measurement of Resistance, Inductance and Capacitance using bridges.
3. To improve the skills in calibrating analog meters.

Course Outcomes:

At the end of this course, students will be able to

1. Summarize the method of calibration of basic instruments.
2. Analyze the performance characteristics of different sensors.
3. Demonstrate the appropriate sensor approach which is most likely to meet a specific biosensor application.
4. Apply the suitable design criteria for developing a medical sensor for a particular application.
5. Develop advanced medical sensors based on the basic transduction principles.
6. Predict the qualitative performance of advanced medical sensors.

LIST OF EXPERIMENTS

1. Blood Pressure Measurement
2. Heart Sound Measurement – PCG KIT
3. Heart Rate Measurement
4. Pulse Measurement using Doppler Ultrasound
5. Angle measurement Using Potentiometer
6. Ultrasonic Blood flow measurement
7. Temperature Measurement Using Thermistor and LM35
8. Displacement Measurement Using LVDT
9. Displacement Measurement Using Capacitive Transducer
10. Weight Measurement Using Strain Gauge
11. Temperature Measurement Using Resistance Temperature Detector
12. Proximity Measurement – Capacitance based

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

Course code	**DIGITAL ELECTRONICS**	**L**	**T**	**P**	**C**
22BM2025		**3**	**0**	**0**	**3**

Course Objective:

1. To impart knowledge on
2. Number systems and binary codes
3. Basic postulates of Boolean algebra, methods for simplifying Boolean Expressions
4. Design procedure for combinational circuits and sequential circuits

Course Outcomes:

After completion of course, students will be able to:

1. Compute the Number System Conversions
2. Simplify the Boolean Expression Using Various Simplification Techniques
3. Design various Combinational Circuits
4. Simulate various Sequential Circuits
5. Implement Combinational Circuits Using PLD
6. Analyze Different Digital Logic Families

Module: 1	**Number Systems & Boolean Algebra**	**7 Hours**

Number Systems - Logic Gates: AND, OR, NOT, NAND, NOR, Exclusive OR and Exclusive NOR .Boolean postulates and laws – De- Morgan's Theorem Principle of Duality Boolean expression Minimization of Boolean expressions — Minterm – Maxterm - SOP – POS- Canonical Forms.

Module: 2	**Simplification of logic functions & Binary Codes**	**8 Hours**

Karnaugh map Minimization – Don't care conditions – Quine Mc Cluskey method of minimization. - Implementations of Logic Functions using gates, NAND–NOR implementations – Multi level gate implementations - Multi output gate implementations. Representation of Signed Numbers -Floating point number representation Binary Codes - BCD -ASCII-EBCDIC-Excess 3 codes-Gray code-error detecting & correcting codes

Module: 3	**Combinational Logic Design**	**7 Hours**

Implementation of Combinational Logic Functions – Half Adder and Full Adder – Half and Full

subtractor – Parallel Adder/Binary Adder – Encoders & Decoders – Multiplexers & Demultiplexers – Code Converters – Comparator - Parity Generator/Checker – Implementation of Logical Functions using Multiplexers.		
Module: 4	**Latches, Flip Flops & Synchronous Sequential Logic Design**	**8 Hours**
Latches, Different types of clocking , Clock Parameters: Pulse width, setup, hold, propagation delay RS, JK, D&T flip flops – JK Master slave flip flop –Excitation tables – Basic models of sequential machines – Concept of State Table – State diagram – State Reduction through Partitioning - Implementation of Synchronous Sequential Circuits-Sequence Generator.		
Module: 5	**Counters & Registers**	**7 Hours**
Asynchronous Counters- Modulus Counters – Timing Waveforms-Counter Applications.- Synchronous Counters–Synchronous Modulus Counters- Shift Register –Johnson Counter- Ring Counter.		
Module: 6	**Digital Logic Families**	**8 Hours**
Basic structure of PLDS: PAL-PLA-PROM Implementation of simple combinational circuits using PLDS. LOGIC FAMILIES: TTL families, Schottky Clamped TTL- Emitter Coupled (ECL)- MOS inverter- CMOS Logic Gates -Comparison of performance of various logic families.		
	Total Lectures	**45 Hours**

Text Books	
1.	M. Morris Mano, "Digital Design", 4th Edition, Prentice Hall of India Pvt. Ltd., 2008.
2.	S.Salivahanan, "Digital Circuits and Design", Oxford University Press, 2018.
Reference Books	
1.	John F.Wakerly, "Digital Design Principles and Practices", Fourth Edition, Pearson/PHI, 2008.
2.	John.M Yarbrough, "Digital Logic Applications and Design", Thomson Learning, 2006.
3.	Charles H.Roth. "Fundamentals of Logic Design", 6th Edition, Thomson Learning, 2013.
4.	Donald P.Leach and Albert Paul Malvino, "Digital Principles and Applications", 6th Edition, TMH, 2006.
6.	Thomas L. Floyd, "Digital Fundamentals", 11th Edition, Pearson Education Inc, 2015.
7.	Donald D.Givone, "Digital Principles and Design", TMH, 2003.
8.	Subir Kumar Sarkar, Asish Kumar De, Souvik Sarkar, "Foundation of Digital Electronics and Logic Design", Pan Stanford Publishing 2014.
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**MEDICAL DIAGNOSTICS AND THERAPEUTIC EQUIPMENT I**	**L**	**T**	**P**	**C**
22BM2026		**3**	**0**	**0**	**3**

Course Objective:		
To impart knowledge on 1.Principle of various bio potential recordings equipment. 2.Working of equipment used for physiological parameters. 3.Diagnostic and therapeutic procedures		
Course Outcomes:		
After completion of course, students will be able to: 1.Identify the procedures for acquisition of physiological signals 2.Demonstrate the methods for vital and biochemical parameters measurement 3.Describe the functions of various non invasive equipments 4.Illustrate the techniques for cardiac equipment 5.Assess the merits of the respiratory equipment based on its applications 6.Analyse the behavior of electrotherapy equipment.		
Module: 1	**Equipment for physiological signals acquisition**	**8 Hours**

Bioelectric signals (ECG, EMG, EEG, EOG & ERG) and their characteristics - Electrodes for ECG, EEG and EMG - Einthoven triangle, Standard 12-lead configurations - ECG Machine – EMG machine – 10-20 electrodes placement system for EEG - EEG machine – Heart sound and characteristics, PCG.		
Module: 2	**Vital parameter and biochemical parameter measurement**	**7 Hours**
Measurement of human body temperature, blood pressure monitor, body mass index, Heart rate, respiration rate, Blood pH, Blood pO2, Blood pCO2 measurement.		
Module: 3	**Equipment for non invasive methods**	**8 Hours**
Spirometer, cardiac output, blood flow meter and signal conditioning circuits. Heart rate measurement - Apnea detectors - Oximetry -Pulse oximeter, Ear oximeter - Computerized patient monitoring system – Bedside, Central Monitoring system.		
Module: 4	**Cardiac equipment**	**8 Hours**
External and implantable pacemakers, Programmable pacemakers, Power sources, Design of encapsulation and leads, Pacing system analyzers. Cardiac Defibrillators, Basic principles and comparison of different Defibrillators, Energy requirements, Synchronous operation, Implantable Defibrillators, Defibrillator analyzers.		
Module: 5	**Respiratory equipment**	**7 Hours**
Principles of constant pressure and constant volume ventilators, Basic principles of electromechanical, Pneumatic and electronic ventilators, Nebulizer, humidifier, Continuous positive airway pressure.		
Module: 6	**Electrotherapy equipment**	**7 Hours**
Electro diagnosis, Electrotherapy, Electrodes, Stimulators for Nerve and Muscle, Stimulator for pain relief, Interferential current therapy, Spinal cord stimulator, Functional Electrical Stimulation.		
	Total Lectures	**45 Hours**
Text Books		
1.	Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology",Pearson Education India, Delhi, 2004.	
2.	Cromwell, "Biomedical Instrumentation and Measurements", Prentice Hall of India, New Delhi, 2007.	
Reference Books		
1.	Khandpur. R. S., "Handbook of Biomedical Instrumentation", Prentice Hall of India, New Delhi, 2003.	
2.	Jacobson B and Webster J G Medical and Clinical Engineering – Prentice Hall of India New Delhi 1999	
3.	John Low & Ann Reed. "Electrotherapy Explained, Principles and Practice". Second Edition. Butterworth Heinemann Ltd. 2000.	
4.	John. G. Webster. "Medical Instrumentation, Application and Design"Fourth Edition. Wiley &sons, Inc, New York.2011.	
Recommended by Board of Studies		
Approved by Academic Council	24th September 2022	

Course code	**MEDICAL DIAGNOSTICS AND THERAPEUTIC EQUIPMENT II**	**L**	**T**	**P**	**C**
22BM2027		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Pulmonary analyzers and aid equipments and their functions on respiratory system
2. Physiotherapy and electrotherapy equipments
3. Instruments dealing with kidney and bones, sensory measurements and special equipments

Course Outcomes:

After completion of course, students will be able to:

1. Describe the principle involved in clinical and optical equipments
2. Identify the various therapeutic devices for pulmonary diseases.
3. Apply the appropriate therapeutic device related to kidney ailment.

4. Demonstrate the functions and applications of electrotherapy and lasers
5. Assess the merits and demerits of the diagnostic equipments for basic senses.
6. Design new therapeutic devices for particular application based on given specifications.

Module: 1	**Clinical and Optical Equipment**	**8 Hours**
Clinical equipment's, glucometer, hemoglobin monitor, Ultrasound scanner, holter monitor, multi parameter monitor, capsule endoscopy, foot scanner., Optical Method - Colorimeter, Spectro photometer, Flame photometer – Chromatography – Mass Spectrometer.		
Module: 2	**Pulmonary Equipment and Analyzers**	**7 Hours**
Regulation of Breathing - Pulmonary gas flow measurements - Pulmonary volume measurements - Respiratory gas analyzers – Nitrogen Gas Analyzer, Oxygen Analyzer - Humidifier, IPPB Unit - Anesthesia machine		
Module: 3	**Instruments Dealing With Kidney**	**8 Hours**
Regulation of Water and Electrolyte Balance – Artificial Kidney – Hemo dialysis - Crafts for dialysis - Peritoneal dialysis - Dialyzers – different types.		
Module: 4	**Electrotherapy Equipment and Therapeutic Lasers**	**7 Hours**
High frequency heat therapy, Principle, Short wave diathermy, Microwave diathermy, Ultrasonic therapy, Lithotripsy, Therapeutic IR radiation, Therapeutic UV Lamps. Basic principles of Biomedical LASERS: Applications of lasers in medicine, CO2 laser, He-Ne laser, Nd-YAG and Ruby laser.		
Module: 5	**Sensory Instrumentation**	**8 Hours**
Mechanism of Hearing, Sound Conduction System - Basic Audiometer, Pure tone audiometer, Audiometer system Bekesy – Hearing Aids - Ophthalmoscope – Tonometer - Measurement of Basal Skin response and Galvanic skin response - Instruments for testing Motor responses - Experimental Analysis of Behavior - Biofeedback Instrumentation.		
Module: 6	**Special Equipment**	**7 Hours**
Endoscopy – Laparoscopy - Cryogenic Equipment - Automated drug delivery system – Components of drug infusion system – Implantable infusion systems, BMD Measurements – SXA – DXA - Quantitative ultrasound bone densitometer		
	Total Lectures	**45 Hours**

Text Books

1.	Geoddes L.A, and Baker L.E, "Principles of Applied Biomedical Instrumentation", John Wiley, 3rd Edition, 1975, Reprint 1989.
2.	Khandpur R.S, "Hand-book of Biomedical Instrumentation", Tata McGraw Hill, 2nd Edition, 2003.

Reference Books

1.	Stuart MacKay R, "Bio-Medical Telemetry: Sensing and Transmitting Biological Information from Animals and Man", Wiley-IEEE Press, 2nd Edition, 1968.
2.	John G, Webster, "Medical Instrumentation application and design", JohnWiley, 3rd Edition, 1997.
3.	Carr Joseph J, Brown, John M, "Introduction to Biomedical equipment technology", John Wiley and sons, New York, 4th Edition, 1997.
4.	Rajarao C, and Guha S.K, "Principles of Medical Electronics and Biomedical Instrumentation", Universities press (India) Ltd, First Edition, Orient Longman ltd, 2001.

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

Course code	**VIRTUAL INSTRUMENTATION FOR BIOMEDICAL ENGINEERS**	**L**	**T**	**P**	**C**
22BM2028		**3**	**0**	**2**	**4**

Course Objective:

To impart knowledge on

1. The basics of Programming Techniques
2. The data acquisition and control of a device by interfacing to a computer.

3. The design of virtual instruments for various biomedical measurements and applications		
Course Outcomes:		
After completion of course, students will be able to: 1.Summarize the basics of LabVIEW programming 2. Interface with real time signals 3. Analyse the application of VIs in medical instrumentation in developing medical instruments 4. Interpret the concepts of data communication and synchronization 5. Perform signal processing operations using virtual instrumentation 6. Apply virtual instrumentation for biomedical applications		
Module: 1	**LabVIEW Programming Principles & Environment**	**8 Hours**
Data flow – Definition, and importance of data flow in LabVIEW – Identify programming practices that enforce data flow in block diagram, Virtual instrumentation (VI), and sub-VIs - Identify programming practices that break data flow – Polymorphism - Define polymorphism - Identify benefits of polymorphism - Determine output or intermediate values of data elements in VI that utilizes polymorphic inputs LabVIEW Environment		
Module: 2	**Software Constructs & Programming Functions**	**8 Hours**
Front panel window and block diagram objects - Controls, indicators, IO controls, and refnums - Property Nodes - Data types and data structures - Flat and Stacked sequence structures - Event structures- Formula Node - Arrays and clusters		
Module: 3	**Data Communication & Synchronization**	**7 Hours**
Local, global, and shared variables – Data Socket - TCP and UDP – Synchronization – Notifiers – Queues - VI Server - configuring the VI Server		
Module: 4	**Virtual Instrumentation (Vi) Design & SubVI Design Techniques**	**8 Hours**
Simple state machine - User interface event handler - Queued message handler - Producer/consumer (data) and producer/consumer (events) - Functional global variables - Connector panes and connection types - Polymorphic subVIs - Options related to subVIs - Error handling – User interface design and block diagram layout		
Module: 5	**Memory, Performance And Determinism**	**8 Hours**
Tools for identifying memory and performance issues - Profile memory and performance - Show buffer allocations- VI metrics - Programming practices - Enforcing dataflow -User interface updates and response to user interface controls -		
Module: 6	**Applications**	**6 Hours**
Applications of LabVIEW in displaying and monitoring vital parameters, Biomedical signal processing, controlling assistive devices.		
	Total Lectures	**45 Hours**

Text Books

1.	. Jovitha Jerome, "Virtual Instrumentation using LabVIEW", PHI Learning, 2010.
2.	S. Sumathi, P.Surekha, "LabVIEW based Advanced Instrumentation Systems", Springer 2007.
3	Gary Jonson, 'LabVIEW Graphical Programming', McGraw Hill, New York, Fourth edition 2006

Reference Books

1.	1. Jon B Olansen and Eric Rosow, "Vitrual Bio-Instrumentation Biomedical, Clinical and Healthcare Applications in LabVIEW" 2001.
2.	2. Rick Bitter, Taqi Mohiuddin, Matt Nawrocki "LabVIEW: Advanced Programming Techniques" Second Edition, CRC press, 2007.
3.	3. Lisa K. Wells & Jeffrey Travis, 'LabVIEW for Everyone', Prentice Hall Inc., First edition 1997.
4.	4. S. Gupta, J.P. Gupta, 'PC interfacing for Data Acquisition & Process Control', Instrument Society of America, Second Edition, 1994
5.	5. Yik Yang "LabVIEW Graphical Programming Cookbook", Packt Publishing Enterprise, 2014.

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

Laboratory Experiments:

1. Waveform Generation
2. Use of While Loop, For Loop and Case Structure
3. Study of Sequential Programming : Flat Sequence and Stack Sequence
4. Use of Arithmetic Functions and Properties : Shift Register, Formula Node and Property Node
5. Data Collection and Console Design : Arrays and Clusters
6. Data Storage Methods using File I/O – Read and Write File
7. Creation of Sub Program using Sub-VI
8. Data Communication using Queues and Notifiers
9. Measurement of Body Temperature
10. Calculation of Peak-to-Peak interval of PPG Signal
11. Measurement of Heart Rate
12. Lung Sound Cancellation from Heart Sound
13. Calculation of Pulse Height of each Pulse in PPG Signal
14. Measurement of Pulse Transit Time

Course code	**ELECTRICAL AND ELECTRONICS FOR BIOMEDICAL ENGINEERS**	**L**	**T**	**P**	**C**
22BM2029		**3**	**1**	**0**	**4**

Course Objective:

To impart knowledge on

1. basic concepts of electric circuits, magnetic circuits and wiring.
2. operation of AC and DC machines.
3. working principle of electronic devices and circuits.

Course Outcomes:

At the end of the course the students will be able to

1. Compute electric circuit parameters for simple problems
2. Understand the working principle and application of electrical machines
3. Analyze the characteristics of analogue electronic devices
4. Outlinethe basic concepts of digital electronics
5. Interpret the operating principles of measuring instruments
6. Recollect the application of electronics in medical world

Module: 1	**ELECTRICAL CIRCUITS**	**10 Hours**

DC Circuits: Circuit Components: Conductor, Resistor, Inductor, Capacitor – Ohm's Law –Kirchhoff's Laws -Independent and Dependent Sources – Simple problems- Nodal Analysis, Mesh analysis with Independent sources only (Steady state) Introduction to AC Circuits and Parameters: Waveforms, Average value, RMS Value, Instantaneous power, real power, reactive power and apparent power, power factor – Steady state analysis of RLC circuits (Simple problems only)

Module: 2	**ELECTRICAL MACHINES**	**10 Hours**

Construction and Working principle-DC separately and Self Excited Generators, EMF Equation, Types and Applications, Working Principle of DC motors, Torque Equation, Types and Applications, Construction, Working principle and applications of Transformers, Three Phase Alternators, Synchronous Motors and Three Phase Induction Motors

Module: 3	**ANALOGUE ELECTRONICS**	**10 Hours**

Resistor, Inductor and Capacitor in Electronic Circuits- Semiconductor Materials: Silicon &Germanium – PN Junction Diodes, Zener Diode -Characteristics Applications – Bipolar Junction Transistor-Biasing, JFET, SCR, MOSFET,IGBT – Types, I-V Characteristics and Applications, Rectifier and Inverters

Module: 4	**DIGITAL ELECTRONICS**	**10Hours**

Review of Number Systems, Binary Codes, Error detection and Correction Codes, Combinational Logic Circuits-Representation of Logic functions-SOP and POS forms, K map representations- Minimization using K maps(Simple Problems), block diagram of processor, Introduction to Embedded systems.

Module: 5	**MEASUREMENTS AND INSTRUMENTATION**	**10 Hours**

Functional elements of an instrument, Standards and calibration, Operating Principle, types -Moving Coil and Moving Iron meters, Measurement of three phase power, Energy Meter, Instrument Transformers-CT and PT, DSO- Block diagram- Data acquisition		
Module: 6	**BIOMEDICAL ELECTRONICS**	**10 Hours**
Magnetic Resonance Imaging, Electrocardiograph- Einthoven's ECG device-ECG graph paper, Sphygmomanometer, Digital Thermometers, Blood gas analyser, Stethoscope		
	Total Lectures	**60 Hours**

Text Books

1. Kothari DP and I.J Nagrath, Basic Electrical and Electronics Engineering, Second Edition, McGraw Hill Education, 2020
2. S.K.Bhattacharya Basic Electrical and Electronics Engineering, Pearson Education, Second Edition, 2017.
3. Sedha R.S., A textbook book of Applied Electronics, S. Chand and Co., 2008
4. James A .Svoboda, Richard C. Dorf, " Introduction to Electric Circuits, Wiley, 2018.
5. A.K. Sawhney, Puneet Sawhney "A Course in Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai and Co, 2015.

Reference Books

1. Kothari DP and I.J Nagrath, Basic Electrical Engineering, Fourth Edition, McGraw Hill Education, 2019.
2. Thomas L. Floyd, ˜Digital Fundamentals11th Edition, Pearson Education, 2017.
3. Albert Malvino, David Bates, ˜Electronic Principles, McGraw Hill Education; 7th edition, 2017.
4. Mahmood Nahvi and Joseph A. Edminister, Electric Circuits, Schaum Outline Series, McGraw Hill, 2002.
5. H.S. Kalsi, ˜Electronic Instrumentation, Tata McGraw-Hill, New Delhi, 2010

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

Course code	**ERGONOMICS AND SPORTS MECHANICS**	**L**	**T**	**P**	**C**
22BM2030		**3**	**0**	**0**	**3**

Course Objective:

To impart knowledge on

1. Recognizing and evaluating hazards (ergonomic in nature) which are likely to cause occupational illnesses or injuries
2. Design and redesign tasks and workstations to fit employees.
3. Understand the concept of biomechanics to various aspects of sports training.

Course Outcomes:

At the end of this course, students will be able to:

1. Apply ergonomic principles to the creation of safer, healthier and more efficient and effective activities in the workplace;
2. Develop appropriate control measures for ergonomic risk factors;
3. Analyze workplace according to good ergonomic principles
4. Paraphrase biomechanics adaptations to various aspects of sports training.
5. Summarize environmental change adaptations in sports training.
6. Interpret the risks associated with adaptations.

Module: 1	**Overview of Ergonomics**	**8 Hours**
Aims, objectives and benefits of ergonomics-The role of the ergonomist-Interfaces between job, person and environment-Applying work physiology - body metabolism, work capacity and fatigue-Static and dynamic postures- Developing ergonomics, professional ergonomists and competence		
Module: 2	**Ergonomics Methods and Techniques**	**7 Hours**
Task analysis and allocation of functions-Risk evaluation quantity and quality of risk-Problem solving - scientific method - Control measures monitoring and feedback - Overall ergonomics approach.		

Module: 3	**Workplace, Job and Product Design**	**7 Hours**
Principles of workstation and system design - Space and workstation design principles-Design of work and practice - Carrying out assessments of risk at VDU workstations - Principles of software ergonomics.		
Module: 4	**Muscle Action in Sport and Exercise**	**8 Hours**
Neural contributions to changes in muscle strength - Mechanical Properties and Performance in skeletal muscles – Muscle and Tendon architecture and athletic performance - Eccentric muscle action in sport and exercise – Stretch – Shortening cycle of muscle function - Biomechanical foundations of strength and Power training.		
Module: 5	**Jumping and Aerial Movement**	**7 Hours**
Aerial Movement - The high jump - Jumping in figure skating - Springboard and platform diving - Determinants of successful ski- Jumping performance.		
Module: 6	**Injury Prevention and Rehabilitation**	**8 Hours**
Mechanisms of musculoskeletal injury - Musculoskeletal loading during landing – Sports related Spinal injuries and their prevention - Impact propagation and its effects on the human body.		
Total Lectures		**45 Hours**
Text Books		
1.	Corlett & Clark 1995 The Ergonomics of Workspaces & Machines Taylor & Francis	
2.	Shephard, R.J. and Astrand, P.-0. (1992) Endurance in sport. Blackwell Science Ltd, USA	
Reference Books		
1.	R.S.Bridger 2003 Introduction to Ergonomics Taylor & Francis	
2.	Kroemer & Grandjean 1997 Fitting the Task to the Human – a text book of Occupational Ergonomics Taylor & Francis	
3.	Fundamentals of Sociology of Sport and Physical Activity, Human Kinetics by Katherine M. Jamieson, Maureen M. Smith.	
Recommended by Board of Studies		
Approved by Academic Council	24th September 2022	

Course code	**3-D PRINTING**	**L**	**T**	**P**	**C**
22BM2031		**3**	**0**	**0**	**3**
Course Objective:					
To impart knowledge on 1. Importance of 3D printing in Manufacturing 2. Real-life scenarios and recommend the appropriate use of 3D printing technology. 3. 3. Comprehend the need of 3D Printing in Bio-medical and health care field.					
Course Outcomes:					
At the end of this course, students will be able to: 1. Summarize the importance of 3D printing in Manufacturing 2. Interpret their design process 3. Identify how technology shifts throughout history have made 3D printing possible 4. Paraphrase the advantages and limitations of each 3D printing technology 5. Design and print objects containing moving parts without assembly. 6. Evaluate the unique advantages of 3D printing to their designs.					
Module: 1	**Introduction**				**8 Hours**
Introduction to Design- Prototyping fundamentals - Introduction to 3D printing and its historical development – advantages in various field					
Module: 2	**Fundamentals of 3-D Printing**				**7 Hours**
3-D Printing, Generic 3D Printing Process, Benefits of 3D Printing, Distinction Between 3D Printing and CNC Machining, Other Related Technologies					
Module: 3	**Development of 3-D Printing technology**				**7 Hours**

Introduction, Computers, Computer-Aided Design Technology, Other Associated Technologies, The Use of Layers, Classification of 3D Printing Processes, Metal Systems, Hybrid Systems, Milestones in 3D Printing Development, 3D Printing around the World.		
Module: 4	**Biobuild Software For Medical Data Transfer**	**8 Hours**
Introduction, Medical Imaging: from Medical Scanner to 3D Model, Computer Approach in Dental Implantology. BioBuild Paradigm - Importing a dataset, Volume reduction, Anatomical orientation confirmation,		
Module: 5	**Scaffold-Based Tissue Engineering & Orthopedic Implants**	**7 Hours**
Introduction, Medical Imaging: from Medical Scanner to 3D Model, Computer Approach in Dental Implantology. BioBuild Paradigm - Importing a dataset, Volume reduction, Anatomical orientation confirmation, Volume editing, Image processing, Build orientation optimization, 3D visualization, RP file generation, Future Enhancements..		
Module: 6	**3-D Printing for Medical Applications**	**8 Hours**
Medical Applications for 3D Printing - Use of 3D Printing to Support Medical Applications, Software Support for Medical Applications, Limitations of 3D Printing for Medical Applications, Further Development of Medical 3D Printing Applications.		
Total Lectures		**45 Hours**
Text Books		
1.	Ian Gibson, Advanced Manufacturing Technology for Medical Applications, John Wiley, 2005.	
Reference Books		
1.	Ian Gibson, David Rosen and Brent Stucker, "Additive Manufacturing Technologies: 3D printing, Rapid prototyping and Direct Digital Manufacturing", Springer, (2014)	
2.	Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping	
3.	Paulo Bartolo and Bopaya Bidanda, Bio-materials and Prototyping Applications in Medicine, Springer, 2008.	
Recommended by Board of Studies		
Approved by Academic Council	24th September 2022	

DEPARTMENT OF BIOMEDICAL ENGINEERING

LIST OF NEW COURSES

Sl. No	Course Code	Course Title	Credits [L:T:P:C]
1.	21BM3001	Medical Instrumentation Design	3:0:0:3
2.	21BM3002	Advanced Biomedical Signal Processing	3:0:0:3
3.	21BM3003	Applied Medical Image Processing	3:0:0:3
4.	21BM3004	Advanced Healthcare System Design	3:0:0:3
5.	21BM3005	Embedded System and Programming	3:0:0:3
6.	21BM3006	Advanced Biomedical Engineering Laboratory	0:0:4:2
7.	21BM3007	Hospital Training	0:0:4:2
8.	21BM3008	Medical Image Processing Laboratory	0:0:4:2
9.	21BM3009	Medical Devices Development Laboratory	0:0:4:2
10.	21BM3010	Medical Sensors and MEMS Technology	3:0:0:3
11.	21BM3011	Human Computer Interface	3:0:0:3
12.	21BM3012	Human Assistive Devices	3:0:0:3
13.	21BM3013	Cognitive Technology for Biomedical Engineers	3:0:0:3
14.	21BM3014	Finite Element Modeling for Biomedical Engineers	3:0:0:3
15.	21BM3015	Rehabilitation Engineering	3:0:0:3
16.	21BM3016	Machine Learning for Healthcare	3:0:0:3
17.	21BM3017	Robotics in Surgery	3:0:0:3
18.	21BM3018	Telehealth Technology	3:0:0:3
19.	21BM3019	Hospital and Equipment Management	3:0:0:3
20.	21BM3020	Physiological Control Systems	3:0:0:3
21.	21BM3021	Ergonomics in Healthcare	3:0:0:3
22.	21BM3022	Medical Ethics and Safety	3:0:0:3
23.	21BM3023	Internet of Things in Healthcare	3:0:0:3
24.	21BM3024	Nanotechnology in Medicine	3:0:0:3
25.	21BM3025	Biomedical Engineering Entrepreneurship	3:0:0:3
26.	21BM3026	Energy Audit and Management for Hospitals	3:0:0:3
27.	21BM3027	Prosthetic Devices	3:0:0:3
28.	21BM3028	Artificial Intelligence in Healthcare	3:0:0:3
29.	21BM3029	Advanced RISC Machine in Biomedical Applications	3:0:0:3
30.	21BM3030	Tissue Engineering and Artificial Organs	3:0:0:3

Course code		L	T	P	C
21BM3001	MEDICAL INSTRUMENTATION DESIGN	3	0	0	3

Course Objective:

The student should be made to:

1. Understand the fundamentals of human physiology system and its functions.
2. Learn the fundamental concepts of physiological parameters measurement.
3. Apply the concepts of various instrumentation techniques for biomedical applications.

Course Outcomes:

At the end of this course, students will be able to

1. Identify the basic functions of various human physiological systems
2. Demonstrate an interfacing circuit for real time bio signal acquisition
3. Construct the suitable instrumentation technique for a specific illness
4. Categorize the medical devices based on its biomedical applications
5. Assess the various parameters, constraints in methodology for effective diagnosis
6. Design of advanced biomedical equipments for various diseases and ensure patient safety

Module: 1	Introduction To Human Physiology	8 Hours

Circulatory system – cardio vascular system-central nervous system – respiratory system – muscular skeletal system – digestive system – excretory system – sensory organs – voluntary and involuntary action.

Module: 2	Biopotentials And Their Measurements	7 Hours

cell and its structure – resting potentials – action potentials – bioelectric potentials – measurement of potentials and their recording – Electrode theory – bipolar and Unipolar electrode-surface electrode – electrode impedance –equivalent circuit for extra cellular electrodes- micro electrodes. basic principles of ECG, EEG, EMG.

Module: 3	**Advanced Medical Instrumentation**	**7 Hours**
Design of instrumentation system for physiological measurements-temperature, pressure, strain, weight, angle measurements using encoder, flow measurements. Sensor selection for speed, location and acceleration measurement.Case study. IoT based medical instrumentation.		
Module: 4	**Cardiovascular System And Instrumentation**	**8 Hours**
Design of instrumentation system for Blood pressure measurement, selection of sensors, design specifications, blood flow measurements, phonocardiography, Cardiac pacemakers, heart lung machines, Tread Mill, Test design of interfacing circuits. Design of interface system. Casestudy.Artificial intelligence in cardiovascular system.		
Module: 5	**Respiratory System And Instrumentation**	**7 Hours**
Mechanics of breathing, regulation of respiration, design of instrumentation system for respiratory system, selection of transducers, artificial respiration therapy, artificial mechanical ventilation, troubleshooting and maintenance of ventilators. Design of interfacing circuits.Case study. Machine Learning in diagnosis.		
Module: 6	**Neurological Instrumentation System**	**8 Hours**
Neurophysiology, design of EEG amplifiers, wireless EEG, Bispectral Index EEG measurements for depth of anesthesia monitoring. Deep learning in neurocomputing.		
	Total Lectures	**45 Hours**

Text Books

1.	Joseph J Carr, John M Brown, "Introduction to medical equipment technology", Pearson education publisher, New Delhi, 2013.
2.	Steven Schreiner, Joseph D. Bronzino, Donald R. Peterson, **"**Medical Instruments and Devices: Principles and Practices**",** CRC Press, 2017.

Reference Books

1.	John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, New York, 2009.
2.	Joseph D. Bronzino, "The Biomedical engineering handbook", Vol I, CRC press, 2000.
3.	Myer Kutz, "Standard Handbook of Biomedical Engineering& Design", McGraw Hill Publisher,UK,2003.
4.	Leslie Cromwell, "Biomedical Instrumentation and measurement", Prentice hall of India, New Delhi, 2007.
5.	Khandpur,R.S,"Handbook of Biomedical Instrumentation", Second Edition. Tata Mc Graw Hill Pub. Co., Ltd. 2003

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

Course code		**L**	**T**	**P**	**C**
21BM3002	**ADVANCED BIOMEDICAL SIGNAL PROCESSING**	**3**	**0**	**0**	**3**

Course Objective:

The student should be made to:

1. Know the basic concepts of Bio signal Processing
2. Learn about the filtering techniques used in Medical Signal Processing
3. Understand the Applications of Signal Processing for Diagnosis.

Course Outcomes:

At the end of this course, students will be able to:

1. Summarize the basic concepts of digital signal processing techniques.
2. Identify the nature of Biomedical signals.
3. Apply the Filtering Techniques.
4. Analyze the Noise Cancellation Techniques for Biosignals.
5. Understand various Techniques for Detection of Events.
6. Develop systems for Biosignal Acquisition and Analysis

Module: 1	**Overview of Digital Signal Processing And Applications**	**8 Hours**
Sampling and aliasing , Signal reconstruction, Signal conversion systems, convolution - Correlation - FFT - decimation in time algorithm, Decimation in Frequency algorithm. Artificial intelligence in signal processing.		
Module: 2	**Introduction to biomedical signals**	**7 Hours**

Nature of biomedical signals - Examples of biomedical signals-EEG, EMG, ECG, VMG, VAG, evoked potentials, Event Related Potentials, Speech Signal, Bioacoustic signals - Objectives and Difficulties of Biomedical Signal Analysis. Deep learning in Biosignal analysis.		
Module: 3	**Filtering Techniques**	**7 Hours**
Random Noise, Structured Noise, and Physiological Noise Time domain filtering – Synchronous averaging, Moving average filters, Frequency domain filters – Design of Butterworth filters- optimal filtering, Machine Learning applications in signal computation.		
Module: 4	**Noise Cancellation in Bio Signals**	**8 Hours**
Adaptive noise cancellation-LMS and RLS algorithms in adaptive filtering – Application: Motion Artifacts in ECG, Powerline Interference in ECG, Maternal Interference in ECG. Machine Learning applications in noise cancellation.		
Module: 5	**Analysis of Biosignals:**	**7 Hours**
Cardiological Signal Processing - Methods in Recording ECG , Waves and Intervals of ECG - ECG Data Acquisition , ECG Parameters and Their Estimation - ECG QRS Detection Technique - Template Matching Technique - Differentiation Based QRS Detection Technique - Simple QRS width Detection Algorithm - High Speed QRS detection Algorithm - Estimation of R-R Interval - Estimation of ST Segment - Analysis of PCG signal - Analysis of EMG signal and EEG Signal. Deep learning for biosignal analysis.		
Module: 6	**Applications**	8 Hours
Adaptive Segmentation of ECG and PCG signals - Time varying analysis of heart rate variability - Detection of Coronary Artery Disease - Analysis of Ectopic ECG beats.		
	Total Lectures	**45 Hours**

Text Books	
1.	Rangaraj M. Rangayyan, “Biomedical signal analysis”, John Wiley &Sons.Inc. 2002.
2.	Monson H.Hayes, “Statistical Digital signal processing”, John Wiley &Sons.Inc 1996
Reference Books	
1.	Arnon Cohen, “Biomedical Signal Processing” Vol I and II,CRC Press, Florida, 1988.
2.	D.C.Reddy, “Biomedical Signal Processing: Principles and Techniques, Tata McGraw Hill Pub, Third reprint 2007.
3.	SanjitK.Mitra “Digital Signal Processing”, A Computer Based Approach”, Tata McGraw- Hill, New Delhi, fourth edition 2011.
4.	John G. Proakis and DimitrisG.Manolakis, “Digital Signal Processing, Algorithms and Applications”, PHI of India Ltd., New Delhi, fourth Edition, 2007.
5.	Khandpur,R.S,”Handbook of Biomedical Instrumentation”, Second Edition. Tata Mc Graw Hill Pub. Co., Ltd. 2003
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code		**L**	**T**	**P**	**C**
21BM3003	**APPLIED MEDICAL IMAGE PROCESSING**	**3**	**0**	**0**	**3**
Course Objective:					
The student should be made to: 1. Learn the fundamentals of medical image processing 2. Understand various medical image processing techniques 3. Apply the methodologies for clinical applications					
Course Outcomes:					
Upon the completion of this course, the student will be able to: 1. Describe the fundamentals to represent the images as per the given requirement 2. Discuss the segmentation method for a given clinical application 3. Explain the spatial transformation and its use for medical application 4. Distinguish between various rendering techniques on medical images 5. Assess the effect of image registration with respect to clinical application 6. Discuss the techniques for reconstruction of CT images					
Module: 1	**Image Representation**				**8 Hours**
Pixels and voxels**,** gray scale and color representation, image file formats, DICOM, other formats- intensity transform functions, and the dynamic range, windowing, histogram and histogram operations, dithering and depth, filtering and Fourier transform. Artificial intelligence in filtering methods.					
Module: 2	**Segmentation**				**7 Hours**

The segmentation problem, Region of interest and centroid, theresholding, region growing, sophisticated segmentation methods, morphological operations, evaluation of segmentation results-Clinical applications. Machine learning techniques in image segmentation.		
Module: 3	**Spatial Transforms**	**7 Hours**
Discretization**,** interpolation and volume regularization, translation and rotation, reformatting, tracking and image guided therapy. Deep learning in image processing.		
Module: 4	**Rendering And Surface Models**	**8 Hours**
Visualization, orthogonal and perspective projection, and their view point, raycasting, surface based rendering-Clinical applications.		
Module: 5	**Registration**	**7 Hours**
Fusing information, registration paradigm, merit functions, optimization strategies-camera calibration, registration to physical space-evaluation of registration results - Clinical applications. Deep learning methods in image registration.		
Module: 6	**CT Reconstruction**	**8 Hours**
Introduction-Radon transform-algebraic reconstruction-Fourier transform and filtering-filtered back projection-Clinical applications. IoT for clinical applications.		
	Total Lectures	**45 Hours**

Text Books

1.	Wolfgang Birkfellner, "Applied medical Image Processing- A basic course", Second Edition, CRC Press, 2014.
2.	Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", Third Edition, Pearson Education, 2010.

Reference Books

1.	Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd., 2011.
2.	William K. Pratt, "Introduction to Digital Image Processing", CRC Press, 2013.
3.	Chris Solomon, Toby Breckon, "Fundamentals of Digital Image Processing – A practical approach with examples in Matlab", Wiley-Blackwell, 2010.
4.	Jayaraman, "Digital Image Processing", Tata McGraw Hill Education, 2011.
5.	Khandpur,R.S,"Handbook of Biomedical Instrumentation", Second Edition. Tata Mc Graw Hill Pub. Co., Ltd. 2003.

Recommended by Board of Studies	
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Course code		**L**	**T**	**P**	**C**
21BM3004	**ADVANCED HEALTHCARE SYSTEM DESIGN**	**3**	**0**	**0**	**3**

Course Objective:

The student should be made to:

1. Understand the needs for wearable devices and the technology
2. Learn the concepts in digital health care and digital hospitals
3. Apply the tools in design, testing and developing digital health care equipment

Course Outcomes:

At the end of this course, students will be able to

1. Identify the available technology for wearable healthcare devices
2. Interpret the need for digital methods of handling medical records
3. Modify the tools and methods for work flow
4. Compare various standards for inter-operability of devices
5. Decide quality and safety standards for developing healthcare systems
6. Formulate advanced strategies for innovation to societal needs.

Module: 1	**Wearable Devices And M-Health Care**	**8 Hours**
Introduction to mobile health care-devices-economy-average length of stay in hospital, outpatient care, health care costs, mobile phones, 4G, smart devices, wearable devices, Uptake of e-health and m-health technologies. Standards, system Design and case study.		
Module: 2	**Digital Radiology**	**7 Hours**
Digital radiology for digital hospital, picture archiving and communication, system integration, digital history of radiology, medical image archives, storage and networks.		
Module: 3	**E-Health**	**7 Hours**
Health care networking, Medical reporting using speech recognition, physiological tests and functional diagnosis with digital methods, tele-consultation in medicine and radiology. Machine learning in diagnosis.		

Module: 4	**Modality**	**8 Hours**
Multimodality registration in daily clinical practice. Mobile healthcare.Casestudy.IoT applications in healthcare.		
Module: 5	**Digital Health**	**7 Hours**
Requirements and best practices, Laws and regulations in Digital health, Ethical issues, barriers and strategies for innovation		
Module: 6	**Standards For Inter Operability**	**8 Hours**
Selection and Implementation in e-Health project, design of medical equipments based on user needs. Security and privacy in digital health care.		
	Total Lectures	**45 Hours**
Text Books		
1.	ChristophThuemmler, Chunxue Bai, "Health 4.0: How Virtualization and Big Data are Revolutionizing Healthcare", Springer, 1st ed. 2017.	
2.	Samuel A. Fricker, ChristophThümmler, AnastasiusGavras, "Requirements Engineering For Digital Health", Springer, 2015	
Reference Books		
1.	Rick Krohn (Editor), David Metcalf, Patricia Salber, "Health-e Everything: Wearablesand The Internet of Things for Health, ebook. 2013.	
2.	WlaterHruby, "Digital revolution in radiology – Bridging the future of health care, second edition, Springer, New York. 2006.	
3.	Khandpur,R.S,"Handbook of Biomedical Instrumentation ",Second Edition. Tata Mc Graw Hill Pub. Co., Ltd. 2003	
4.	John, G. Webster. Medical Instrumentation: Application and Design. Second Edition. Wiley Publisher, New Delhi. 2013.	
5.	Joseph J Carr, John M Brown, "Introduction to medical equipment technology", Pearson education publisher, New Delhi, 2013.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code		**L**	**T**	**P**	**C**
21BM3005	**EMBEDDED SYSTEM AND PROGRAMMING**	**3**	**0**	**0**	**3**
Course Objective:					
To impart knowledge on: 1. Basic concepts of Embedded Systems 2. Various techniques used for designing an embedded system. 3. 3. Real time system with an examples					
Course Outcomes:					
Upon the completion of this course, the student will be able to: 1. Discuss the basics of embedded systems and its hardware units 2. Identify the various tools and development process of embedded system 3. Create the programming for embedded system design 4. Demonstrate the various I/O interfacing with microcontroller 5. Summarize the real time models, languages and operating systems 6. Design a real time embedded system for biomedical applications					
Module: 1	**System Design**				**8 Hours**
Definitions-Characteristics -Architecture of an embedded system-Overview of micro-controllers and microprocessors- Classifications of an embedded system - Embedded processor architectural definitions-Embedded hardware units and devices in a system, Design Process, Design process and metrics in embedded system, Design challenges, Optimising the design metrics, Skills required for an embedded system designer.					
Module: 2	**Embedded Software Tools for Programming**				**7 Hours**
Embedded software development Process, Host and Target machine, Linking and Locating Software, Getting embedded software into the target system, Converting embedded C programming into Machine codes, Embedded Software IDE for programming, Embedded Software Tools.					
Module: 3	**Course in Embedded C**				**7 Hours**
Review of embedded C programming Language,Programming in assembly language and high level language, C program elements, Embedded C programming- Simple programs, High level language descriptions of software for embedded system, Basics of Python programming.					
Module: 4	**Hardware interfacing and Programming Skills**				**8 Hours**

Study of microcontroller, Interfacing and Programming – Switch, Keypad, LED, Seven segment displays, Data Acquisition system, A/D, D/A converters, Timers and Counters. Interrupt concept.		
Module: 5	**Techniques for Embedded Systems**	**7 Hours**
State Machine and state Tables in embedded system design, Simulation and Emulation of embedded systems. Real time models, Language and Operating Systems-Tasks and task states, operating system services, RTOS functions, Interrupt routine in RTOS environment.		
Module: 6	**Real Time Applications**	**8 Hours**
Body temperature measurement, Stepper motor control.Embedded system in biomedical application- Wireless sensor technologies, Body sensor network, Patient monitoring system. Case study.		
	Total Lectures	**45 Hours**

Text Books	
1.	RajKamal, "Embedded Systems Architecture, Programming and Design", Tata McGrawHill ,Second Edition, 2008
2.	Tim Wilhurst, "An Introduction to the Design of Small Scale Embedded Systems,Palgrave, 2004.
Reference Books	
1.	Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2005.
2.	Frank Vahid, Tony Givargis, "Embedded Systems Design", Wiley India, 2006
3.	Khandpur R.S, "Hand-book of Biomedical Instrumentation", Tata McGraw Hill, 2nd Edition, 2003.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code		**L**	**T**	**P**	**C**
21BM3006	**ADVANCED BIOMEDICAL ENGINEERING LABORATORY**	**0**	**0**	**4**	**2**

Course Objective:

The student should be made to:

1. Learn the methods of recording Biosignals and design of interfacing circuits
2. work with calibration of medical devices
3. study the modeling and analysis of physiological systems

Course Outcomes:

Upon the completion of this course, the student will be able to:

1. Record the biosignals
2. Understand the selection of sensors
3. Design the biosignal processing circuits
4. Analyse the modeling and analysis physiological parameters
5. Compare various standards
6. Perform the calibration of medical devices

LIST OF EXPERIMENTS

1. Record and analyze the ECG signal
2. Record and analyze the EMG signal.
3. Record and analyze the EEG signal.
4. Design, selection and testing of micro pressure for medical applications
5. Design, selection and testing of micro flow sensor for medical application
6. Design and testing of strain sensor for biomechanics applications
7. Design and analysis of angle sensor for GAIT system
8. Modeling of respiration system and analysis
9. Modeling of cardiovascular system
10. Modeling and analysis of muscle reflex
11. Calibration of infusion pump
12. Design and testing of patient monitoring system
13. Simulation and Calibration and ECG recording system
14. Design of control system for cardiac assist devices
15. Calibration and design of CPAP device
16. Testing and calibration of oxygen concentrator

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Course code		L	T	P	C
21BM3007	HOSPITAL TRAINING	0	0	4	2

Course Objective:

The student should be made to:

1. Work and testing of various medical equipments
2. Have experience in hospital work environment
3. Assess various methods of quality in medical devices

Course Outcomes:

Upon completion of the course, the student should be able to:

1. Demonstrate the functions of medical equipments
2. Identify the specifications, operating procedure, and maintenance log
3. Modify the applications for specific purpose
4. Experiment the effect of human factors on design of medical devices
5. Access the regulations, standards and certification of devices
6. Integrate the functions, analyse the data and develop methodologies

List of Experiments:

1.	Study and testing of the instruments for vital sign monitoring
2.	Study and testing of the instruments for respiration monitoring
3.	Study and testing of the anesthesia machine
4.	Study and testing of the instruments for post operative care
5.	Study and testing of the equipments in ICU, ICCU, HDU, NICU
6.	Study and testing of the equipments in operation theatre
7.	Study and testing of the equipments for minimally access surgery
8.	Study and testing of the equipments in dentistry
9.	Study and testing of the equipments in urology
10.	Study and testing of the equipments for chemotherapy
11.	Study and testing of the equipments for physiotherapy
12.	Study and testing of the equipments for podiatry
13.	Study on Equipments for waste handling
14.	Study on quality standards, medical record and certification
15.	Handling of power sources, water and general maintenance practices
16.	MiniProject
17.	Study on ISO standards, regulatory Practices and safety

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Course code		L	T	P	C
21BM3008	MEDICAL IMAGE PROCESSING LABORATORY	0	0	4	2

Course Objective:

The student should be made to:

1. Work with various medical image data
2. Have experience in MatLab for image processing
3. Process medical images using various methods

Course Outcomes:

Upon the completion of this course, the student will be able to:

1. Demonstrate the manipulation of images for the specified requirement
2. Identify the region of interest using segmentation and morphological operations
3. Modify the image geometry for specific purpose
4. Show the effect of rending on given image
5. Indicate the results of fusion and registration of images
6. Demonstrate image reconstruction using the given data

LIST OF EXPERIMENTS

1. Basic operations on medical images
2. Enhancement of medical images
3. Image segmentation using thresholding and region based methods
4. Morphological operations on medical images
5. Translation and rotation of medical images
6. Image reformatting and tracking

7. Volume rendering and Surface rendering 8. Methods for medical image fusion using artificial intelligence 9. Image registration methods using deep learning 10. Image reconstruction using machine learning
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Course code		**L**	**T**	**P**	**C**
21BM3009	**MEDICAL DEVICES DEVELOPMENT LABORATORY**	**0**	**0**	**4**	**2**

Course Objective:

The student should be made to:
1. understand the fundamentals of Embedded system
2. develop programming techniques in real time applications
3. design and develop biomedical devices and products in healthcare

Course Outcomes:

Upon the completion of this course, the student will be able to:
1. Create an embedded C program for various I/O interfacing in medical devices
2. Implement hardware timer concepts for providing delay
3. Develop real time embedded systems for biomedical applications
4. Apply internet protocols for data transmission
5. Design interfacing circuits to acquire real time data and process it using software
6. Integrate the sensor with internet protocol for online monitoring

LIST OF EXPERIMENTS
1. Port Programming
2. Input and Output device Interfacing
3. Concept of timer for generating hardware delay
4. PWM generation
5. Biosensor Interfacing
6. ON/OFF Relay control
7. Low Power wireless transmission of Biosignals
8. Analysis of biosignals and image with Raspberry Pi using python
9. Configuring Raspberry Pi processor for cloud storage and interfacing of biosignals
10. Design of Online Patient monitoring system –IoT implementation
11. Mobile phone based design of medical devices for continuous monitoring system
12. Web server based monitoring and control

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Course code	**MEDICAL SENSORS AND MEMS TECHNOLOGY**	**L**	**T**	**P**	**C**
21BM3010		**3**	**0**	**0**	**3**

Course Objective:

The student should be made to:
1. Understand the in depth and quantitative view of medical sensors and its characteristics
2. Knowledge of the current state of the art to micro sensor fabrication methods
3. Apply the tools to design and development of sensors for the medical applications

Course Outcomes:

At the end of this course, students will be able to
1. Identify the principle of medical sensors and its interfacing circuits
2. Classify the micro sensor materials, synthesis, fabrication and its characterization
3. Choose the design tools to test and develop products to required specifications
4. Infer the most relevant challenges facing in the fabrication process
5. Judge a sensor based on standard performance criteria and environmental impact
6. Construct the micro system for appropriateness for an application and user.

Module: 1	**Classification Of Medical Sensors**	**7 Hours**

Sensors for Pressure Measurement- Sensors for Motion and Force Measurement- Sensors for Flow Measurement -Temperature Measurement- Sensors for speed, torque, vibration- smart sensors, design of interface system. Artificial intelligence in sensor technology.

Module: 2	**Microsystem Design**	**8 Hours**

Technological Breakthrough, Dielectrics for Use in MEMS Applications, Piezoelectric Thin Films for MEMS Applications, Modeling of Piezoelectric MEMS, Interface Circuits for Capacitive MEMS Gyroscope, Advanced MEMS Technologies for Tactile Sensing and Actuation, MEMS-Based Micro Hot-Plate Devices, Inertial Sensor. Design of microsystem for sensing and control.Case study. Machine Learning tools in system design and analysis.		
Module: 3	**Material For MEMS And NEMS**	**7 Hours**
Working principle of Microsystems, materials for MEMS and Microsystems, micromachining, System modeling, Properties of materials, Synthesis, selection and characteristics of materials. Artificial intelligence in material characteristics.		
Module: 4	**Fabrication Methods**	**8 Hours**
Clean room, microfabrication methods, Lithography, epitaxy, sputtering, deposition, surface and bulk micromachining. Case study.		
Module: 5	**Microsensors And Actuators**	**7 Hours**
Mechanical sensors and actuators – beam and cantilever, piezoelectric materials, thermal sensors and actuators- micromachined thermocouple probe, Peltier effect, heat pumps, thermal flow sensors, micro gripper microlens, microneedle, micropumps-Testing of the performance using software tools. Deep learning in actuator design and analysis.Applications of Optimization tools.		
Module: 6	**Software Tools**	**8 Hours**
Modeling and design, using MatLab, Design of sensors, pressure sensor, vibration sensor, actuators Analysis using solvers, MatLab, Comsol, mechanical solver, electrical solver. Machine learning tools in design and analysis.		
	Total Lectures	**45 Hours**
Text Books		
1.	VikasChoudhary, Krzysztof Iniewski, "MEMS: Fundamental Technology and Applications", CRC Press, UK, 2017.	
2.	Tatsuo Togawa; Toshiyo Tamura; P. Ake Oberg, "Biomedical Sensors and Instruments", CRC Press,UK 2011.	
Reference Books		
1.	Octavian Adrian Postolache and Subhas Chandra Mukhopadhyay, "Sensors for Everyday Life: Healthcare Settings (Smart Sensors, Measurement and Instrumentation), CRC Press, 2017.	
2.	Gabor Harsanyi, "Sensors In Biomedical Applications: Fundamentals, Technology & Applications", CRC Press, USA, 2000.	
3.	Tai Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw Hill Publishing Company, New Delhi, 2002.	
4.	Marc J. Madou 'Fundamentals of Microfabrication: The Science of Miniaturization', CRC Press, 2002.	
5.	Mohammad Ilyas, Imad Mahgoub, "Handbook of Sensor Networks Compact Wireless and Wired Sensing Systems" CRC Press, USA. 2005.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**HUMAN COMPUTER INTERFACE**	**L**	**T**	**P**	**C**
21BM3011		**3**	**0**	**0**	**3**
Course Objective:					
The student should be made to: 1. Understand the fundamentals of EEG signal acquisition techniques 2. Learn the feature extraction methods 3. Design EEG based robotic application					
Course Outcomes:					
At the end of this course, students will be able to 1. Identify the data acquisition methods for EEG signal 2. Classify the types of signals and its components 3. Choose the design tools to develop simulation models 4. Classify the signals to develop the applications 5. Assess the systems based on the design specifications 6. Construct the applications for medical diagnosis and robots					
Module: 1	**Human Computer Interaction**				**7 Hours**

Introduction to theories within cognitive and perceptual psychology, human decision making and actions in computer supported situations. Design and construction, Interaction between human and computerized technical systems.Artificial intelligence in decision making.		
Module: 2	**Introduction To Brain Computer Interfaces**	**8 Hours**
Concept of BCI, Invasive and Non-invasive Types, EEG Standards, Signal Features, Spectral Components, EEG Data Acquisition, Pre-processing, Hardware and Software, Artifacts, Methods to Remove, Near Infrared BCI.Machine learning for brain computer interface.		
Module: 3	**BCI Approaches**	**7 Hours**
Movement Related EEG Potentials, Mental States, Visual Evoked Potential. P300 virtual platform.		
Module: 4	**EEG Feature Extraction Methods**	**8 Hours**
Time/Space Methods, Fourier Transform, Wavelets, AR models, Band pass filtering, PCA, Laplacian Filters, Linear and Non-linear Features. Deep learning and artificial intelligence in feature extraction methods.		
Module: 5	**EEG Feature Translation Methods**	**7 Hours**
LDA, Regression, Memory Based Vector Quantization, Gaussian Mixture Modeling, Hidden Markov Modeling.		
Module: 6	**BCI Controlled Robots**	**8 Hours**
Case Study of Problems in BCI, Case Study of Brain Actuated Control applications.		
	Total Lectures	**45 Hours**
Text Books		
1.	Chang S. Nam (Editor), Anton Nijholt (Editor), Fabien Lotte, " Brain–Computer Interfaces Handbook: Technological and Theoretical Advances", CRC Press, UK. 2018.	
2.	Maureen Clerc, Laurent Bougrain, Fabien Lotte, "Brain Computer Interfaces 2: Technology and Applications", Wiley Publisher, 2016.	
Reference Books		
1.	Rajesh P. N. Rao, "Brain-Computer Interfacing: An Introduction", 1st Edition, Cambridge University Press, 2018.	
2.	Andrew Webb, "Statistical Pattern Recognition", Wiley International, Second Edition, 2002.	
3.	R.Spehlmann, "EEG Primer", Elsevier Biomedical Press, 1981.	
4.	Bishop C.M, "Neural Networks for Pattern Recognition", Oxford, Clarendon Press, 1995.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**HUMAN ASSISTIVE DEVICES**	**L**	**T**	**P**	**C**
21BM3012		**3**	**0**	**0**	**3**

Course Objective:

The student should be made to:

1. Introduce the Fundamental terms and concepts of human assist devices
2. Learn various assist device functions and characteristics.
3. Apply design tools for modeling and analysis of assist devices

Course Outcomes:

At the end of this course, students will be able to

1. Identify the requirements for human assist devices
2. Classify the systems based on applications
3. Relate soft tools for analysis and design of devices for specific applications
4. Infer the merits of human assist system and its influence to environment.
5. Choose the methodologies in measurement systems and conditions
6. Combine instrumentation techniques for development of assist devices to human needs

Module: 1	**Heart Lung Machine And Artificial Heart**	**7 Hours**
Condition to be satisfied by the H/L System. Different types of Oxygenators, Pumps, Pulsatile and Continuous Types, Monitoring Process, Shunting, The Indication for Cardiac Transplant, Driving Mechanism, Blood Handling System, Functioning and different types of Artificial Heart, Mock test setup for assessing its Functions.Artificial intelligence in assist devices.		
Module: 2	**Cardiac Assist Devices**	**8 Hours**
Synchronous Counter pulsation, Assisted through Respiration Right Ventricular Bypass Pump, Left Ventricular Bypass Pump, Open Chest and closed Chest type, Intra Aortic Balloon Pumping, Arterial Pumping,		

Prosthetic Cardio Valves, Principle and problem, Biomaterials for implantable purposes, its characteristics and testing. Case study.		
Module: 3	**Artificial Kidney**	**7 Hours**
Indication and Principle of Hemodialysers, Membrane, Dialysate, Different types of hemodialysers, Monitoring Systems, Wearable Artificial Kidney, Implanting Type- Modeling and analysis. Case study.Machine learning in analysis and testing of devices.		
Module: 4	**Prosthetic And Orthodic Devices**	**8 Hours**
Hand and Arm Replacement - Different Types of Models Externally Powered Limb Prosthesis Feedback in Orthodic System, Functional Electrical Stimulation, Haptic Devices.		
Module: 5	**Respiratory And Hearing Aids**	**7 Hours**
Intermittent positive pressure, Breathing Apparatus Operating Sequence, Electronic IPPB unit with monitoring for all respiratory parameters. Types of Deafness, Hearing Aids- Construction and Functional Characteristics.		
Module: 6	**Sensory Augmentation And Substitutions**	**8 Hours**
Classification of Visual Impairments, Prevention and cure of visual impairments, Visual Augmentation, Tactile vision substitution, auditory substitution and augmentation, tactile auditory substitution, Assistive devices for the visual impaired. IoT based assist devices.		
	Total Lectures	**45 Hours**
Text Books		
1.	Kolff W.J, "Artificial Organs", John Wiley and Sons, New York, 1979.	
2.	Andreas.F.Vonracum,"Hand book of biomaterial evalution",Mc-MillanPublishers, 1980.	
Reference Books		
1.	Albert M.Cook, Webster J.G., "Therapeutic Medical Devices", Prentice Hall Inc., New Jersey, 1982.	
2.	John. G. Webster – Bioinstrumentation - John Wiley & Sons (Asia) Pvt Ltd, 2004.	
3.	Muzumdar A., "Powered Upper Limb Prostheses: Control, Implementation and Clinical Application, "Springer, 2004.	
4.	Rory A Cooper, "An Introduction to Rehabilitation Engineering, Taylor & Francis, CRC Press, UK. 2006.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**COGNITIVE TECHNOLOGY FOR BIOMEDICAL ENGINEERS**	**L**	**T**	**P**	**C**
21BM3013		**3**	**0**	**0**	**3**
Course Objective:					
The student should be made to: 1. Learn the various soft computing frame works 2. Be familiar with design of various neural networks and fuzzy logic 3. Learn genetic programming and hybrid systems					
Course Outcomes:					
Upon completion of the course, the student should be able to: 1. Identify various soft computing frame works 2. Interpret various neural networks and fuzzy logic methods 3. Relate genetic programming and hybrid soft computing 4. Select computing techniques for biomedical applications 5. Assess hybrid techniques 6. Design diagnostic and therapeutic methods					
Module: 1	**Introduction To Artificial Neural Networks**				**7 Hours**
Characteristics- learning methods – taxonomy – Evolution of neural networks- McCulloch-Pitts neuron - linear separability - Hebb network - supervised learning network: perceptron networks - adaptive linear neuron, multiple adaptive linear neuron. Artificial intelligence in medical applications.					
Module: 2	**Types Of Neural Networks**				**8 Hours**
BPN, RBF, TDNN- associative memory network: auto-associative memory network, hetero-associative memory network, BAM, hopfield networks, iterative autoassociative memory network & iterative associative memory network – unsupervised learning networks: Kohonenself organizing feature maps, LVQ – CP networks, ART network. Case studies on biomedical applications.					
Module: 3	**Fuzzy Logic**				**7 Hours**
Membership functions: features, fuzzification, methods of membership value assignments- Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy					

measures - formation of rules-decomposition of rules, fuzzy inference systems-overview of fuzzy expert system-fuzzy decision making. Case studies on biomedical applications.		
Module: 4	**Genetic Algorithm**	**8 Hours**
Genetic algorithm and search space - general genetic algorithm, operators - Generational cycle, stopping condition, constraints. Classification, genetic programming, multilevel optimization, real life problem, Advances in GA. Case studies on biomedical applications using deep learning.		
Module: 5	**Hybrid Soft Computing Techniques**	**7 Hours**
Neuro-fuzzy hybrid systems - genetic neuro hybrid systems - genetic fuzzy hybrid and fuzzy genetic hybrid systems - simplified fuzzy ARTMAP. Case studies on biomedical applications.		
Module: 6	**Applications**	**8 Hours**
A fusion approach of multispectral images with SAR, optimization of traveling salesman problem using genetic algorithm approach, soft computing based hybrid fuzzy controllers. Case studies on biomedical applications.		
	Total Lectures	**45 Hours**

Text Books	
1.	Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications" Pearson Education, 2010.
2.	S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.
Reference Books	
1.	J.S.R.Jang, C.T. Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", Pearson Education 2004.
2.	S.Rajasekaran and G.A.VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd., 2006.
3.	George J. Klir, Ute St. Clair, Bo Yuan, "Fuzzy Set Theory: Foundations and Applications", Prentice Hall, New Delhi. 1997.
4.	Simon Haykin, "Neural Networks Comprehensive Foundation", Second Edition, Pearson Education, 2005.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**FINITE ELEMENT MODELING FOR BIOMEDICAL ENGINEERS**	**L**	**T**	**P**	**C**
21BM3014		**3**	**0**	**0**	**3**

Course Objective:

The students should be made to**:**

1. Understand the concepts of finite element methods for biomechanical analysis
2. Study beam elements and scalar problem in two dimension
3. Create applications to field problems

Course Outcomes:

At the end of this course, the students should be able to:

1. Define modeling using finite element formulation
2. Identify boundary conditions and mesh elements
3. Relate finite element analysis in biomechanical research
4. Select the tools and develop the models
5. Assess the models and observe the performance
6. Create physiological model for biomedical applications

Module: 1	**Introduction To Modeling**	**7 Hours**
Historical Background, Mathematical Modeling of field problems in Engineering, Governing Equations, Natural and Essential Boundary conditions - Basic concepts of the Finite Element Method. One Dimensional Second Order Equations, Discretization, element types- Linear and Higher order Elements Derivation of Shape functions and Stiffness matrices and force vectors Assembly of Matrices - solution of problems from solid and bio mechanics- Structural, stress, and strain analysis of the human body and/or artificial implants.Artificial intelligence based design applications.		
Module: 2	**Beam Elements And Scalar Problem In Two Dimention**	**8 Hours**
Fourth Order Beam Equation Transverse deflections - Natural frequencies of beams and Longitudinal vibration. Second Order 2D Equations involving Scalar Variable Variational formulation Finite Element formulation Triangular elements Shape functions and element matrices and vectors. Application to Field Problems in Bio mechanics, Quadrilateral elements.		
Module: 3	**Applications To Field Problems**	**7 Hours**

Higher order elements. Natural co-ordinate systems Isoparametric elements Shape functions for isoparametric elements One, two and three dimensions Serendipity elements Numerical integration and application to plane stress problems transformation in coordinates- Jacobian of transformation-order of convergence- numerical integration example problems- shape functions in natural coordinates- rectangular elements- Lagrange family- Serendipity family rectangular prisms- tetrahedral elements. Deep learning tools in analysis.		
Module: 4	**Isoparametric Formulation And Miscellaneous Topics**	**8 Hours**
Introduction to elasticity equations stress strain relations plane problems of elasticity element equations Plane stress, plane strain and axisymmetric problems stress-strain-time or constitutive equations for soft connective tissue components Modelling and force analysis of musculoskeletal systems Stress calculations.		
Module: 5	**Non-Linear Analysis**	**7 Hours**
Introduction to Non-linear problems - some solution methods- computational procedure- simple material nonlinearity, stress stiffening, contact interfaces- problems of gaps and contact- geometric non-linearity- modeling considerations.		
Module: 6	**Impact Analysis**	**8 Hours**
Mechanical properties of biological and commonly used biomedical engineering materials - Critical reviews of finite element analysis in biomechanical research.		
	Total Lectures	**45 Hours**

Text Books

1.	J N Reddy, "Finite element methods", Tata Mc GrawHill, 2003.
2.	Seshu, "Text Book of finite element analysis", Prentice Hall, New Delhi, 2003.

Reference Books

1.	Connie McGuire, "Finite Element Analysis: Biomedical Aspects", NY Research press, 2015.
2.	Moratal D., "Finite Element Analysis from Biomedical Applications to Industrial Developments", InTech Publisher, 2014.
3.	King-Hay Yang, "Basic Finite Element Method as Applied to Injury Biomechanics", Elsevier Academic Press. 2017.
4.	Suvranu De and FarshidGuilak, "Computational Modeling in Biomechanics", Springer, 2010.

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

Course code	**REHABILITATION ENGINEERING**	**L**	**T**	**P**	**C**
21BM3015		**3**	**0**	**0**	**3**

Course Objective:

The student should be made to:

1. Know about various types of disability and its rehabilitation models
2. Understand the integration of sensor and actuators to combat disability
3. Build rehabilitation robots for training and applications in rehabilitation

Course Outcomes:

At the end of this course, students will be able to

1. Describe the basic terminology in rehabilitation and models for societal applications
2. Classify the sensors and actuators for particular applications.
3. Discover the new methodology and systems for societal needs related to disability
4. Compare the devices and methods under various environmental conditions
5. Criticize the design, performance, cost, user need and affordability
6. Develop the products based on cost effectiveness, user needs, environment friendly

Module: 1	**Introduction To Rehabilitation**	**7 Hours**
Introduction, models, Health, disability, quality of life, Safety standards, Community based rehabilitation, independence, mobility, reforms.		
Module: 2	**Transducer And Actuators For Rehabilitation**	**8 Hours**
Linear and Angular displacement transducer, velocity Strain, Force measurement, Motion sensor- accelerometer, Proximity sensor, optical encoder Electrical actuators for rehabilitation, electromechanical mechanism, Pneumatic actuators, Hydraulic actuators.IoT based application design.		
Module: 3	**Technology And Disability**	**7 Hours**
Design of upper limb, Design of lower limb,prosthetics design, and design parameters. Deep learning based design and analysis.		
Module: 4	**Robots In Rehabilitation**	**8 Hours**

Physiology basics of neuromotor recovery, neurorehabilitation, robots assisted rehabilitation therapy, actuator design methods and controllers. Exoskeleton applications for upper and lower limb.rehabilitationrobotics,Mobility and navigation.		
Module: 5	**Rehabilitation Training And Assessment**	**7 Hours**
Assessment methods, computational models**,** interactive training, software tools, Personal and patient transportation system, Design of Smart wheel chair, Gait training, wearable robotic systems,robots in activities for daily living.		
Module: 6	**Control Of Exoskeleton**	**8 Hours**
EMG based controls. Modeling, simulation and control of exoskeleton.		
	Total Lectures	**45 Hours**
Text Books		
1.	Barbara Gibson, "Rehabilitation: A Post-critical Approach", Rehabilitation Science in Practice Series, First Edition, 2016.	
2.	Myer Kutz, "Standard Handbook of Biomedical Engineering& Design", McGraw Hill Publisher,UK,2003.	
Reference Books		
1.	Roberto Colombo (Editor), Vittorio Sanguineti, "Rehabilitation Robotics: Technology and Application",1st Edition, Elsevier, UK, 2018.	
2.	Volker Dietz, Tobias Nef, William Zev Rymer, "Neuro Rehabilitation technology", Springer, London, 2012.	
3.	Clarence W. de Silva, "Sensors and Actuators: Engineering System", CRC Press, UK, 2016.	
4.	**Xie**, Shane, "Advanced Robotics for Medical Rehabilitation: Current State of the Art and Recent Advances, 2016.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**MACHINE LEARNING FOR HEALTHCARE**	**L**	**T**	**P**	**C**
21BM3016		**3**	**0**	**0**	**3**
Course Objective:					
The student should be made to: 1. Learn the concept of machine learning. 2. Analyse recent advances in machine learning algorithms 3. Explore supervised and unsupervised learning paradigms towards applications					
Course Outcomes:					
After completion of course, students would be able to: 1. Describe features that can be used for a particular machine learning approach 2. Classify contrast pros and cons of various machine learning techniques 3. Illustrate various methods for developing the application 4. Infer various machine learning approaches and paradigms. 5. Choose the methods towards challenges 6. Create solution to human problems in healthcare domain					
Module: 1	**Supervised Learning**				**7 Hours**
Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naive Bayes Linear models: Linear Regression, Logistic Regression, Generalized Linear Models Support Vector Machines, Nonlinearity and Kernel Methods-Beyond Binary Classification: Multi-class/Structured Outputs, Ranking					
Module: 2	**Unsupervised Learning**				**8 Hours**
Clustering: K-means/Kernel K-means, Dimensionality Reduction: PCA and kernel PCA, Matrix Factorization and Matrix Completion, Generative Models (mixture models and latent factor models)					
Module: 3	**Evaluating Algorithms**				**7 Hours**
Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods, Boosting, Bagging, Random Forests.					
Module: 4	**Sparse Modeling And Estimation**				**8 Hours**
Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning. Medical applications case study.					
Module: 5	**Scalable Machine Learning**				**7 Hours**

Online and Distributed Learning, A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference		
Module: 6	**Recent Trends**	**8 Hours**
Various learning techniques of Machine Learning and classification methods for IoMT applications. Various models for IoMT, and applications. Healthcare applications case study.		
	Total Lectures	**45 Hours**
Text Books		
1.	Kevin Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012	
2.	Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning", Springer 2009.	
Reference Books		
1.	Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 2007.	
2.	Arvin Agah, "Medical Applications of Artificial Intelligence", CRC Press, 2017.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**ROBOTICS IN SURGERY**	**L**	**T**	**P**	**C**
21BM3017		**3**	**0**	**0**	**3**
Course Objective:					
The student should be made to: 1. Understand the fundamentals of robotics and its degree of freedom 2. Learn the various sensor and actuators required for its functions 3. Apply the machine learning concepts in medical applications					
Course Outcomes:					
The Student will be able to 1. Identify the fundamental concepts in robotic systems 2. Interpret the types of sensors and actuators for its applications 3. Choose the design tools to develop artificial intelligence techniques 4. Classify the conditions required for testing and control of autonomous robots 5. Judge the safety aspects to human and environment 6. Construct the robots for assisting in surgery					
Module: 1	**Introduction To Robotics**				**7 Hours**
Degrees of freedom, path planning, Lagrange equation of motion, kinetics, payload, Links and Joints.					
Module: 2	**Sensors And Actuators**				**8 Hours**
Gripper, tactile sensor, Sensor for vision and motion, Interfacing techniques, proximity switches, controllers. Path planning, path tracking.					
Module: 3	**Programmable Controller**				**7 Hours**
Artificial intelligence, machine vision, design of controllers based on embedded system, feedback control design. Human machine interface. Case studies.					
Module: 4	**Human-Robot Interaction**				**8 Hours**
Human factors: perception, motor skills, social aspect of interaction, safety, Haptic robots, collision detection, autonomous robots. Machine learning based path tracking.					
Module: 5	**Medical Robotics**				**7 Hours**
surgical robotics, robot supported diagnostics, micro-robots, nanorobots at the cell level, Robots in medical applications. case study. IoT based robot control.					
Module: 6	**Surgical Robot**				**8 Hours**
Configuration, kinematics and workspace, design of intraocular robot surgery, Haptics, Laparoscopic robotic surgery, applications of smart materials. Case study.					
	Total Lectures				**45 Hours**
Text Books					
1.	Mohsen Shahinpoor, SiavashGheshmi, "Robotic Surgery: Smart Materials, Robotic Structures, and Artificial Muscles", CRC Press, 2015.				
2.	Jacob Rosen, Blake Hannaford, Richard. M. Satava, "Surgical Robotics", Systems Applications and Visions", Springer, 2011.				
Reference Books					
1.	Farid Gharagozloo, FarzadNajam, "Robotic surgery", McGraw Hill Publishers, US, 2009.First edition.				
2.	Bruno Siciliano and Lorenzo Sciavicco, "Robotics: Modeling, Planning and Control", Springer, 2010.				

3.	Bruno Siciliano, OussamaKhatib, “Springer Handbook of Robotics”, Springer, 2008.
4.	M. Tavakoli, R.V. Patel, M. Moallem, A. Aziminejad, Haptics for Teleoperated Surgical Robotic Systems, World Scientific, 2008.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**TELEHEALTH TECHNOLOGY**	**L**	**T**	**P**	**C**
21BM3018		**3**	**0**	**0**	**3**

Course Objective:

The student should be made to:

1. Introduce the concept of telemedicine
2. Understand the Benefits and Limitations of Telemedicine.
3. Know Security and Standards and their use in Telemedicine Applications

Course Outcomes:

1. Justify the need of telemedicine
2. Comprehend the various types of information
3. Realize the various data acquisition and storage system
4. Describe the issues in data handling and strategic Planning
5. Describe the role of Internet in telemedicine
6. Apply telemedicine in different fields like cardiology, oncology, pathology etc.

Module: 1	**Introduction To Telemedicine**	**7 Hours**

Data types, Data acquisition Systems, Display Systems, Data Storage Systems, Communication Networks.

Module: 2	**Multimedia Data Exchange And Telemedicine Quality Control**	**8 Hours**

Networking Architecture, Protocol Hierarchies for Multimedia communication, Media Coding. Data analytics in telemedicine.Artificial intelligence in medical coding.

Module: 3	**Internet In Telehealth Care**	**7 Hours**

Security, Quality of Service, Personal Communication, Medical Data Sharing, Telemedicine Needs, E-mail applications, World Wide Web, Teleworking, Teleteaching, Organizational Environment – Teleworking design and development.

Module: 4	**Data Handling**	**8 Hours**

Data security and privacy, Mechanism of security, Security on Internet, security and legal issues, Liability and legal aspects, Main Deontological applications, Contract scenarios, legal protection.

Module: 5	**Planning And Other Social Aspects**	**7 Hours**

Constraints for use of telehealth care, Costs/benefits, Planning for implementation, Forces affecting technology transfer, Scenarios for technology transfer, Technology transfer requirements, Strategy of telehealth care.

Module: 6	**Healthcare Applications**	**8 Hours**

Teleradiology, Telepathology, Telecytology, Telecardiology, Teleoncology, Teledermatology, Tele-Home care, TelesurgeryTelepsychiatry, Primary Care, Telephonic Medicine. IoT in health care

Total Lectures	**45 Hours**

Text Books

1.	Olga Ferrer-Roca, M.SosaLudicissa, “Handbook of Telemedicine”, IOS press 2002.
2.	A.C.Norris, “Essentials of Telemedicine and Telecare”, John Wiley & Sons, 2002.

Reference Books

1.	E-Health, Telehealth, and Telemedicine: A Guide to Startup and Success By Marlene Maheu, Pamela Whitten, Ace Allen E-Health, 2001.
2.	Current Principles and Practices of Telemedicine and E-health, RifatLatifi, IOS Press, 2008.
3.	Steven F. Viegas, Kim Dunn, “Telemedicine: Practicing in the Information Age, 2000.
4.	Richard Wootton, John Craig, Victor Patterson, “Introduction to Telemedicine, second edition, 2013.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**HOSPITAL AND EQUIPMENT MANAGEMENT**	**L**	**T**	**P**	**C**
21BM3019		**3**	**0**	**0**	**3**

Course Objective:

The student should be made to:

1. Understand the fundamentals of health care delivery services
2. Learn the procedures in maintenance of equipments
3. Apply the design principles in engineering systems

Course Outcomes:		
The Student will be able to 1. Identify the principle of organizational structures and regulatory services 2. Classify the types of codes followed and applications 3. Modify the design to develop support systems 4. Infer the most challenges in environment and market trends 5. Evaluate the systems based on the safety criteria to environment 6. Create the methodology for new equipments to user needs		
Module: 1	**Health And Hospital Management**	**7 Hours**
Health organisation of the country, the State, the Cities and the Region, Management of Hospital Organisation, Nursing Sector, Medical Sector, Central Services, Technical Department, Definition and Practice of Management by Objective, Transactional Analysis Human Relation in Hospital, Importance of Team Work, Legal aspect in Hospital Management. Case study: Health survey.		
Module: 2	**Regulatory And Voluntary Guidelines And Health Care Codes**	**8 Hours**
FDA Regulation, Joint Commission of Accreditation for Hospitals, National Fire Protection Association Standard, ISO, NABL, ISO:13485, ISO:14791, risk management, Environmental regulation. Case study on risk management.		
Module: 3	**Healthcare Supply Chain Management**	**7 Hours**
Essentials of healthcare supply chain management, designing sustainable health care supply chain, performance metrics, emerging trends in healthcare supply chain management. Data analytics in supply chain management.		
Module: 4	**Clinical Engineering**	**8 Hours**
Role to be performed in Hospital, Manpower & Market, Professional Registration, Maintenance of Hospital support system, surveillance network, electric power management, Medical gas production, waste disposal, inventory control. Case study: RF ID tag for inventory. IoT in inventory management.		
Module: 5	**Safety Equipments**	**7 Hours**
Operation of safety devices, personnel safety equipments, Gas mask, Radiation measurements, equipment safety systems, elements of basic first aid, fire fighting, Case study: Safety Awareness.		
Module: 6	**Equipment Maintenance Management**	**8 Hours**
Organizing the maintenance operation, biomedical equipment procurement procedure, proper selection, compatibility, testing and installation, purchase and contract procedure, trained medical staff, on proper use of equipment and operating instructions. Maintenance of job planning, preventive maintenance, maintenance budgeting, contract maintenance.		
	Total Lectures	**45 Hours**
Text Books		
1.	Hokey Min, "Healthcare Supply Chain Management: Basic Concepts and principles", Business expert press, NewYork, 2014.	
2.	Keith Willson, Keith Ison, SlavikTabakov, "Medical Equipment Management", CRC Press, 2013.	
Reference Books		
1.	Webster.J.G. and Albert M.Cook, "Clinical Engineering Principles and Practices Prentice Hall Inc., Englewood Cliffs, New Jersey, 1979.	
2.	Robin Guenther, Gail Vittori, "Sustainable Healthcare Architecture", Wiley, 2013.	
3.	Sharma D K, R.C.Goyal, "Hospital administration and human Resource Management in Hospital", Prentice Hall of India, New Delhi, 2017.	
4.	Syed Amin Tabish "Hospital and Health services Administration Principles and Practices" Oxford Press, New Delhi, 2001.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	PHYSIOLOGICAL CONTROL SYSTEM	L	T	P	C
21BM3020		3	0	0	3
Course Objective:					
The student should be made to: 1. Learn the modeling techniques of physiological systems. 2. Understand physiology and control techniques 3. Study the various regulatory systems of the human body.					
Course Outcomes:					
1. Describe the concepts of modeling and simulation 2. Differentiate characteristics of physiological systems					

3. Show various concepts of biofeedback methods
4. Categorize adaptive and learning techniques
5. Criticize various control methodology for medical device applications
6. Design the biomedical systems useful for community

Module: 1	**Modeling of Physiological Systems**	**7 Hours**
Systems Analysis, examples of physiological control systems, differences between engineering and physiological control systems. Generalized system properties, mathematical approach, electrical analogs, linear models, lung mechanics, muscle mechanics, distributed parameter versus lumped parameter models.		
Module: 2	**Analysis of Physiological Models**	**8 Hours**
Static and dynamic analysis of physiological systems: regulation of cardiac output, blood glucose regulation, chemical regulation of ventilation, electrical model of neural control mechanism, sleep apnea, respiration. Machine learning tools in analysis of physiological system.		
Module: 3	**Biofeedback In Physiological System**	**7 Hours**
Circulatory System: respiration system, cardiovascular measurements, EEG and EMG, Pupil reflux. Blood pressure, heart rate. Case study.		
Module: 4	**Stability Analysis**	**5 Hours**
Routh-Hurwitz, Root locus, Lyapnov methods.		
Module: 5	**Control Techniques**	**10 Hours**
Introduction to adaptive control, Direct and indirect adaptive control, Model reference adaptive control, Parameter convergence, Persistence of excitation Adaptive back stepping, Adaptive control of nonlinear systems, Composite adaptation. Case study.Artificial intelligence in physiological control.		
Module: 6	**Advanced Controllers**	**8 Hours**
Robust adaptive control Neural Network-based control Reinforcement learning-based control, Repetitive learning control, Predictive control, Robust adaptive control.		
	Total Lectures	**45 Hours**

Text Books

1.	Physiological control systems: Analysis, Simulation and estimation, IEEE Press Series on Biomedical Engineering, 2018.
2.	John Enderly, Joseph Bronzino, "Introduction to Biomedical Engineering", Third Edition, Academic Press Series in Biomedical Engineering, 2012.

Reference Books

1.	William B.Blesser, "A System Approach to Biomedicine", McGraw Hill Book Co., New York, 2009.
2.	ManfreoClynes and John H.Milsum, "Biomedical Engineering System", McGraw Hill and Co., New York, 2001.
3.	J.J.E. Slotine, and W. Li, "Applied Nonlinear Control", Prentice-Hall, 1991.
4.	P. Ioannou& B. Fidan, "Adaptive Control Tutorial", SIAM, Philadelpia, 2006.

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

Course code	**ERGONOMICS IN HEALTHCARE**	**L**	**T**	**P**	**C**
21BM3021		**3**	**0**	**0**	**3**

Course Objective:

The student should be made to:

1. Introduce the Fundamental terms and concepts of human factors
2. Learn principles and optimize human well-being and overall performance.
3. Apply methodology for human stress work area.

Course Outcomes:

At the end of this course, students will be able to

1. Identify the problems in posture and work efficiency
2. Classify the workspace and related systems
3. Choose signal processing techniques for analysis and feature extraction.
4. Relate the anthropometric concepts to human system and environment.
5. Assess the methodologies in measurement systems and conditions
6. Construct instrumentation techniques for development of user friendly systems

Module: 1	**Ergonomics In Healthcare**	**7 Hours**
Human factors and ergonomics in health care, ergonomic challenges in patient safety, work system design in healthcare, effect of workplace on healthcare workers, healthcare work schedule. Human error in healthcare, error reduction strategies.		

Module: 2	**Human–Machine System**	**8 Hours**
Human machine interaction**,** human technological system, manual, mechanical, automated system, human system reliability, human system modeling, Human Output And Control, material handling, motor skill, human control of systems, controls and data entry devices, hand tools and devices.		
Module: 3	**Workplace Design**	**7 Hours**
Applied anthropometry, workspace design and seating, design of computer worktable, case studies. Environmental conditions. Workplace design.		
Module: 4	**Measurement System**	**8 Hours**
Physical stress and fatigue measurement using EMG and EEG. Assessment and evaluation tools for musculoskeletal disorder and patient handling techniques. Design of assessment system: Case study. Deep learning in EMG, EEG analysis.		
Module: 5	**Ergonomics Methodologies**	**7 Hours**
Cognitive work analysis in healthcare, risk management for medical products, analysis of workflow, simulation based trainings, Information technology design and development, programmes and implementation models, patient safety and ergonomics for patient safety. Data analytics in ergonomic analysis.		
Module: 6	**Ergonomics Applications In Hospital**	**8 Hours**
Human factors and ergonomics in ICU, emergency department, pediatrics, home care, primary care, anesthesia, medication safety, infection prevention, surgical excellence. Case study.		
	Total Lectures	**45 Hours**

Text Books	
1.	Pascale Carayon, "Handbook of Human Factors and Ergonomics in Health Care and Patient Safety, Second Edition, CRC Press, UK. 2017.
2.	Alan Hedge**, "**Ergonomic Workplace Design for Health, Wellness, and Productivity, CRC Press, 2016.
Reference Books	
1.	Bridger R S, "Introduction to Ergonomics", Taylor and Francis, London, 2003.
2.	Vincent G. Duffy, Advances in Human Factors and Ergonomics in Healthcare, Advances in Human Factors and Ergonomics Series, 2017.
3.	Mccormic.E.J., and Sanders.M.S, "Human factors in Engineering and Design", McGraw Hill, New Delhi, 1993.
4.	Webster, "Medical Instrumentation Application and Design", Wiley India Pte Ltd, New Delhi, 2014.
5.	Pascale Carayon, " Handbook of Human Factors and Ergonomics in Health Care and Patient Safety", CRC Press, USA. 2012.
	Stephen J. Guastello, "Human Factors Engineering and Ergonomics: A Systems Approach, Second Edition, CRC Press, USA. December 2013.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**MEDICAL ETHICS AND SAFETY**	**L**	**T**	**P**	**C**
21BM3022		**3**	**0**	**0**	**3**

Course Objective:

The student should be made to:

1. Provide a source of useful ideas, concepts, and techniques
2. Improve performance to avoid patient injury, achieving efficacious treatment
3. Reduce Medical error and controlling health care costs.

Course Outcomes:

At the end of this course, students will be able to

1. Identify the mechanical and electrical safety standards of medical equipment
2. Understand device specific safety goals
3. Interpret reasonable, acceptable and effective remedies and counter measure
4. Select the clinical suitability to the impact of the device on the environment
5. Device more reliable medical equipment incorporating safety goals
6. Combine new techniques for device management

Module: 1	**Reliability And Safety Testing**	**7 Hours**
Reliability – Types of reliability – Reliability optimization & assurance – Reliability's effect on medical devices – The concept of failure – Causes of failure – Types of Failures in Medical devices – Safety testing – Device specific safety goals, Failure assessment and Documentation – Visual inspection: External & Internal visual inspection – Measurement – Safety parameters, Function test. Data analytics in reliability analysis.		
Module: 2	**Medical Devices Handling, Environmental Safety**	**8 Hours**

Safe medical devices – Handling and operation – Medical Application safety – Usability – Clinical assessment – Environmental safety. Deep learning in clinical assessment.		
Module: 3	**Electrical Safety**	**7 Hours**
Safety Mechanics – Electrical Safety – Biological aspect – Limitation of Voltages - Macroshock and Microshock – Earth and Protection – Leakage currents – Magnetic fields and compatibility – Basic assumptions in safety technology – Safety classes.		
Module: 4	**Medical Devices Standards**	**8 Hours**
Medical Standards and Regulations – Device classification – Registration and listing –CE, UL standards, ICMED regulations– Investigational Device Exemptions – Institutional Review Boards – IDE format – Good laboratory practices – Good manufacturing practices.		
Module: 5	**Ethical Theories & Moral Principles**	**7 Hours**
Theories-Deontology& Utilitarianism, Casuist theory, Virtue theory, The Right Theory. Principles - Non-Maleficence, Beneficence, Autonomy, Veracity, Justice. Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research, Bioethical issues in Human Genetics & Reproductive Medicine.		
Module: 6	**Introduction To Medical Ethics**	**8 Hours**
Definition of Medical ethics, Scope of ethics in medicine, American medical Association code of ethics, CMA code of ethics- Fundamental Responsibilities, The Doctor and the Patient, The Doctor and the Profession, Professional Independence, The Doctor and Society. Data analytics in medical ethics.		
	Total Lectures	**45 Hours**
Text Books		
1.	Norbert Leitgeb "Safety of Electro-medical Devices Law – Risks – Opportunities" Springer Verlog, 2010.	
2.	Bertil Jacobson and Alan Murray, "Medical Devices Use and Safety", Elsevier, 2007.	
Reference Books		
1.	Richard Fries, "Reliable Design of Medical Devices – Second Edition", CRC Press, Taylor & Francis Group, 2006.	
2.	Robert M Veatch, "Basics of Bio Ethics", Second Edition. Prentice- Hall, Inc. 2003	
3.	Domiel A Vallero, "Biomedical Ethics for Engineers", Elsevier Pub.1st edition, 2007	
4.	Erich H. Loewy, "Textbook of Medical Ethics", Springer; 2014.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**Internet of Things in Healthcare**	**L**	**T**	**P**	**C**
21BM3023		**3**	**0**	**0**	**3**
Course Objective:					
The student should be made to: 1. Teach the internet concepts and design methodology 2. Teach fundamentals of embedded system 3. Teach importance of embedded and IoT in health care.					
Course Outcomes:					
At the end of this course, students will be able to 1. Acquire the knowledge & concepts of IoT. 2. Explain the basic concepts of IoT Protocols. 3. Illustrate the concepts of embedded system for health care applications. 4. Categorize the importance of digital health 5. Criticize the ethical issues in health care 6. Develop an application based on IoT in health care					
Module: 1	**Internet Concepts And Infrastructure**				**7 Hours**
Broad Band Transmission facilities, Open Interconnection standards, Local Area Networks, Wide Area Networks, Network management, Network Security, Cluster computers. Internet concepts, Capabilities and limitations of the internet.Interfacing Internet server applications to corporate databases HTML and XML Web page design through programming and the use of active components.Data analytics in medical data processing.					
Module: 2	**Design Methology And Protocols**				**8 Hours**
Introduction, Characteristics, Physical design, Protocols, Logical design, Enabling technologies, IoT Levels, Domain Specific IoTs, IoT vs M2M. IOT design methodology, IoT systems management, IoT Design Methodology Specifications Integration and Application Development.					
Module: 3	**Embedded Systems**				**7 Hours**

Generic Embedded Systems Structure- Components of Embedded Systems- Sensors and Actuators-importance of Analog/Digital Conversion- Embedded system based physiological monitoring system- Health care innovations using embedded system. Evolution of digital health- challenges and opportunities of digital health- importance of digital health.		
Module: 4	**Ethical Issues In Health Care**	**8 Hours**
Ethical implications of digital health technologies- privacy, confidentiality and security of personal health data- ethical framework and guidelines in digital health, principles of biomedical ethics.		
Module: 5	**IoT In Health Care Applications**	**7 Hours**
IoT based health care- physiological parameter monitoring system- future challenges in health care- health care echo system with IoT- IoT for personalized health care- wearable device characteristics-analysis of power aware protocols. Artificial intelligence in health monitoring.		
Module: 6	**Standards For E-Health Applications**	**8 Hours**
Social network analysis in health care embedded health care system for senior resident using IoT.		
	Total Lectures	**45 Hours**
Text Books		
1.	Eugene C. Nelson, Paul B. Batalden, Marjorie M. Godfrey, Quality By Design: A Clinical Microsystems Approach John Wiley & sons 2007.	
2.	Samuel A. Fricker, ChristophThuemmler, AnastasiusGavras, Requirements Engineering for Digital Health, Springer 2015.	
Reference Books		
1.	Klaus Pohl, HaraldHonninger, Reinhold Achatz, Manfred Broy, Model-Based Engineering of Embedded Systems: The SPES 2020 Methodology, Springer 2012	
2.	Adrian Mc Ewen, Hakim Cassimally, "Designing the Internet of Things", Wiley, 2013.	
3.	Andrew S Tanenbaum, "Computer Networks", Pearson Education Pvt Ltd, New Delhi, 4th Edition, 2012.	
4.	Stallings, William, "Data and computer communications", Pearson Education Pvt Ltd, New Delhi, 2007	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**NANOTECHNOLOGY IN MEDICINE**	**L**	**T**	**P**	**C**
21BM3024		**3**	**0**	**0**	**3**
Course Objective:					
The student should be made to: 1. To know basic nanotechnological principles and characterization methods 2. To understand the essential features of biology and nanotechnology 3. Create the new areas of bio nanotechnology and nanomedicine.					
Course Outcomes:					
The student will be able to: 1. Define the newest findings in the area of nanomedicine 2. Classify the materials for nano therapeutics 3. Show the advanced methods of nano synthesis 4. Explain the characteristics of nanoparticles in diagnosis 5. Choose nanotechnology in appropriate medical applications 6. Implement the perspectives in own research					
Module: 1	**Introduction of Nanoparticles**				**7 Hours**
Overview of nanotechnology from medical perceptive, different types of nanobiomaterials and nanostructure interactions.Synthesis, characterization, and properties smart nanomaterials, Surface modification.					
Module: 2	**Biofunctionalization of Nanomaterials**				**8 Hours**
Nanocarriers, liposomes, polymer capsules, polymer nanoparticles. Artificial intelligence in nanomaterials.					
Module: 3	**Protein As Nanostructures**				**7 Hours**
Protein based nanostructures building blocks and templates Proteins as transducers and amplifiers nanobioelectronic devices and polymer nanocontainers microbial production of inorganic nanoparticles magnetosomes.					
Module: 4	**DNA as nanostructures**				**8 Hours**
DNA based nanostructures Topographic and Electrostatic properties of DNA Hybrid conjugates of gold nanoparticles DNA oligomers use of DNA molecules in nanomechanics.					
Module: 5	**Nanoparticles In Diagnosis**				**7 Hours**

Introduction to nanoparticles in diagnostics nuclear imaging, optical imaging, PET, Micro PET, cardio vascular disease studies, imaging and therapy of thrombosis, emerging Ethical issues and toxicology of nanomaterials.Deep learning in disease diagnosis.		
Module: 6	**Nanotherapeutics**	**8 Hours**
Nanoparticles as carriers in drug delivery- design, manufacture and physiochemical properties, transport across biological barriers, nanotechnology in Cancer therapy, lung infectious disease, bone treatment, nano particles for oral vaccination and skin disease.		
	Total Lectures	**45 Hours**
Text Books		
1.	Niemeyer, C.A. Mirkin, "Nano biotechnology Concepts, Applications and Perspectives", Wiley, 2004.	
2.	Douglas Natelson, Nanostructures and Nanotechnology, Cambridge University Press, 2015.	
Reference Books		
1.	ArunavaGoswami, "Nanobiotechnology: Basic and Applied Aspects", Anthem Press, 2017.	
2.	CM, Niemeyer, C.A. Mirkin, "Nano biotechnology Concepts, Applications and Perspectives", Wiley, 2004.	
3.	Challa, S.S.R. Kumar, Josef Hormes, CarolaLeuschaer., "Nanofabrication towards Biomedical Applications, Techniques, Tools, Applications and Impact" Wiley, 2005.	
4.	Harry F. Tibbals, Medical Nanotechnology and Nanomedicine, CRC Press, 2010.	
5.	Richard C. Dorf, "Sensors, Nanoscience, Biomedical Engineering, and Instruments Sensors Nanoscience Biomedical Engineering", CRC Press, USA. 2006.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	**BIOMEDICAL ENGINEERING ENTREPRENEURSHIP**	**L**	**T**	**P**	**C**
21BM3025		**3**	**0**	**0**	**3**

Course Objective:

The student should be made to:

1. To learn fundamentals of entrepreneurship
2. To apply the methods of entrepreneurship in medical field
3. To evaluate the medical devices and market trends

Course Outcomes:

At the end of this course, students will be able to

1. Describe the role of biomedical engineers in entrepreneurship
2. Interpret the background for biomedical engineers in entrepreneurship
3. Acquire the skills and techniques required towards innovation
4. Categorize the resources and funding agencies
5. Judge the right product based on market needs
6. Compile and quantify the opportunities and challenges

Module: 1	**Scope For Biomedical Engineering Entrepreneurship**	**7 Hours**
Fundamentals and models, Advancements in biomedical field, Supporting societies and professional activities.Impact of innovation in medical devices.Casestudy. Artificial intelligence in innovation of medical devices.		
Module: 2	**Venture**	**8 Hours**
Assessing the venture, Establish venture invention, market research, presenting the business plan, case study. Data analytics in market research.		
Module: 3	**Regulations**	**7 Hours**
Certification, ISI, CE, UL, NABL and FDA regulations, ISO:13485, ISO:14791, risk management, Environmental regulation. Case study on risk management.Case study.		
Module: 4	**Identifying The Grants**	**8 Hours**
Identify and organize support for product development, funding agencies, collaborative initiatives, and angel investors.		
Module: 5	**Impact of Globalization**	**7 Hours**
Medical product manufacturing, marketing, leadership, quality management. Machine learning techniques in product design.		
Module: 6	**Environmental Awareness**	**8 Hours**
Environmental regulations, safety, safe disposal, preventing pollution, preventing health hazards.		
	Total Lectures	**45 Hours**
Text Books		

1.	Jen-Shih Lee “Biomedical Engineering Entrepreneurship”, World Scientific Publishing, USA. 2010.
2.	Brant Cooper, Patrick Vlaskovits, “The Lean Entrepreneur”, Wiley, 2nd edition, New Jersy, 2016.
Reference Books	
1.	Nathan Furr, Jeff Dyer, “The Innovator's Method: Bringing the Lean Start-up into Your Organization”, Harvard Business Press, Boston, 2014.
2.	Jen-Shih Lee, “Being a Biomedical Entrepreneur: Growth of the Biomedical Industry”, World Scientific Publishing, Singapore.
3.	Stephen Roper, “Entrepreneurship -A Global Perspective”, CRC Press, 2013.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**ENERGY AUDIT AND MANAGEMENT FOR HOSPITALS**	**L**	**T**	**P**	**C**
21BM3026		**3**	**0**	**0**	**3**

Course Objective:

Students will be able to:

1. Understand the need and concepts for energy auditing
2. Know about different audit instruments used in practice
3. Identify the energy sources and optimal utility of electrical energy

Course Outcomes:

At the end of this course, students will be able to :

1. Acquire the background required for engineers to meet the role of energy managers
2. Classify the techniques required to implement energy management
3. Identify and quantify the energy intensive business activities in a hospital
4. Perform Basic Energy Audit in an hospital complex
5. Identify the methods of alternate energy sources for hospitals
6. Construct the optimal utility concepts for efficient hospital systems

Module: 1	**Introduction To Energy Audit**	**7 Hours**

System Approach: End use approach to efficient use of Electricity, Electricity tariff types Energy auditing: Types and objectives - audit instruments, ECO assessment and Economic methods, Specific energy analysis-Minimum energy paths-consumption models-Case study.

Module: 2	**Energy Efficient Controls**	**8 Hours**

Electric motors and starting efficiency-Motor Efficiency and Load Analysis Energy efficient /high efficient Motors-Case study Load Matching and selection of motors, Variable speed drives; Pumps and Fans-Efficient Control strategies-Optimal selection and sizing Optimal operation and Storage; Case study.

Module: 3	**Transformer Loading and Efficiency Analysis**	**7 Hours**

Feeder, cable loss evaluation, case study Reactive Power management-Capacitor, Sizing-Degree of Compensation-Capacitor losses Location-Placement, Maintenance. Case study.

Module: 4	**Peak Demand Controls- Methodologies**	**8 Hours**

Types of Industrial loads-Optimal Load, scheduling-case study, Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes Electronic ballast-Power quality issues-Luminaries, case study.

Module: 5	**Alternate Energy Sources For Hospitals**	**7 Hours**

Diesel based Power generating units- Solar based power plants, solar panel, wind mill, power storage. Biomass plant, gasifier.

Module: 6	**Cogeneration**	**8 Hours**

Methods, and Schemes Optimal operation of cogeneration plants-case study Electric loads of Air conditioning & Refrigeration, Energy conservation measures- Cool storage, Types-Optimal operation. Case study.

	Total Lectures	**45 Hours**

Text Books	
1.	Anthony J. Pansini, Kenneth D. Smalling, “Guide to Electric Load Management”, Pennwell Pub; 1998.
2.	Howard E. Jordan, “Energy-Efficient Electric Motors and Their Applications., Plenum Pub 2nd edition, 1994.
Reference Books	
1.	Y P Abbi and Shashank Jain, “Handbook on Energy Audit and Environment Management” TERI, 2006.
2	Desai, Ashok V., “Non Conventional Energy”, Wiley Eastern Ltd., 1990.
3	Challal, D. S., “Food, Feed and Fuel from Biomass”, IBH Publishing Co. Pvt. Ltd., 1991.
4	C. Y. WereKo-Brobby and E. B. Hagan, “Biomass Conversion and Technology”, John Wiley & Sons, 1996.
Recommended by Board of Studies	

Approved by Academic Council	25th September 2021

Course code	**PROSTHETIC DEVICES**	**L**	**T**	**P**	**C**
21BM3027		**3**	**0**	**0**	

Course Objective:

To impart knowledge on:

1. basic concepts and applications of artificial limbs
2. instrumentation and control techniques involved in prosthetic devices
3. fabrication methods, testing and regulatory aspects

Course Outcomes:

At the end of the course, the student will demonstrate the ability to:

1. Understand challenges and scope of artificial limbs to human
2. Design Sensors and Control System for positioning and movement
3. Learn the basic of actuators and applications
4. Apply the material fabrication and testing
5. Develop applications in assist devices for limbs.
6. Implement medical device regulation

Module: 1	**Introduction to Artificial Limbs**	**7 Hours**
Definition - Classification - components - Degrees of freedom, need and challenges, applications to amputee.		
Module: 2	**Sensors and Actuators**	**8 Hours**
Coordinates - Reference frames - Workspace - Robot languages – Actuators, electric and smart actuators,SensorDesign, Case Studies.		
Module: 3	**Trajectory planning and Control**	**8 Hours**
Characteristics, electric actuators - Trajectory planning- Non-linear Image control- Deep leaning tools, Case Studies.		
Module: 4	**Motion Control**	**7 Hours**
Processing and Vision Systems- Vision based guidance,Introduction to Gait Analysis, Artificial intelligence based controls, Case studies.		
Module: 5	**Materials and Fabrication**	**8 Hours**
Introduction to 3D printing, materials, synthesis, scanning, design of product, simulation tools, testing, machine controls. Case Studies.		
Module: 6	**Regulations and applications**	**7 Hours**
Prosthesis in Knee Disarticulation, Transfemoral Amputees, -Prosthesis for upper and lower limb Amputation and Wrist Disarticulation-Recent Advances in regulations for prosthetic devices. Case studies.		
	Total Lectures	**45 Hours**

Text Books

1.	Michelle Lusardi, Millee Jorge, Caroline Nielsen, “Orthotics and Prosthetics in Rehabilitation”, Third edition, Elsevier, 2007.
2.	Millee Jorge, “Orthotics and Prosthetics in Rehabilitation”, third edition, Saunders Elsevier publishing, , Missouri, 2013.

Reference Books

1.	Chinnathurai R, Sekar P, Kumar M Ramaa, Manoj K Nithya, Kumar C Senthil, “Short Textbook of Prosthetics and Orthotics”, Jaypee Digital publishing, 2010.
2	R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated approach", Prentice Hall of India, 2003.
3	K.S.Fu, Ralph Gonzalez and C.S.G.Lee, "Robotics", TATA McGraw Hill, Aug., 2008.

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

Course code	**ARTIFICIAL INTELLIGENCE IN HEALTHCARE**	**L**	**T**	**P**	**C**
21BM3028		**3**	**0**	**0**	

Course Objective:

Enable the student to

1. understand the various fundamental characteristics of Artificial Intelligence
2. learn to represent knowledge in solving healthcare problems
3. analyze designing of software agents and its application.

Course Outcomes:		
The student will be able to 1. understand the basics of Artificial Intelligence. 2. summarize the appropriate search algorithms for medical problem, 3. represent a problem using behavioral logics. 4. apply AI problem solving techniques 5. develop simple intelligent system for medical diagnosis 6. Application development for healthcare problems in society		
Module: 1	**Exploration of Artificial Intelligence:**	**7 Hours**
Overview of Artificial intelligence - Definition - Future of Artificial Intelligence - Behavioral Characteristics of Intelligent Agents - Typical Intelligent Agents - Problem Solving Approach to healthcare problems.		
Module: 2	**Problem Solving Methods**	**8 Hours**
Problem solving Methods - Search Strategies- Uninformed - Informed - Heuristics - Local Search Algorithms and Optimization Problems - Searching with Partial Observations - Constraint Satisfaction Problems - Constraint Propagation - Backtracking Search. Case studies.		
Module: 3	**AI Decision Tree**	**8 Hours**
Learning methods, Rule-based systems- Decision tree learning- Reinforcement learning. AI in Medical diagnosis.		
Module: 4	**Knowledge Representation**	**7 Hours**
First Order Predicate Logic - Prolog Programming - Unification - Forward Chaining-Backward Chaining - Resolution - Knowledge Representation - Ontological Engineering-Categories and Objects - Events - Mental Events and Mental Objects - Reasoning Systems for Categories - Reasoning with Default Information. Case studies.		
Module: 5	**Software Agents**	**8 Hours**
Architecture for Intelligent Agents - Agent communication - Negotiation and Bargaining - Argumentation among Agents - Trust and Reputation in Multi-agent systems. Biomedical applications.		
Module: 6	**Medical Applications of AI**	**7 Hours**
Blood pressure control, Speech Recognition – Robot control for surgical applications - Hardware - Perception - Planning – Moving image guidance.		
	Total Lectures	**45 Hours**
Text Books		
1.	M. Tim Jones, “Artificial Intelligence: A Systems Approach ”, Jones and Bartlett Publishers, Inc.; First Edition, 2015 Reprint. ISBN-13: 978-9380298139.	
2.	Nils J. Nilsson, “The Quest for Artificial Intelligence”, Cambridge University Press, 2009. ISBN-13: 978-0521122931	
Reference Books		
1.	William F. Clocksin and, Christopher S. Mellish, “Programming in Prolog: Using the ISO Standard”, Fifth Edition, Springer, 2012 Reprint. ISBN 978-3-642-55481-0, DOI 10.1007/978- 3-642-5548.	
2	Ian Millington, John Funge, “Artificial intelligence for Games”, Second edition, Morgan Kaufmann Publishers, CRC Press, 2012, ISBN: 978-0-12-374731-0.	
3	S. Russell and P. Norvig, “Artificial Intelligence: A Modern Approach”, Prentice Hall, Third Edition, 2016. ISBN-1537600311, 97-81537600314.	
4	David L. Poole and Alan K. Mackworth, “Artificial Intelligence: Foundations of Computational Agents”, Cambridge University Press, 2010. ISBN-13: 978-0521519007.	
Recommended by Board of Studies		
Approved by Academic Council	25th September 2021	

Course code	ADVANCED RISC MACHINE IN BIOMEDICAL APPLICATIONS	L	T	P	C
21BM3029		3	0	0	
Course Objective:					
Enable the student to 1. To study ARM architectural support for system development and operating system 2. To understand different ARM architecture and Embedded ARM applications 3. Gain the knowledge about ARM processor in Biomedical applications.					
Course Outcomes:					
At the end of the course, the student will demonstrate the ability to: 1. Understand basics of ARM processor					

2. Design System for interfacing
3. Learn the basic of operating system
4. Apply the concepts for biomedical applications
5. Develop advanced applications in artificial intelligence
6. Implement medical device regulation and safety standards

Module: 1	**ARM Architecture**	**7 Hours**
ARM Architecture ARM Design Philosophy, Registers, Program Status Register, Instruction Pipeline, Interrupts and Vector Table, Architecture Revision, ARM Processor Families.		
Module: 2	**ARM Instruction Set**	**8 Hours**
Data Processing Instructions, Addressing Modes, Branch, Load, Store Instructions, PSR Instructions, Conditional Instructions. Thumb Instruction Set: Register Usage, Other Branch Instructions, Data Processing Instructions, Single Register and Multi Register Load -Store Instructions, Stack, Software Interrupt Instructions		
Module: 3	**Architectural Support For System Development And Operating Systems**	**7 Hours**
Architectural Support for System Development and Operating Systems: Hardware system prototyping tools, The ARMulator, The JTAG boundary scan test architecture, The ARM debug architecture, Embedded Trace, Signal processing support, An introduction to operating systems, The ARM system control coprocessor, CP15 protection unit registers, ARM protection unit, CP15 MMU registers, ARM MMU architecture, Synchronization, Context switching.		
Module: 4	**Embedded ARM Applications**	**8 Hours**
Embedded ARM Applications: The VLSI Ruby II Advanced Communication Processor, The VLSI ISDN Subscriber Processor, The OneC™ VWS22100 GSM chip, The Ericsson-VLSI Bluetooth Baseband Controller, The ARM7500 and ARM7500FE, The ARM7100, The SA1100.		
Module: 5	**ARM Processor For Biomedical Applications**	**7 Hours**
ARM Processor for Biomedical Applications-Introduction,Lowcost medical devices, Medical System-on-Chip Applications. Case Study.		
Module: 6	**ARM Processor For Telemedicine Applications**	**7 Hours**
Heart rate monitoring, Biomedical Data Acquisition, Telemedicine. Case study.		
	Total Lectures	**45 Hours**

Text Books

1.	Andrew N.Sloss, Dominic Symes, Chris Wright, ARM Systems Developer's Guide: Designing & Optimizing System Software, Elsevier, 2004.
2.	William Hohl, ARM Assembly Language, Fundamentals and Techniques, Taylor & Francis, 2009.

Reference Books

1.	ARM System-on-Chip Architecture (2nd Edition) by Steve Furber, Publisher: Addison-Wesley Professional, 2000.
2	ARM Architecture Reference Manual, ARM Limited, Issue E, June 2000.
3	Joseph Yiu, ―The definitive guide to ARM Cortex-M3‖, Elsevier, 2nd Edition.

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

Course code		**L**	**T**	**P**	**C**
21BM3030	**TISSUE ENGINEERING AND ARTIFICIAL ORGANS**	**3**	**0**	**0**	**3**

Course Objective:

This course helps the learners

1. To understand basics of Tissue Engineering
2. To understand fundamentals of cell mechanisms
3. To learn the biomaterials for the implantable prostheses

Course Outcomes:

By successfully completing this course, students will be able to:

1. Describe and use the fundamental tools and techniques used in tissue engineering.
2. Compare and contrast various strategies for repairing tissues.
3. Show mastery of fundamental topics in tissue engineering
4. Learn the cell culture and critical components of bioreactor/tissue design.
5. Evaluate tissue engineering components.
6. Develop artificial organs

Module: 1	**Basics Of Tissue Engineering**	**7 Hours**

Introduction to Tissue Engineering - Objectives of Tissue Engineering - Basic definitions - Structure and organization of Tissues – Development of Tissue – Tissue exchange and diffusion of simple metabolites – Tissue Equivalent - Wound Healing Process - Biocompatibility and toxicity assessment.		
Module: 2	**Fundamentals Of Cell Mechanisms**	**8 Hours**
Cell adhesion, Cell migration and Cell aggregation – Cell growth and Cell cycle. Cellular Interactions: Cell – Cell and Cell – Matrix. Control of Cell migration in Tissue Engineering –Cell delivery and Recirculation – Cell Culture in vitro – 3D culture in Tissue Engineering - In vitro Organogenesis - Cell transplantation.		
Module: 3	**Biomaterials In Tissue Engineering**	**7 Hours**
Definition – Biological vs Nonbiological materials – Extra Cellular Matrix – Collagen, Chitin & Degradable and Nondegradable materials – Polymer, Ceramics and Metals – Cell interaction with different materials –- Scaffolds - Control releaser agents in Tissue Engineering – Cell interaction with suspension and gels – Tissue response to implants.		
Module: 4	**Stem Cells In Tissue Engineering**	**8 Hours**
Introduction of Stem cells – Hemopoetic Stem cells - Embryonic Stem cells - Adult stem cells – Cancer Stem cells – Cord Blood cells – Induced Pluripotent Stem cells - Stem cell identification - Surface markers & FACS analysis – Differentiation, Dedifferentiation and Immortalization – Application of stem cells in tissue Engineering.		
Module: 5	**Tissue Engineering Applications**	**7 Hours**
Synthetic components – Artificial organs – Joints and dental prostheses - Connective Tissue Engineering – Cardiovascular Tissue Engineering – Neural Tissue Engineering - Cell and Drug Delivery systems.		
Module: 6	**Artificial Organs**	**8 Hours**
Artificial skin, Artificial blood vessels, Artificial pancreas, Artificial liver, Regeneration of bone, muscle, Nerve regeneration.		
	Total Lectures	**45 Hours**

Text Books	
1.	Joseph P. Vacanti, Tissue Engineering and Regenerative Medicine, Cold Spring Harbor Laboratory Press, 2017.
2.	MasoudMozafari, FarshidSefat, Anthony Atala, Handbook of Tissue Engineering Scaffolds: Volume One, Elsevier Science, 2019
Reference Books	
1.	W. Mark Saltzman Tissue Engineering – Engineering principles for design of replacement organs and tissue –- Oxford University Press inc New York, 2004.
2	Gray E Wnek, Gray L Browlin – Encyclopaedia of Biomaterials and Biomedical Engineering Marcel Dekker Inc New York, 2004.
3	R.Lanza, J.Gearhart et.al,(Eds), Essential of Stem cell Biology, Elsevier Academic Press, 2006.
4	SujataV.Bhatt, Biomaterials (2nd Edition), Narosa Publishing House, 2005.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

DEPARTMENT OF BIOMEDICAL ENGINEERING

LIST OF NEW COURSES (2020)

S. No	Course Code	Course Title	Hours per Week			Credits
			L	T	P	
1	19BM2031	Medical Internet of Things	3	0	0	3
2	19BM2032	Cloud Computing Applications in Biomedical Engineering	3	0	0	3
3	19BM2033	Python Programming for Biomedical Applications	3	0	0	3
4	19BM2034	Data Analytics for Biomedical Engineering	3	0	0	3
5	19BM2035	Block Chain Technology	3	0	0	3
6	19BM2036	Augmented/Virtual Reality Applications in Biomedical Engineering	3	0	0	3
7	19BM2037	Deep Learning for Biomedical Applications	3	0	0	3
8	20BM2001	Medical Physics	3	0	0	3
9	20BM2002	Biochemistry for Biomedical Engineers	3	0	0	3
10	20BM2003	Medical Coding	3	0	0	3
11	20BM2004	Cancer Biology	3	0	0	3
12	20BM2005	Entrepreneurship for Biomedical Engineers	3	0	0	3
13	20BM2006	Biology for Engineers	3	0	0	3
14	20BM2007	Hospital and Equipment Management	3	0	0	3
15	20BM2008	Brain Computer Interface	3	0	0	3
16	20BM2009	Introduction to Biomedical Engineering	3	0	0	3
17	20BM2010	Analytical Instrumentation	3	0	0	3

19BM2031	MEDICAL INTERNET OF THINGS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Impart necessary and practical knowledge of components of Internet of Things
2. Gain Knowledge on IoT protocols
3. Deal with case studies related to healthcare applications of IoT.

Course Outcomes:

At the end of the course, The Student will be able to

1. Understand internet of Things and its hardware and software components
2. Interface I/O devices, sensors & communication modules
3. Remotely monitor data and control devices
4. Develop understanding of data analytics and supporting devices
5. Discuss about Case studies on IoT applications in health care
6. Develop real life IoT based medical applications

Module 1: Introduction to IoT : **(8 hrs)**

Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT, Wireless Body Area Networking.

Module 2: Elements of IoT : **(7 hrs)**

Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

Moduel 3: IoT Application Development : **(7 hrs)**

Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.

Module 4: Data Analytics And Supporting Services: **(8 hrs)**

Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning – No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework – Django – AWS for IoT – System Management with NETCONF-YANG

Module 5 : Building IoT with RASPBERRY PI & ARDUINO: (8 hrs)

Building IOT with RASPERRY PI- IoT Systems - Logical Design using Python – IoT Physical Devices & Endpoints - IoT Device -Building blocks -Raspberry Pi -Board - Linux on Raspberry Pi - Raspberry Pi Interfaces -Programming Raspberry Pi with Python - Other IoT Platforms - Arduino.

Module 6: Case Study/Health Care: **(7 hrs)**

IOT in Emergency and Healthcare services,, Components of IoT healthcare, Remote health care, Real time monitoring, Preventive care, Preventive Cardiological Monitoring, Health care systems- Activity Monitoring

Text Books:

1. A Handbook of Internet of Things in Biomedical and Cyber Physical System, **Bălaş**, V.E., **Solanki**, V.K., **Kumar**, R., **Ahad,** ISBN 978-3-030-23983-1, 2019
2. Medical Internet of Things, Hamed Farhadi, Intech Open, 2019.
3. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press)
4. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)
5. Raspberry Pi Iot in C, Harry Fairhead , 1st edition, 2016, I/O Press;, ISBN-13: 978-1871962468.

Reference Books:

1. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)
2. **Bălaş**, V.E., **Solanki**, V.K., **Kumar**, R., **Ahad, "**A Handbook of Internet of Things in Biomedical and Cyber Physical System" , ISBN 978-3-030-23983-1, 2019
3. Vijay Madisetti, Arshdeep Bahga, Ïnternet of Things, "A Hands on Approach", University Press, 2018
4. Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs, 2-17
5. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017

19BM2032	CLOUD COMPUTING APPLICATIONS IN BIOMEDICAL ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. Learn the fundamentals of cloud computing
2. Provide knowledge about virtualization and could services
3. Gain understanding about the cloud computing applications in biomedical engineering.

Course Outcomes:

At the end of the course, The Student will be able to

1. Recall the concepts of cloud computing
2. Compare different models of cloud computing
3. Explain virtualization and classify services of cloud computing

4. Illustrate architecture and programming in cloud
5. Describe the platforms for development of cloud applications and List the application of cloud.
6.
7. Apply the technology for healthcare applications

Module 1:Introduction: **(7 hrs)**

Cloud Computing at a Glance, The Vision of Cloud Computing, Defining a Cloud, Cloud Computing Reference Model, Characteristics and Benefits, Challenges, Historical Developments

Module 2: Distributed Systems and Virtualization: (8 hrs)

Web 2.0, Service-Oriented Computing, Utility-Oriented Computing, Building Cloud Computing Environments, Application Development, Infrastructure and System Development, Computing Platforms and Technologies, Amazon Web Services (AWS), Google AppEngine, Microsoft Azure, Hadoop, Force.com and Salesforce.com, Manjrasoft AnekaVirtualization in Cloud Computing: Virtualization, Introduction, Characteristics of Virtualized Environments , Virtualization and Cloud Computing, Pros and Cons of Virtualization, Technology Examples Xen: Paravirtualization, VMware: Full Virtualization, Microsoft Hyper-V

Module 3: Cloud Computing Architecture: **(7 hrs)**

Introduction, Cloud Reference Model, Architecture, Infrastructure / Hardware as a Service, Platform as a Service, Software as a Service, Types of Clouds, Public Clouds, Private Clouds, Hybrid Clouds, Community Clouds, Economics of the Cloud, Open Challenges, Cloud Definition, Cloud Interoperability and Standards Scalability and Fault Tolerance Security, Trust, and Privacy Organizational Aspects

Module 4: Concurrent Computing: (8 hrs)

Thread Programming, Programming Applications with Threads, Thread APIs, Techniques for Parallel Computation with Threads, Multithreading with Aneka, Introducing the Thread Programming Model, Aneka Thread vs. Common Threads, Domain Decomposition: Matrix Multiplication, Functional Decomposition: Sine, Cosine, and Tangent. High-Throughput Computing: Task Programming, Task Computing, Characterizing a Task, Computing Categories, Frameworks for Task Computing, Task-based Application Models, Parameter Sweep Applications, MPI Applications, Workflow Applications with Task Dependencies

Module 5: Data Intensive Computing: (8 hrs)

Map-Reduce Programming, Introduction to Data Intensive Computing - Characterizing Data-Intensive Computations, Challenges Ahead, Historical Perspective, Technologies for Data-Intensive Computing, Storage Systems, Programming Platforms, Aneka MapReduce Programming, Introducing the MapReduce Programming Model, Example Application,

Module 6: Healthcare Applications Case Studies: (7 hrs)

An Adaptive Cloud Prototype Model for Health Care system using Software Defined Network (SDN), Big Data Analytics for Childhood Pneumonia monitoring, Diabetes, Patient monitoring by Cloud Computing, Trust-Privacy Issues in Cloud Based Healthcare Services.

Text Books::

1. Rajkumar Buyya, Christian Vecchiola, and Thamarai Selvi “Mastering Cloud. Computing” McGraw Hill Education, 2016.
2. Chintan M. Bhatt S. K. Peddoju, “Cloud Computing Systems and Applications in Healthcare”, 2019.
3. Derrick Rountree and Ileana Castrillo “The Bascis of Cloud Computing” Springer, 2015

Reference Books::

1. Dan C. Marinescu, Cloud Computing Theory and Practice, Morgan Kaufmann, Elsevier 2013

19BM2033	PYTHON PROGRAMMING FOR BIOMEDICAL APPLICATIONS	L	T	P	C
		2	0	2	3

Course Objectives:

1. Understand the most important libraries of Python, and its recommended programming styles and idioms.
2. Learn core Python scripting elements such as variables and flow control structures.
3. Develop applications using Python for robotics.

Course Outcomes:

At the end of the course, The Student will be able to

1. Outline the structure and components of a Python program.
2. Explain loops and decision statements in Python.
3. Illustrate class inheritance in Python for reusability
4. Choose lists, tuples, and dictionaries in Python programs.
5. Assess object-oriented programs with Python classes.
6. Develop simple code for biomedical applications.

Module 1 - Introduction to Python, Data Types, Expressions: (8 hrs)

Introduction to Python Programming - Running Code in the Interactive Shell, Input, Processing and Output, Editing, Saving and Running a Script - Data Types, String Literals, Escape Sequences, String Concatenation, Variables and the Assignment Statement - Numeric Data Types Module, The Main Module, Program Format and Structure and Running a Script from a Terminal Command Prompt

Module 2: Loops and Expressions: **(7 hrs)**

Iteration - for loop - Selection - Boolean Type, Comparisons, and Boolean Expressions, if-else Statements, One-Way Selection Statements, Multi-way if Statements, Logical Operators and Compound Boolean Expressions, Short-Circuit Evaluation and Testing Selection Statements - Conditional Iteration - while loop.

Module 3: Strings and Text Files: (6 hrs)

Strings - Accessing Characters and Substrings in Strings, Data Encryption, Strings and Number Systems and String Methods - Text Files - Text Files and Their Format, Writing Text to a File, Writing Numbers to a File, Reading Text from a File, Reading Numbers from a File and Accessing and Manipulating Files and Directories on Disk.

Module 4: Lists and Dictionaries: (8 hrs)

Lists - List Literals and Basic Operators, Replacing an Element in a List, List Methods for Inserting and Removing Elements, Searching and Sorting a List, Mutator Methods and the Value None, Aliasing and Side Effects, Equality and Tuples - Defining Simple Functions - Syntax , Parameters and Arguments, return Statement, Boolean Functions and main function, DICTIONARIES - Dictionary Literals, Adding Keys and Replacing Values, Accessing Values, Removing Keys and Traversing a Dictionary.

Module 5: Design with Functions and Design with Classes: (8 hrs)

Design with Functions and Design with Classes - Functions as Abstraction Mechanisms, Problem Solving with Top-Down Design, Design with Recursive Functions and Managing a Program's Namespace - DESIGN WITH CLASSES - Objects and Classes, Data Modeling and Structuring Classes with Inheritance and Polymorphism.

Module 6: Case Studies in Biomedical Engineering : (8 hrs)

Medical Imaging, Speech Recognition, Genomics, Drug Discovery, Patient Health Monitoring, Virtual Assistance, Predictive Analytics in Healthcare.

Experiments:

The list of experiments will be notified by the HoD at the beginning of each semester.

Text Books:

1. Paul Barry, Head First Python 2e, O′Reilly, 2nd Revised edition, 2016, ISBN-13: 978-1491919538.
2. Kenneth A. Lambert, Martin Osborne, Fundamentals of Python: From First Programs Through Data Structures, Course Technology, Cengage Learning, 2010, ISBN-13: 978-1-4239-0218-8.

Reference Books:

1. Zed A. Shaw, Learn Python The Hard Way, Addison-Wesley, Third Edition, 2014, ISBN-13: 978-0-321-88491-6.
2. Dave Kuhlman, A Python Book: Beginning Python, Advanced Python, and Python Exercises, 2013, ISBN: 9780984221233.
3. Kent D Lee, Python Programming Fundamentals, Springer-Verlag London Limited, 2011, ISBN 978-1-84996-536-1.

19BM2034	DATA ANALYTICS FOR BIOMEDICAL ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

To improve knowledge on

1. Fundamental concepts and methods of Big data analysis.
2. Data exploration, visualization and statistical analysis for given data set.
3. Performing big data analytics for Biological data set.

Course Outcomes:

At the end of the course, the students will be able to

1. Demonstrate fundamental knowledge of Big data analytics.
2. Explore different types of data from different sources.
3. Write R script to analyse data from data interface.
4. Develop and generate different types of charts and graphs.
5. Perform various statistical analysis using R packages for given data set.
6. Apply knowledge of big data analytics on bioinformatics and health care data set.

Module 1: Introduction: (8 hrs)

Big data analytics overview, Data life cycle, Traditional Data mining Life cycle, CRISP, Big Data life cycle methodologies, Machine learning implementation, Recommender system , Dashboard, Ad-Hoc analysis.

Module 2: Data Exploration and Visualization: (8 hrs)

Problem Definition, Data Collection, Data Pre-processing, Data Cleaning – Homogenization, Heterogenization, Summarizing data, Data Exploration and Visualization.

Module 3: Big Data Methods: (6 hrs)

Introduction to R programming, Data Frames, Atomic vectors, Factors, Data types, Variables, Functions, working with excel files, Data interface.

Module 4: Charts & Graphs: (8 hrs)

Develop pie chart, 3D pie chart, Histograms, Bar chart, Group bar chart, Stacked Bar chart, Line graph, Multiline graph and Box plot.

Module 5: Statistical Methods: (7 hrs)

Regression models, Linear Regression, Multiple regression, Logistic regression, Mean, Median, Mode, Chi-Square test, T-Test.

Module 6: Big data analytics for Health care: (8 hrs)

Big data analytics in diagnostics, Health care, preventive medicine , precision medicine, population health, Text mining on complex biomedical literature, medical imaging.

Text Books::

1. Venkat Ankam, “Big Data analytics”, Packt publishing 2016
2. Parag Kulkarni, Sarang Joshi, ”Big Data analytics“, PHI learning2016

Reference Books::

1. Wang, Baoying, Big Data Analytics in Bioinformatics and Health

19BM2035	BLOCK CHAIN TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. Gain a conceptual understanding of block chain
2. Provide an overview of the applications of Block Chain Technology
3. Deal with the operations of Block Chain Technology

Course Outcomes:

The Student will be able to

1. Understand the fundamentals of Block Chain Technology.
2. Describe the concept of Crypto Currency
3. Develop Block Chain based solutions and write smart contract.
4. Build and deploy Block Chain application for on premise and cloud based architecture.
5. Integrate ideas from various domains and implement them using block chain technology in different perspectives.
6. Develop Block chain applications pertaining to biomedical engineering.

Module 1: Introduction : (8 hrs)

Overview of Block chain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Public vs Private Block chain, Understanding Crypto currency to Block chain, Permissioned Model of Block chain, Overview of Security aspects of Block chain .

Module 2: Understanding Block chain with Crypto currency : **(8 hrs)**

Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic cryptocurrency. Bitcoin and Block chain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay.

Module 3: Working with Consensus in Bitcoin: (6 hrs)

Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the monopoly problem, Proof of Stake, Proof of Burn and Proof of Elapsed Time, life of a Bitcoin Miner, Mining Difficulty, Mining Pool.

Module 4: Understanding Block chain for Enterprises : **(8 hrs)**

Permissioned Block chain: Permissioned model and use cases, Design issues for Permissioned block chains, Execute contracts, State machine replication, Overview of Consensus models for permissioned block chain- Distributed consensus in closed environment, Paxos, RAFT Consensus, Byzantine general problem, Byzantine fault tolerant system, Lamport-Shostak-Pease BFT Algorithm, BFT over Asynchronous systems.

Module 5: Enterprise application of Block chain: (7 hrs)

Cross border payments, Know Your Customer (KYC), Food Security, Mortgage over Block chain, Block chain enabled Trade, We Trade – Trade Finance Network, Supply Chain Financing, Identity on Block chain

Module 6: Block chain application development: (8 hrs)

Hyperledger Fabric- Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract using Hyperledger Fabric, Writing smart contract using Ethereum, Overview of Ripple and Corda.

Text Books::

1. Melanie Swan, “Block Chain: Blueprint for a New Economy”, O’Reilly, 2015
2. Josh Thompsons, “Block Chain: The Block Chain for Beginners- Guide to Block chain Technology and Leveraging Block Chain Programming”,2015

Reference Books::

1. Daniel Drescher, “Block Chain Basics”, Apress; 1stedition, 2017
2. Anshul Kaushik, “Block Chain and Crypto Currencies”, Khanna Publishing House, Delhi.
3. Imran Bashir, “Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained”, Packt Publishing,2018

4. Ritesh Modi, "Solidity Programming Essentials: A Beginner's Guide to Build Smart Contracts for Ethereum and Block Chain", Packt Publishing,2018
5. Salman Baset, Luc Desrosiers, Nitin Gaur, Petr Novotny, Anthony O'Dowd, Venkatraman Ramakrishna, "Hands-On Block Chain with Hyperledger: Building Decentralized Applications with Hyperledger Fabric and Composer", Import, 2018

19BM2036	AUGUMENTED/ VIRTUAL REALITY APPLICATIONS IN BIOMEDICAL ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. Learn the concepts and principles of virtual and augmented reality
2. Understand VR and AR environment and software
3. Gain knowledge about the applications for Biomedical Engineering.

Course Outcomes:

At the end of the course, the students will be able to:

1. Recall basic concepts of virtual and augmented reality
2. Describe the geometric modelling and Virtual environment.
3. Work with Virtual Environment and Augmented Reality systems
4. Perform experiments with the Hardware and Software tools
5. Develop Virtual Reality applications.
6. Summarize the applications of Block Chain Technology for Biomedical Applications

Module 1: Introduction to Augmented Reality and Virtual Reality : (8 hrs)

Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark. Augmented Reality Concepts: History of Augmented Reality, Multimodal displays: Haptic, Tactile and Tangible Displays, Visual Perception

Module 2: Geometric Modelling: (6 hrs)

Geometric Modelling: Introduction, From 2D to 3D, 3D space curves, 3D boundary representation. Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection

Module 3: Virtual Environment and Augmented Reality Systems: (8 hrs)

Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system. Augmented Reality Systems – Types, Taxonomy of Augmented Reality, Helmet, Headup display, Smart Glasses, Projection

Module 4: VR Hardware and Software: (8 hrs)

Human Factors: Introduction, the eye, the ear, the somatic senses. VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems. VR Software: Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML, Khronos Group – AR Toolkit – Augmented Reality Operating System – Role of Augmented Reality interfaces – Players and Platforms

Module 5: AV/VR Applications: (8 hrs)

Introduction, Engineering, Entertainment, Science, Training. The Future: Virtual environment, modes of interaction. Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.

Module 6: AR/VR for Biomedical Applications: (7 hrs)

Augmenting Dental Care – Virtual Reality for Rehabilitation – Medical Model Generation.

Text Books

1. John Vince, "Virtual Reality Systems ", Pearson Education Asia, 2007.
2. Dieter Schmalstieg, Tobias Hollerer, "Augmented Reality: Principles and Practice", Addison-Wesley Professional, 2016.

Reference Books:

1. Anand R., "Augmented and Virtual Reality", Khanna Publishing House, Delhi.
2. Adams, "Visualizations of Virtual Reality", Tata McGraw Hill, 2000.
3. Grigore C. Burdea, Philippe Coiffet , "Virtual Reality Technology", Wiley Inter Science, 2nd Edition, 2006.
4. William R. Sherman, Alan B. Craig, "Understanding Virtual Reality: Interface, Application and Design", Morgan Kaufmann, 2008.
5. Jon Peddie, "Augmented Reality – Where We Will All Live", Springer International Publishing AG, 2017.

19BM2037	DEEP LEARNING FOR BIOMEDICAL APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Learn the basics of deep learning.
2. Gain knowledge on the concepts of deep reinforcement learning
3. Provide an overview on the trends in deep learning

Course Outcomes:s

1. Recall the fundamentals of deep learning.
2. Compare the various models of deep learning.
3. Describe the concepts of deep unsupervised learning.
4. Discuss about the application of deep learning in computer vision.
5. Analyse the latest trends in deep learning.

Module 1: Introduction: **(8 hrs)**

History and Rise of Deep Learning, Impact of Deep Learning, Motivation of Deep Architecture, Challenges and Applications, Deep learning Hardware and software frameworks

Module 2: Deep Learning Models: **(7 hrs)**

Convolutional Neural Networks, Restricted Boltzmann Machines, Recurrent Neural Networks, Practical Examples

Module 3: Deep Unsupervised Learning: (7 hrs)

Autoencoders (standard, sparse, denoising, contractive, etc), Variational Autoencoders, Adversarial Generative Networks, Autoencoder and DBM Attention and memory models, Dynamic memory networks.

Module 4: Deep Reinforcement Learning: **(8 hrs)**

Value learning based algorithms, Policy search based algorithms, Actor critic based algorithm, Deep Q Network, Implementing Deep Reinforcement Learning.

Module5: Deep Learning in Computer Vision: (7 hrs)

Origin of CNN, Data Transformations, Network Layers and regularization, Popular CNN Architecture: Alexnet, Googlenet, Visual Geometry, Resnet.

Module 6: Trends in Deep Learning: **(8 hrs)**

Recent Models of Deep Learning, Genomics, Predictive Medicine, Clinical Imaging, Lip Reading, Visual Reasoning.

Text Books::

1. Wei Di, Anuragh Bharadwaj, "Deep Learning Essentials", Jianing Wei, Packt Publishers, 2018.
2. Nikhil Buduma, Nicholas, "Fundamentals of Deep Learning", O Reilly Media, 2017.

Reference Books::

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning",MIT Press, 2016.
2. Suraj Sawant. "Deep Learning", IGI Global, 2018.

Course code	MEDICAL PHYSICS	L	T	P	C
20BM2001		3	0	0	3

Course Objective:

1. To comprehend the fundamental principles of light and sound.
2. To impart knowledge on Radiation and radioactive nuclides.
3. To transfer knowledge in applications of light, sound and radiation in medicine.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Illustrate the fundamentals of light.
2. Assess the significance of sound in medicine.
3. Comprehend radioactive nuclides.
4. Outline the interaction of radiation with matter.
5. Comprehend basic quantities of radiation.
6. Understand the applications of light, sound and radiation in medicine.

Module: 1	Non Ionizing Radiation	8 Hours

Non-ionizing Electromagnetic Radiation: Overview of non-ionizing radiation effects-Electromagnetic Spectrum- Low Frequency Effects- Higher frequency effects. Physics of light, Measurement of light and its unit- limits of vision and color vision an overview, Thermography– Fundamentals of Near Infrared Spectroscopy

Module: 2	Sound in Medicine	7 Hours

Physics of sound, Normal sound levels –ultrasound fundamentals – Generation of ultrasound (Ultrasound Transducer) - Interaction of Ultrasound with matter; Cavitations, Reflection, Transmission- Scanning systems – Artifacts- Ultrasound-Doppler shift

Module: 3	Principles of Radioactive nuclides	7 Hours

Radioactive Decay – Spontaneous Emission – Isometric Transition – Gamma ray emission, alpha, beta, Positron decay, electron capture, Sources of Radioisotopes Natural and Artificial radioactivity, Decay series, Production of radionuclides – Cyclotron produced Radionuclide- Reactor produced Radio-nuclide-fission and electron Capture reaction, radionuclide Generator-Technetium generator.

Module: 4	Interaction of Radiation with Matter	8 Hours

Interaction of charged particles with matter –Specific ionization, Linear energy transfer range,Bremsstrahlung, Annihilation, Interaction of X and Gamma radiation with matter- Photoelectric effect, Compton Scattering , Pair production, Attenuation of Gamma Radiation ,Interaction of neutron with matter and their clinical significance.

Module: 5	Basic radiation quantities	8 Hours

Introduction -exposure- Inverse square law-KERMA-Kerma and absorbed dose –stopping power - relationship between the dosimetric quantities - Bremsstrahlung radiation, Bragg's curve- concept of LD 50- Stochastic and Non-stochastic effects, Different radiation Unit, Roentgen, gray, Sievert.

Module: 6	Clinical Applications	7 Hours

Thermography Applications - Clinical Applications of Doppler – Applications of Gamma radiation in medicine - Radionuclide used in Medicine and Technology.

	Total Lectures	45 Hours

Text Books

1. Medical Physics, John R Cameran , James G Skofronick John-Wiley & Sons Publications, 2002.
2. Fundamental Physics of Radiology, W.J. Meredith and J.B. Massey, Varghese Publishing house, 2011

Reference Books

1. Introduction to Radiation Biology, P.Uma Devi, A.Nagarathnam , B S SatishRao ,ChurChill Livingstone Pvt Ltd, 2013.
2. The Physics of Medical Imaging, S.Webb, Taylor and Francis, 2013

3.	Ultrasonic Medical Physics Handbook series, J.P.Woodcock, Adam Hilger,Bristol, 2002
4.	Basic Ultrasound , "Hylton B.Meire and Pat Farrant", John Wiley& Sons ,1994.
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**BIOCHEMISTRY FOR BIOMEDICAL ENGINEERS**	**L**	**T**	**P**	**C**
20BM2002		**3**	**0**	**0**	**3**

Course Objective:

1. To ensure students will have strong foundation in structure, properties and function of various biomolecules.
2. To introduce them to the basic structure of biomolecules which are involved in metabolic pathways.
3. To understand the industrial-market value and significance of these biomolecules and to apply these in the fundamentals of biotechnology

Course Outcomes:

1. Acquire knowledge on structure, properties and biological functions of carbohydrates, lipids and proteins which help them to understand the significance of biomolecules in bioprocesses and biotechnology
2. Acquire knowledge on nucleic acids structure, properties and functions of nucleic acids
3. Assess the significance of Vitamins and mineral functions
4. Help them to analyze industrial-market value of these biomolecules and relate them with the scope of biotechnology
5. Justify the clinical and biological significance of these biomolecules
6. Understand the complexes of different biomolecules and their biomedical significance

Module: 1	**CARBOHYDRATES**	**9 Hours**

Classification, structure, properties and functions of carbohydrates: Monosaccharides, Disaccharides, Oligosaccharides-examples; Polysaccharide – classes- homo and hetero polysaccharides, conjugated carbohydrates, glycolysis, gluconeogenesis ,TCA cycle, Pentose Phosphate Pathway, glycogenesis, Glycogen Storage Disease, Respiratory chain and ATP synthesis

Module: 2	**FATTY ACIDS AND LIPIDS**	**9 Hours**

Fatty acids- basic structure, types, properties, functions and essential fatty acids; ketone bodies, Classes, structure, properties and functions of lipids: Simple lipid-fat and wax, Compound lipid-Phospholipid, sphingolipid, ether lipid and glycolipid, Derived lipid – cholesterol biosynthesis, fatty acid biosythesis and degradation, Inborn errors of lipid metabolism.

Module: 3	**AMINO ACIDS, PEPTIDES AND PROTEINS**	**9 Hours**

Amino acids- classification, properties; Essential amino acids; Peptide bond, significant natural and artificial peptides –examples; Proteins- structure / conformation levels-primary, secondary, tertiary and quaternary, Ramachandran plot, classification, Biosynthesis of aromatic amino acids-tyr,trp,phe, biodegradation of proteins and urea cycle, Review on amino acid metabolic disorders.

Module: 4	**NUCLEOTIDES AND NUCLEIC ACIDS**	**9 Hours**

Nucleotides- composition, structure, properties and functions; Nucleic acids- types (RNA, DNA), DNA structure-Chargaff's rule on DNA base composition, unusual forms of DNA, RNA types, structure and functions, biosynthesis of purines and pyrimidines and its degradation, Inborn errors of nucleic acid metabolism - Review.

Module: 5	**VITAMINS**	**4 Hours**

Vitamins: classification (A, D, E, K, and B-complex members), basic structure, source, daily requirement, functions and deficiency symptoms.

Module: 6	**MINERALS – FUNCTIONS AND DISORDERS**	**5 Hours**

Minerals: classification- macro elements and microelements, specific function and deficiency disorders, review on vitamins and mineral supplementations	
Total Lectures	**45 Hours**
Text Books	
1.	Jain and Jain "Biochemistry", Chand publication, 2008.
2.	Lehninger, A. L, Nelson D. L and Cox, M. M, "Principles of Biochemistry", Freeman Publishers, New York, fourth edition, 2005.
Reference Books	
1.	Murray R.K, Granner B.K, Mayes P.A, Rodwell V.W. "Harper's Biochemistry", Prentice Hall International, 2008.
2.	Lubert Stryer, "Biochemistry", WH Freeman & Co., 4th edition, 2000
3.	Voet and Voet, "Biochemistry", John Wiley & Sons Inc., 2nd Edition, 2013.
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**MEDICAL CODING**	**L**	**T**	**P**	**C**
20BM2003		**3**	**0**	**0**	**3**

Course Objective:

1. To study the fundamentals of medical coding
2. To study the concepts of types of medical coding
3. To study about various health care facilities and health care organization

Course Outcomes:

On the successful completion of the course, students will be able to:

CO1 Understand the various medical terminologies and basics of medical coding basics.
CO2 Examine the ICD and its different forms
CO3 Demonstrate CPT and it various categories and their necessities
CO4 Analyze the concept of HCPCS codes, its types and modifiers
CO5 Point out the requirement of crosswalking in medical coding
CO6 Familiarize the various health care facilities and health organizations

Module: 1	**Medical terminology**	**9 Hours**

Etymology, medical words, Medical Instruments & Equipment, Medical Specialties & Specialists, Diagnostic Medicine, Abbreviations, Anatomy and Physiology, Pharmacology, Drug listing – generic alpha, name brand cross-reference, plus 200 of the most commonly prescribed drugs, Medical Coding Basics-Introduction-Need, Types of Medical Coding, Medical Coding Tools & Resources.

Module: 2	**ICD**	**9 Hours**

Introduction, ICD-9, ICD-10, ICD-11, Overview of ICD-9-CM Layout, Steps to Look Up a Diagnosis Code, ICD-9-CM Official Guidelines for Coding and Reporting, medical necessity, **NCHS.**

Module: 3	**CPT**	**9 Hours**

Introduction to CPT, CPT Category I, II & III Codes, **CMS,** sections of CPT, Significance of Parent codes, CPT Modifiers, **CPT Evaluation and Management,** Symbols and significance, Alphanumeric codes overview of categories II and III.

Module: 4	**HCPCS codes**	**9 Hours**

Introduction, Significance and Usage, HCPCS Level I and HCPCS Level II codes, CPT vs HCPCS, Modifiers Level II HCPCS, Dental codes, Miscellaneous codes , Temporary national codes, Types of temporary HCPCS Level II Codes

Module: 5	Crosswalking	4 Hours
Introduction, Requirement, Mapping, GEMS, CPT code-Musculoskeletal coding, Digestive System Coding, Urology and Reproductive system coding, Pulmonology and Cardiovascular coding.		
Module: 6	**Health Insurance Specialist**	**4 Hours**
Description, Medical Care Reimbursement, Health Organizations (MCO), Insurance Claims, Payer Processing, Private Insurers, Medicare, Medicaid, TriCare, Worker's Compensation.		
	Total Lectures	**45 Hours**

Text Books	
1.	Johnson, S. L., & Linker, R. (2015). Understanding medical coding: A comprehensive guide. Cengage Learning.
2.	Aalseth, P. (2014). Medical coding. Jones & Bartlett Publishers.
Reference Books	
1.	Shiland, B. J. (2014). Medical Terminology & Anatomy for ICD-10 Coding-E-Book. Elsevier Health Sciences
2.	Buck, C. J. (2016). Step-by-Step Medical Coding, 2017 Edition-E-Book. Elsevier Health Sciences.
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	CANCER BIOLOGY	L	T	P	C
20BM2004		3	0	0	3

Course Objective:

1. To provide basic understanding of cancer biology
2. To introduce the concept of oncogenes
3. To learn the types of therapy preferred for treating cancer

Course Outcomes:

At the end of the course, the student will be able to:

1. Describe the molecular and cellular mechanisms that lead to cancer.
2. Analyze the primarily focus on the role of growth factors that leads to cancer
3. Evaluate the role of gene mutation in the development of cancer
4. Discuss on oncogenes, tumor suppressor genes, angiogenesis and signal transduction mechanisms in tumor formation.
5. Understand the fundamental principles behind cancer diagnosis and prevention.
6. Explain the various therapeutic management system for cancer biology

Module: 1	FUNDAMENTALS OF CANCER BIOLOGY	9 Hours
Regulation of cell cycle, mutations that cause changes in signal molecules, effects on receptor, signal switches, tumour suppressor genes, modulation of cell cycle in cancer, different forms of cancers, diet and cancer. Cancer screening and early detection, Detection using biochemical assays, tumor markers, molecular tools for early diagnosis of cancer.		
Module: 2	**PRINCIPLES OF CARCINOGENESIS**	**9 Hours**
Theory of carcinogenesis, Chemical carcinogenesis, metabolism of carcinogenesis, principles of physical carcinogenesis, x-ray radiation-mechanisms of radiation carcinogenesis.		
Module: 3	**PRINCIPLES OF MOLECULAR CELL BIOLOGY OF CANCER**	**9 Hours**
Signal targets and cancer, activation of kinases; Oncogenes, identification of oncogenes, retroviruses and oncogenes, detection of oncogenes. Oncogenes/proto oncogene activity, Growth factors related to transformation, Telomerases.		
Module: 4	**PRINCIPLES OF CANCER METASTASIS**	**9 Hours**
Clinical significances of invasion, heterogeneity of metastatic phenotype, metastatic cascade, basement membrane disruption, three step theory of invasion, proteinases and tumour cell invasion.		

Module: 5	CANCER PREVENTION AND DIAGNOSIS	4 Hours
Carcinogens and DNA damage, Epidemology and cancer , Genomic screening , Infectious agents that cause cancer - Cancer nanotechnology.		
Module: 6	**NEW MOLECULES FOR CANCER THERAPY**	**4 Hours**
Different forms of therapy, chemotherapy, radiation therapy, detection of cancers, prediction of aggressiveness of cancer, advances in cancer detection. Use of signal targets towards therapy of cancer; Gene therapy.		
	Total Lectures	**45 Hours**

Text Books

1.	R Kelly, D. Santibanez, LP Victor and Julio Antonio, "Control of Robot Manipulators in Joint Space", Springer, 2005.
2.	A Sabanovic and K Ohnishi, "Motion Control Systems", John Wiley & Sons (Asia), 2011.

Reference Books

1.	Maly B.W.J, Virology A Practical Approach, IRLl Press, Oxford, 1987
2.	Dunmock N.J And Primrose S.B, Introduction to Modern Virology, Blackwell scientific Publications, Oxford, 1988.
3.	Maly B.W.J, An Introduction Top Cellular And Molecular Biology of Cancer., Oxford Medical Publications, 1991

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	ENTREPRENEURSHIP FOR BIOMEDICAL ENGINEERS	L	T	P	C
20BM2005		3	0	0	3

Course Objective:

- To learn the skills to establish a biomedical firm
- To implement and copyright the ideas into Inventions
- To understand the importance of Sales and Marketing

Course Outcomes:

At the end of the course, the students will be able to:

1. To study the Technologies in Medical Industry
2. To understand the concepts of Entrepreneurship
3. To analyse the need in building an organisation, patenting and FDA.
4. To understand the Financial Management and Product Manufacturing
5. To familiarise Marketing and Business Globalization
6. To apply the concepts of Biomedical Engineering for inventions and device development.

Module: 1	BIOMEDICAL INDUSTRY	8 Hours
Challenges & Opportunities – Medical Technology – Pharmaceutical Industry – Innovations in Medical Technology - Development and Growth of Pacemaker Industry – Impact of MedTech innovations on Healthcare – Three Development Phases of Entrepreneurship.		
Module: 2	**ASSESSING THE VENTURE**	**7 Hours**
Evaluating the Entrepreneurship: Entrepreneur Team – Nature – Practising Entrepreneurship – Development of Wearable & Wireless Devices, Establishing the Venture Invention: 3 Inventions of Medtronic Inc. around 1960s – Evaluating the Invention – Robotics & Artificial Intelligence – Medical Imaging – Information Technology, Researching the market for the Invention		
Module: 3	**LAUNCHING THE VENTURE**	**7 Hours**
Forming the Company: Organizational Structure – Capitals required for the Company's Operation – Company Registration – Share Distribution – Exit Strategy, Patenting the Invention: US Patent –		

Trademark Office – Importance of Patenting – Process of Patenting, FDA Regulations – Food and Drug Administration – Safety & Effectiveness of Medical Devices		
Module: 4	**BUILDING UP THE ENTERPRISE**	**8 Hours**
Financing & Accounting: Account Management – Budgeting – Financial Projections, Negotiating Process, Manufacturing the Product: Procurement & Outsourcing – Current Good Management Practice (cGMP) – Accountability – Risk Management – Lifecycle Management for Maximum Value		
Module: 5	**MARKETING, EXPANDING AND GLOBALIZING THE BUSINESS**	**7 Hours**
Marketing & Sales: Know the Customers – Market Characteristics of Medical Devices – Customer Relationship Management (CRM) – Marketing Ethics and Legal Compliance, Expanding & Globalizing the Business: World Prevalence of Diseases – Healthcare in UK/Germany/France/Italy – Healthcare Systems and Biomedical Industry in China – Global Markets of Medical Devices – Challenges of Global Marketing		
Module: 6	**CASE STUDIES ON BIOMEDICAL APPLICATIONS**	**8 Hours**
Covid-19 Pandemic Assistive Devices - Inventions in various fields of Biomedical Engineering – Devices Developed.		
	Total Lectures	**45 Hours**

Text Books

1.	Jen-shih Lee, "Being A Biomedical Entrepreneur - Growth of The Biomedical Industry", World Scientific Publication Co. Pvt. Ltd., 2019.

Reference Books

1.	Jen-shih Lee, "Being A Biomedical Entrepreneur - Growth of The Biomedical Industry", World Scientific Publication Co. Pvt. Ltd., 2019.
2.	Jen-shih Lee, "Biomedical Engineering Entrepreneurship", World Scientific Publication Co. Pvt. Ltd., 2010.
3.	Riadh Habash, "Green Engineering: Innovation, Entrepreneurship and Design", CRC Press, Taylor & Francis Group, 2017

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**BIOLOGY FOR ENGINEERS**	**L**	**T**	**P**	**C**
20BM2006		**3**	**0**	**0**	**3**

Course Objective:

1. To comprehend the fundamental principles of Life and Life forms
2. To impart knowledge on biodiversity and genetic theory.
3. To transfer knowledge in applications of biology in Industries.

Course Outcomes:

The Student will be able to

1. Illustrate the fundamentals of living things, their classification, cell structure and biochemical constituents
2. Assess the significance of biodiversity in world.
3. Comprehend genetics and the immune system
4. Outline cause, symptoms, diagnosis and treatment of common diseases.
5. Comprehend nervous system and mechanochemistry.
6. Understand and apply future trends in biology.

Module: 1	Introduction To Life And Biomolecules	8 Hours
Classification of life forms - Characteristics of living organisms--cell theory-structure of prokaryotic and eukaryotic cell-Introduction to biomolecules: definition-general classification and important functions of carbohydrates-lipids-proteins-nucleic acids vitamins and enzymes.		
Module: 2	**Biodiversity**	**8 Hours**
Plant System: basic concepts of plant growth-nutrition-photosynthesis and nitrogen fixation-Animal System: elementary study of digestive-respiratory-circulatory-excretory systems and their functions. Microbial System: history-types of microbes-economic importance and control of microbes.		
Module: 3	**Evolution, Genetics And Immune System**	**8 Hours**
Evolution: theories of evolution-Mendel's cell division–mitosis and meiosis-evidence of e laws of inheritance- nucleic acids as a genetic material-central dogma immunity antigens-antibody-immune response.		
Module: 4	**Human Diseases**	**7 Hours**
Lifestyle diseases -diabetes, obesity, blood pressure, heart disease, stroke, tuberculosis and diseases associated with drug abuse-Definition- causes, symptoms, diagnosis, treatment and prevention of cancer.		
Module: 5	**Nervous System, Cell Signaling And Mechanochemistry**	**8 Hours**
Basics of nervous system and neural networks- General principles of cell signaling - ATP synthase structure - The bacterial flagellar motor - Cytoskeleton -Bioremediation.		
Module: 6	**Biology For Industrial Applications**	**6 Hours**
Stem cell and tissue engineering - bioreactors - biopharming - recombinant vaccines-drugdiscovery-biofertilizer-biofilters-biosensors-biopolymers-bioenergy-biomaterials-biochips.		
	Total Lectures	**45 Hours**

Text Books

1.	A Text book of Biotechnology, R. C. Dubey, S. Chand Higher Academic Publications, 2013
2.	Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011.

Reference Books

1.	ThyagaRajan. S., Selvamurugan. N., Rajesh.M.P., Nazeer.R.A., Richard W. Thilagaraj, Barathi.S., and Jaganthan.M.K., "Biology for Engineers", Tata McGraw-Hill, New Delhi, 2012
2.	Cell Biology and Genetics (Biology: The unity and diversity of life Volume I), Cecie Starr, Ralph Taggart, Christine Evers and Lisa Starr, Cengage Learning, 2008
3.	Biotechnology Expanding horizon, B.D. Singh, Kalyani Publishers, 2012
4.	Jon Cooper, "Biosensors A Practical Approach", Bellwether Books, 2004.
5.	Diseases of the Human Body, Carol D. Tamparo and Marcia A. Lewis, F.A. Davis Company, 2011.
6.	Martin Alexander, "Biodegradation and Bioremediation", Academic Press, 1994.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	HOSPITAL AND EQUIPMENT MANAGEMENT	L	T	P	C
20BM2007		3	0	0	3

Course Objective:

The student should be made to:

1. Understand the fundamentals of health care delivery services
2. Learn the procedures in maintenance of equipments
3. Apply the design principles in engineering systems

Course Outcomes:

At the end of this course, students will be able to

1. Identify the principle of organizational structures and regulatory services
2. Classify the types of codes followed and applications
3. Modify the design to develop support systems
4. Infer the most challenges in environment and market trends
5. Evaluate the systems based on the safety criteria to environment
6. Create the methodology for new equipments to user needs

Module: 1	**Health And Hospital Management**	**7 Hours**

Health organisation of the country, the State, the Cities and the Region, Management of Hospital Organisation, Nursing Sector, Medical Sector, Central Services, Technical Department, Definition and Practice of Management by Objective, Transactional Analysis Human Relation in Hospital, Importance of Team Work, Legal aspect in Hospital Management. Case study: Health survey.

Module: 2	**Regulatory And Voluntary Guidelines And Health Care Codes**	**8 Hours**

FDA Regulation, Joint Commission of Accreditation for Hospitals, National Fire Protection Association Standard, ISO, NABL, ISO:13485, ISO:14791, risk management, Environmental regulation. Case study on risk management.

Module: 3	**Healthcare Supply Chain Management**	**7 Hours**

Essentials of healthcare supply chain management, designing sustainable health care supply chain, performance metrics, emerging trends in healthcare supply chain management.

Module: 4	**Clinical Engineering**	**8 Hours**

Role to be performed in Hospital, Manpower & Market, Professional Registration, Maintenance of Hospital support system, surveillance network, electric power management, Medical gas production, waste disposal, inventory control. Case study: RF ID tag for inventory.

Module: 5	**Safety Equipments**	**7 Hours**

Operation of safety devices, personnel safety equipments, Gas mask, Radiation measurements, equipment safety systems, elements of basic first aid, fire fighting, Case study: Safety Awareness.

Module: 6	**Equipment Maintenance Management**	**8 Hours**

Organizing the maintenance operation, biomedical equipment procurement procedure, proper selection, compatibility, testing and installation, purchase and contract procedure, trained medical staff, on proper use of equipment and operating instructions. Maintenance of job planning, preventive maintenance, maintenance budgeting, contract maintenance.

	Total Lectures	**45 Hours**

Text Books

1. Hokey Min, “Healthcare Supply Chain Management: Basic Concepts and principles”, Business expert press, NewYork, 2014
2. Keith Willson, Keith Ison, Slavik Tabakov, “Medical Equipment Management”, CRC Press, 2013.
3. Webster.J.G. and Albert M.Cook, “Clinical Engineering Principles and Practices Prentice Hall Inc., Englewood Cliffs, New Jersey, 1979.

Reference Books

1. Robin Guenther, Gail Vittori, “Sustainable Healthcare Architecture”, Wiley, 2013
2. Sharma D K, R.C.Goyal, “Hospital administration and human Resource Management in Hospital”, Prentice Hall of India, New Delhi, 2017
3. Syed Amin Tabish “Hospital and Health services Administration Principles and Practices” Oxford Press, New Delhi, 2001

Recommended by Board of Studies	

Approved by Academic Council	12th September 2020

Course code	BRAIN COMPUTER INTERFACE	L	T	P	C
20BM2008		3	0	0	3

Course Objective:

The student should be made to:

1. Understand the fundamentals of EEG signal acquisition techniques
2. Learn the feature extraction methods
3. Design EEG based robotic application

Course Outcomes:

At the end of this course, students will be able to

1. Identify the data acquisition methods for EEG signal
2. Classify the types of signals and its components
3. Choose the design tools to develop simulation models
4. Classify the signals to develop the applications
5. Assess the systems based on the design specifications
6. Construct the applications for medical diagnosis and robots

Module: 1	Human Computer Interaction	7 Hours

Introduction to theories within cognitive and perceptual psychology, human decision making and actions in computer supported situations. Design and construction, Interaction between human and computerized technical systems.

Module: 2	Introduction To Brain Computer Interfaces	8 Hours

Concept of BCI, Invasive and Non-invasive Types, EEG Standards, Signal Features, Spectral Components, EEG Data Acquisition, Pre-processing, Hardware and Software, Artifacts, Methods to Remove, Near Infrared BCI

Module: 3	BCI Approaches	7 Hours

Movement Related EEG Potentials, Mental States, Visual Evoked Potential. P300 virtual platform.

Module: 4	EEG Feature Extraction Methods	8 Hours

Time/Space Methods, Fourier Transform, Wavelets, AR models, Band pass filtering, PCA, Laplacian Filters, Linear and Non-linear Features.

Module: 5	EEG Feature Translation Methods	7 Hours

LDA, Regression, Memory Based Vector Quantization, Gaussian Mixture Modeling, Hidden Markov Modeling

Module: 6	BCI Controlled Robots	8 Hours

Case Study of Problems in BCI, Case Study of Brain Actuated Control applications.

	Total Lectures	45 Hours

Text Books

1. Chang S. Nam(Editor), Anton Nijholt(Editor), Fabien Lotte, " Brain–Computer Interfaces Handbook: Technological and Theoretical Advances", CRC Press, UK. 2018
2. Maureen Clerc, Laurent Bougrain, Fabien Lotte, "Brain Computer Interfaces 2: Technology and Applications", Wiley Publisher, 2016
3. Rajesh P. N. Rao, "Brain-Computer Interfacing: An Introduction", 1st Edition, Cambridge University Press, 2018

Reference Books	
1.	Andrew Webb, “Statistical Pattern Recognition”, Wiley International, Second Edition, 2002
2.	R.Spehlmann, “EEG Primer”, Elsevier Biomedical Press, 1981.
3.	Bishop C.M, “Neural Networks for Pattern Recognition”, Oxford, Clarendon Press, 1995.
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	INTRODUCTION TO BIOMEDICAL ENGINEERING	L	T	P	C
20BM2009		3	0	0	3

Course Objective:

1. To introduce the field of biomedical engineering and role of biomedical engineers in society.
2. To impart knowledge on principles of various diagnostic, therapeutic equipment.
3. Achieve familiarity with some basic ethical framework and medical standards to be followed in hospitals.

Course Outcomes:

The Student will be able to

1. Interpret the role of biomedical engineering in society
2. Demonstrate the principles of various diagnostic devices.
3. Identify the various techniques used in diagnosis though imaging.
4. Describe the working principles of various therapeutic and assist devices.
5. Understand device specific safety goals and standards.
6. Illustrate the concepts of ethical theories and moral principles for the health professions.

Module: 1	Introduction	7 Hours

Historical Perspective-Evolution of modern healthcare system-Modern Healthcare system-Role of Biomedical engineers in various domain -Recent advances in Biomedical Engineering-Professional status of biomedical engineering-Professional Societies for Biomedical Engineering.

Module: 2	Fundamentals of Medical Instrumentation	8 Hours

Anatomy and Physiology – Sources of biomedical signals- basic medical instrumentation system-Performance requirements –Intelligent Medical Instrumentation Systems - PC based Medical Instruments - General constraints in design of medical instruments.

Module: 3	Diagnostic Imaging	8 Hours

X-rays, Nuclear Medical Imaging-Positron Emission Tomography-Magnetic Resonance Imaging Scanners-Diagnostic Ultrasound- Thermal imaging systems.

Module: 4	Introduction to Biomedical Equipment	8 Hours

ECG – EEG - Cardiac Pacemakers - Cardiac Defibrillators – Haemodialysis Machines-Artificial Kidney-Dialyzers- Ventilators-Humidifiers, Nebulizers and Aspirators- Anaesthesia Machine.

Module: 5	Medical Safety Standards	7 Hours

Medical standards and regulations – Institutional Review Boards – Good Laboratory Practices -Good Manufacturing Practices -Human factors.

Module: 6	Ethical Practices in Health Care	7 Hours

Morality and Ethics-A Definition of terms,Human Experimentation-Ethical issues in feasibility studies, Ethical issues in emergency use, Ethical issues in treatment use-Codes of ethics for bio engineers.

	Total Lectures	45 Hours

Text Books

1.	Enderle, John D, Bronzino, Joseph D, Blanchard, Susan M- Introduction to Biomedical Engineering-ElsevierInc2ndedition,2005

2.	R. S. Khandpur, Handbook of Biomedical Instrumentation, McGraw-Hill Publishing Company Limited, 2ndedition, 2003.
Reference Books	
1.	Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurement, Prentice Hall of India, New Delhi,2nd edition, 2002
2.	John G Webster, Medical Instrumentation: Application and Design, John Wiley and sons, New York,4thedition,2010. Daniel A Vallero, Biomedical ethics for Engineers, Elsevier publication, 1st edition, 2007
3.	Joseph. J Carr, John M Brown, Introduction to Biomedical Equipment Technology, John Wiley& Sons, New York,4th edition, 2008.
4.	Norbert Leitgeb "Safety of Electro-medical Devices -Risks Opportunities" Springer/Wein, 2010.
5.	Michael Domach-"Introduction to Biomedical Engineering", Pearson, 2004.
6.	Daniel A Vallero, Biomedical ethics for Engineers, Elsevier publication, 1st edition,2007
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**ANALYTICAL INSTRUMENTATION**	**L**	**T**	**P**	**C**
20BM2010		**3**	**0**	**0**	**3**

Course Objective:

1. Understand the working of an instrument for a particular analysis with its merits, demerits and limitations.
2. Learn specific technique employed for monitoring different pollutants in air and water.
3. Know the instruments used in hospital for routine clinical analysis, drug and pharmaceutical laboratories, oil refineries and above all for environmental pollution monitoring.

Course Outcomes:

The Student will be able to

1. Identify various techniques and methods of analysis which occur in the various regions of the spectrum.
2. Summarize the unique methods of separation of closely similar materials, the most powerful being gas chromatography.
3. Outline the important analytical methods of industrial gases and pollution monitoring instruments.
4. Discuss the principle involved in pH and dissolved component analyzers.
5. Illustrate the methods of electromagnetic resonance
6. Investigate the structures using microscopic methods of analysis.

Module: 1	**Colorimetry And Spectrophotometry**	**8 Hours**

Significance of Invitro Diagnostics- **S**pecial methods of analysis – Beer-Lambert law – Colorimeters – UV-Visible spectrophotometers – Single and double beam instruments – Sources and detectors – IR Spectrophotometers – Types – Attenuated total reflectance flame photometers – Atomic absorption spectrophotometers – Sources and detectors – FTIR spectrophotometers – Flame emission photometers – Fluorescence spectrophotometer

Module: 2	**Chromatography**	**7 Hours**

Different techniques – Gas chromatography – Detectors – Liquid chromatographs – Applications – High-pressure liquid chromatographs – Applications.

Module: 3	**Gas Analyzers And Pollution Monitoring Instruments**	**7 Hours**

Types of gas analyzers – Oxygen, NO2 and H2S types, IR analyzers, thermal conductivity analyzers, analysis based on ionization of gases. Air pollution due to carbon monoxide, hydrocarbons, nitrogen oxides, sulphur dioxide estimation - Dust and smoke measurements

Module: 4	**pH Meters and Dissolved Component Analyzers**	**8 Hours**
Principle of pH measurement, glass electrodes, hydrogen electrodes, reference electrodes, selective ion electrodes, ammonia electrodes, cyclic voltametry, biosensors, dissolved oxygen analyzer – Sodium analyzer – Silicon analyzer.		
Module: 5	**Electro Magnetic Resonance**	**7 Hours**
NMR – Basic principles – NMR spectrometer - Applications. Electron Spin Resonance spectroscopy– Basic principles, Instrumentation and applications.		
Module: 6	**Microscopic Techniques**	**8 Hours**
Scanning Electron Microscope (SEM), - Basic principles, Instrumentation and applications. Transmission Electron Microscope (TEM) – Basic principles – Instrumentation and applications. Mass spectrometers – Different types – Applications.		
	Total Lectures	**45 Hours**

Text Books	
1.	R.S. Khandpur, 'Handbook of Analytical Instruments', Tata McGraw Hill publishing Co. Ltd., 2007.
2.	Sivasankar, "Instrumental Methods of Analysis", OUP India, 2012
Reference Books	
1.	Robert D. Braun, 'Introduction to Instrumental Analysis', McGraw Hill, Singapore, 1987.
2.	Liptak, B.G, Process Measurement and Analysis, Chilton Book Company, 1995
3.	G.W. Ewing, 'Instrumental Methods of Analysis', McGraw Hill, 1992
4.	R.K.Jain, Mechanical and Industrial Measurements, Khanna Publishers, New Delhi, 1999
5.	H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, 'Instrumental Methods of Analysis', CBS publishing& distribution, 1995.
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

DEPT. OF BIOMEDICAL ENGINEERING

LIST OF NEW COURSES

S.No.	Course Code	Name of the Course	L:T:P	Credits
1.	19BM1001	Biology for Engineers	3:0:0	3
2.	19BM1002	Introduction to Biomedical Engineering	3:0:0	3
3.	19BM2001	Sensory and Motor Rehabilitation	3:0:0	3
4.	19BM2002	Biomedical Optics	3:0:0	3
5.	19BM2003	Biometric Systems	3:0:0	3
6.	19BM2004	Nuclear Medicine	3:0:0	3
7.	19BM2005	Analytical Instrumentation	3:0:0	3
8.	19BM2006	Graphical System Design for Biomedical Engineers	3:0:0	3
9.	19BM2007	Bio-MEMS Technology	3:0:0	3
10.	19BM2008	Machine Learning and Artificial Intelligence	3:0:0	3
11.	19BM2009	Telemedicine	3:0:0	3
12.	19BM2010	Biomaterials and Artificial Organs	3:0:0	3
13.	19BM2011	Patient and Device Safety	3:0:0	3
14.	19BM2012	Robots in Healthcare	3:0:0	3
15.	19BM2013	Radiological Imaging Techniques	3:0:0	3
16.	19BM2014	Biomechanics	3:0:0	3
17.	19BM2015	Medical Ethics and Standards	3:0:0	3
18.	19BM2016	Signals and Systems for Biomedical Engineers	3:0:0	3
19.	19BM2017	Biophysics and Biochemistry	3:0:0	3
20.	19BM2018	Human Anatomy and Physiology	3:0:2	4
21.	19BM2019	Biomedical Sensors	3:0:0	3
22.	19BM2020	Signal Conditioning Circuits	3:0:0	3
23.	19BM2021	Signal Conditioning Circuits Laboratory	0:0:3	1.5
24.	19BM2022	Control System for Biomedical Engineers	3:0:0	3
25.	19BM2023	Image Processing for Medical Applications	3:0:0	3
26.	19BM2024	Image processing Laboratory for Medical Applications	0:0:3	1.5
27.	19BM2025	Embedded systems for Biomedical Applications	3:0:0	3
28.	19BM2026	Embedded Systems Laboratory for Biomedical Applications	0:0:3	1.5
29.	19BM2027	BioMEMS laboratory	0:0:3	1.5
30.	19BM2028	Medical Imaging Techniques	3:0:0	3
31.	19BM2029	Medical Equipment Maintenance and Troubleshooting	3:0:0	3
32.	19BM2030	Hospital Training	0:0:2	1

19RO1001	MATERIAL SCIENCE	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Phase diagrams and alloys
2. Electric, Mechanical and Magnetic properties of materials
3. Advanced Materials used in engineering applications

Course Outcomes:

The Student will be able to

1. Describe the various phase diagrams and their applications
2. Explain the applications of Ferrous alloys
3. Discuss about the electrical properties of materials
4. Summarize the mechanical properties of materials and their measurement
5. Differentiate magnetic, dielectric and superconducting properties of materials
6. Describe the application of modern engineering materials

Module 1: Introduction (6 hrs)
Historical perspective-Classification-Atomic Structure and Inter atomic Bonding –Structure of Crystalline solids- Phase diagrams

Module 2: Ferrous Alloys (9 hrs)
The iron-carbon equilibrium diagram - phases, invariant reactions - microstructure of slowly cooled steels - eutectoid steel, hypo and hypereutectoid steels - effect of alloying elements on the Fe-C system - diffusion in solids - Fick's laws - phase transformations - T-T-T-diagram for eutectoid steel – pearlite, bainite and martensite transformations

Module 3: Electrical Properties (9 hrs)
Conducting materials-quantum free electron theory -Fermi Dirac Statistics-Band theory of solids - the density of states. Magnetostriction. Electron ballistics- materials for thermionic emission electron guns-electron gun for electron beam machining-electric discharge plasma - EDM machining.

Module 4: Mechanical Properties (8 hrs)
Tensile test - plastic deformation mechanisms - slip and twinning - strengthening methods - strain hardening - refinement of the grain size - solid solution strengthening - precipitation hardening - creep resistance - creep curves - mechanisms of creep - creep-resistant materials - fracture - the Griffith criterion - critical stress intensity factor and its determination - fatigue failure - fatigue tests - methods of increasing fatigue life - hardness - Rockwell and Brinell hardness - Knoop and Vickers microhardness.

Module 5: Magnetic, Dielectric And Superconducting Materials (8 hrs)
Ferromagnetism – domain theory – types of energy – hysteresis – hard and soft magnetic materials – ferrites - dielectric materials – types of polarization – Langevin-Debye equation – frequency effects on polarization - dielectric breakdown – insulating materials – Ferroelectric materials - superconducting materials and their properties.

Module 6: Advanced Materials (5 hrs)
Liquid crystals-types-application as display devices-photonic crystals- ferro elastic materials-multiferroics, Bio mimetic materials. Composites-nanophase materials-physical properties and applications.

Text Books:

1. Balasubramaniam, R. "Callister's Materials Science and Engineering". Wiley India Pvt. Ltd., 2014.
2. Raghavan, V. "Physical Metallurgy: Principles and Practice". PHI Learning, 2015.

Reference Books:

1. William D CallisterJr, "Materials Science and Engineering-An Introduction", John Wiley and Sons Inc., Sixth Edition, New York,2010.
2. Raghavan, V. "Materials Science and Engineering : A First course". PHI Learning, 2015
3. Shetty.M.N., "Material Science and Engineering – Problems with Solutions", PHI, 2016
4. Shaffer J P, Saxena A, Antolovich S D, Sanders T H Jr and Warner S B, "The Science and Design of Engineering Materials", McGraw Hill Companies Inc., New York, 1999.

19RO1002	ENGINEERING PRACTICES	L	T	P	C
		1	0	3	2.5

Course Objectives:
To impart knowledge on
1. Carpentry Joints, Fitting and Welding Practices
2. Basics of Electronic Circuit components, Instruments and Wiring
3. PCB design and fabrication

Course Outcomes:
The Student will be able to
1. Assemble mechanical devices and equipment by applying carpentry and fitting practices.
2. Apply welding and drilling skills to fabricate useful products.
3. Design simple electric circuits and apply different types of wiring.
4. Identify the operation and handling of measuring instruments.
5. Perform troubleshooting of electric motors
6. Fabricate PCB boards for specific applications.

List of Experiments:
1. Making of rectangular planning in carpentry
2. Making of middle lap joint in carpentry
3. Making of Square filing in Fitting

4. Making of V joint in Fitting
5. Drilling holes and welding of Mild Steel plates
6. Study of simple electrical circuit diagrams and wiring
7. Study of electrical connection of basic electrical equipment
8. Study of handling of all measuring instruments and Oscilloscope (Multimeter, Wattmeter, Clamp meter, ammeter, voltmeter, CRO, DSO etc)
9. Study of Electrical Cables, HRC Fuse, MCB. simple relay and Contactors
10. Troubleshooting of Electric Motors
11. PCB layout design using software.
12. PCB fabrication, Components soldering and Trouble shooting
13. Assembly of simple Robots

19RO2001	THEORY AND PROGRAMMING OF CNC MACHINES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study the design aspects of an automation system
2. Learn about the design of belt conveyors
3. Understand the issues involved during integration of automation components

Course Outcomes:

The Student will be able to

1. Classify the types of CNC machines and read their electrical circuit diagram
2. Select the parameters for optimum performance and read the PLC ladder diagram with reference to the PLC I/O s
3. Perform the sizing of servomotors and do drive optimization.
4. Design electrical power, and control circuits for a CNC machine and interface various sensors to CNC/PLC
5. Develop CNC programs for lathes, select the right tools, take offsets and do machining of a component.
6. Estimate the machine hour rate of a CNC machine and do the regular and preventive maintenance.

Module 1: Introduction (8 hrs)

History - Advantages and disadvantages of CNC, block diagram of CNC - Principle of operation- Features available in CNC systems. DNC, Networking of CNC machines - Ethernet. Electrical cabinet and control panel wiring. Electrical standards. Types Of CNC Machines : Types and constructional features of machine tools- Turning centres, machining centers, grinding machines, EDMs, turret punch press, laser and water jet cutting machines, Design considerations – Axis representations, Various operating modes of a CNC machine.

Module 2: Control Units (7 hrs)

Functions of CNC, system hardware, contouring control - interpolation, software development process. Parameters and diagnosis features. Interfacing with keyboard, monitor, field inputs, outputs, MPG. Open architecture systems and PC based controllers. Role of PLC in CNC machines.- hardware and I/O configuration.

Module 3: Drive Units (8 hrs)

Axis drive arrangements, ball screw, timing belts and couplings, Analog and digital drives. AC&DC servomotors, DC and AC servo drives for axis motors, servo tuning. Stepper motors and drives, spindle motors & drives- DC &AC. Selection criteria, drive optimization and protection.

Module 4: Control And Feedback Devices (8 hrs)

MCCB, MCB, control relays, contactors, overload relays, cables & terminations. Applications of feedback devices in CNC machines- Absolute and incremental encoders, resolvers, linear scales, Proximity switches, limit switches – Thermal sensors, pressure and float switches. Positioning of sensors in CNC.

Module 5: NC Part Programming Process (8 hrs)

Axis notation, EIA and ISO codes, Explanation of basic codes.Tooling concepts, machining methods, part geometry and writing of tool motion statements.Canned cycles. Development of simple manual part programs for turning operations. Simulation of part programme. Post processors - CNC part programming with CAD/CAM systems.

Module 6: Economics And Maintenance (7 hrs)

Factors influencing selection of CNC Machines, Cost of operation of CNC Machines, Practicalaspects of introducing CNC machines in industries, Maintenance of CNC Machines Preventive Maintenance, TPM, Importance of earthing on the performance and life of machines.

Text Books:

1. Steve F Krar, "Computer Numerical Control Simplified", Industrial Press, 2001.
2. Radhakrishnan P., "Computer Numerical Control Machines", New Central Book Agency, 1992.

Reference Books:

1. YoremKoren, "Computer Control of Manufacturing Systems", Pitman, London, 2005.
2. HMT Limited, "Mechatronics", Tata McGraw Hill, New Delhi, 1998.
3. Suk Hwan, SeongKyoon, dae -Hyuk, "Theory and Design of CNC Machines", Springer,\ 2008
4. Hans.B.Kief, Helmut, "CNC Handbook", Mc GrawHill Professional, 2012.
5. Thyer.G.E., "Computer Numerical Control of Machine Tools", Newnes, 2012.

19RO2002	AUTONOMOUS VEHICLES	L	T	P	C
		3	0	0	3

Course Objectives:

1. Introduce the fundamental aspects of Autonomous Vehicles.
2. Gain Knowledge about the Sensing Technology and Algorithms applied in Autonomous vehicles.
3. Understand the Connectivity Aspects and the issues involved in driverless cars.

Course Outcomes:

The Student will be able to

1. Describe the evolution of Automotive Electronics and the operation of ECUs.
2. Compare the different type of sensing mechanisms involved in Autonomous Vehicles.
3. Discuss about the use of computer vision and learning algorithms in vehicles.
4. Summarize the aspects of connectivity fundamentals existing in a driverless car.
5. Identify the different levels of automation involved in an Autonomous Vehicle.
6. Outline the various controllers employed in vehicle actuation.

Module 1: Introduction (8 hrs)

Evolution of Automotive Electronics -Basic Control System Theory applied to Automobiles -Overview of the Operation of ECUs -Infotainment, Body, Chassis, and Powertrain Electronics-Advanced Driver Assistance Systems-Autonomous Vehicles

Module 2: **Sensor Technology for Autonomous Vehicles (8 hrs)**

Basics of Radar Technology and Systems -Ultrasonic Sonar Systems -LIDAR Sensor Technology and Systems -Camera Technology -Night Vision Technology -Use of Sensor Data Fusion -Kalman Filters

Module 3: **Computer Vision and Deep Learning for Autonomous Vehicles (7 hrs)**

Computer Vision Fundamentals -Advanced Computer Vision -Neural Networks for Image Processing – TensorFlow -Overview of Deep Neural Networks -Convolutional Neural Networks

Module 4: **Connected Car Technology (8 hrs)**

Connectivity Fundamentals - DSRC (Direct Short Range Communication) - Vehicle-to-Vehicle Technology and Applications -Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications -Security Issues.

Module 5:Autonomous Vehicle Technology (7 hrs)

Driverless Car Technology-Different Levels of Automation -Localization - Path Planning. Controllers to Actuate a Vehicle - PID Controllers -Model Predictive Controllers, ROS Framework

Module 6:Autonomous Vehicles' Biggest Challenges (7 hrs)

Technical Issues, Security Issues, Moral and Legal Issues.

Text Books:

1. Hong Cheng, "Autonomous Intelligent Vehicles: Theory, Algorithms and Implementation", Springer, 2011.
2. Williams. B. Ribbens: "Understanding Automotive Electronics", 7th Edition, Elsevier Inc, 2012.

Reference Books:

1. Shaoshan Liu, Liyun Li, "Creating Autonomous Vehicle Systems", Morgan and Claypool Publishers, 2017.
2. Marcus Maurer, J.ChristianGerdes, "Autonomous Driving: Technical, Legal and Social Aspects" Springer, 2016.
3. Ronald.K.Jurgen, "Autonomous Vehicles for Safer Driving", SAE International, 2013.
4. James Anderson, KalraNidhi, Karlyn Stanly, "Autonomous Vehicle Technology: A Guide for Policymakers", Rand Co, 2014.

5. Lawrence. D. Burns, ChrostopherShulgan, “Autonomy – The quest to build the driverless car and how it will reshape our world”, Harper Collins Publishers, 2018

19RO2003	AUTOMOTIVE EMBEDDED SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the basic components of modern automotive systems.
2. Understand the application of microcontrollers in ECU design and the In-Vehicle Communication protocols.
3. To provide an overview of the Automotive Open Systems Architecture (AUTOSAR)

Course Outcomes:

The Student will be able to

1. Describe the function of basic components used in modern automotive systems.
2. Discuss about the applications of microcontrollers in ECU design.
3. Summarize the various In-Vehicle Communication Protocols and their features.
4. Outline the diagnostic protocols and their functions.
5. Illustrate the practical applications of Automotive Open Systems Architecture (AUTOSAR)
6. Discuss about the Quality and Safety Standards to be adopted in Automotive Systems.

Module 1: Automotive Embedded Systems (8 hrs)

Introduction to Modern Automotive Systems-Evolution of Electronics and Software in automobiles -ECUs and their application areas in Automotive -Engine Management Systems -Body & Comfort Electronics Systems -Infotainment Systems -Advanced Driver Assistance Systems and V2X Systems -Autonomous Driving Systems -Current Trends and Challenges

Module 2:Micro Controllers in ECU Design (8 hrs)

Overview of AURIX Micro Controller -Architecture, Memory Map, Lock Step etc. -Peripherals used in Automotive Applications -GTM, QSPI, DSADC etc. -AURIX SafeTLib -Real time Operating Systems and Scheduling Concepts -Practical Experiments using AURIX Eval Kit.

Module 3: In-Vehicle Communication Protocols (7 hrs)

Overview of In-Vehicle Communication Protocols – CAN, LIN, Flex Ray, MOST, Ethernet -Controller Area Network (CAN)-CANoe, CANalyzer Fundamentals -CAPL Scripting, Panel Simulation.

Module 4: In-Vehicle Diagnostics (7 hrs)

Overview of Diagnostic Protocols – KWP 2000 and UDS.

Module 5: AUTOSAR (Automotive Open Systems Architecture) (8 hrs)

Platform Based Development -AUTOSAR Overview -AUTOSAR RTE, BSW, SWC -AUTOSAR Methodology & Workflow -AUTOSAR Tools Overview -Practical Experiments using AUTOSAR Tools.

Module 6: Automotive Quality, Safety and Security Standards (7 hrs)

Common Failures in Automotive Systems -ASPICE Development Process -MISRA C Standard -ISO 26262 Functional Safety Standard -SAE J3061 Security Standard.

Text Books:

1. Ronald K Jurgen: “Distributed Automotive Embedded Systems” SAE International, 2007.
2. Williams. B. Ribbens: “Understanding Automotive Electronics”, 7th Edition, Elsevier Inc, 2012.

Reference Books:

1. Robert Bosch: “Automotive Handbook”, 6th Edition, John Wiley and Sons, 2004.
2. Ronald K Jurgen: “Automotive Electronics Handbook”, 2nd Edition, McGraw-Hill, 1999
3. Nicolas Nivet, Francoise Simonot, “Automotive Embedded Systems Handbook”, CRC Press, 2017.
4. Kevin Roebuck,”AUTOSAR – Automotive Open System Architecture – High Impact Strategies”, Computers, 2011.
5. Dominique Paret, “Multiplexed Networks for Embedded Systems”, Wiley International, 2007.

19RO2004	ROBOTIC CONTROL SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide knowledge on the various robotic systems with the help of mathematical models.
2. To introduce the control aspects of non-linear systems.
3. To learn the concepts of non-linear observer design.

Course Outcomes:

The Student will be able to

1. Describe the characteristics of a robotic system from its dynamic model.
2. Analyze the stability of robotic systems with the help of theorems.
3. Illustrate the various task space control schemes available.
4. Discuss about the various Non Linear Control schemes.
5. Explain the concepts of Optimal Control System.
6. Develop nonlinear observer schemes.

Module 1: Introduction and Overview of Robotic Systems and their Dynamics (8 hrs)

Forward and inverse dynamics. Properties of the dynamic model and case studies. Introduction to nonlinear systems and control schemes.

Module 2: System Stability and Types of Stability (7 hrs)

Lyapunov stability analysis, both direct and indirect methods. Lemmas and theorems related to stability analysis.

Module 3: Joint Space and Task Space Control Schemes (7 hrs)

Position control, velocity control, trajectory control and force control.

Module 4: Nonlinear Control Schemes (8 hrs)

Proportional and derivative control with gravity compensation, computed torque control, sliding mode control, adaptive control, observer based control and robust control.

Module 5: Optimal Control: Introduction - Time varying optimal control – LQR steady state optimal control – Solution of Ricatti's equation – Application examples.

Module 6: Nonlinear Observer Schemes: Design based on acceleration, velocity and position feedback. Numerical simulations using software packages.

Text Books:

1. R Kelly, D. Santibanez, LP Victor and Julio Antonio, "Control of Robot Manipulators in Joint Space", Springer, 2005.
2. A Sabanovic and K Ohnishi, "Motion Control Systems", John Wiley & Sons (Asia), 2011.

Reference Books:

1. R M Murray, Z. Li and SS Sastry, "A Mathematical Introduction to Robotic Manipulation", CRC Press, 1994.
2. J J Craig, "Introduction to Robotics: Mechanics and Control", Prentice Hall, 2004.
3. J J E Slotine and W Li, "Applied Nonlinear Control", Prentice Hall, 1991.
4. Sebastian Thrun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics", MIT Press, 2005.
5. Carlos, Bruno, Georges Bastin, "Theory of Robot Control", Springer, 2012.

19RO2005	INDUSTRIAL ROBOTICS AND MATERIAL HANDLING SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Learn about the types of robots used in material handling systems.
2. Understand the use of vision systems in automation systems.
3. Gain knowledge on the different methods of material handling.

Course Outcomes:

The Student will be able to

1. Differentiate the various types of Industrial Robots and their architecture.
2. Apply the concepts of image processing for robotic inspection systems.
3. Analyze the applications of robots in various industrial application.
4. Design and fabricate simple grippers for pick and place application.
5. Identify the right Robot for a given industrial application.
6. Select the right material handling system for a given application.

Module 1: Introduction (7 hrs)

Types of industrial robots, Load handling capacity, general considerations in Robotic material handling, material transfer, machine loading and unloading, CNC machine tool loading, Robot centered cell.

Module 2: Robots for Inspection (8 hrs)

Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection, software considerations.

Module 3: Other Applications (7 hrs)

Application of Robots in continuous arc welding, Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications.

Module 4: End Effectors (8 hrs)
Gripper force analysis and gripper design for typical applications, design of multiple degrees of freedom, active and passive grippers.
Module 5: Selection of Robot (7 hrs)
Factors influencing the choice of a robot, robot performance testing, economics of robotization, Impact of robot on industry and society.
Module 6: Material Handling (8 hrs)
Concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, monorails, rail guided vehicles, conveyor systems, cranes and hoists, advanced material handling systems, automated guided vehicle systems, automated storage and retrieval systems(ASRS), bar code technology, radio frequency identification technology. Introduction to Automation Plant design software.

Text Books:

1. Richard D Klafter, Thomas Achmielewski and MickaelNegin, "Robotic Engineering – An integrated Approach" Prentice HallIndia, New Delhi, 2001.
2. Mikell P Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson Education, 2015.

Reference Books:

1. James A Rehg, "Introduction to Robotics in CIM Systems", Prentice Hall of India, 2002.
2. Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994.
3. Richard. K. Miller, "Industrial Robot Handbook", Springer, 2013.
4. Cotsaftis, Vernadat, "Advances in Factories of the Future, CIM and Robotics", Elsevier, 2013.
5. Gupta.A.K, Arora. S. K., "Industrial Automation and Robotics", University Science Press, 2009.

19RO2006	MICROROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:
1. Provide brief introduction to micromachining and the principles of microsystems
2. Understand the various flexures, actuators and sensor systems.
3. Discuss the methods of implementation of micro robots.

Course Outcomes:
The Student will be able to
1. Describe the principles of microsystems and micromachining.
2. Analyze the effectsof scaling laws on physical and electrical properties and the materials to be used to MEMS.
3. Specify the characteristics of various flexures, actuators and sensor systems
4. Provide a task specification of micro robots and its applications based on the knowledge about micro robots
5. Outline the various methods of implementation of micro robots.
6. Discuss about the principle of micro fabrication and micro assembly.

Module 1: Introduction (7 hrs)
MST (Micro System Technology) – Micromachining - Working principles of Microsystems - Applications of Microsystems.
Module 2: Scaling Laws and Materials for MEMS (8 hrs)
Introduction - Scaling laws - Scaling effect on physical properties, scaling effects on Electrical properties, scaling effect on physical forces. Physics of Adhesion - Silicon-compatible material system - Shape memory alloys - Material properties: Piezoresistivity, Piezoelectricity and Thermoelectricity.
Module 3: Flexures, Actuators and Sensors (7 hrs)
Elemental flexures - Flexure systems - Mathematical formalism for flexures. Electrostatic actuators, Piezo-electric actuators, Magneto-strictive actuators. Electromagnetic sensors, Optical-based displacement sensors, Motion tracking with microscopes.
Module 4: Micro robotics (8 hrs)
Introduction, Task specific definition of micro-robots - Size and Fabrication Technology based definition of micro robots - Mobility and Functional-based definition of micro-robots - Applications for MEMS based micro-robots.

Module 5: Implementation of Micro robots (8 hrs)
Arrayed actuator principles for micro-robotic applications – Micro-robotic actuators - Design of locomotive micro-robot devices based on arrayed actuators. Micro-robotics devices: Micro-grippers and other micro-tools - Micro conveyors - Walking MEMS Micro-robots – Multi-robot system: Micro-robot powering, Micro-robot communication.
Module 6: Micro fabrication and Micro assembly (7 hrs)
Micro-fabrication principles - Design selection criteria for micromachining - Packaging and Integration aspects – Micro-assembly platforms and manipulators.

Text Books:
1. Mohamed Gad-el-Hak, "The MEMS Handbook", CRC Press, New York, 2002.
2. Yves Bellouard, "Microrobotics Methods and Applications", CRC Press, Massachusetts, 2011.

Reference Books:
1. NadimMaluf and Kirt Williams, '"An Introduction to Microelectromechanical systems Engineering", Artech House, MA, 2002.
2. Julian W Gardner, "Microsensors: Principles and Applications", John Wiley & Sons, 1994.
3. SergejFatikow, Ulrich Rembold, "Microsystem Technology and Microrobotics", Springer, 2013.
4. Nicolas Chaillet, Stephane Regnier, "Microrobotics for Micromanipulation", Wiley, 2013.
5. Vikas Choudhry, Krzystof, "MEMS: Fundamental Technology and Applications", CRC Press, 2013.

19RO2007	COGNITIVE ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:
1. Provide brief introduction to robot cognition and perception
2. Understand the concepts of path planning algorithms.
3. Gain knowledge on the robot programming packages used in localization and mapping.

Course Outcomes:
The Student will be able to
1. Discuss about the basics of robot cognition and perception
2. Illustrate the different methods of map building and the robot simulation and execution of a program
3. Analyze the various path planning techniques by briefing about the robot's environment and explaining about the programs used
4. Develop knowledge about simultaneous localization and mapping based techniques and paradigms.
5. Elaborate the various robot programming packages for display,tele-operation and other applications.
6. Describe the aspects of Imaging Techniques used in Robotic Applications.

Module 1: Cybernetic View of Robot Cognition And Perception (6 hrs)
Introduction to the Model of Cognition, Visual Perception, Visual Recognition, Machine Learning, Soft Computing Tools and Robot Cognition.
Module 2: Map Building (8 hrs)
Introduction, Constructing a 2D World Map, Data Structure for Map Building, Explanation of the Algorithm, An Illustration of Procedure Traverse Boundary, An Illustration of Procedure Map Building ,Robot Simulation, Execution of the Map Building Program.
Module 3: Randomized Path Planning (8 hrs)
Introduction, Representation of the Robot's Environment, Review of configuration spaces, Visibility Graphs, Voronoi diagrams, Potential Fields and Cell Decomposition, Planning with moving obstacles, Probabilistic Roadmaps, Rapidly exploring random trees, Execution of the Quad tree-Based Path Planner Program.
Module 4: Simultaneous Localization and Mapping (SLAM) (8 hrs)
Problem Definition, Mathematical Basis, Examples: SLAM in Landmark Worlds, Taxonomy of the SLAM Problem, Extended Kalman filter, Graph-Based Optimization Techniques, ParticleMethods Relation of Paradigms.
Module 5: Robot Programming Packages (8 hrs)
Robot Parameter Display, Program for BotSpeak, Program for Sonar Reading Display, Program for Wandering Within the Workspace, Program for Tele-operation, A Complete Program for Autonomous Navigation.
Module 6: Imaging Geometry: (7 hrs)
Introduction – Necessity for 3D Reconstruction – Building Perception – Imaging Geometry – Global Representation – Transformation to Global Co-ordinate System.

Text Books:

1. Patnaik, Srikanta, "Robot Cognition and Navigation - An Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2007.
2. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005.

Reference Books:

1. Sebastian Tharun, Wolfram Burgard, Dieter Fox, "ProbabilisticRobotics", MIT Press, 2005.
2. Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg 2008.
3. HoomanSomani,"Cognitive Robotics", CRC Press, 2015.
4. Jared Kroff,"Cognitive Robotics: Intelligent Robotic Systems", Wilford Press, 2016.
5. Lidia Ogiela, Marek Ogiela, "Advances in Cognitive Information Systems", Springer, 2012.

19RO2008	CLOUD ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide an overview of telerobotics
2. Understand the concept of networked telerobotic systems
3. Provide knowledge on the functions of online robots

Course Outcomes:

The Student will be able to

1. Discuss about the basic principles of telerobotics
2. Describe the concepts of wired and wireless communication for networked telerobotic systems.
3. Explain the fundamentals of robot manipulation and teleoperation
4. Design and fabricate the software architecture and interface for networked robot systems on the web
5. Analyze the performance of mobile robots controlled through the web
6. Outline the software architecture for telerobotics.

Module 1: Introduction (6 hrs)

Telerobotics: Overview and background – Brief history.

Module 2: Communications And Networking (8 hrs)

The Internet – Wired Communication Links – Wireless Links – Properties of Networked Telerobotics – Building a Networked Telerobotic system – State command Presentation – Command Execution/ State Generation – Collaborative Control

Module 3: Fundamentals Of Online Robots (8 hrs)

Introduction – Robot Manipulators – Teleoperation – Teleoperation on a local network – Teleoperation via a constrained link.

Module 4: Online Robots (8 hrs)

Introduction to networked robot system on the Web – Software Architecture and design – Interface design.

Module 5: Remote Mobility (8 hrs)

Autonomous Mobile Robot on the Web – Mobile Mini Robots – Performance of Mobile Robots controlled through WEB – Handling Latency in Internet based Tele operation

Module 6: Case Study (7 hrs)

Computer Networked Robotics – Online Robots and the Robot Museum.

Text Books:

1. Bruno Siciliano, OussamaKhatib, "Springer Handbook of Robotics", Springer Science and Business, 2010.
2. Ken Goldberg, Roland Siegwart, "Beyond Webcams – An Introduction to Online Robots", MIT Press, 2010.

Reference Books:

1. BorkoFurht, Armando Escalante, "Handbook of Cloud Computing", Springer Science & Business, 2010.
2. Peter Sinčák, Pitoyo Hartono, MáriaVirčíková, JánVaščák, Rudolf Jakša , "Emergent Trends in Robotics and Intelligent Systems", Springer, 2014.
3. Joao Pedro, Carvalho Rosa, "Cloud Robotics – Distributed Robotics using Cloud Computing", Coimbra, 2016.

4. AnisKoubaa, ElhadiShakshuki, “Robots and Sensor Clouds”, Springer, 2015.
5. Nak. Y. Chung, “Networking Humans, Robots and Environments”, Bentham Books, 2013.

19RO2009	MEDICALROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide knowledge on the application of robotics in the field of health care
2. Overview of the sensor requirements for localization and tracking in medical applications
3. Understand the design aspects of medical robots

Course Outcomes:

The Student will be able to

1. Describe the types of medical robots and the concepts of navigation and motion replication.
2. Discuss about the sensors used for localization and tracking
3. Summarize the applications of surgical robotics
4. Outline the concepts in Rehabilitation of limbs and brain machine interface
5. Classify the types of assistive robots.
6. Analyze the design characteristics, methodology and technological choices for medical robots.

Module 1: **Introduction (7 hrs)**

Types of medical robots - Navigation - Motion Replication - Imaging - Rehabilitation and Prosthetics - State of art of robotics in the field of healthcare.

Module 2: Localization And Tracking (8 hrs)

Position sensors requirements - Tracking - Mechanical linkages - Optical - Sound-based - Electromagnetic - Impedance-based - In-bore MRI tracking - Video matching - Fiber optic tracking systems - Hybrid systems.

Module 3: **Control Modes (8 hrs)**

Radiosurgery - Orthopedic Surgery - Urologic Surgery and Robotic Imaging - Cardiac Surgery – Neurosurgery – case studies.

Module 4: Rehabilitation (7 hrs)

Rehabilitation for Limbs - Brain-Machine Interfaces - Steerable Needles – case studies.

Module 5: Robots In Medical Care (7 hrs)

Assistive robots –types of assistive robots – case studies.

Module 6: Design of Medical Robots (8 hrs)

Characterization of gestures to the design of robots- Design methodologies- Technological choices - Security.

Text Books:

1. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, “Robot Modeling and Control”, Wiley Publishers, 2006.
2. Paula Gomes, "Medical robotics- Minimally Invasive surgery", Woodhead, 2012.

Reference Books:

1. AchimSchweikard, Floris Ernst, “Medical Robotics”, Springer, 2015.
2. Jocelyne Troccaz, “Medical Robotics”, Wiley-ISTE, 2012.
3. VanjaBonzovic, ”Medical Robotics”, I-tech Education publishing,Austria,2008.
4. Daniel Faust, “Medical Robots”, Rosen Publishers, 2016.
5. Jocelyne Troccaz, “Medical Robotics”, Wiley, 2013.

19RO2010	MACHINE LEARNING FOR ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Understanding the concepts of machine learning
2. Study in detail about unsupervised learning, dimensionality concepts
3. Concepts of neural networks in robots with case studies.

Course Outcomes:

The Student will be able to

1. Discuss about the concepts of machine learning
2. Describe the types of trees and bias
3. Outline the supervised learning methods with various case studies
4. Compare the learning methodologies and dimensionality concepts
5. Summarize the applications of neural networks in robotic applications.

6. Illustrate the applications of machine learning using case studies.

Module 1: Introduction (7 hrs)

Machine learning – Varieties of Machine learning – Learning Input- Output functions: Types of learning – Input Vectors – Outputs – Training regimes – Noise – Performance Evaluation.

Module 2: Foundations Of Supervised Learning (7 hrs)

Decision trees and inductive bias – Geometry and nearest neighbors – Logistic regression – Perceptron – Binary classification.

Module 3: Advanced Supervised Learning (8 hrs)

Linear models and gradient descent – Support Vector machines – Naïve Bayes models and probabilistic modeling – Model selection and feature selection – Model Complexity and Regularization.

Module 4: Unsupervised Learning (8 hrs)

Curse of dimensionality, Dimensionality Reduction, PCA, Clustering – K-means – Expectation Maximization Algorithm – Mixtures of latent variable models – Supervised learning after clustering – Hierarchical clustering

Module 5: Neural Networks: (7 hrs)

Network Representation, Feed-forward Networks, Back propagation, Gradient-descent method.

Module 6: Case Studies: (8 hrs)

Line following using Supervised Learning techniques – A simulation model for understanding both regression and classification techniques - Study of the effectiveness of the Bias-variance. Obstacle avoidance and navigation of a mobile robot in an unknown environment with the help of Neural Network -Use of stochastic PCA and the PCA neural network to find low dimensional features. Building a feed-forward neural network to ascertain automatic navigational queries.

Text Books:

1. Michalski, Carbonell, Tom Mitchell, 'Machine Learning', Springer, 2014.
2. Peter Flach, 'Machine Learning: The Art and Science of Algorithms that make sense of data', Cambridge, 2014.

Reference Books:

1. Hal Daume III, 'A Course in Machine Learning', Todo, 2015.
2. EthemAlpaydin,'Introduction to Machine Learning',The MIT Press, 2004
3. David MacKay, 'Information Theory, Inference and Learning Algorithms', Cambridge, 2003
4. Bruno Apolloni, Ashish Ghosh, FerdaAlpasian, "Machine Learning and Robot Perception", Springer, 2005.
5. Judy Franklin, Tom Mitchell, SebastinThrun, "Recent Advances in Robot Learning: Machine Learning", Springer, 2012.

19RO2011	ROBOT OPERATING SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Introduce the basics of Robot Operating Systems and its architecture.
2. Provide knowledge on the hardware interfacing aspects.
3. Understand the applications of ROS in real world complex applications

Course Outcomes:

The Student will be able to

1. Describe the need for ROS and its significance
2. Summarize the Linux commands used in robotics
3. Discuss about the concepts behind navigation through file system.
4. Explain the concepts of Node debugging
5. Analyze the issues in hardware interfacing
6. Discuss about the applications of ROS

Module 1: Introduction to ROS: **(7 hrs)**

Introduction –The ROS Equation - History - distributions -difference from other meta-operating systems– services - ROS framework – operating system – releases.

Module 2: Introduction to Linux Commands (7 hrs)

UNIX commands - file system – redirection of input and output - File system security - Changing access rights – process commands – compiling, building and running commands – handling variables

Module 3: Architecture of Operating System (8 hrs)
File system - packages – stacks – messages – services – catkin workspace – working with catkin workspace – working with ROS navigation and listing commands
Module 4: Computation Graph Level (7hrs)
Navigation through file system -Understanding of Nodes – topics – services – messages – bags – master – parameter server.
Module 5: Debugging And Visualization (8 hrs)
Debugging of Nodes – topics – services – messages – bags – master – parameter – visualization using Gazebo – Rviz – URDF modeling – Xacro – launch files.
Hardware Interface: Sensor Interfacing – Sensor Drivers for ROS – Actuator Interfacing – Motor Drivers for ROS.
Module 6: Case Studies: **Using ROS In Real World Applications (8 hrs)**
Navigation stack-creating transforms -odometer – imu – laser scan – base controller – robot configuration – cost map – base local planner – global planner – localization – sending goals – TurtleBot – the low cost mobile robot.

Text Books:
1. Lentin Joseph, "Robot Operating Systems (ROS) for Absolute Beginners, Apress, 2018
2. Aaron Martinez, Enrique Fernández, "Learning ROS for Robotics Programming", Packt Publishing Ltd, 2013.

Reference Books:
1. Jason M O'Kane, "A Gentle Introduction to ROS", CreateSpace, 2013.
2. AnisKoubaa, "Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.
3. Kumar Bipin, "Robot Operating System Cookbook", Packt Publishing, 2018.
4. Wyatt Newman, "A Systematic Approach to learning Robot Programming with ROS", CRC Press, 2017.
5. Patrick Gabriel, "ROS by Example: A do it yourself guide to Robot Operating System", Lulu, 2012.

19RO2012	ARTIFICIAL INTELLIGENCE IN ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:
1. Study the concepts of Artificial Intelligence.
2. Learn the methods of solving problems using Artificial Intelligence.
3. Introduce the concepts of Expert Systems and Machine learning.

Course Outcomes:
The Student will be able to
1. Identify problems that are amenable to solution by AI methods.
2. Identify appropriate AI methods to solve a given problem.
3. Formalize a given problem in the language/framework of different AI methods.
4. Summarize the learning methods adopted in AI.
5. Design and perform an empirical evaluation of different algorithms on a problem formalization.
6. Illustrate the applications of AI in Robotic Applications.

Module 1: Introduction (7 hrs)
History, state of the art, Need for AI in Robotics. Thinking and acting humanly, intelligent agents, structure of agents.
Module 2: Problem Solving (8 hrs)
Solving problems by searching –Informed search and exploration–Constraint satisfaction problems– Adversarial search, knowledge and reasoning–knowledge representation – first order logic.
Module 3: Planning (8 hrs)
Planning with forward and backward State space search – Partial order planning – Planning graphs– Planning with propositional logic – Planning and acting in real world.
Module 4: Reasoning (7hrs)
Uncertainty – Probabilistic reasoning–Filtering and prediction–Hidden Markov models–Kalman filters– Dynamic Bayesian Networks, Speech recognition, making decisions.

Module 5: Learning (8 hrs)
Forms of learning – Knowledge in learning – Statistical learning methods –reinforcement learning, communication, perceiving and acting, Probabilistic language processing, and perception.
Module 6: AI In Robotics (7 hrs)
Robotic perception, localization, mapping- configuring space, planning uncertain movements, dynamics and control of movement, Ethics and risks of artificial intelligence in robotics.

Text Books:
1. Stuart Russell, Peter Norvig, "Artificial Intelligence: A modern approach", Pearson Education, India, 2016.
2. Negnevitsky, M, "Artificial Intelligence: A guide to Intelligent Systems",. Harlow: AddisonWesley, 2002.

Reference Books:
1. David Jefferis, "Artificial Intelligence: Robotics and Machine Evolution", Crabtree Publishing Company, 1992.
2. Robin Murphy, Robin R. Murphy, Ronald C. Arkin, "Introduction to AI Robotics", MIT Press, 2000.
3. Francis.X.Govers, "Artificial Intelligence for Robotics", Packt Publishing, 2018.
4. Huimin Lu, Xing Lu, "Artificial Intelligence and Robotics", Springer, 2017.
5. Michael Brady, Gerhardt, Davidson, "Robotics and Artificial Intelligence", Springer, 2012.

19RO2013	INDUSTRIAL ENERGY MANAGEMENT SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:
1. Provide an overview of Energy Management System in Industry.
2. Gain understanding of the renewable sources.
3. Introduce the concepts of waste management in industry.

Course Outcomes:
The Student will be able to
1. Discuss the need for industrial energy balance
2. Describe the functioning of utility plants and renewable energy sources
3. Compare the various distribution systems.
4. Explain the functioning of equipment used in energy management.
5. Summarize the concept of energy recovery from waste and the need of automation.
6. Discuss about the use of computers in Energy Management.

Module 1: Introduction (7 hrs)
World Energy Resources - Industrial Energy Balance -Energy End users – Industrial Energy Consumption.
Module 2: Utility Plants and Renewable Sources (8 hrs)
Solar, wind, hydraulic, energy from waste – energy storage – applicability in industry – Electrical Sub Stations – Boiler Plants
Module 3: Distribution Systems (6 hrs)
Electric Distribution Systems – Thermal Distribution Systems **–** Co generation plants.
Module 4: Equipment Facilities (8 hrs)
Pumps and Fans – Air Compressors – Industrial Cooling Systems – Heat Exchangers.
Module 5: Waste Management (8 hrs)
Introduction – Energy Recovery from Waste – Waste and Energy Management Functions in Industry.
Module 6: Computers for Energy Management (8 hrs)
Introduction – Factory Functioning – Energy Saving – Control of Boiler Plants and Substations – Air compressor plan control.

Text Books:
1. Giovanni Petrecca, "Industrial Energy Management -Principles and applications", Kluwer Academic Publishers, 2016.
2. KaushikBhattacharjee, "Industrial Energy Management Strategies – Creating a Culture of Continuous Improvement", Fairmont Press, 2018.

Reference Books:
1. Zoran Morvay, DušanGvozdenac, " Applied Industrial Energy and Environment Management", John Wiley and Sons, 2008

2. Alan P Rossiter, Beth P Jones, “Energy Management and Efficiency for the Process Industries”, Wiley, 2013.
3. Steve Doty, Wayne C Turner, “Energy Management Handbook”, CRC Press, 2004.
4. David Thorpe, “Energy Management in Industry: The Earthscan Expert Guide”, Taylor and Francis, 2013.
5. PatrikThollander, Jenny Palm, “Improving Energy Efficiency in Industrial Energy Systems”, Springer, 2012.

19RO2014	ROBOTICS AND AUTOMATION IN FOOD INDUSTRY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the need for robotics and automation in food industry
2. Provide an overview of the sensors and gripper mechanisms for food sector.
3. Understanding the various applications of automation in food industry.

Course Outcomes:

The Student will be able to

1. Specify the characteristics of robots used in food industry.
2. Identify the applications of sensors in food industry.
3. Describe about the different types of gripper mechanisms
4. Describe the use of sensor networks and quality control in food sector
5. Discuss about the advanced methods for control of food process.
6. Summarize the applications of automation and robotics in food industry.

Module 1: Introduction (7 hrs)

Process Control Systems and Structure in the Food Industry – Process Control Methods – Robotics in the food industry – Automation – Specification for a food sector robot – future trends.

Module 2: Sensors and Automation (8 hrs)

Sensors for automated food process control – Special Considerations – Measurement Methods – Device Integration – Applications - Machine Vision- Optical Sensors – SCADA in food industry.

Module 3: Gripper Technology (8 hrs)

Gripper Challenges in food industry – Gripping Physics – Pinching and enclosing grippers – Penetrating Grippers – Suction Grippers – Surface Effect Grippers –Selection of appropriate gripping mechanism.

Module 4: Sensor Networks and Intelligent Quality Control Systems (8 hrs)

Wireless sensor networks – applications in agriculture and food production – future trends – intelligent control systems using fuzzy logic.

Module 5: Advanced Methods for control of food processes (7 hrs)

Introduction – Case Study of Bio conversion in a batch fed reactor – Design of PID Controller for fed batch process – Real time optimization.

Module 6: Applications (7 hrs)

Case Study – Bulk sorting – Food chilling and processing – meat processing – poultry industry –sea food processing – confectionary -

Text Books:

1. Darwin Caldwell, Robotics and Automation in the Food Industry – Current and Future Technologies” Woodhead Publishing, 2013.
2. Moore.C.A., “Automation in Food Industry”, Springer, 2012.

Reference Books:

1. Selwyn Piramuthu and Wie Zhou “RFID and Sensor Network Automation in the Food Industry”, Wiley Blackwell, 2016.
2. Luo Zongwei, “Robotics, Automation and Control in Industrial and Service Settings”, Advances in Civil and Industrial Engineering, 2015.
3. Jonathan Love, “Process Automation Handbook: A Guide to Theory and Practice”, Springer, 2007.
4. Fellows. P. J. “Food Processing Technology: Principles and Practice”, Woodhead Publishing, 2009.
5. Mittal, “Computerized Control Systems in the Food Industry”, Routledge, 2018.

19RO2015	NEURAL NETWORKS AND FUZZY SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Introduce the fundamentals of Neural Networks and its applications.
2. Provide an overview of deep learning and convolutional neural networks.
3. Gain understanding about the fundamentals of Fuzzy Logic and its applications

Course Outcomes:

The Student will be able to

1. Classify the types of neural networks.
2. Discuss about the applications of neural networks.
3. Describe the concepts of deep learning and convolutional neural networks
4. Compare fundamentals of classical logic and fuzzy logic concepts.
5. Characterize the fuzzy membership functions.
6. Summarize the applications of fuzzy logic controllers.

Module 1: Introduction to Neural Networks (7 hrs)

Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, McCulloch - Pitts Neuron, Simple Neural Nets for Pattern Classification, Linear Separability - Hebb Net, Perceptron, Adaline, Madaline - Architecture, algorithm, and Simple Applications.

Module 2: Neural Network Applications (8 hrs)

Training Algorithms for Pattern Association - Hebb rule and Delta rule, Heteroassociative, Autoassociative and Iterative Auto associative Net, Bidirectional Associative Memory - Introduction to Neural Network Controllers

Module 3: Deep Learning and Convolution Neural Networks (8 hrs)

Evolution of deep learning – Impact of deep learning – Motivation for deep architecture – Applications – Deep Learning in Computer Vision – Convolutional Neural Networks – Popular CNN Architecture – Simple Applications.

Module 4: Classical and Fuzzy Sets and Relations (7 hrs)

Properties and Operations on Classical and Fuzzy Sets, Crisp and Fuzzy Relations - Cardinality, Properties and Operations, Composition, Tolerance and Equivalence Relations, Simple Problems.

Module 5: Membership Functions (8 hrs)

Features of membership function, Standard forms and Boundaries, fuzzification, membership value assignments, Fuzzy to Crisp Conversions, Defuzzification methods.

Module 6: Applications (7 hrs)

Neural Networks: Case Studies: Inverted Pendulum, CMAC, Robotics, Image compression, and Control systems - Fuzzy Logic: Mobile robot navigation, Autotuning a PID Controller.

Text Books:

1. Jacek M. Zurada, 'Introduction to Artificial Neural Systems', Jaico Publishing home, 2002.
2. Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 2009.

Reference Books:

1. LaureneFausett, Englewood cliffs, N.J., 'Fundamentals of Neural Networks', Pearson Education, 2008.
2. Simon Haykin, 'Neural Networks', Pearson Education, 2003.
3. George.J.Klir, 'Fuzzy Sets and Fuzzy Logic – Theory and Applications', Pearson, 2015.
4. Rajasekaran, VijayalakshmiPai, "Neural Networks, Fuzzy Systems and Evolutionary Algorithms", PHI Learning, 2017.
5. Shigeo Abe, "Neural Networks and Fuzzy Systems", Springer, 2012.

19RO2016	MICROCONTROLLERS FOR ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart basic knowledge about architecture of controller.
2. To get familiarized with the instruction sets in controller.
3. To explore the necessity of controller in real time applications.

Course Outcomes:

The Student will be able to

1. Describe the architecture of 8051 controllers
2. Classify different types of instruction set and addressing modes
3. Express their knowledge in designing a system using 8051
4. Discuss the general features of RISC architecture
5. Summarize the specific features of cortex controller
6. Develop interfacing program with controller

Module 1: The 8051 Architecture (8 hrs)

Internal Block Diagram - CPU - ALU - address - data and control bus - working registers - SFRs - Clock and RESET circuits - Stack and Stack Pointer - Program Counter - I/O ports - Memory Structures - Data and Program Memory - Timing diagrams and Execution Cycles. Comparison of 8-bit microcontrollers - 16-bit and 32-bit microcontrollers. Definition of embedded system and its characteristics - Role of microcontrollers in embedded Systems. Overview of the 8051 family.

Module 2: Instruction Set and Programming (8 hrs)

Addressing modes: Introduction - Instruction syntax - Data types - Subroutines Immediate addressing - Register addressing - Direct addressing - Indirect addressing - Relative addressing - Indexed addressing - Bit inherent addressing - bit direct addressing. 8051 Instruction set - Instruction timings. Data transfer instructions - Arithmetic instructions - Logical instructions - Branch instructions - Subroutine instructions - Bit manipulation instruction. Assembly language programs - C language programs. Assemblers and compilers. Programming and debugging tools.

Module 3: Memory and I/O Interfacing: (7 hrs)

Memory and I/O expansion buses - control signals - memory wait states. Interfacing of peripheral devices such as General Purpose I/O - ADC - DAC - timers - counters - memory devices. External Communication Interface (8 Hours) Synchronous and Asynchronous Communication. RS232 - SPI - I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

Module 4: High Performance RISC Architecture: (8 hrs)

ARM 9 RISC architecture merits and demerits – The programmer's model of ARM Architecture – 3- stage pipeline ARM organization - 3-stage pipeline ARM organization – ARM instruction execution – Salient features of ARM instruction set

Module 5: High Performance Microcontroller Architectures: (8 hrs)

Introduction to the Cortex-M Processor Family - ARM 'Cortex-M4' architecture for microcontrollers – Thumb 2 instruction technology – Internal Registers - Nested Vectored Interrupt controller - Memory map - Interrupts and exception handling – Applications of Cotex-M4 architecture

Module 6: Applications: (6 hrs)

LED – LCD and keyboard interfacing. Stepper motor interfacing – DC Motor interfacing – sensor interfacing.

Text Books:

1. M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, " The8051Microcontroller and Embedded Systems: Using Assembly and C" ,Pearson Education, 2007.
2. Joseph Yiu The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors, 3rd Edition, Kindle Edition, 2013

Reference Books:

1. K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning,2005.
2. R. Kamal, "Embedded System", McGraw Hill Education,2009.
3. R. S. Gaonkar, ", Microprocessor Architecture: Programming and Applications with the 8085" , Penram International Publishing, 1996
4. Steve Furber , "ARM System –On –Chip architecture", Addision Wesley, 2000.

19RO2017	MICROCONTROLLERS LABORATORY FOR ROBOTICS	L	T	P	C
		0	0	2	1

Course Objectives:

1. To enable the students to understand the programming techniques of Microcontrollers.
2. To design suitable sensor application using Microcontrollers.
3. To understand the concepts of peripherals

Course Outcomes:

The Student will be able to

1. Understand and apply the fundamentals of assembly level programming of Microcontroller.
2. Work with standard real time interfaces of Microcontroller.
3. Generate signals with Microcontroller.
4. Perform timer-based operation with Microcontroller.
5. Develop a motor control with Microcontroller.
6. Develop interfacing with sensor

List of Experiments

1. Arithmetic operations
2. Sorting of number
3. Concepts of timer
4. Interfacing I/O peripherals
5. Interfacing ADC
6. Interfacing DAC
7. PWM signal generation
8. Stepper motor interface
9. Interfacing keyboard and display unit
10. Interfacing temperature sensor
11. Interfacing accelerometer sensor
12. Interfacing servo motor

19BM1001	BIOLOGY FOR ENGINEERS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To comprehend the fundamental principles of Life and Life forms
2. To impart knowledge on biodiversity and genetic theory.
3. To transfer knowledge in applications of biology in Industries.

Course Outcomes:

The Student will be able to

1. Illustrate the fundamentals of living things, their classification, cell structure and biochemical constituents
2. Assess the significance of biodiversity in world.
3. Comprehend genetics and the immune system
4. Outline cause, symptoms, diagnosis and treatment of common diseases.
5. Comprehend nervous system and mechanochemistry.
6. Understand and apply future trends in biology.

Module 1: Introduction To Life And Biomolecules: (8 hrs)

Classification of life forms – Body plan and Design of Life forms- Characteristics of living organisms--cell theory-structure of prokaryotic and eukaryotic cell-Introduction to biomolecules: definition-general classification and important functions of carbohydrates-lipids-proteins-nucleic acids vitamins and enzymes-genes and chromosome.

Module 2: Biodiversity: (8 hrs)

Plant System: basic concepts of plant growth-nutrition-photosynthesis and nitrogen fixation-Animal System: elementary study of digestive-respiratory-circulatory-excretory systems and their functions. Microbial System: history-types of microbes-economic importance and control of microbes.

Module 3: Evolution, Genetics And Immune System: (8 hrs)

Evolution: theories of evolution-Mendel's cell division–mitosis and meiosis-evidence of e laws of inheritance-variation and speciation- nucleic acids as a genetic material-central dogma immunity antigens-antibody-immune response.

Module 4: Human Diseases (7 hrs)

Lifestyle diseases -diabetes, obesity, blood pressure, heart disease, stroke, tuberculosis and diseases associated with drug abuse-Definition- causes, symptoms, diagnosis, treatment and prevention of cancer and Hepatitis.

Module 5: Nervous System, Cell Signaling And Mechanochemistry (8 hrs)

Basics of nervous system and neural networks- General principles of cell signaling - ATP synthase structure - The bacterial flagellar motor - Cytoskeleton -Bioremediation.

Module 6: Biology For Industrial Applications (6 hrs)

Transgenic plants and animals-stem cell and tissue engineering-bioreactors-biopharming-recombinant vaccines-cloning-drugdiscovery-biofertilizer-biocontrolbiofilters-biosensors-biopolymers-bioenergy-biomaterials-biochips.

Text Books:

1. A Text book of Biotechnology, R. C. Dubey, S. Chand Higher Academic Publications, 2013.
2. Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011

Reference Books:

1. ThyagaRajan. S., Selvamurugan. N., Rajesh.M.P., Nazeer.R.A., Richard W. Thilagaraj, Barathi.S., and Jaganthan.M.K., "Biology for Engineers", Tata McGraw-Hill, New Delhi, 2012.
2. Cell Biology and Genetics (Biology: The unity and diversity of life Volume I), Cecie Starr, Ralph Taggart, Christine Evers and Lisa Starr, Cengage Learning, 2008
3. Biotechnology Expanding horizon, B.D. Singh, Kalyani Publishers, 2012
4. Jon Cooper, "Biosensors A Practical Approach", Bellwether Books, 2004.
5. Diseases of the Human Body, Carol D. Tamparo and Marcia A. Lewis, F.A. Davis Company, 2011.
6. Martin Alexander, "Biodegradation and Bioremediation", Academic Press, 1994.

19BM1002	INTRODUCTION TO BIOMEDICAL ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the field of biomedical engineering and role of biomedical engineers in society.
2. To impart knowledge on principles of various diagnostic, therapeutic equipment.
3. Achieve familiarity with some basic ethical framework and medical standards to be followed in hospitals.

Course Outcomes:

The Student will be able to

1. Interpret the role of biomedical engineering in society
2. Demonstrate the principles of various diagnostic devices.
3. Identify the various techniques used in diagnosis though imaging.
4. Describe the working principles of various therapeutic and assist devices.
5. Understand device specific safety goals and standards.
6. Illustrate the concepts of ethical theories and moral principles for the health professions.

Module 1: Introduction: (7 hrs)

Historical Perspective-Evolution of modern healthcare system-Role of Biomedical engineers in various domain -Professional status of biomedical engineering-General constraints in design of medical instrumentation systems.

Module 2: Fundamentals of Medical Instrumentation (8 hrs)

Anatomy and Physiology – Sources of biomedical signals- basic medical instrumentation system-General block of medical instrumentation system – Performance requirements –General constraints in design of medical instruments.

Module 3: Diagnostic Imaging (8 hrs)

X-rays, Nuclear Medical Imaging-Positron Emission Tomography-Magnetic Resonance Imaging Scanners-Diagnostic Ultrasound- Thermal imaging systems.

Module 4: Introduction to Biomedical Equipment (8 hrs)

ECG – EEG - Cardiac Pacemakers - Cardiac Defibrillators – Haemodialysis Machines-Artificial Kidney-Dialyzers- Ventilators-Humidifiers, Nebulizers and Aspirators- Anaesthesia Machine.

Module 5: Medical Safety Standards: (7 hrs)

Medical standards and regulations – Institutional Review Boards – Good Laboratory Practices -Good Manufacturing Practices -Human factors.

Module 6: Ethical Practices in Health Care (7 hrs)

Morality and Ethics-A Definition of terms,Human Experimentation-Ethical issues in feasibility studies, Ethical issues in emergency use, Ethical issues in treatment use-Codes of ethics for bio engineers.

Text Books:

1. Enderle, John D, Bronzino, Joseph D, Blanchard, Susan M- Introduction to Biomedical Engineering-ElsevierInc2ndedition,2005.
2. R. S. Khandpur, Handbook of Biomedical Instrumentation, McGraw-Hill Publishing Company Limited, 2ndedition,2003.

Reference Books:

1. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and

Measurement, Prentice Hall of India, New Delhi,2nd edition, 2002.
2. John G Webster, Medical Instrumentation: Application and Design, John Wiley and sons, New York,4thedition,2010. Daniel A Vallero, Biomedical ethics for Engineers, Elsevier publication, 1st edition, 2007
3. Joseph. J Carr, John M Brown, Introduction to Biomedical Equipment Technology, John Wiley& Sons, New York,4th edition, 2008.
4. Norbert Leitgeb "Safety of Electro-medical Devices -Risks Opportunities" Springer/Wein, 2010.
5. Michael Domach-"Introduction to Biomedical Engineering", Pearson, 2004.
6. Daniel A Vallero, Biomedical ethics for Engineers, Elsevier publication, 1st edition,2007

19BM2001	SENSORY AND MOTOR REHABILITATION	L	T	P	C
		3	0	0	3

Course Objectives:

1. Study basics of Rehabilitation Engineering
2. Gain knowledge of the recent developments in the field of rehabilitation engineering.
3. Understand various assistive technology for vision & hearing

Course Outcomes:

The Student will be able to

1. Identify the models of rehabilitation
2. Interpret the techniques for disabilities related to sensory and motor functions
3. Construct the test bench, tools and methods for troubleshooting
4. Compare various standards and specifications.
5. Decide quality and safety standards in design of devices for user needs
6. Formulate advanced methods to solve critical problems related to old aged

Module 1: Introduction to Rehabilitation Engineering (7 hrs)

Introduction to Rehabilitation Engineering - PHAATE model - Clinical practice of rehabilitation Engineering - Low technology tools - Service delivery – Universal design - Design based on human ability - Standards for assistive technology - Test for best design

Module 2: Wheel Chair (7 hrs)

Seating Assessment - Interventions in seating system - Biological aspects of tissue health - Support surface classification - Manual wheelchairs – Electric power wheelchairs - Power assisted wheelchairs - Wheel chair standards & tests - Wheel chair transportation

Module 3: Orthotic & Prosthetic Devices (8 hrs)

Anatomy of upper & lower extremities - Classification of amputation types, Prosthesis prescription - Components of upper limb prosthesis - Fabrication of prosthesis - Components of lower limb prosthesis – Orthoses: Its need and types - Lower extremity- and upper extremity- orthoses - Slints – materials used.

Module 4: Assistive Technology for Vision (8 hrs)

Anatomy of eye, Categories of visual impairment - Cortical & retinal implants - Auditory Information Display - Blind mobility aids – reading writing & graphics access, Orientation & navigation Aids

Module 5: Assistive Technology for Hearing (7 hrs)

Anatomy of ear – hearing functional assessment - Surgical and non-surgical hearing aids - Assistive technology solutions for hearing Tactile - Information Display

Module 6: Advanced Applications (8 hrs)

Functional Electrical stimulation - Robots in rehabilitation - Rehabilitation in sports -Daily living aids - Assistive technology for dyslexia - Computer & internet access for challenged people - Neural engineering in rehabilitation engineering - Role of biomedical engineering in rehabilitation

Text Books:

1. Rory A, Cooper, Hisaichi Ohnabe, Douglas A, Hodson, "An Introduction to Rehabilitation Engineering", CRC Press, First edition, 2006.
2. Dejan Popovic, Thomas Sinkjaer "Control of Movement for the Physically Disabled: Control for Rehabilitation Technology" Springer Science & Business Media, 2012

Reference Books:

1. Marion A Hersh, Michael A, Johnson, "Assistive Technology for Visually impaired and blind people", Springer Publications, First edition, 2008.
2. Suzanne Robitaille, "The illustrated guide to Assistive technology and devices–Tools and gadgets for living independently", Demos Health New York, First edition, 2010.

3. Dario Farina, Winnie Jensen, Metin Akay, “Introduction to Neural Engineering for Motor Rehabilitation” John Wiley & Sons, 2013
4. Terri M. Skirven, A. Lee Osterman, Jane Fedorczyk, Peter C. Amadio “Rehabilitation of the Hand and Upper Extremity”, 2-Volume Set E-Book: Expert Consult Elsevier Health Sciences, 2011
5. AlenjandroHernanadz – Arieta, Constantanious Dermitzakis, Dana Damina, Max Lungarella, “Sensory- Motor Coupling in Rehabilitation Robotics” , Open access Book Chapter, Intech Open limited, August 2008.

19BM2002	BIOMEDICAL OPTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Understand the characteristics of tissue when it is exposed to light
2. Learn about the Instrumentation in photonics
3. Know about various optical sources and applications of lasers in medicine

Course Outcomes:

The Student will be able to

1. Recall the optical properties
2. Explain the different measurement techniques in medical optics
3. Illustrate the concept of biomedical optics in various real life applications
4. Analyze the instrumentation involved in biomedical optics
5. Apply laser instrumentation in medical diagnosis and therapy
6. Discuss the therapeutic applications in the field of medicine

Module 1: Optical Properties of the Tissues (8 hrs)

Optical properties of the tissues: Refraction, Scattering, Absorption, Light transport inside the tissue, Tissue properties, Laser Characteristics as applied to medicine and biology-Laser tissue Interaction-Chemical-Thermal- Electromechanical – Photoabalative processes.

Module 2: Instrumentation in Photonics (8 hrs)

Instrumentation in photonics: Instrumentation for absorption, Scattering and emission measurements, excitation light sources – high pressure arc lamp, LEDs, Lasers, Optical filters, - optical detectors – Time resolved and phase resolved detectors.

Module 3: Laser Applications (7 hrs)

Laser applications: Lasers in ophthalmology- Dermatology –Dentistry-Urology-Otolaryngology - Tissue welding.

Module 4: Imaging System Fundamentals (7 hrs)

Endoscopic imaging system fundamentals, Angioscope, Videoscopy, Fluorescence endoscopy, Flourescent probes in biomedical applications

Module 5: Non Thermal Diagnostic Applications (8 hrs) Non thermal diagnostic applications: Optical coherence tomography, Elastography, Laser Induced Fluorescence (LIF)-Imaging, FLIM Raman Spectroscopy and Imaging, FLIM – Holographic and speckle application of lasers in biology and medicine.

Module 6:Therapeutic Applications (7 hrs)

Therapeutic applications: Phototherapy, Photodynamic therapy (PDT) - Principle and mechanism - Oncological and nononcological applications of PDT - Biostimulation effect – applications-Laser Safety Procedures.

Text Books:

1. Tuan Vo Dinh, Biomedicla Photonics Handbook, CRC Press, Newyork, 2003
2. Lasers and Current Optical Techniques in Biology, Royal Society of Chemistry, 2004.

Reference Books:

1. MarkolfH.Niemz, “Laser-Tissue Interaction Fundamentals and Applications”, Springer, 2007
2. Abraham Katzir, “Lasers and Optical Fibers in Medicine”, Academic press Inc.
3. Maini, Anil. Lasers and Optoelectronics: Fundamentals, Devices and Applications, John Wiley & Sons, Incorporated, 2013.
4. Elias Greenbaum, Radiation physics for medical physicists (Biological and Medcial physics, biomedical engineering) Springer, 2014
5. Mark Csele: Fundamentals of Light source and Lasers” Wiley Inderscience Publishers 2004.

19BM2003	BIOMETRIC SYSTEMS	L 3	T 0	P 0	C 3

Course Objectives:

1. Understand the basic concepts of fingerprint, iris, face and speech recognition.
2. Study the general principles of design of biometric systems and the underlying trade-offs
3. Introduce the knowledge on personal privacy and security implications of biometrics based identification technology and the issues realized

Course Outcomes:

The Student will be able to

1. Infer the technologies of fingerprint, iris, face and speech recognition.
2. Expertise in the general principles of design of biometric systems and the underlying trade-offs.
3. Priorities the work on identification and recognition depends on physiological and behavioral characteristics
4. Identifying the interfacing technologies for real time biometric applications
5. Inculcate knowledge on personal privacy and security implications of Biometrics based identification technology and the issues involved.
6. Discuss the Biometric applications in the field of medicine

Module 1: Biometric Fundamentals(8 hrs)

Biometrics versus traditional techniques – Characteristics - Key biometric processes -Verification – Image processing/pattern recognition- filtering- edge detection- smoothening- enhancement- Biometric matching - Performance measures in biometric systems - Assessing the privacy risks of biometrics.

Module 2: Image processing fundamentals(8 hrs)

Convolution- linear/non-linear filtering- Special filters- enhancement filter- edge detection- Laplacian- unsharp masking- high boot filtering- sharpening special filtering- thresholding- localization- Robert's method- Sobal's method- Canny edge detection- Positive/negative identification- Biometric system security- Authentication protocols- Authentication methods.

Module 3: Physiological Biometrics Characteristics(7 hrs)

Facial scan - Ear scan, Retina scan -Iris scan - Finger scan - automated fingerprint identification system - Palm print - Hand vascular geometry analysis - DNA - Dental.

Module 4: Behavioral Biometrics Characteristic(7 hrs)

Signature scan - Keystroke scan - Voice scan, Gait recognition - Gesture recognition - Video face - mapping the body technology.

Module 5: Biometric Interfaces(7 hrs)

Human machine interface - BHMI structure, Human side interface: Iris image interface - Hand geometry and fingerprint sensor - Machine side interface - Parallel port - Serial port - Network topologies.

Module 6: Biometric Applications(8 hrs)

Categorizing biometric applications, Application areas: Criminal and citizen identification – Surveillance - PC/network access - E-commerce and retail/ATM - Costs to deploy - Issues in deployment - Biometrics in medicine - cancellable biometrics.

Text Books:

1. Ruud M. Bolle et al, “Guide to Biometrics”, Springer, USA, 2003.
2. Richard O Duda, David G. Strok, Peter E hart, “Pattern Classification”, Wiley 2007
3. Rafael C. Gonzalez, Richard Eugene Woods, “Digital Image Processing using MATLAB”, Mc-Graw Hill 2010

Reference Books:

1. Anil K. Jain, Arun Ross, and KarthikNandakumar, “Introduction to biometrcis”, 2011
2. James Wayman, Anil Jain, DavideMaltoni, Dario Maio, “Biometric Systems, Technology Design and Performance Evaluation”, Springer, 2005
3. S.Y. Kung, S.H. Lin, M.W.Mak, “Biometric Authentication: A Machine LearningApproach” Prentice Hall, 2005
4. Nalini K Ratha, Ruud Bolle, “Automatic fingerprint Recognition System”, Springer, 2003
5. L C Jain, I Hayashi, S B Lee, U Halici, “Intelligent Biometric Techniques in Fingerprint and Face Recognition” CRC Press, 1999.
6. David D Zhang, “Automated Biometrics: Technologies and Systems”, Kluwer Academic Publishers, New Delhi, 2005

19BM2004	NUCLEAR MEDICINE	L	T	P	C
		3	0	0	3

Course Objectives:

1. Understand the construction and principle of operation of various nuclear medicine instruments.
2. Know some knowledge about the characteristics and mechanisms of radio pharmaceuticals
3. Study the diagnostics and therapeutic applications of nuclear medicine and radiation safety procedures and regulations.

Course Outcomes:

The Student will be able to

1. Acquire knowledge about radiation activity in the living cells.
2. Identify the key principles of nuclear medicine and radioactivity.
3. Analyze the working principle of advanced nuclear medicine imaging systems.
4. Interpret the effects of ionizing and non-ionizing radiations
5. Analyze the effect of microwave on human organs and systems.
6. Suggest suitable therapeutic radiation for diseases without any side effects.

Module 1: Basics of Nuclear Medicine(8 hrs)

Radioactivity and interaction of radiation; Alpha, Beta and gamma emission, Laws of radioactive decay, Mechanisms of radioactive delay, Radiation intensity and exposure, Decay schemes and energy levels, Compton scattering, Pair productions, Particle interactions

Module 2: Radiopharmaceuticals(8 hrs)

Radionuclide production, 99Mo/99mTc generator, Mechanism of localization, Types of radiopharmaceuticals, characteristics of radio pharmaceuticals, Radiopharmaceuticals for diagnosis and treatments in human, Dispensing of radio pharmaceuticals, RIA radiopharmaceuticals and kits production.

Module 3: Nuclear Medicine Instrumentation(7 hrs)

Construction and principle operation of Gamma camera, Rectilinear scanner, Basic principles of pulse height analyser, Radiation detectors-Ionization chamber, Geiger Muller counter, Semiconductor detectors, Scintillation detectors, Electronic Instrumentation for radiation detection system,

Module 4 : Diagnostic Applications of Radionuclide(7 hrs)

PET-CT, Single photon emission computed tomography (SPECT), Radio iodine therapy for Thyrotoxicosis , Differentiated thyroid cancers, Palliative treatment for bone metastasis - 32P and 89 Strontium Dosage,

Module 5: Therapeutic Applications of Radionuclide(7 hrs)

Intravascular particulate radio nuclide Therapy, Receptor targeted therapy, 131I- MIBG Therapy, Targeted internal radiation in HCC: 90 Y, Radio-synovectomy using Yttrium

Module 6 : Radiation Safety(8 hrs)

Radiation protection indifferent nuclear isotope therapy procedures, Management of radiation accidents, Radiation effect on pregnancy and fertility, Diagnosis, evaluation and treatment of radiation overexposure, Instruments used in radiation survey & monitoring, Handling of radioactive patients, Role of national and international bodies in radiation safety, ICRP recommendations, BARC regulations regarding limits of radiation exposure

Text Books:

1. Simon Cherry, James Sorenson, Michael Phelps. “Physics in Nuclear Medicine”, Elsevier Saunders, 4th Edition, 2012.
2. Jennifer Prekeges, “Nuclear Medicine Instrumentation”, Jones and Barlett publishers, 1st edition, 2011.

Reference Books:

1. Max.H.Lombardi, “Radiation safety in Nuclear Medicine”, CRC Press, Florida, USA, 2nd edition 1999.
2. Fred A Mettler, Milton J Guiberteau, “Essentials of nuclear Medicine and molecular imaging” 7th Edition, Elseiver, 2018
3. Harvey Ziessman, Janis O Malley, James Thrall, “Nuclear Medicine”, Fourth Edition, Elseiver, 2013
4. Pete Shackett, “Nuclear Medicine technology”, Second Edition, Lipkott William Wilkkins, USA 2008
5. Jennifer Prekeges, “Nuclear Medicine Instrumentation”, Second revised Edition, John and Barelett Publishers, Inc USA, 2012.

19BM2005	ANALYTICAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

Course Objectives:

1. Understand the working of an instrument for a particular analysis with its merits, demerits and limitations.
2. Learn specific technique employed for monitoring different pollutants in air and water.
3. Know the instruments used in hospital for routine clinical analysis, drug and pharmaceutical laboratories, oil refineries and above all for environmental pollution monitoring.

Course Outcomes:

The Student will be able to

1. Identify various techniques and methods of analysis which occur in the various regions of the spectrum.
2. Summarize the unique methods of separation of closely similar materials, the most powerful being gas chromatography.
3. Outline the important analytical methods of industrial gases and pollution monitoring instruments.
4. Discuss the principle involved in pH and dissolved component analyzers.
5. Illustrate the methods of electromagnetic resonance
6. Investigate the structures using microscopic methods of analysis.

Module 1: Colorimetry And Spectrophotometry(8 hrs)

Special methods of analysis – Beer-Lambert law – Colorimeters – UV-Visible spectrophotometers – Single and double beam instruments – Sources and detectors – IR Spectrophotometers – Types – Attenuated total reflectance flame photometers – Atomic absorption spectrophotometers – Sources and detectors – FTIR spectrophotometers – Flame emission photometers – Fluorescence spectrophotometer

Module 2 :Chromatography(7 hrs)

Different techniques – Gas chromatography – Detectors – Liquid chromatographs – Applications – High-pressure liquid chromatographs – Applications.

Module3:Gas Analyzers And Pollution Monitoring Instruments: (7 hrs)

Types of gas analyzers – Oxygen, NO2 and H2S types, IR analyzers, thermal conductivity analyzers, analysis based on ionization of gases. Air pollution due to carbon monoxide, hydrocarbons, nitrogen oxides, sulphur dioxide estimation - Dust and smoke measurements.

Module 4 : pH Meters and Dissolved Component Analyzers (8 hrs)

Principle of pH measurement, glass electrodes, hydrogen electrodes, reference electrodes, selective ion electrodes, ammonia electrodes, cyclic voltametry, biosensors, dissolved oxygen analyzer – Sodium analyzer – Silicon analyzer.

Module 5:Electro Magnetic Resonance: (7 hrs)

NMR – Basic principles – NMR spectrometer - Applications. Electron Spin Resonance spectroscopy– Basic principles, Instrumentation and applications.

Module 6: Microscopic Techniques (8 hrs)

Scanning Electron Microscope (SEM), - Basic principles, Instrumentation and applications. Transmission Electron Microscope (TEM) – Basic principles – Instrumentation and applications. Mass spectrometers – Different types – Applications.

Text Books:

1. R.S. Khandpur, ‘Handbook of Analytical Instruments’, Tata McGraw Hill publishing Co. Ltd., 2007.
2. Sivasankar, “Instrumental Methods of Analysis”, OUP India, 2012.

Reference Books:

1. Robert D. Braun, ‘Introduction to Instrumental Analysis’, McGraw Hill, Singapore, 1987.
2. Liptak, B.G, Process Measurement and Analysis, Chilton Book Company, 1995
3. G.W. Ewing, ‘Instrumental Methods of Analysis’, McGraw Hill, 1992.
4. R.K.Jain, Mechanical and Industrial Measurements, Khanna Publishers, New Delhi, 1999
5. H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, ‘Instrumental Methods of Analysis’, CBS publishing& distribution, 1995.

19BM2006	GRAPHICAL SYSTEM DESIGN FOR BIOMEDICAL ENGINEERS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Study the basics of Programming Techniques
2. Learn the data acquisition and control of a device by interfacing to a computer.
3. Design virtual instruments for various biomedical measurements and applications.

Course Outcomes:

The Student will be able to

1. Understand the basics of LabVIEW programming
2. Interface with real time signals
3. Analyzing the application of VIs in medical instrumentation in developing medical instruments
4. Interpret the concepts of data communication and synchronization
5. Perform signal processing operations using virtual instrumentation
6. Apply virtual instrumentation for biomedical applications

Module 1 :LabVIEW Programming Principles & Environment(8 hrs)

Data flow – Definition, and importance of data flow in LabVIEW – Identify programming practices that enforce data flow in block diagram, Virtual instrumentation (VI), and sub-VIs - Identify programming practices that break data flow – Polymorphism - Define polymorphism - Identify benefits of polymorphism - Determine output or intermediate values of data elements in VI that utilizes polymorphic inputs LabVIEW Environment -Front panel window, block diagram, and connector pane - Identify which types of VIs do not have a block diagram - Identify the purpose of the connector pane and icon – Palettes

Module 2 : Software Constructs & Programming Functions: **(8 hrs)**

Front panel window and block diagram objects - Controls, indicators, IO controls, and refnums - Property Nodes - Data types and data structures - Working with objects and data types on front panel windows – Program control structures and data storage - Flat and Stacked sequence structures - Event structures- Formula Node - Arrays and clusters

Module 3 : Data Communication & Synchronization : (7 hrs)

Local, global, and shared variables – Data Socket - TCP and UDP – Synchronization – Notifiers – Queues - VI Server - configuring the VI Server - Error handling VIs and functions - Debugging tools and techniques.

Module 4 : Virtual Instrumentation (Vi) Design & SubVI Design Techniques (8 hrs)

Simple state machine - User interface event handler - Queued message handler - Producer/consumer (data) and producer/consumer (events) - Functional global variables - Connector panes and connection types - Polymorphic subVIs - Options related to subVIs - Error handling – User interface design and block diagram layout - Modular and hierarchical design - SubVI icons and connector pane layout (standard) - VI properties - Documenting Vis

Module 5 : Memory, Performance And Determinism (8 hrs)

Tools for identifying memory and performance issues - Profile memory and performance - Show buffer allocations- VI metrics - Programming practices - Enforcing dataflow -User interface updates and response to user interface controls - Data type selection, coercion, and buffer allocation - Array, string, and loop operations -Local and global variables, Property Nodes.

Module 6:Applications(6 hrs)

Applications of LabVIEW in displaying and monitoring vital parameters, Biomedical signal processing, controlling assistive devices.

Text Books:

1. S. Sumathi, P.Surekha, “LabVIEW based Advanced Instrumentation Systems”, Springer 2007.
2. Gary Jonson, ‘LabVIEW Graphical Programming’, McGraw Hill, New York, Fourth edition 2006.

Reference Books:

1. Jon B Olansen and Eric Rosow, “Vitrual Bio-Instrumentation Biomedical, Clinical and Healthcare Applications in LabVIEW” 2001.
2. Rick Bitter, TaqiMohiuddin, Matt Nawrocki “LabVIEW: Advanced Programming Techniques” Second Edition, CRC press, 2007.
3. Lisa K. Wells & Jeffrey Travis, ‘LabVIEW for Everyone’, Prentice Hall Inc., First edition 1997.
4. S. Gupta, J.P. Gupta, ‘PC interfacing for Data Acquisition & Process Control’, Instrument Society of America, Second Edition, 1994

5. Andrew McDonough, “LABVIEW: Data Acquisition and Analysis for movement Sciences, Prentice Hall, USA 2000”

19BM2007	BIO-MEMS TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. Introduce the concepts of micro electromechanical systems in medical use
2. Learn the materials used and the micro manufacturing of devices
3. Apply Microsystems and their applications in medical field

Course Outcomes:

The Student will be able to

1. Identify the principles of sensors and actuators
2. Summarize the optical devices and applications
3. Classify the performance of microfluidic devices to the environment
4. Use the software tools for designing and analyzing the sensors
5. Recommend the suitable principles of testing for biomedical conditions
6. Create simple systems for medical applications

Module 1 : MEMS In Healthcare(8 hrs)

MEMS and Microsystems- Introduction - Typical MEMS and Microsystem Products - Application of Micro-system in Healthcare Industry – Working Principles of Microsystems Micro-sensors – Micro-actuation - MEMS with Micro actuation– Micro accelerators.

Module 2 : Fundamentals of MOEMS(7 hrs)

Micro-Opto Electromechanical Systems: Fundamental principle of MOEMS Technology, Advantages - Light Modulators, Beam splitter – Micro-lens, Micro-mirrors - Digital Micro-mirror Device, Grating Light Valve, Optical Switch, Waveguide and Tuning

Module 3 : Microfluidic Systems(8 hrs)

Microfluidics- Introduction and Fluid Properties, Applications of MFS- Fluid Actuation Methods- Electrophoresis, Dielectrophoresis, Electrowetting, Optoelectrowetting, Electroosmosis Flow, Electrothermal Flow, Thermocapillary Effect- Microfluidic Channel- Microdispenser- Microneedle- Microfilter.

Module 4:BioMEMS(7hrs)

Introduction to BioMEMS, BioMEMS for Clinical Monitoring, Lab on a chip, DNA Sensors, E-Nose, E-Tongue. Microsystem approaches to PCR, MEMS based Implantable Drug Delivery System, Emerging BioMEMS Technology.

Module 5:Micromachining(7 hrs)

Micro system technology-photolithography-X-ray lithography-etching-deposition-Material properties-Thin film process-Clean room-Laser deposition-Thin film diode-transistor- FET-ISFET. Software tools for design, analysis and testing.

Module 6 : Testing Tools and Techniques(8 hrs)

Introduction to nanoscale phenomena, Nanoparticles- Nanomaterial characterization – XRD, TEM, SEM, Scanning Tunneling microscopy, AFM, Biomolecular sensing for cancer diagnostics using carbon nanotubes, Carbon nanotube biosensors, Magnetic nanoparticles for MR Imaging, Nano-devices in biomedical applications.

Text Books:

1. Tai-Ran Hsu, “MEMS & Microsystems- Design, Manufacture and Nanoscale Engineering”, John Wiley & Sons, 2 nd Edition 2008
2. Nitaigour Premchand Mahalik, “MEMS”, Tata McGraw Hill, 2 nd Reprint 2008

Reference Books:

1. Albert Folch, “Introduction to Bio mems, ” CRC Press, First Edition, 2012.
2. N.P.Mahalik, “Micro manufacturing & Nanotechnology”, Springer, 2006.
3. SergeyEdwardLysherski.NanoandMicro-electromechanicalsystems.Second Edition.CRCPress.2005.
4. Wanjun Wang, Steven A. Soper, “BioMEMS Technologies and Applications”, CRC Press. 2006.
5. Abraham P. Lee, James L. Lee, “BioMEMS and Biomedical Nano technology”, Vol.I, Springer, 2006.

19BM2008	MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE	L	T	P	C
		3	0	0	3

Course Objectives:

1. Learn the concept of machine learning.
2. Explore supervised and unsupervised learning paradigms towards applications
3. Understand the various concepts of artificial intelligence

Course Outcomes:

The Student will be able to

1. Describe features that can be used for a particular machine learning approach
2. Classify contrast pros and cons of various machine learning techniques
3. Infer various machine learning approaches and paradigms.
4. Interpret various neural networks and fuzzy logic methods
5. Illustrate the fuzzy logic concepts using examples
6. Interrelate genetic algorithm concepts for the given problem

Module 1: Introduction to Machine Learning(8 hrs)

Learning – Types of Machine Learning – The Brain and the Neuron – Design a Learning System – Perspectives and Issues in Machine Learning – Concept Learning Task – Finding a Maximally Specific Hypothesis – Version Spaces and the Candidate Elimination Algorithm – Linear Discriminants

Module 2 : Supervised and Unsupervised Learning (8 hrs)

Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Nearest Neighbor Methods – Naive Bayes Linear models: Linear Regression, Logistic Regression – Data Clustering Algorithms – K means Algorithms – Fuzzy C means clustering – mountain clustering – subtractive clustering

Module 3 : Introduction to Artificial Neural Networks (8 hrs)

Characteristics- learning methods – taxonomy – Evolution of neural networks- McCulloch-Pitts neuron - linear separability - Hebb network - supervised learning network: perceptron networks - adaptive linear neuron, multiple adaptive linear neuron

Module 4: Types of Neural Network(7 hrs)

BPN, associative memory network: auto-associative memory network, hetero-associative memory network, BAM, Hopfield networks, Kohonen self-organizing, ART network. Case studies on biomedical applications

Module 5:Fuzzy Logic(7 hrs)

Classical set Vs Fuzzy set – Operation and Properties –Fuzzy Relations – Fuzzy Logic control – Fuzzification, Membership functions- Defuzzification, Rule Based System, and Applications.

Module 6: Genetic Algorithm(7 hrs)

Genetic algorithm and search space - general genetic algorithm, operators in GA - genetic programming – multilevel optimization – advances in GA

Text Books:

1. Tom M Mitchell, ―Machine Learning‖, First Edition, McGraw Hill Education India Ltd, 2013.
2. Jang J.S.R., Sun C.T and Mizutani E, "Neuro Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence", Prentice Hall, 2008.

Reference Books:

1. Stephen Marsland, "Machine Learning: An Algorithmic Perspective", CRC Press, 2015.
2. LaureneFausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications",Pearson Education India, 2006.
3. TimothyJ Ross, "Fuzzy logic with Engineering Applications", John Wiley and Sons, 2009.
4. Ton J. Cleophas, Aeilko H. Zwinderman, "Machine Learning in Medicine", Springer, Revised Edition 2, 2015.
5. S.Rajasekaran and G A VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithm:Synthesis and Applications", Prentice Hall, India, 2003.

19BM2009	TELEMEDICINE	L	T	P	C
		3	0	0	3

Course Objectives:

1. Introduce the key principles of telemedicine and health.
2. Understand telemedical technology.
3. Learn telemedical standards and its application.

Course Outcomes:

The Student will be able to

1. Understand the concepts of Telemedicine
2. Interpret the legal aspects of Telemedicine
3. Illustrate multimedia technologies in telemedicine.
4. Use protocols behind encryption techniques for secure transmission of data.
5. Explain the data acquisition and the data storage devices
6. Apply telehealth in healthcare

Module 1 : Introduction to Telemedicine (7 hrs)

History and Evolution of telemedicine, Functional diagram of telemedicine system, Essential Parameters for Telemedicine, Delivery Modes in Telemedicine , Benefits and Limitations of Telemedicine.

Module 2 : Ethical , Security And Legal Aspects of Telemedicine(8 hrs)

Confidentiality, patient rights and consent: confidentiality and the law, the patient-doctor relationship, access to medical records, consent treatment - data protection & security, jurisdictional issues, intellectual property rights, Security in Telemedicine systems – Access control, Fire wall, Encryption, Authentication, Digital certificate, Digital Timestamp

Module 3 :Telemedical Technology(8 hrs)

Principles of Multimedia - Text, Audio, Video, data, PSTN, POTS, ANT, ISDN, Internet, Wireless Communication - GSM satellite, and Micro wave, Modulation techniques, Types of Antenna, Satellite communication, Mobile hand-held devices and mobile communication. Internet technology and telemedicine using worldwide, Video and audio conferencing

Module 4 : Data Acquisition And Storage System (7 hrs)

Acquisition System – Camera, Scanners, Display Systems – Analogue Devices, LCD, Laser Displays, Holographic Representation, Virtual Screen devices, Storage System – Magnetic System, Optical System, Solid State Disk

Module 5: Data Security and Standards(8 hrs)

Encryption, Cryptography, Mechanisms of encryption, phases of Encryption, Protocols: TCP/IP, ISO-OSI, Standards to followed DICOM, HL7, H. 320 series (Video phone based ISBN) T. 120, H.324 (Video phone based PSTN)

Module 6:Applications(7 hrs)

Telemedicine access to health care services – health education and self-care. · Introduction to robotics surgery, Telesurgery. Teleradiology, Telepathology

Text Books:

1. Olga Ferrer Roca, M.SosaIudicissa , “Hand book of Telemedicine”, IOS press, 2002.
2. Norris.A.C, “Essentials of Telemedicine and Telecare”, John Sons & Ltd, 2002.

Reference Books:

1. R.S.Khandpur “Telemedicine Technology and Applications (mhealth, Telehealth and ehealth)”, PHI Learning Pvt.Ltd, Delhi 2017.
2. Wootton, R., Craig, J., Patterson, V., “Introduction to Telemedicine. Royal Society of Medicine” Press Ltd, Taylor & Francis 2006.
3. Latifi, R. “Current Principles and Practices of Telemedicine and e-Health” IOHS Press, Washington DC, 2008.
4. Bashshur, R.L., Shannon G.W. “History of Telemedicine”, New Rochelle NY: Mary Ann Liebert Publishers, 2009.
5. Victor Lyuboslavsky, “Telemedicine and Telehealth 2.0: A Practical Guide for Medical Providers and Patients”, CreateSpace Independent Publishing Platform; 1 edition (November 3, 2015)

19BM2010	BIOMATERIALS AND ARTIFICIAL ORGANS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Learn and understand the Concepts, Classification and Properties, and Structural variations in biomaterials.
2. Understand the testing of implants and cell-interfacing materials.
3. Know the applications of biomaterials in Artificial Organs and their development.

Course Outcomes:

The Student will be able to

1. Identify and know the structural variations in biomaterials.
2. Determine and classify the various properties of biomaterials.
3. Explain the methods for testing implants with different aspects of biomaterials
4. Recall the cell-biomaterial interactions for constructing artificial organs.
5. Remember the Interfacing materials and ethical implications.
6. Apply the biomaterials in the healthcare sectors.

Module 1: **Structural Variations in Biomaterial(8 hrs)**

Definition, classification and properties of bio-materials, Surface, bulk, mechanical and biological. Types of biomaterials; Biological response to biomaterials; Crystal structure of metals; Crystal structure of ceramics; Carbon based materials; General structure of polymers; Synthesis of polymers. Bending properties; Time dependent properties – creep properties of polymers; Influence of porosity and the degradation of mechanical properties; Introduction to fatigue.

Module 2: Properties of Biomaterials(8 hrs)

Wound-healing and blood compatibility. Surface modification of biomaterials – plasma treatment, radiation grafting, self-assembled monolayers (SAMs), Langmuir – Blogett films and covalent biological coatings; Protein properties that affect biomaterial surface interaction; biomaterial surface interaction that affect interactions with proteins; Protein adsorption kinetics; DLVO model for cell adhesion; Assays to determine the effects of cell-material interactions – agar diffusion assay, adhesion assays and migration assays.

Module 3: **Biocompatibility(8 hrs)**

Biocompatibility–Toxicology, Biocompatibility, Mechanical and Performance Requirements, Regulation. Biomaterials associated infection. Cytocompatibility evaluation laboratory, Tissue compatibility evaluation laboratory, Hemocompatibility evaluation laboratory, Sterility evaluation laboratory, Histopathology evaluation laboratory, Physiochemical evaluation laboratory.

Module 4:**Implantation (7 hrs)**

In vitro assays for inflammatory response due to biomaterial implantation; Fibrous encapsulation of healing process; Ideal features of soft tissue implants; Metallic Implant materials, Polymeric Implant materials, Tissue replacement materials-soft, hard and blood interfacing materials.

Module 5: Oxygenators &Audiometer (7 hrs)

Heart, heart valves, oxygenators - bubble, film oxygenators and membrane oxygenators. Gas flow rate and area for membrane oxygenators - Anatomy & Physiology of EAR-air conduction, bone conduction, masking, functional diagram of an audiometer.

Module 6: Dialysers & Lung Devices(7 hrs)

Dialysers - Haemodialysis: flat plate type, coil type and hollow fiber. Haemodialysis Machine, Portable kidney machine - Brief of lungs gaseous exchange / transport, artificial heart - Lung devices.

Text Books:

1. John B.Park Joseph D. Bronzino, “Biomaterials - Principles and Applications” CRC Press, 4th edition, 2003.
2. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons. An Introduction to Materials in Medicine. Academic Press. USA, 2006.

Reference Books:

1. L Hench J. Jones, “Biomaterials, Artificial Organs and Tissue Engineering”, Woodhead Publishing, 2005.
2. Michael Lysaght and Thomas Webster, “Biomaterials for artificial Organs”, Woohead Publishing series in biomaterials, 2010
3. Sujata V. Bhatt, “Biomaterials” Second Edition, Narosa Publishing House,2005.
4. Rajendran V. and Marikani A., Materials Science, Tata McGraw Hill Pub. Company Ltd., New Delhi, 2004

19BM2011	PATIENT AND DEVICE SAFETY	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide a source of useful ideas, concepts, and techniques that could be selectively applied to reduce an intolerable rate of unacceptable errors, mistakes, goofs, or short comings in expected Medical Device performance.
2. Understand the principle of safety and risk management for avoiding patient injury.
3. Study the various Medical Devices Standards, Regulations.

Course Outcomes:

The Student will be able to

1. Identify the mechanical and electrical safety standards of medical equipment
2. Understand device specific safety goals
3. Interpret reasonable, acceptable and effective remedies.
4. Access the clinical suitability to under the impact of the device on the environment
5. Device more reliable medical equipment incorporating safety goals
6. Suggest new techniques for device management

Module 1: Basics of Reliability and Concept of Failure(8 hrs)

Reliability and Safety Testing: Reliability – Types of reliability – Reliability optimization & assurance – Reliability's effect on medical devices – The concept of failure – Causes of failure – Types of Failures in Medical devices – Safety testing – Device specific safety goals

Module 2 : Safety and Risk Management (8 hrs)

Failure assessment and Documentation – Visual inspection: External & Internal visual inspection – Measurement – Safety parameters, Function test - Risk Management: Safety and risk management – Risk, Deciding on acceptable risk, Factors important to medical device risk assessment – Risk management – Tools for risk estimation – Liability – Manufacturer's and physician's responsibilities

Module 3 : Environmental & Ecological Safety (7 hrs)

Devices Handling, Environmental & Ecological Safety: Safe medical devices – Handling and operation – Medical Application safety – Usability – Clinical assessment – Environmental safety – Interference with the environment – Environmental conditions, Impact on the environment – Ecological safety

Module 4 : Mechanical and Electrical Safety (7 hrs)

Mechanical and Electrical Safety: Safety Mechanics – Electrical Safety – Biological aspect – Limitation of Voltages - Macroshock and Microshock – Earth and Protection – Leakage currents – Magnetic fields and compatibility – Basic assumptions in safety technology – Safety classes

Module 5 : Medical Devices Standards, Regulations(8 hrs)

Medical Standards and Regulations – Device classification – Registration and listing – Declaration of conformance to a recognized standard – Investigational Device Exemptions (IDEs) – Institutional Review Boards (IRBs) – IDE format – Good laboratory practices (GLPs) – Good manufacturing practices (GMPs) – Human factors – Design control

Module 6 : Medical Devices Directives (7 hrs)

The Medical Devices Directives (MDD) – Definition, Process and choosing the appropriate directive – Active Implantable Medical Devices Directive (AIMDD) – In Vitro Diagnostic Medical Devices Directive (IVDMDD).

Text Books:

1. Richard Fries, "Reliable Design of Medical Devices – Second Edition", CRC Press, Taylor & Francis Group, 2006.
2. Norbert Leitgeb "Safety of Electro-medical Devices Law – Risks – Opportunities" Springer Verlog/Wein, 2010.

Reference Books:

1. Bertil Jacobson and Alan Murray, "Medical Devices Use and Safety", Elsevier Limited, 2007.
2. Gordon R Higson, "Medical Device Safety – The regulation of Medical Devices for Public Health and Safety", IOP Publishing Limited, Bristol and Philadelphia, 2002.
3. Shayne Cox Gad, "Safety Evaluation of Medical Devices" Second Edition, Marcel Dekker Inc., 2002.
4. Case Studies of Medical Device Adverse Events, Saudi Food and Drug Authority, 2007
5. Michael Wiklund, Jonathan Kendler, Alison Strochlic, "Usability Testing of Medical Devices", Second edition, CRC Press, Taylor and Francis Group, 2015

19BM2012	ROBOTS IN HEALTHCARE	L	T	P	C
		3	0	0	3

Course Objectives:

1. Understand the basic concepts of robots and types of robots, manipulators, actuators and grippers.
2. Study about various types of sensors and power sources
3. Study the various applications of robot in the medical field.

Course Outcomes::

The Student will be able to

1. Identify the concepts of robotics, motion, joints
2. Summarize the principles of sensors and actuators for robots
3. Use the software tools for designing and analyzing the robot motion
4. Classify the performance to various sensors to its environment
5. Recommend the suitable principles for specific conditions
6. Create simple robots for surgical applications

Module 1 : Introduction of Robotics : (8 hrs)

Introduction to Robotics and its history, Overview of robot subsystems, Degrees of freedom, configurations and concept of workspace, Automation, Mechanisms and movements, Dynamic stabilization- Applications of robotics in medicine

Module 2 : Actuators and Grippers : (8 hrs)

Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors, Various types of Grippers, Design consideration in vacuum and other methods of gripping, PD and PID feedback actuator models,

Module 3:Manipulators: (7 hrs)

Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and pneumatic manipulator

Module 4: Basic Kinematics: (6 hrs)

Forward Kinematic Problems, Inverse Kinematic Problems, Solutions of Inverse Kinematic problems

Module 5 : Power Sources and Sensors : (8 hrs)

Sensors and controllers, Internal and external sensors, position, velocity and acceleration sensors, Proximity sensors, force sensors, laser range finder, variable speed arrangements, Path determination - Machinery vision, Ranging – Laser- Acoustic, Magnetic fiber optic and Tactile sensor

Module 6: Robotics In Medicine: (8 hrs)

Da Vinci Surgical System, Image guided robotic systems for focal ultrasound based surgical applications, System concept for robotic Tele-surgical system for off-pump CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery, Pediatric-, and General- Surgery, Gynecologic Surgery, General Surgery and Nano robotics.

Text Books::

1. Nagrath and Mittal, “Robotics and Control”, Tata McGraw-Hill, First edition, 2003.
2. Spong and Vidhyasagar, “Robot Dynamics and Control”, John Wiley and Sons, First edition, 2008.

Reference Books::

1. Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki and Sebastian Thurn, “Principles of Robot Motion: Theory, Algorithms, and Implementations”, Prentice Hall of India, First edition, 2005.
2. Jacob Rosen, Blake Hannaford & Richard M Satava, “Surgical Robotics: System Applications & Visions”, Springer 2011.
3. Barbara Webb and Thomas Consi. R, “BioRobotics: Methods & Applications”, AAAI Press/MIT Press, First Edition, 2001.
4. ConstantinosMavroidis, Antoine Ferreira, “Nanorobotics: Current approaches and Techniques”, Springer 2011.
5. Fu.K.S, Gonzalez.R.C. Lee, C.S.G, “Robotics, control, sensing, Vision and Intelligence”, Tata McGraw Hill International, First edition, 2008.

19BM2013	RADIOLOGICAL IMAGING TECHNIQUES	L	T	P	C
		3	0	0	3

Course Objectives:

1. Study the quality assurance test for radiography, method of recording sectional images
2. Study the functioning of radio isotopic imaging equipment.
3. Study the MRI, image acquisition and reconstruction

Course Outcomes::

The Student will be able to

1. List out the various medical imaging techniques.
2. Explain the principle of specific medical imaging techniques.
3. Interpret the imaging outputs.
4. Identify the suitable medical imaging techniques for specific pathology.
5. Devise new ideas to solve certain issues in medical imaging.
6. Justify the impact of medical imaging system for diagnosis.

Module 1 : X-Ray and CT Imaging : (8 hrs)

Principles and production of soft X-rays and hard X-rays- Details of radiographic and fluoroscopic images in X-Ray systems- Screen-film and image intensifier systems - Evolution of CT machines - CT image formation- Conversion of X-ray data into scan image, Mathematical details of various algorithms- spiral CT, Transverse tomography- CT Angiography

Module 2 : PET and SPECT Imaging : (8 hrs)

Introduction to emission tomography, basic physics of radioisotope imaging Compton cameras for nuclear imaging, PET scanner principles, SPECT, Computer techniques in fast acquisition Analytic image reconstruction techniques, Attenuation, scatter compensation in SPECT spatial compensation in SPECT.

Module 3 : Magnetic Resonance Imaging (MRI) : (8 hrs)

Principles of MRI pulse sequence – image acquisition and reconstruction techniques – MRI instrumentation magnetic gradient system RF coils – receiver system functional MRI – MRI artifacts- Various types of pulse sequences for fast acquisition of imaging, NMR spectroscopy - Application of MRI

Module 4: Ultrasonic Imaging: (7 hrs)

Production of ultrasound – properties and principles of image formation, capture and display – principles of A-mode, B-mode and M-mode display – Doppler ultra sound and color flow mapping – applications of diagnostic ultra sound.

Module 5:Infra-RedImaging: (6 hrs)

Physics of thermography – imaging systems – pyroelectric Videocon camera clinical thermography – liquid crystal thermography.

Module 6:Other Imaging Techniques: (8 hrs)

Optical coherence tomography (OCT): Introduction and its medical applications - Advances in image resolutions - Speed in Picture Archiving and Communication Systems (PACS) in medical imaging.

Text Books::

1. Khandpur.R.S. “Handbook of Biomedical Instrumentation”. Second edition Tata McGraw Hill Pub. Co. Ltd., 2003.
2. John Ball and Tony Price Chesney’s, “Radiographic Imaging”. Blackwell Science Limited, U.K. 2006.
3. Farr, “The Physics of Medical Imaging”, AdemHilger, Bristol & Philadelphia, 2007.
4. Joseph Bronzino. “The Physics of Medical Imaging”. Second edition.2005.

Reference Books::

1. M. Analoui, J.D. Bronzino, D.R.Peterson, “Medical Imaging: Principles and Practices”, CRC Press, 2012.
2. S. Webb, “Physics of Medical Imaging”, Taylor & Francis, 2010.
3. T. Farncombe, K. Iniewski, “Medical Imaging: Technology & Applications”, CRC Press, 2013.
4. J.S. Benseler, “The Radiology Handbook: A pocket guide to medical imaging”, Ohio University Press, 2006.
5. R.R.Carlton, A.M.Adler, “Principles of Radiographic Imaging: An Art and a Science”, Delmar Cengage Learning; Fifth Eddition, 2012.
6. N.B.Smith, A. Webb, “Introduction to Medical Imaging Physics, Engineering and Clinical Applications”, CRC Press, 2010.

19BM2014	BIOMECHANICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Understand the principles of mechanics that is used to analyze human movement.
2. Study the structure and functions of bones, cartilage and of skeletal muscle
3. Study the loads applied to skeletal system and fluid mechanics to human body

Course Outcomes::

The Student will be able to

1. Recognize the concepts of mechanics and kinematics for human movements
2. Interpret the human factors that affect the environmental conditions
3. Apply the engineering techniques in human physiological applications
4. Analyze the properties and functions for effective performance.
5. Evaluate the methods, solutions to human problems for specific needs
6. Design the advanced system concepts implement solutions to human factors problem.

Module 1: Fundamentals of Mechanics: (8 hrs)

Newton's law- mechanical behavior of bodies in contact, work, power and energy relationship – Angular kinematics of human movement-measuring angles, angular kinematic relationships –relationships between linear and angular motion.

Module 2 : Fundamentals of Kinematics : (8 hrs)

Angular kinetics of human movement-resistance to angular acceleration, angular momentum – Equilibrium and human movement-equilibrium, center of gravity, stability and balance – Kinematic concepts for human motion-forms of motion and joint movement terminology – Kinetic concepts for human motion-basic conceptsrelated to kinetics .- mechanical loads on the human body. Instrumentation techniques for muscle and toe strength, Hand grip dynamometer.

Module 3 : Bone and Cartilage : (7 hrs)

Bone structure & composition, blood circulation in bone – mechanical properties of bone, viscoelastic properties of bone – Maxwell &Voight models – viscoelastic properties of articular cartilage – Anisotropy and composite models for bone –Bone growth and development – Bone response to stress – Osteoporosis – causes, diagnosis, treatment – Elasticity and strength of bone. Bone Implants and materials.

Module 4 :Bio fluid Mechanics : (7 hrs)

Newtonian viscous fluid, non-viscous fluid – Rheological properties of blood –Structure and composition of blood vessel – Remodeling of blood vessels –Nature of fluids, Propulsion in fluid medium – Mechanical properties of arterioles, capillary vessels and veins – Bio-viscoelastic solids- Measurement techniques.

Module 5 : Mechanics of Skeletal Muscle : (8 hrs)

Structure of skeletal muscle –muscle fibers, motor units – Structure of skeletal muscle-fiber types, fiber architecture – Sliding element theory of skeletal muscle.-Skeletal muscle function – Contraction of skeletal muscle and hill's three element model – Factors affecting muscular force generation – Muscular strength, power and endurance – Muscle injuries-Pain and gate control theory. Testing methods.

Module 6 :**Mechanics of Shoulder, Spine And Hip : (7 hrs)**

Structure of the shoulder – Movements of shoulder complex – Loads on the shoulder – Structure of the spine – Movements of the spine – Muscles and loads on the spine – Structure and movements of the hip – Loads on the hip-Gait analysis and biomedical Applications.

Text Books::

1. Fung Y C, Biomechanics: "Mechanical Properties of Living Tissues",Springer, 2nd edition, 1993.
2. Susan J Hall, "basic biomechanics", Tata McGraw hill, 4th edition, 2004.

Reference Books::

1. Dhanjoo N Ghista, Applied Biomedical Engineering Mechanics, CRC Press, taylor and Francis, 2008
2. Ronald L Hutsun, "Principles of Biomechanics", CRC Press, taylor and Francis, 2009.
3. Webster J G, "Medical instrumentation –Application & design", John Wileyand Sons Inc., 3rd edition, 2003.
4. Schneck D J, and Bronzino J D, "Biomechanics- Principles andApplications", CRC Press, 2nd Edition, 2000.
5. Duane Knudson, "Fundamentals of Biomechanics", Springer, 2nd edition, 2007

19BM2015	MEDICAL ETHICS AND STANDARDS	L 3	T 0	P 0	C 3

Course Objectives:

1. Achieve familiarity with some basic ethical framework& understand how these ethical frameworks can help us to think through contemporary questions in medical ethics.
2. Know about the legal and ethical principles and application of these principles in health care settings
3. Gain knowledge about the medical standards that to be followed in hospitals.

Course Outcomes:

The Student will be able to

1. Identify the scope of medical ethics
2. Illustrate the concepts of ethical theories and moral principles for the health professions
3. Explain the purpose of medical standards
4. Acquire knowledge about hospital accreditation standards
5. Summarize the importance of hospital safety standards
6. Recommend the suitable principles of medical equipment safety standards in hospitals

Module 1: Introduction to Medical Ethics: (8 hrs)

Definition of Medical ethics, Scope of ethics in medicine, American medical Association code ofethics, CMA code of ethics- Fundamental Responsibilities, The Doctor and the Patient, The Doctorand the Profession, Professional Independence, The Doctor and Society.

Module 2: Ethical Theories and Moral Principles: (8 hrs)

Theories-Deontology & Utilitarianism,Casuist theory, Virtue theory, The Right Theory. Principles Non-Maleficence, Beneficence, Autonomy, Veracity, Justice. Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research, Bioethical issues in Human Genetics & Reproductive Medicine

Module 3: Medical Standards: (8 hrs)

Evolution of Medical Standards – IEEE 11073 - HL7 – DICOM – IRMA - LOINC – HIPPA –Electronics Patient Records – Healthcare Standard Organizations – JCAHO (Join Commission on Accreditation of Healthcare Organization) - JCIA (Joint Commission International Accreditation) - Evidence Based Medicine - Bioethics.

Module 4: Hospital Accreditation Standards: (6 hrs)

Accreditation - JCI Accreditation & its Policies. Patient centered standards, Healthcare Organization management standards -Indian Perspective.

Module 5 : Hospital Safety Standards : (8 hrs)

Life Safety Standards- Protecting Occupants, Protecting the Hospital From Fire, Smoke, and Heat, Protecting Individuals From Fire and Smoke, Providing and Maintaining Fire Alarm Systems, Systems for Extinguishing Fires Environment of Care Standards-Minimizing EC Risks, Smoking Prohibitions, Managing Hazardous Material and Waste, Maintaining Fire Safety Equipment, Features, Testing, Maintaining, and Inspecting Medical Equipment.

Module 6: Medical Equipment Safety Standards: (7 hrs)

General requirements for basic safety & essential performance of medical equipment. IEC 60601standards-Base Standard-general requirement of electrical medical devices, Collateral Standards EMC radiation protection &programmable medical device system, Particular Standards-type ofmedical device

Text Books::

1. JohnnaFisher, “Biomedical Ethics: A Canadian Focus.” Oxford University Press Canada 2009.
2. Ben Mepham,”Bioethics-—An Introduction for the biosciences”,Oxford, 2008.
3. Domiel A Vallero, “Biomedical Ethics for Engineers”, Elsevier Pub.1st edition, 2007.

Reference Books::

1. Joint Commission Accreditation Standards for Hospitals, 2nd edition 2003.
2. NilsHoppe and Jose Miola, “Medical law and Medical Ethics”, Cambridge University Press2014.
3. Robert M Veatch,” Basics of Bio Ethics”, Second Edition. Prentice- Hall,Inc, 2003
4. Physical Environment Online: A Guide to The Joint Commissions Safety Standards, HCPro, Inc.2010
5. Mohan Bansal, “Medical informatics”, Tata Mc Graw Hill Publishing Ltd, 2003.

19BM2016	SIGNALS AND SYSTEMS FOR BIOMEDICAL ENGINEERS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Know the basic concepts of bio signals and its importance.
2. Learn about the time and frequency domain techniques.
3. Understand the analysis of bio signals.

Course Outcomes:

At the end of the course, students will be able to

1. Identify the nature of biomedical signals.
2. Analyze the spectral characteristics of continuous-time periodic and aperiodic signals using Fourier analysis.
3. Classify systems based on their properties and determine the response of LTI system using Laplace transform.
4. Apply Laplace transform and Z- transform to analyze continuous-time and discrete-time signals and systems.
5. Analyze system properties based on impulse response by FIR, IIR filtering techniques.
6. Demonstrate mathematical tools in characterization of physiological system.

Module 1: Introduction to Signals (7 Hours)

Basics of Biomedical Signals and systems- representation –Sampling and quantization-Periodic, aperiodic and transient ,stationary and non- stationary signals. Two- dimensional signals-Images. Linear and Non Linear systems-Linear System theory- Stability of systems.

Module 2: Fourier Transform: (8 Hours)

Time and frequency -domain signal representatives, Fourier series analysis, Symmetry, Frequency and Complex representation, The continuous Fourier transform, The discrete Fourier series and discrete Fourier transform, The Fourier transform and power spectrum: Implications and applications. Spectral averaging, Stationarity and time-frequency Analysis.

Module 3: Joint Time-Frequency Analysis of Biomedical Signals (8 Hours)

The Short- Term Fourier Transform. The Gaborand Adaptive Gabor Transforms, The Wigner-Ville and Pseudo-Wigner Transforms, Cohen's General Class of JTF Distributions JTFA Using Wavelets, Applications of JTFA to Physiological Signals.

Module 4: Linear Systems is the Frequency Domain (8 Hours)

The transfer function. The response of system elements to sinusoidal inputs-phasor analysis. The transfer function spectral plots. Linear systems analysis in the complex frequency domain: The Laplace transform and the Analysis of Transients - The Laplace transform, The inverse Laplace transform, Laplace analysis - the Laplace transfer function, Nonzero initial conditions- initial and final value theorems, The Laplace domain and the frequency domain

Module 5: Linear Systems In The Time Domain (8 Hours)

Convolution and simulation, Linear system analysis: Applications, Linear filters, filter types, Filter attenuation slope-filter order, Filter initial sharpness, FIR versus IIR filter characteristics, Finite impulse response(FIR) filters, Infinite impulse response filters, The digital transfer function and the Z-transform, The digital transfer function.

Module 6: **Biomedical Signals And Systems Analysis (6 Hours)**

Concurrent, coupled and correlated processes, filtering for removal of artifacts, event detection, wave shape and wave form complexity, analysis of non-stationary signals. Mathematical Tools Used in the characterization of Physiological Systems. Complex systems in biology and medicine - properties and examples.

Text Books:

1. John Semmlow,"Signals and Systems for Bioengineers"Elsevier India Private Limited,2012.
2. Rangaraj M.Rangayyan, Biomedical Signal Analysis:ACase-StudyApproach,2nd,Wiley,2012.
3. Robert B.Northrop, Signals and Systems Analysis in BiomedicalEngineering,2ndEdition,CRCPress,Taylor& Francis Group,2012.

Reference Books:

1. SureshR.Devasahayam,"Signals and Systems in Biomedical Engineering : Signal Processing and Physiological Systems Modeling", Academic/PlenumPublishers,2000.
2. Lathi. B. P, "Linear Systems and Signals", Oxford University Press,2ndEdition,2005.
3. J. Proakis and D. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", 4th Edition, Prentice-Hall, 2006.
4. LiTan,"Digital Signal Processing: Fundamentals and Applications", Elsevier,2008.
5. Mrinal Mandal, Amir Asif, "Continuous and Discrete Time Signals and Systems", Cambridge

University Press, 2008.

19BM2017	BIOPHYSICS AND BIOCHEMISTRY	L	T	P	C
		3	0	0	3

Course Objectives:

1. Understand the basic principles of physics and chemistry in medicine.
2. Learn the basic physiological parameters and physical laws governing human body.
3. Know the instruments and range of measurement of vital parameters.

Course Outcomes:

1. Demonstrate knowledge of the fundamental concepts in physics and chemistry that underlie biological processes.
2. Define the structural characteristics of nucleic acids and proteins
3. examine parameters that variously determine physiological conditions
4. Describe the principles that govern biomolecular interactions
5. Study the fundamentals of various biochemical and physical measurements
6. Study the determination of vital body parameters for physiological measurements.

Module 1: Introduction to Biochemistry: (7 Hours)

Cell Structure and cellular constituents and functions, Biomolecules, Functional groups of organic biomolecules, Major classes of biomolecules: amino acids, proteins, peptide bonds, DNA. Components of nucleic acids, base pairing, Watson and crick DNA structure, DNA as the genetic material, DNA replication

Module 2: Amino acids and Proteins: (7 Hours)

Ionization of water, weak acids & weak bases, dissociation constants, buffering in biological systems, titration curves of amino acids, Isoelectric point 1^0, 2^0 ,3^0, structure of proteins and purification techniques of proteins.

Module 3: Lipids and Carbohydrates: (7 Hours)

Structure and function, Lipids, structural and storage lipids, structural lipids in membrane, phospholipids, glycolipids, lipids as signals, cofactors and pigments, carbohydrates in general: classifications and metabolism.

Module 4: Thermodynamics of living systems: **(8 Hours)**

Conservation of energy in living systems, Entropy and Life, Gibbs and Standard free energy, Equilibrium constant, Coupled reactions. Viscosity and biological importance, Surface tension, Factors influencing surface tension, Biological importance

Module 5: Dynamics of biomolecules: (8 Hours)

Cell membrane and transport, Composition and architecture of cell membrane, Diffusion, Laws of diffusion, Active transport, Facilitated diffusion, Osmosis, Osmotic pressure, Osmoregulation Donnan Potential, Ion selective channels, Voltage gated, molecular mechanism of signal transduction.

Module 6: Analysis of fluids and metabolic disorders: **(8 Hours)**

Composition of Blood, serum, Cerebrospinal fluid and urine, Analysis of blood- :Hemoglobin, Total cell and Differential cell (TC/DC) counts , Erythrocyte sedimentation Rate (ESR); Clotting time. Glucose; Lipid profile; Urea; Gases: Oxygen and Carbon dioxide levels; pH, Serum: Proteins, Albumin/Globulin Ratio; Bilirubin; Creatinine; Uric acid; Electrolytes, Urine: Color, odor, sediment, crystals, glucose; protein/albumin.

Text Books:

1. Nelson, D.L. and M.M. Cox, "Principles of Biochemistry, 4th edition, W. H Freeman & CO. 2005"
2. E.K. Yeargers, "basic biophysics for biology", Mc Graw Hill 2004

Reference Books

1. Philip Nelson, "Biological Physics- Energy, Information, Life", W. H freeman, 2013
2. Rodney Coterill, "Biophysics and Introduction", Springer 2014
3. Pranav Kumar, "Fundamentals and Techniques of Biophysics and molecular biology" Second edition, Pathfinder Publication , 2016
4. Christopher K. Mathews, K. E. Van Holde, Dean R. Appling, Spencer J. Anthony-cahill, "Biochemistry", Secon Edition, Pearson 2012
5. J L Jain, Sunjay Jain, Nitin Jain , "Fundamentals of Biochemistry", S chand publication 2012
6. Fromm, Herbert J., Hargrove, Mark, "Essentials of Biochemistry", Springer 2012

19BM2018	HUMAN ANATOMY AND PHYSIOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Basic structural and functional elements of human body.
2. Organs and structures involving in system formation and functions.
3. Understand all systems in the human body.

Course Outcomes:

The Student will be able to

1. Recall the basic elements of human body.
2. Compare the major bones and their processes as they relate to each region of the body.
3. Interpret the major organs and components of the respiratory system.
4. Recognize the major organs and vessels of the cardiovascular system.
5. Describe the basic components and functions of urinary and special sensing systems.
6. Demonstrate the structure and functions of nervous systems.

Module 1: Basic Elements of Human Body (9 Hours)

Cell: Structure and organelles - Functions of each component in the cell. Cell membrane – transport across membrane – origin of cell membrane potential – Action potential Tissue: Types – Specialized tissues – functions, Types of glands.

Module 2: Skeletal and Respiratory System (7 Hours)

Skeletal system: Bone types and functions – Joint - Types of Joint - Cartilage and functions

Module 3: Respiratory System (7 Hours)

Respiratory System: Components of respiratory system – Respiratory Mechanism. Types of respiration - Oxygen and carbon dioxide transport and acid base regulation.

Module 4: Circulatory System (8 Hours)

Blood composition - functions of blood – functions of RBC.WBC types and their functions Blood groups – importance of blood groups – identification of blood groups. Blood vessels - Structure of heart – Properties of Cardiac muscle – Conducting system of heart -Cardiac cycle – ECG - Heart sound - Volume and pressure changes and regulation of heart rate –Coronary Circulation. Factors regulating Blood flow.

Module 5: Urinary and Special Sensory System(7 Hours)

Urinary system: Structure of Kidney and Nephron. Mechanism of Urine formation and acid base regulation – Urinary reflex – Homeostasis and blood pressure regulation by urinary system. Special senses: Eye and Ear.

Module 6: Nervous System (7 Hours)

Structure of a Neuron – Types of Neuron. Synapses and types. Conduction of action potential in neuron Brain – Divisions of brain lobes - Cortical localizations and functions - EEG. Spinal cord – Tracts of spinal cord - Reflex mechanism – Types of reflex, Autonomic nervous system and its functions.

Text Books::

1. Elaine.N. Marieb,“Essential of Human Anatomy and Physiology”, Eight edition, Pearson Education NewDelhi, 2007.
2. Gillian Pocock, Christopher D. Richards, "The Human Body- An introduction for Biomedical and Health Sciences", Oxford University Press, USA, 2009.

References:

1. William F. Ganong,"Review of Medical Physiology, 22nd edition, McGraw Hill New Delhi, 2005
2. Eldra Pearl Solomon."Introduction to Human Anatomy and Physiology", W.B.Saunders Company, 2003.
3. Arthur C. Guyton, "Text book of Medical Physiology", 11 th Edition, Elsevier Saunders, 2006

19BM2019	BIOMEDICAL SENSORS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide introduction to the field of medical sensors and an in depth and quantitative view of device design and performance analysis.
2. To provide knowledge on the principle and operation of different medical transducers.
3. To introduce the application of sensors and transducers in the physiological parameter measuring system.

Course Outcomes:

The Student will be able to

1. Identify the calibration procedure for the basic instruments involved in physiological parameter measurement.
2. Interpret the errors in measurement by analyzing the performance characteristics of the sensors.
3. Demonstrate the appropriate sensor approach which is most likely to meet a specific biosensor application.
4. Apply the suitable design criteria for developing a medical sensor for a particular application.
5. Develop advanced medical sensors based on the basic transduction principles.
6. Predict the qualitative performance of advanced medical sensors.

Module 1: Science of Measurement (8 hrs)

Generalized Instrumentation System, General properties of input transducer. Static Characteristics: Accuracy, Precision, Resolution, Reproducibility, Sensitivity, Drift, Hysteresis, Linearity, Input Impedance and Output Impedance. Dynamic Characteristics: First Order and Second Order Characteristics, Time Delay, Transfer Function – First and Second Order Systems.

Module 2: Different transduction principles (8 Hours)

Temperature transducers- thermo resistive transducers, thermoelectric, Displacement transducers - potentiometric, resistive strain gauges, inductive displacement, and capacitive displacement transducer. Pressure transducer- indirect method - measurement of blood pressure using sphygmomanometer, piezo-electric type, catheter tip transducers, measurement of intracranial pressure, catheter tip- implantable type. Optical Sensors -

Module 3: Biological sensors (7 Hours)

Study of Various corpuscles like Pacinian, functions and modelling, Chemoreceptor, hot and cold receptors, baro- receptors, sensors for smell, sound, vision, osmolality and taste.

Module 4: BioSensors (7 Hours)

Electrolytic sensors, optical sensor, fiber optic sensors. Biosensors in clinical chemistry, medicine and health care.

Module 5: Bio chemical sensors (7 Hours)

Introduction, Advantages and limitations, various components of Biosensors, Biocatalysts based biosensors, bio-affinity based biosensors & microorganisms based biosensors, Types of membranes used in biosensor constructions.

Module 6: Bio potential electrodes (8 Hours)

Electrodes Electrolyte Interface, Half Cell Potential, Polarization, Polarizable and Non Polarizable, Electrodes, Calomel Electrode, Electrode Circuit Model, Electrode Skin-Interface and Motion Artifact. Body Surface Electrodes. Ion exchange membrane electrodes, oxygen electrodes, CO_2 electrodes enzyme electrode, ISFET for glucose, urea.

Text Books:

1. Medical Instrumentation-Application and Design by John G. Webster, 2013
2. Transducers for Biomedical Measurements: Principles and Applications, Richard S.C. Cobbold, John Wiley & Sons, 2004.

Reference Books:

1. Electronics in Medicine and Biomedical Instrumentation by Nandini K. Jog PHI Second Edition 2013.
2. Instrument Transducer – An Introduction to their performance and design, Hermann K P. Neubert.
3. Biomedical sensors – Fundamentals and application by Harry N, Norton.
4. Biomedical Transducers and Instruments, Tatsuo Togawa, ToshiyoTamma and P. Akeoberg.

19BM2020	SIGNAL CONDITIONING CIRCUITS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Bioelectric amplifiers
2. Filters and circuits
3. Application of signal conditioning in biomedical field

Course Outcomes:

The Student will be able to

1. Identify the origin and characteristics of various biosignals and its acquisition.
2. Apply the signal conditioning circuits for biomedical field.

3. Analyze and deign bio filters and isolation circuits used in medical signal conditioning.
4. Interface the bioelectric signals with analog and digital circuits for data acquisition
5. Create the various circuits for designing medical equipments using different ICs
6. Recommend the various safety standards in biomedical instrumentation

Module 1: Biopotential Measurement (6 Hours)

Biopotentials and bioelectric currents, Nature of Bio Electricity: Bioelectric Currents, Nernst Potential, Diffusion Potential, Action potential, Detection of Bio electric events, bio-electrode and electrode-skin interface, Need for bioamplifiers and biosignal Conditioning.

Module 2: Operational Amplifiers and Its Biomedical Applications (8 Hours)

Operational Amplifiers Basic opamps parameters, Ideal and practical opamp, application of opamp in biomedicine- Adder, subtractor, analog integrator, differentiator, preamplifiers, Transimpedence circuits.

Module 3: Basic Filters and Isolation Circuits (8 Hours)

Active filters and Medical Isolation Amplifiers: First order and second order active filters, Instrumentation amplifier, Types of isolation amplifiers and optocouplers.

Module 4: Biosignal Data Acquisition Systems (8 Hours)

Comparators, Comparator applications, Multivibrators,555 timers, Astable and monostable, Pacemaker circuits, Aliasing and sampling, Analog to Digital, Digital to Analog conversion.

Module 5: Special Analog Circuits (8 Hours)

Special analog circuits and systems used in biomedical transmission, Phase Detectors-Analog and Digital, Voltage Controlled Oscillators, Various VCO ICS, Phase locked loops.

Module 6: Advanced Biomedical Instrumentation and Safety Standards (7 Hours)

Modulation and demodulation of biosignals, IC thermometers and advanced biomedical instrumentation systems, Electrical Interface problems and Safety Standards in Bio Potential Measurements.

Text Books:

1. Robert B. Northrop, "Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation", CRC Press, II Edition, New York, 2017
2. Sergio Franco, "Design with Operational Amplifier and Analog Integrated Circuits", TMH, 3rd Edition, 2009.

Reference Books:

1. Myer Kutz, "Biomedical Engineering and Design Handbook", II Edition, Volume 1, McGraw Hill Professional,2011
2. Robert F. Coughlin, Frederick F. Driscoll, "Operational Amplifiers & Linear Integrated Circuits", Prentice-Hall, 6th Edition,2004.
3. Milman&Hallkias, "Integrated Electronics-Analog and Digital Circuit", McGraw Hill, II Edition,2011
4. Roy Choudhury and Shail Jain, "Linear integrated circuits", Wiley Eastern Ltd,2002

19BM2021	SIGNALS CONDITIONING CIRCUITS LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

To impart knowledge on

1. Design of filters and amplifier circuits for bioelectric amplifiers.
2. Different preamplifiers used for amplifying the bio signals.
3. Application of signal conditioning in biomedical field.

Course Outcomes:

The Student will be able to

1. Summaries the principles of various digital ICs
2. Identify and apply the amplifiers and various signal conditioning circuits for biosignals acquisition.
3. Demonstrate the basic concepts for filtering of bio signals
4. Design and build various analog and digital interfaces for signal conversion
5. Select suitable circuits to design various biomedical devices
6. Apply and analyze the front end analogue circuit design for ECG, EMG, EEG, etc.

List of Experiments

1. Study of basic digital logic used in biosignal conditioning
2. Study of different data storage flip-flops used in medical hardware's
3. Study of different data storage flip-flops used in medical hardware's

4. Design of basic op-amp circuits for biosignal processing
5. Design of waveshaping circuits
6. Instrumentation amplifier for ECG amplification
7. Design of constant current source and transimpedence circuits.
8. Design of preampilifer circuit
9. Design of medical isolation amplifier
10. Biosignal data acquisition system
11. Design of pacemaker circuit
12. Design of active filters for biosignal acquisition (PPG Signal Acquisition)

19BM2022	CONTROL SYSTEM FOR BIOMEDICAL ENGINEERS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Bio control systems modeling technique.
2. Time response analysis and frequency response analysis.
3. Analyze biological control systems.

Course Outcomes:

The Student will be able to

1. Represent the system in various forms.
2. Interpret the response of the system in time domain.
3. Analyze the frequency response of any system
4. Examine the stability of the system.
5. Compute the mathematical model of physiological systems.
6. Summarize the features of physiological system.

Module 1: Engineering Control Systems (7 Hours)

Basic structure of control system, Positive and Negative Feedback, transfer functions, modeling of electrical systems, block diagram and signal flow graph representation of systems

Module 2: Time Domain Analysis (8 Hours)

Introduction to simulation, Step response of first order and second order systems, determination of time domain specifications of first and second order systems. Definition of steady state error constants and its computation.

Module 3: Frequency Domain Analysis (8 Hours)

Frequency response, determination of gain margin and phase margin using Bode plot, use of Nichol's chart to compute resonant frequency and band width.

Module 4: Stability Analysis (8 Hours)

Definition of stability, Routh-Hurwitz criteria of stability, construction of root locus, Nyquist stability criterion, Nyquist plot and determination of closed loop stability.

Module 5: Physiological Systems (7 Hours)

Difference between engineering and physiological control systems, generalized system properties, models with combination of system elements. Physiological system modeling, linear model of respiratory mechanics.

Module 6: Case Studies (7 Hours)

Mathematical Model of chemical regulation of ventilation, linear model of muscle mechanics, model of regulation of cardiac output, model of Neuromuscular reflex motion

Text Books:

1. Michael. C. K. Khoo, "Physiological control systems", IEEE press, Prentice –Hall of India, 2001.
2. Benjamin C. Kuo, "Automatic control systems", Prentice Hall of India,7th edition, 1995

Reference Books:

1. M. Gopal "Control Systems Principles and design", Tata McGraw Hill ,2002
2. John Enderle, Susan Blanchard, Joseph Bronzino, "Introduction to Biomedical Engineering" second edition, Academic Press, 2005.
3. Richard C. Dorf, Robert H. Bishop," Modern control systems", Pearson, 2004.

19BM2023	IMAGE PROCESSING FOR MEDICAL APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Digital image fundamentals.
2. Low level image processing techniques.
3. Segment, compress and analyze images

Course Outcomes:

The Student will be able to

1. Describe the digital image fundamentals for a given condition
2. Illustrate the effect of image enhancement techniques on images
3. Distinguish between image restoration filters
4. Discuss about the image segmentation procedure
5. Compute the level of compression achieved for the given image data
6. Explain and compute features useful for image representation and recognition

Module 1: Digital Image Fundamentals (7 Hours)

Introduction – Origin – Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels - color models, Medical imaging applications

Module 2: Image Enhancement (8 Hours)

Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering– Smoothing and Sharpening Spatial Filtering – Frequency Domain: Introduction to Fourier Transform – Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters., Application of filtering in medical images.

Module 3: Image Restoration and Segmentation (8 Hours)

Noise models– Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering, Application of filtering in medical images.

Module 4: Segmentation (7 Hours)

Detection of Discontinuities–Edge Linking and Boundary detection – Region based segmentation- Morphological processing- erosion and dilation, Application of edge detection.

Module 5: Wavelets and Image Compression (8 Hours)

Wavelets – Sub band coding - Multiresolution expansions - Compression: Fundamentals – Image Compression models – Error Free Compression – Variable Length Coding – Bit-Plane Coding –Lossless Predictive Coding – Lossy Compression – Lossy Predictive Coding – Compression Standards, Case study

Module 6: Image Representation and Recognition (7 Hours)

Boundary representation – Chain Code – Polygonal approximation, signature, boundary segments –Boundary description – Shape number – Fourier Descriptor, moments- Regional Descriptors –Topological feature, Texture - Patterns and Pattern classes - Recognition based on matching.

Text Books:

1. Rafael C. Gonzales, Richard E. Woods, “Digital Image Processing”, Third Edition, Pearson Education, 2010.
2. Anil Jain K. “Fundamentals of Digital Image Processing”, PHI Learning Pvt. Ltd., 2011.

Reference Books:

1. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, “Digital Image Processing Using
3. MATLAB”, Third Edition Tata McGraw Hill Pvt. Ltd., 2011.
4. Willliam K Pratt, “Digital Image Processing”, John Willey, 2002.
5. Malay K. Pakhira, “Digital Image Processing and Pattern Recognition”, First Edition, PHI LearningPvt. Ltd., 2011.
6. Chris Solomon, Toby Breckon, “Fundamentals of Digital Image Processing – A practical approach with examples in Matlab”, Wiley-Blackwell, 2010.
7. Jayaraman, “Digital Image Processing”, Tata McGraw Hill Education, 2011

19BM2024	IMAGE PROCESSING LABORATORY FOR MEDICAL APPLICATIONS	L	T	P	C
		0	0	3	1.5

Course Objectives

To impart knowledge on

1. Working with various medical image data
2. Usage of Simulation tools for image processing
3. Process medical images using various methods

Course Outcomes:

The Student will be able to

1. Demonstrate basic operations on a given image to obtain specific output
2. Produce enhanced images using spatial and frequency domain filters
3. Assess the performance of image restoration techniques under given condition
4. Identify the object in a given image through segmentation
5. Show the effect of image compression on given image data
6. Compute the features useful for image analysis

List of Experiments:

1. Basic operations on images
2. Color conversion of images
3. Image enhancement using point operations
4. Image enhancement using spatial domain filters
5. Image enhancement using frequency domain filters
6. Image restoration in the presence of noise and degradation
7. Image segmentation using edge and region based methods
8. Morphological operations on images
9. Multiresolution analysis of images using wavelets
10. Image compression using lossless and lossy methods
11. Histogram processing o Images
12. Extraction of shape and texture features from an image
13. Image pseudo coloring

19BM2025	EMBEDDED SYSTEMS FOR BIOMEDICAL APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Basic concepts of Embedded Systems
2. Various techniques used for designing an embedded system.
3. Real time system with an examples

Course Outcomes:

The Student will be able to

1. Discuss the basics of embedded systems and its hardware units
2. Identify the various tools and development process of embedded system
3. Demonstrate the various I/O interfacing with microcontroller
4. Create the programming for embedded system design
5. Summarize the real time models, languages and operating systems
6. Design a real time embedded system for biomedical applications

Module 1: System Design (7 Hours)

Embedded system, Processor embedded into a system, Embedded hardware units and devices in a system, Embedded software in a system, Embedded system architecture, Classifications, Skills required for an embedded system designer. Typical application scenario of embedded systems

Module 2: Embedded Systems Design, Development Process and Tools (8 Hours)

Complex systems and microprocessor, Design process and metrics in embedded system, Design challenges, Optimising the design metrics, Issues related to embedded software development, Hardware software co-design, Embedded system design technology, Embedded software development process and tools, Host and Target machine, Linking and Locating Software, Getting embedded software into the target system, Design process

Module 3: Real World Interfacing (8 Hours)
Study of microcontroller, Processor and memory organization, Switch, Keypad and LED interfacing, Seven segment display interfacing, Data Acquisition system, A/D, D/A converters, Timers, Counters, Actuators.

Module 4: Programming Concepts (7 Hours)
Programming in assembly language and high level language, C program elements, Embedded C programming- Simple programs, High level language descriptions of software for embedded system, Java based embedded system design.

Module 5: Techniques for Embedded Systems (8 Hours)
State Machine and state Tables in embedded system design, Simulation and Emulation of embedded systems. Real time models, Language and Operating Systems-Tasks and task states, operating system services, RTOS functions, Interrupt routine in RTOS environment.

Module 6: Biomedical Applications (7 Hours)
Body temperature measurement, Stepper motor control. Embedded system in biomedical application- Wireless sensor technologies, Body sensor network, Patient monitoring system. Case study

Text Books:
1. RajKamal, "Embedded Systems Architecture, Programming and Design", Tata McGrawHill ,Second Edition, 2008
2. Tim Wilhurst, "An Introduction to the Design of Small Scale Embedded Systems,Palgrave, 2004.

Reference Books:
1. Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2005.
2. Frank Vahid, Tony Givargis, "Embedded Systems Design", Wiley India, 2006
3. Khandpur R.S, "Hand-book of Biomedical Instrumentation", Tata McGraw Hill, 2nd Edition, 2003.

19BM2026	EMBEDDED SYSTEMS LABORATORY FOR BIOMEDICAL APPLICATIONS	L	T	P	C
		0	0	3	1.5

Course Objectives:
To impart knowledge on
1. To impart knowledge on the integration of hardwae circuits with software
2. To introduce the concepts of programming in an IDE and download it into a processor
3. To learn about the practical aspects of data acquistion and analysis

Course Outcomes:
The Student will be able to
1. Design interfacing circuits to acquire real time data and process it using software
2. Develop real time embedded systems for biomedical applications
3. Apply communication protocols for data transmission
4. Create an embedded C program for various I/O interfacing
5. Implement timer concept for providing real time delay
6. Integrate the sensor with microcontroller for embedded system design

List of Experiments:
1. Bit wise port access
2. Interfacing Running Display
3. Interfacing of byte wise input output module
4. Heart rate measurement using timer (for 60 sec)
5. Study of timer interrupt for pulse rate measurement
6. Interfacing temperature sensor
7. Relay Interface
8. Interfacing rehabilitation devices
9. Position control
10. Interfacing communication protocols- I^2C
11. Wave generation for nerve and muscle stimulator
12. Real time application-Simulation

19BM2027	BIOMEMS LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

To Impart knowledge about

1. The working principle of MEMS sensors
2. To Study the methodologies of testing and calibration
3. To learn simulation tools for design and application development

Course Outcomes:

The Student will be able to

1. Examine the functions and test the characteristics of MEMS sensors
2. Classify the methods of analyzing physiological models
3. Implement the appropriate design constrains
4. Evaluate the performance of sensors using simulation tools
5. Test and validate the performance of MEMS devices
6. Create and integrate MEMS based measurement systems for biomedical applications.

List of Experiments

1. Study the characteristics of MEMS pressure sensor for Blood pressure measurement
2. Study the characteristics of MEMS flow sensor for respiration flowmetry
3. Study the characteristics of MEMS accelerometer for human movement
4. Study the characteristics of flexiforce sensor for angle measurement
5. Testing of thin film devices for optical and electrical properties
6. Construction of 3-D models of microdevices, blood vessels, bone using Comsol
7. Design of MEMS based microbeam using simulation tools Comsol
8. Design of MEMS based microcantilever using simulation tools Comsol
9. Design of MEMS based microdiaphragm using simulation tools Comsol
10. Design and simulation of MEMS device (pressure sensor) using Comsol
11. Simulation and Analysis of MEMS sensors using Comsol
12. Hardware Testing and Analysis of MEMS sensors using XRD, SEM and spectrometer.

19BM2028	MEDICAL IMAGING TECHNIQUES	L	T	P	C
		3	0	0	3

Course Objectives:

1. Study scattered radiations and different types of radio diagnostic unit
2. Study he techniques to visualize opaque, transparent organs.
3. Study the special techniques adopted to visualize different sections of any organ

Course Outcomes:

The Student will be able to

1. List out the various medical imaging techniques.
2. Explain the principle of specific medical imaging techniques.
3. Interpret the imaging outputs.
4. Identify the suitable medical imaging techniques for specific pathology.
5. Devise new ideas to solve certain issues in medical imaging.
6. Justify the impact of medical imaging system for diagnosis.

Module 1 : **Medical X-Ray Equipment and Digital Imaging (8 Hours)**

Nature of X-Rays - X- ray Absorption - Tissue Contrast . X-Ray Equipment – X- ray Tube, collimator , Bucky Grid, power supply. Digital Radiography - discrete digital detectors, storage phosphor and film Scanning. X-Ray Image intensifier tubes - Fluoroscopy – Digital Fluoroscopy. Angiography, Cine angiography. Digital Subtraction Angiography. Mammography.

Module 2 : **CT Imaging (7 Hours)**

Principles of Tomography - First to Fifth generation scanners – Image reconstruction Technique - Back projection and Iterative method. Spiral CT Scanning - Ultra fast CT Scanners - X-Ray Sources – Collimation – X-Ray Detectors – Viewing System.

Module 3 : **Magnetic Resonance Imaging (MRI) (8 Hours)**

Fundamentals of Magnetic Resonance -Principles of MRI pulse sequence – image acquisition and reconstruction techniques – MRI instrumentation magnetic gradient system RF coils – receiver system functional MRI Rotat ion and Precession – induct ion of a magnetic resonance signal – bulk Magnetization –

Relaxation Processes T1 and T2. – MRI artifacts- Various types of pulse sequences for fast acquisition of imaging, NMR spectroscopy - Application of MRI

Module 4: **Ultrasonic and Infrared Imaging (8 Hours)**

Production of ultrasound – properties and principles of image formation, capture and display – principles of A-mode, B-mode and M-mode display – Doppler ultra sound and color flow mapping – applications of diagnostic ultra sound. Physics of thermography – imaging systems – pyroelectric Videocon camera clinical thermography – liquid crystal thermography.

Module 5: PET and SPECT Imaging (7 Hours)

Introduction to emission tomography, basic physics of radioisotope imaging- Compton cameras for nuclear imaging, pet scanner principles, SPECT, computer techniques in fast acquisition analytic image reconstruction techniques, attenuation, scatter compensation in SPET spatial compensation in SPECT.

Module 6:**Other Imaging Techniques (7 Hours)**

Optical coherence tomography (OCT): Introduction and its medical applications - Advances in image resolutions - Speed in Picture Archiving and Communication Systems (PACS) in medical imaging, Safety aspects in Radio diagnosis.

Text Books:

1. Gopal B Saha , "Physics and Radiobiology of Nuclear Medicine", Third Edition, Springer 2006
2. Myer Kutz, "Standard handbook of Biomedical Engineering and Design," Mc Graw Hill 2003
3. John Ball and Tony Price Chesney's, "Radiographic Imaging". Blackwell Science Limited, U.K. 2006.
4. Farr, "The Physics of Medical Imaging", Adem Hilger, Bristol & Philadelphia, 2007.

Reference Books:

1. M. Analoui, J.D. Bronzino, D.R.Peterson, "Medical Imaging: Principles and Practices", CRC Press, 2012.
2. S. Webb, "Physics of Medical Imaging", Taylor & Francis, 2010.
3. T. Farncombe, K. Iniewski, "Medical Imaging: Technology & Applications", CRC Press, 2013.
4. J.S. Benseler, "The Radiology Handbook: A pocket guide to medical imaging", Ohio University Press, 2006.
5. R.R.Carlton, A.M.Adler, "Principles of Radiographic Imaging: An Art and a Science", Delmar Cengage Learning; Fifth Eddition, 2012.
6. N.B.Smith, A. Webb, "Introduction to Medical Imaging Physics, Engineering and Clinical Applications", CRC Press, 2010.

19BM2029	MEDICAL EQUIPMENT MAINTENANCE AND TROUBLESHOOTING	L	T	P	C
		3	0	0	3

Course Objectives:

1. Understand troubleshooting of electrical and electronic equipment.
2. Learn the troubleshooting of medical equipment.
3. Apply the tools in design, testing and developing medical equipment

Course Outcomes:

1. Identify the reasons for equipment failure.
2. Interpret the need for grounding aspects, maintenance and troubleshooting.
3. Construct the test bench, tools and methods for troubleshooting
4. Compare various standards and specifications.
5. Decide quality and safety standards
6. Formulate advanced methods to solve critical problems.

Module 1: Testing of Electrical Equipments (8 Hours)

AC, DC power supply, Grounding, shielding, Guarding, insulation testing, insulation resistance measurement, Types of Circuit Breakers, Rating – Testing of circuit breakers –Transformer testing- Earthing –Earth wires - Earthing of appliances –contactor, relay testing–CT and PT, Panel wiring- Megger-Testing equipment and instruments.

Module 2: Testing of Electronic Components (7 Hours)

Troubleshooting of PCB boards, Calibration of analog and digital sensor probe, Display interface, DC Power supply design, testing, Safe electrical practice,
Cables and standard, Fuse.

Module 3: Testing of Surgical Equipment (8 Hours)
Functions and operating procedure-Testing and maintenance of Heart lung machine, surgical lights, ventilator, patient monitor, anesthesia machine, dialyzer, surgical tools.
Module 4: Troubleshooting of Equipments (8 Hours)
X-ray machines, Troubleshooting of ECG recorders, incubator, baby warmer, infusion pumps, annual maintenance, contract requirements, vendor services, quality and safety standards.
Module 5: **Life Cycle Management of Medical Equipment (7 Hours)**
Cost of the medical equipment, maintenance cost, replacement analysis, managing equipment service, decision making, extracting optimal benefit from medical equipment over its life cycle. Case study.
Module 6: Reliability in medical devices: (7 Hours) Need for reliability, Tools for reliability assurance, MTBF, MTTR, FMEA, Fault tree analysis, Markov method, cause failure analysis. Human errors in healthcare systems, human factors approach to reduce error, Quality assurance through regulatory compliance: ISO: 9000, FDA, IEEE, ASTM, UL, CE. Computerized Maintenance management system for medical equipment.

Text Books:

1. B.S. Dhillon, "Medical Device Reliability and Associated Areas", CRC Press, UK, 2000.
2. Joseph. J Carr, John M Brown, Introduction to Biomedical Equipment Technology, John Wiley& Sons, New York,4thedition, 2008.
3. Keith Willson, Keith Ison, Slavik Tabakov, "Medical equipment management", CRC Press, UK, 2014.

Reference Books:

1. Jenny Dooley,John Lehnert Virginia Evans, "Career Paths: Medical Equipment Repair", Express Publishing, UK,2018
2. Shakti Chatterjee, Aubert Miller, "Biomedical Instrumentation systems", Cengage Learning Technology & Engineering, 2010.
3. David Herres, "Troubleshooting and Repairing Commercial Electrical Equipment", McGraw Hill Professional edition, 2013.
4. R. S. Khandpur**, "**Troubleshooting Electronic Equipment**"** 1st Edition**,** McGraw Hill, 2007.

19BM2030	19BM2030 HOSPITAL TRAINING	L	T	P	C
		0	0	2	1

Course Objectives:
1. To understand the scope of health care services and health policies.
2. To familiarize the medical device working standards, maintenance procedures
3. To know the need of biomedical engineers in research and development

Course Outcomes:
1. Identify the need and significance of biomedical engineering and health policies.
2. Appreciate the need for standard and quality management in hospitals.
3. Apply the knowledge of computer and information technology in health care.
4. Develop technology to solve human problems.
5. Appraise the code of ethics in design and development
6. Evaluate device safety and ensure a secure hospital environment.

Description
Provide Training to the students on challenges in Hospital equipment maintenance, Hospital Administration and Planning. It helps in developing leaders for solving problems in current issues of technology development, health care services, Telemedicine, Bio-Medical Waste Management and rural healthcare.

BIOMEDICAL ENGINEERING

LIST OF COURSES

S.No.	Course Code	Name of the Course	L:T:P	Credits
1.	18BM2001	Human Anatomy and Physiology	3:0:0	3
2.	18BM2002	Biomedical Sensors and Transducers	3:0:0	3
3.	18BM2003	Biomedical Sensors and Transducers Laboratory	3:0:0	1
4.	18BM2004	Medical Diagnostics and Therapeutic Equipment I	3:0:0	3
5.	18BM2005	Biosignal Conditioning Circuits	3:0:0	1
6.	18BM2006	Biosignal Conditioning Circuits Laboratory	0:0:2	1
7.	18BM2007	Biocontrol System	3:1:0	4
8.	18BM2008	Biomedical Image Processing	3:0:0	3
9.	18BM2009	Biomedical Image processing Laboratory	0:0:2	1
10.	18BM2010	Biosignal Processing	3:0:0	3
11.	18BM2011	Biosignal Processing Laboratory	0:0:2	1
12.	18BM2012	Computational Intelligence	3:0:0	3
13.	18BM2013	Modeling of Physiological systems	3:0:0	3
14.	18BM2014	Real Time Embedded systems	3:0:0	3
15.	18BM2015	Medical Diagnostics and Therapeutic Equipment II	3:0:0	3
16.	18BM2016	Biomedical Instrumentation Laboratory	0:0:2	1
17.	18BM2017	Embedded Based Biomedical System Laboratory	0:0:2	1
18.	18BM2018	Bioelectronics	3:0:0	3
19.	18BM2019	Biomedical Instrumentation	3:0:0	3
20.	18BM2020	Hospital Management	3:0:0	3
21.	18BM3001	Advanced Medical Instrumentation Design	3:0:0	3
22.	18BM3002	Advanced Medical Signal Processing	3:0:0	3
23.	18BM3003	Applied Medical Image Processing	3:0:0	3
24.	18BM3004	Advanced Healthcare System Design	3:0:0	3
25.	18EI3020	Advanced Course in Embedded C	2:0:2	3
26.	18BM3005	Clinical Instrumentation Laboratory	0:0:4	2
27.	18BM3006	Biosensors & MEMS Laboratory	0:0:4	2
28.	18BM3007	Medical Image Processing Laboratory	0:0:4	2
29.	18BM3008	Hospital Training	0:0:4	2
30.	18BM3009	Medical Sensors and MEMS Technology	3:0:0	3
31.	18BM3010	Human Computer Interface	3:0:0	3
32.	18BM3011	Human Assist Devices	3:0:0	3
33.	18BM3012	Cognitive Technology for Biomedical Engineers	3:0:0	3
34.	18BM3013	Finite Element Modeling for Biomedical Engineers	3:0:0	3
35.	18BM3014	Rehabilitation Engineering	3:0:0	3
36.	18BM3015	Machine Learning	3:0:0	3
37.	18BM3016	Robotics in Surgery	3:0:0	3
38.	18BM3017	Telehealth Technology	3:0:0	3
39.	18BM3018	Hospital and Equipment Management	3:0:0	3
40.	18BM3019	Physiological Control Systems	3:0:0	3
41.	18BM3020	Ergonomics in Hospital	3:0:0	3
42.	18BM3021	Medical Ethics and Safety	3:0:0	3
43.	18BM3022	Embedded Systems and IoT in Healthcare	3:0:0	3
44.	18BM3023	Nanotechnology and Applications	3:0:0	3
45.	18BM3024	Biomedical Engineering Entrepreneurship	3:0:0	3
46.	18BM3025	Energy Audit and Management for Hospitals	3:0:0	3

18BM2001	HUMAN ANATOMY AND PHYSIOLOGY	L 3	T 0	P 0	C 3

Course objectives:

To impart knowledge on

1. Basic structural and functional elements of human body.
2. Organs and structures involving in system formation and functions.
3. Understand all systems in the human body.

Course outcomes:

At the end of this course, students will demonstrate the ability to

1. Recall the basic elements of human body.
2. Compare the major bones and their processes as they relate to each region of the body.
3. Interpret the major organs and components of the respiratory system and understand their functions.
4. Recognize the major organs and vessels of the cardiovascular system and understand their functions.
5. Describe briefly the basic components and functions of urinary and special sensing systems.
6. Demonstrate the structure and functions of nervous systems.

Module 1: Basic Elements of Human Body (9 Hours)

Cell: Structure and organelles - Functions of each component in the cell. Cell membrane – transport across membrane – origin of cell membrane potential – Action potential Tissue: Types – Specialized tissues – functions, Types of glands.

Module 2: Skeletal and Respiratory System (7 Hours)

Skeletal system: Bone types and functions – Joint - Types of Joint - Cartilage and functions

Module 3: Respiratory System (7 Hours)

Respiratory System: Components of respiratory system – Respiratory Mechanism. Types of respiration - Oxygen and carbon dioxide transport and acid base regulation.

Module 4: Circulatory System (8 Hours)

Blood composition - functions of blood – functions of RBC.WBC types and their functions Blood groups – importance of blood groups – identification of blood groups. Blood vessels - Structure of heart – Properties of Cardiac muscle – Conducting system of heart -Cardiac cycle – ECG - Heart sound - Volume and pressure changes and regulation of heart rate –Coronary Circulation. Factors regulating Blood flow.

Module 5: Urinary and Special Sensory System (7 Hours)

Urinary system: Structure of Kidney and Nephron. Mechanism of Urine formation and acid base regulation – Urinary reflex – Homeostasis and blood pressure regulation by urinary system. Special senses: Eye and Ear.

Module 6: Nervous System (7 Hours)

Structure of a Neuron – Types of Neuron. Synapses and types. Conduction of action potential in neuron Brain – Divisions of brain lobes - Cortical localizations and functions - EEG. Spinal cord – Tracts of spinal cord - Reflex mechanism – Types of reflex, Autonomic nervous system and its functions.

Text Books:

1. Elaine.N. Marieb,“Essential of Human Anatomy and Physiology”, Eight edition, Pearson Education NewDelhi, 2007.
2. Gillian Pocock, Christopher D. Richards, "The Human Body- An introduction for Biomedical and Health Sciences", Oxford University Press, USA, 2009.

Reference Books:

1. William F. Ganong,"Review of Medical Physiology, 22nd edition, McGraw Hill New Delhi, 2005
2. Eldra Pearl Solomon."Introduction to Human Anatomy and Physiology", W.B.Saunders Company, 2003.
3. Arthur C. Guyton, "Text book of Medical Physiology", 11 th Edition, Elsevier Saunders, 2006
4. Khandpur. R. S., “Handbook of Biomedical Instrumentation”, Prentice Hall of India, New Delhi, 2003.

18BM2002	BIOMEDICAL SENSORS AND TRANSDUCERS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. To provide introduction to the field of medical sensors and an in depth and quantitative view of device design and performance analysis.
2. To provide knowledge on the principle and operation of different medical transducers.
3. To introduce the application of sensors and transducers in the physiological parameter measuring system.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Identify the calibration procedure for the basic instruments involved in physiological parameter measurement.
2. Interpret the errors in measurement by analyzing the performance characteristics of the sensors.
3. Demonstrate the appropriate sensor approach which is most likely to meet a specific biosensor application.
4. Apply the suitable design criteria for developing a medical sensor for a particular application.
5. Develop advanced medical sensors based on the basic transduction principles.
6. Predict the qualitative performance of advanced medical sensors.

Module 1: Science of Measurement (8 Hours)

Generalized Instrumentation System, General properties of input transducer. Static Characteristics: Accuracy, Precision, Resolution, Reproducibility, Sensitivity, Drift, Hysteresis, Linearity, Input Impedance and Output Impedance. Dynamic Characteristics: First Order and Second Order Characteristics, Time Delay, Error Free Instrument, Transfer Functions. Design Criteria, Generalized Instrument Specifications.

Module 2: Biological sensors (7 Hours)

Study of various corpuscles like Pacinian, functions and modelling, Chemoreceptor, hot and cold receptors, baro- receptors, sensors for smell, sound, vision, osmolality and taste.

Module 3: Biosensors (7 Hours)

Introduction, Advantages and limitations, various components of Biosensors, Biocatalysts based biosensors, bio-affinity based biosensors & microorganisms based biosensors, biologically active material and analyte. Types of membranes used in biosensor constructions.

Module 4: Bio potential electrodes (8 Hours)

Electrodes Electrolyte Interface, HalfCell Potential, Polarization, Polarizable and Non Polarizable, Electrodes, Calomel Electrode, Electrode Circuit Model, Electrode Skin-Interface and Motion Artifact. Body Surface Electrodes.Ion exchange membrane, electrodes, oxygen electrodes, CO2 electrodes enzyme electrode, construction, ISFET for glucose, urea.

Module 5: Biochemical Sensors (7 Hours)

Electrolytic sensors, optical sensor, fiber optic sensors. Biosensors in clinical chemistry, medicine and health care.

Module 6: Different transduction principles (8 Hours)

Temperature transducers, thermo resistive transducers, thermoelectric, p-n junction, chemical thermometry. Displacement transducers, potentiometric, resistive strain gauges, inductive displacement, and capacitive displacement transducer. Pressure transducer, indirect method, measurement of blood pressure using sphygmomanometer, instrument based on Korotkoff sound, strain gauge and LVDT transducers, capacitive and piezo-electric type, catheter tip transducers, measurement of intracranial pressure, catheter tip- implantable type.

Text Books

1. Medical Instrumentation-Application and Design by John G. Webster, 2013
2. Transducers for Biomedical Measurements: Principles and Applications, Richard S.C. Cobbold, John Wiley & Sons, 2004.

Reference Books

1. Electronics in Medicine and Biomedical Instrumentation by Nandini K. Jog PHI Second Edition 2013.
2. Instrument Transducer – An Intro to their performance and design, Hermann K P. Neubert.
3. Biomedical sensors – fundamentals and application by Harry N, Norton.
4. Biomedical Transducers and Instruments, Tatsuo Togawa, ToshiyoTamma and P. Akeoberg.

18BM2003	BIOMEDICAL SENSORS AND TRANSDUCERS LABORATORY	L	T	P	C
		0	0	2	1

Course Objectives:

To impart knowledge on

1. To introduce the practical aspects of various medical transducers and their characteristics.
2. To impart knowledge in measurement of Resistance, Inductance and Capacitance using bridges.
3. To improve the skills in calibrating analog meters.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Understand the method of calibration of basic instruments.
2. Analyze the performance characteristics of different sensors.
3. Demonstrate the appropriate sensor approach which is most likely to meet a specific biosensor application.
4. Apply the suitable design criteria for developing a medical sensor for a particular application.
5. Develop advanced medical sensors based on the basic transduction principles.
6. Predict the qualitative performance of advanced medical sensors.

List of Experiments

1. Blood Pressure Measurement
2. Heart Sound Measurement
3. Heart Rate Measurement
4. 4.Pulse Measurement using Doppler Ultrasound
5. Galvanic Skin Resistance Measurement
6. Design of Hearing Aid
7. Temperature Measurement Using Thermistor and LM35
8. Displacement Measurement Using LVDT
9. Displacement Measurement Using Capacitive Transducer
10. Weight Measurement Using Strain Gauge
11. Temperature Measurement Using Resistance Temperature Detector
12. Measurement of Pressure

18BM2004	MEDICAL DIAGNOSTICS AND THERAPEUTIC EQUIPMENT I	L	T	P	C
		3	0	0	3

Course objectives:

To impart knowledge on

1. Principle of various bio potential recordings equipment.
2. Working of equipment used for physiological parameters.
3. Diagnostic and therapeutic procedures

Course outcomes:

At the end of this course, students will demonstrate the ability to

1. Identify the procedures for acquisition of physiological signals
2. Demonstrate the methods for vital and biochemical parameters measurement
3. Describe the functions of various non invasive equipments
4. Illustrate the techniques for cardiac equipment
5. Assess the merits of the respiratory equipment based on its applications
6. Analyse the behavior of electrotherapy equipment.

Module 1: Equipment for physiological signals acquisition (8 Hours)

Bioelectric signals (ECG, EMG, EEG, EOG & ERG) and their characteristics - Electrodes for ECG, EEG and EMG - Einthoven triangle, Standard 12-lead configurations - ECG Machine – EMG machine – 10-20 electrodes placement system for EEG - EEG machine – Heart sound and characteristics, PCG.

Module 2: Vital parameter and biochemical parameter measurement (7 Hours)

Measurement of human body temperature, blood pressure monitor, body mass index, Heart rate, respiration rate, Blood pH, Blood pO2, Blood pCO2 measurement.

Module 3: Equipments for non invasive methods (8 Hours)

Spirometer, cardiac output, blood flow meter and signal conditioning circuits. Heart rate measurement - Apnea detectors - Oximetry -Pulse oximeter, Ear oximeter - Computerized patient monitoring system – Bedside, Central Monitoring system.

Module 4: Cardiac equipment (8 Hours)
External and implantable pacemakers, Programmable pacemakers, Power sources, Design of encapsulation and leads, Pacing system analyzers. Cardiac Defibrillators, Basic principles and comparison of different Defibrillators, Energy requirements, Synchronous operation, Implantable Defibrillators, Defibrillator analyzers.
Module 5: Respiratory equipment (7 Hours)
Principles of constant pressure and constant volume ventilators, Basic principles of electromechanical, Pneumatic and electronic ventilators, Nebulizer, Ventilator testing.
Module 6: Electrotherapy equipment (7 Hours)
Electro diagnosis, Electrotherapy, Electrodes, Stimulators for Nerve and Muscle, Stimulator for pain relief, Interferential current therapy, Spinal cord stimulator, Diaphragm pacing for artificial ventilation. Functional Electrical Stimulation.

Text Books

1. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology",Pearson Education India, Delhi, 2004.
2. Cromwell, "Biomedical Instrumentation and Measurements", Prentice Hall of India, New Delhi, 2007.

Reference Books

1. Khandpur. R. S., "Handbook of Biomedical Instrumentation", Prentice Hall of India, New Delhi, 2003.
2. Jacobson B and Webster J G Medical and Clinical Engineering – Prentice Hall of India New Delhi 1999
3. John Low & Ann Reed. "Electrotherapy Explained, Principles and Practice". Second Edition. Butterworth Heinemann Ltd. 2000.
4. John. G. Webster. "Medical Instrumentation, Application and Design"Fourth Edition. Wiley &sons, Inc, New York.2011.

18BM2005	BIOSIGNAL CONDITIONING CIRCUITS	L	T	P	C
		3	0	0	3

Course Objectives:
To impart knowledge on
1. Bioelectric amplifiers
2. Filters and circuits
3. Application of signal conditioning in biomedical field

Course Outcomes:
At the end of this course, students will demonstrate the ability to
1. Identify the origin and characteristics of various biosignals and its acquisition.
2. Apply the signal conditioning circuits for biomedical field.
3. Analyze and deign bio filters and isolation circuits used in medical signal conditioning.
4. Interface the bioelectric signals with analog and digital circuits for data acquisition
5. Create the various circuits for designing medical equipments using different ICs
6. Recommend the various safety standards in biomedical instrumentation

Module 1: Biopotential Measurement (8 Hours)
Biopotentials and bioelectric currents, Nature of Bio Electricity: Bioelectric Currents, Nernst Potential, Diffusion Potential, Action potential, Detection of Bio electric events, bio-electrode and electrode-skin interface, Need for bioamplifiers and biosignal Conditioning.
Module 2: Operational Amplifiers and Its Biomedical Applications (8 Hours)
Operational Amplifiers Basic opamps parameters, Ideal and practical opamp, application of opamp in biomedicine- Adder, subtractor, analog integrator, differentiator, preamplifiers, Transimpedence circuits.
Module 3: Basic Filters and Isolation Circuits (7 Hours)
Active filters and Medical Isolation Amplifiers: First order and second order active filters, Instrumentation amplifier, Types of isolation amplifiers and optocouplers.
Module 4: Biosignal Data Acquisition Systems (8 Hours)
Comparators, Comparator applications, Multivibrators, 555 timers, Astable and monostable, Pacemaker circuits, Aliasing and sampling, Analog to Digital, Digital to Analog conversion.
Module 5: Special Analog Circuits (7 Hours)
Special analog circuits and systems used in biomedical transmission, Phase Detectors-Analog and Digital, Voltage Controlled Oscillators, Various VCO ICS, Phase locked loops.

Module 6: Advanced Biomedical Instrumentation and Safety Standards (7 Hours)
Modulation and demodulation of biosignals, IC thermometers and advanced biomedical instrumentation systems, Electrical Interface problems and Safety Standards in Bio Potential Measurements.

Text Books

1. Robert B. Northrop, "Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation", CRC Press, II Edition, New York,2017
2. Sergio Franco, "Design with Operational Amplifier and Analog Integrated Circuits", TMH, 3rd Edition, 2009.

Reference Books

1. Myer Kutz, "Biomedical Engineering and Design Handbook", II Edition, Volume 1, McGraw Hill Professional,2011
2. Robert F. Coughlin, Frederick F. Driscoll, "Operational Amplifiers & Linear Integrated Circuits", Prentice-Hall, 6th Edition,2004.
3. Milman & Hallkias, "Integrated Electronics-Analog and Digital Circuit", McGraw Hill, II Edition,2011
4. Roy Choudhury and Shail Jain, "Linear integrated circuits",Wiley Eastern Ltd,2002

18BM2006	BIOSIGNAL CONDITIONING CIRCUITS LABORATORY	L	T	P	C
		0	0	2	1

Course objectives:
To impart knowledge on

1. Design of filters and amplifier circuits for bioelectric amplifiers.
2. Different preamplifiers used for amplifying the bio signals.
3. Application of signal conditioning in biomedical field.

Course outcomes:
At the end of this course, students will demonstrate the ability to

1. Summaries the principles of various digital ICs
2. Identify and apply the amplifiers and various signal conditioning circuits for biosignals acquisition.
3. Demonstrate the basic concepts for filtering of bio signals
4. Design and build various analog and digital interfaces for signal conversion
5. Select suitable circuits to design various biomedical devices
6. Apply and analyze the front end analogue circuit design for ECG, EMG, EEG, etc.

List of Experiments

1. Study of basic digital logic used in biosignal conditioning
2. Study of different data storage flip-flops used in medical hardware's
3. Study of different data storage flip-flops used in medical hardware's
4. Design of basic op-amp circuits for biosignal processing
5. Design of waveshaping circuits
6. Instrumentation amplifier for ECG amplification
7. Design of constant current source and transimpedence circuits.
8. Design of preampilifer circuit
9. Design of medical isolation amplifier
10. Biosignal data acquisition system
11. Design of pacemaker circuit
12. Design of active filters for biosignal acquisition (PPG Signal Acquisition)

18BM2007	BIOCONTROL SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:
To impart knowledge on

1. Bio control systems modeling technique.
2. Time response analysis and frequency response analysis.
3. Analyze biological control systems.

Course Outcomes:
At the end of this course, students will demonstrate the ability to

1. Represent the system in various forms.

2. Interpret the response of the system in time domain.
3. Analyze the frequency response of any system
4. Examine the stability of the system.
5. Compute the mathematical model of physiological systems.
6. Summarize the features of physiological system.

Module 1: Engineering Control Systems (7 Hours)

Basic structure of control system, Positive and Negative Feedback, transfer functions, modeling of electrical systems, block diagram and signal flow graph representation of systems

Module 2: Time Domain Analysis (8 Hours)

Introduction to simulation, Step response of first order and second order systems, determination of time domain specifications of first and second order systems. Definition of steady state error constants and its computation.

Module 3: Frequency Domain Analysis (8 Hours)

Frequency response, determination of gain margin and phase margin using Bode plot, use of Nichol's chart to compute resonant frequency and band width.

Module 4: Stability Analysis (8 Hours)

Definition of stability, Routh-Hurwitz criteria of stability, construction of root locus, Nyquist stability criterion, Nyquist plot and determination of closed loop stability.

Module 5: Physiological Systems (7 Hours)

Difference between engineering and physiological control systems, generalized system properties, models with combination of system elements. Physiological system modeling, linear model of respiratory mechanics.

Module 6: Case Studies (7 Hours)

Mathematical Model of chemical regulation of ventilation, linear model of muscle mechanics, model of regulation of cardiac output, model of Neuromuscular reflex motion

Text Books

1. Michael. C. K. Khoo, "Physiological control systems", IEEE press, Prentice –Hall of India, 2001.
2. Benjamin C. Kuo, "Automatic control systems", Prentice Hall of India, 7th edition, 1995

Reference Books

1. M. Gopal "Control Systems Principles and design", Tata McGraw Hill ,2002
2. John Enderle, Susan Blanchard, Joseph Bronzino, "Introduction to Biomedical Engineering" second edition, Academic Press, 2005.
3. Richard C. Dorf, Robert H. Bishop," Modern control systems", Pearson, 2004.
4. Yazdan Bavafa-Toosi, "Introduction to Linear Control Systems" 1st Edition, 2017

18BM2008	BIOMEDICAL IMAGE PROCESSING	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Digital image fundamentals.
2. Low level image processing techniques.
3. Segment, compress and analyze images

Course outcomes:

At the end of this course, students will demonstrate the ability to

1. Describe the digital image fundamentals for a given condition
2. Illustrate the effect of image enhancement techniques on images
3. Distinguish between image restoration filters
4. Discuss about the image segmentation procedure
5. Compute the level of compression achieved for the given image data
6. Explain and compute features useful for image representation and recognition

Module 1: Digital Image Fundamentals

Introduction – Origin – Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels - color models.

Module 2: Image Enhancement

Spatial Domain:Gray level transformations – Histogram processing – Basics of Spatial Filtering– Smoothing and Sharpening Spatial Filtering – Frequency Domain:Introduction to Fourier Transform – Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters.

Module 3: Image Restoration and Segmentation

Noise models– Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering.

Module 4: Segmentation

Detection of Discontinuities–Edge Linking and Boundary detection – Region based segmentation- Morphological processing- erosion and dilation.

Module 5: Wavelets and Image Compression

Wavelets – Subband coding - Multiresolution expansions - Compression:Fundamentals – Image Compression models – Error Free Compression – Variable Length Coding – Bit-Plane Coding – Lossless Predictive Coding – Lossy Compression – Lossy Predictive Coding – Compression Standards.

Module 6: Image Representation and Recognition

Boundary representation – Chain Code – Polygonal approximation, signature, boundary segments – Boundary description – Shape number – Fourier Descriptor, moments- Regional Descriptors – Topological feature, Texture - Patterns and Pattern classes - Recognition based on matching.

Text book:

1. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata McGraw Hill Pvt. Ltd., 2011.
2. Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd., 2011.

Reference Books:

1. Willliam K Pratt, "Digital Image Processing", John Willey, 2002.
2. Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", First Edition, PHI LearningPvt. Ltd., 2011.
3. Chris Solomon, Toby Breckon, "Fundamentals of Digital Image Processing – A practical approach with examples in Matlab", Wiley-Blackwell, 2010.
4. Jayaraman, "Digital Image Processing", Tata McGraw Hill Education, 2011

18BM2009	BIOMEDICAL IMAGE PROCESSING LABORATORY	L	T	P	C
		0	0	2	1

Course objectives

To impart knowledge on

1. Work with various medical image data
2. Matlab for image processing
3. Process medical images using various methods

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Demonstrate basic operations on a given image to obtain specific output
2. Produce enhanced images using spatial and frequency domain filters
3. Assess the performance of image restoration techniques under given condition
4. Identify the object in a given image through segmentation
5. Show the effect of image compression on given image data
6. Compute the features useful for image analysis

List of Experiments:

1. Basic operations on images
2. Colour conversion of images
3. Image enhancement using spatial domain filters
4. Image enhancement using frequency domain filters
5. Image restoration in the presence of noise alone
6. Image restoration in the presence of noise and degradation
7. Image segmentation using edge and region based methods
8. Morphological operations on images
9. Multiresolution analysis of images using wavelets
10. Image compression using lossless and lossy methods
11. Representation of boundary in an image
12. Extraction of shape and texture features from an image

18BM2010	BIOSIGNAL PROCESSING	L 3	T 0	P 0	C 3

Course Objectives:

To impart knowledge on

1. Signal processing fundamentals.
2. Filter design and its applications.
3. Analyzing biosignals using biosignal processing methods

Course outcomes:

At the end of this course, students will demonstrate the ability to

1. Describe the fundamentals of signal processing
2. Identify the effect of IIR Digital filter design
3. Illustrate the various applications of IIR filter
4. Discuss about the FIR Filter design and applications
5. Show the various methods to analyze biosignals
6. Explain the biosignal processing concepts for real time applications

Module 1: Fundamentals of Signal Processing (7 Hours)

Sampling and aliasing, simple signal conversion systems,Spectral analysis, FFT -decimation in time algorithm, Decimation in Frequency algorithm, Different types of bioelectric signals and its basic characteristics.

Module 2: IIR Digital Filter Design (8 Hours)

Impulse invariant method, Bilinear transformation method, Design of bilinear transformation method using Butterworth and Chebyshev techniques, Design of impulse invariant method using Butterworth and Chebyshev techniques.

Module 3: IIR Digital Filter Applications (8 Hours)

Warping and pre-warping effect, frequency transformation, Frequency domain filters- removal of high frequency noise - Butterworth low pass filters, Removal of low frequency noise - Butterworth high pass filters

Module 4: FIR Digital Filter Design and Its Applications (7 Hours)

Characteristics of FIR filter, FIR filter design using windowing techniques- Rectangular, Hamming, Hanning and Blackmann windows, Time domain filters- synchronized averaging, moving average filters, Introduction to adaptive filters.

Module 5: Analysis of Biosignals (8 Hours)

P-wave detection, QRS complex detection-derivative based method, Pan Tompkins algorithm, Template matching method, Signal averaged ECG, Analysis of heart rate variability-time domain method and frequency domain methods, Synchronized averaging of PCG envelopes, Envelogram, analysis of PCG signal, EMG signal analysis.

Module 6: Case studies in BSP (7 Hours)

ECG rhythm analysis, normal and ectopic ECG beats, analysis of exercise ECG, Analysis of respiration, spectral analysis of EEG signals, Case studies- in ECG and PCG, PCG and carotid pulse, ECG and Atrial Electrogram, Cardio respiratory interaction, EMG and Vibromyogram (VMG).

Text Books:

1. Rangaraj.M.Rangayyan, "Biomedical signal processing", Wiley-IEEE press, 2nd Edition, 2015.
2. S.Salivahnan, C.Gnanapriya, "Digital signal processing", Tata McGraw-Hill, New Delhi, 2nd Edition, 2011.

Reference Books:

1. John G. Proakis and DimitrisG.Manolakis, "Digital signal processing, algorithms and applications", PHI of India Ltd., New Delhi, 4th Edition, 2007.
2. Reddy D.C, "Biomedical signal processing: Principles and techniques", Tata McGraw-Hill, New Delhi, 2nd Edition, 2005.
3. Eugene N. Bruce, "Biomedical Signal Processing and Signal Modeling" 1st Edition, 2001
4. Anke Meyer-Baese, Fabian J. Theis, "Biomedical Signal Analysis: Contemporary Methods and Applications" The MIT Press Cambridge, 2010

18BM2011	BIOSIGNAL PROCESSING LABORATORY	L	T	P	C
		0	0	2	1

Course objectives:

To impart knowledge on

1. Various biosignals
2. Matlab/LabVIEW for biosignal processing
3. Processing biosignals using various methods

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Demonstrate Fourier transformations on a given data
2. Design IIR and FIR filters for the given specification
3. Assess the characteristics of given ECG signal
4. Examine the given EMG signal for specific analysis
5. Show the reason for changes in respiratory signal
6. Demonstrate the usage of software tools for biosignal analysis

List of Experiments:

1. DFT and FFT computation
2. IIR filters design-digital Butterworth filter
3. IIR filters design-digital Chebyshev filter
4. FIR filter design using windowing techniques
5. Adaptive filter design
6. Analysis of PPG signals
7. Detection of QRS complex in ECG
8. Analysis of EMG
9. Analysis of heart rate variability
10. Analysis of respiratory signal
11. Spectral analysis of EEG signals
12. Implementation of bio signal analysis using LabVIEW

18BM2012	COMPUTATIONAL INTELLIGENCE	L	T	P	C
		3	0	0	3

Course objectives:

To impart knowledge on

1. Various soft computing techniques
2. Design of various neural networks
3. Fuzzy logic and genetic algorithm

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Describe various characteristics of artificial neural network
2. Explain the architecture and training algorithm for a given neural network
3. Discuss the fuzzy logic concepts using examples
4. Interrelate genetic algorithm concepts for the given problem
5. Assess the significance of hybridization of soft computing techniques
6. Explain the application of given soft computing technique

Module 1: Introduction to Artificial Neural Networks (8 Hours)

Characteristics- learning methods – taxonomy – Evolution ofneural networks- McCulloch-Pitts neuron - linear separability - Hebb network - supervised learning network: perceptronnetworks - adaptive linear neuron, multiple adaptive linear neuron

Module 2: Types of Neural Networks (8 Hours)

BPN, RBF, TDNN- associative memory network: auto-associative memory network, hetero-associative memory network, BAM,hopfield networks, iterative auto associative memory network & iterative associative memory network –unsupervised learning networks: Kohonen self organizing feature maps, LVQ – CP networks, ART network

Module 3: Fuzzy Logic (8 Hours)

Membership functions: features, fuzzification, methods of membership value assignments-Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - measures of fuzziness -fuzzy integrals - fuzzy rule base andapproximate reasoning : truth values and tables, fuzzy propositions, formation of rules-

decompositionof rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems-overview of fuzzy expertsystem-fuzzy decision making

Module 4: Genetic Algorithm (7 Hours)

Genetic algorithm and search space - general genetic algorithm – operators - Generational cycle - stopping condition – constraints - classification - genetic programming – multilevel optimization – reallife problem- advances in GA

Module 5: Hybrid Soft Computing Techniques (7 Hours)

Neuro-fuzzy hybrid systems - genetic neuro hybrid systems - genetic fuzzy hybrid and fuzzy genetichybrid systems - simplified fuzzy ARTMAP

Module 6: Applications (7 Hours)

A fusion approach of multispectral images with SAR, optimization of traveling salesman problem using genetic algorithm approach, soft computing based hybrid fuzzy controllers

Text Books:

1. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms And Applications" Pearson Eduction, 2010
2. S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.

References:

1. J.S.R.Jang, C.T. Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI / Pearson Education 2004.
2. S.Rajasekaran and G.A.VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithm:Synthesis& Applications", Prentice-Hall of India Pvt. Ltd., 2006.
3. David E. Goldberg, "Genetic Algorithm in Search Optimization and Machine Learning" PearsonEducation India, 2013.
4. Simon Haykin, "Neural Networks Comprehensive Foundation" Second Edition, Pearson Education, 2005

18BM2013	MODELLING OF PHYSIOLOGICAL SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Basic ideas related to modeling.
2. Different modelling techniques of physiological systems.
3. Various regulatory systems of the human body.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Analyze the concepts of modelling
2. Differentiate the dynamics and static characteristics of physiological systems
3. Assemble the various concepts in modelling of circulatory system
4. Design and perform the modelling for physio thermo regulatory systems
5. Create various models for human filtration system
6. Evaluate the mass-balance concept for biological system

Module 1: Basics of physiological control systems (7 Hours)

Systems Analysis, examples of physiological control systems, differences between engineering and physiological control systems. Generalized system properties, mathematical approach, electrical analogs, linear models, lung mechanics, muscle mechanics, distributed parameter versus lumped parameter models

Module 2: Analysis of Physiological Models (7 Hours)

Static and dynamic analysis of physiological systems: regulation of cardiac output, blood glucose regulation, chemical regulation of ventilation, electrical model of neural control mechanism

Module 3: Modelling of Circulatory System (7 Hours)

Circulatory System: Physical, chemical and rheological properties of blood, problems associated with extra corporeal blood flow, dynamics of circulatory system.

Module 4: Modelling of Regulatory System (8 Hours) Thermal Regulatory System: Parameters involved, Control system model etc. Biochemistry of digestion, types of heat loss from body, models of heat transfer between subsystem of human body like skin core, etc. and systems like within body, body, environment, etc.

Module 5: Modelling of Filteration In Human Body (8 Hours) Ultra-Filtration System: Transport through cells and tubules, diffusion, facilitated diffusion and active transport, methods of waste removal, counter current model of urine formation in nephron, Modeling Henle's loop.

Module 6: Modelling and Regulation Of Respiration (8 Hours)
Respiratory System: Modelling oxygen uptake by RBC and pulmonary capillaries, Mass balancing by lungs, Gas transport mechanisms of lungs, oxygen and carbon dioxide transport in blood and tissues

Text Books

1. Physiological control systems: Analysis , Simulation and estimation -IEEE Press Series on Biomedical Engineering, 2018
2. David O Cooney, Biomedical Engineering Principles, Marcel Decker Pub. Co 2002

Reference Books

1. John Enderly, Joseph Bronzino. Introduction to Biomedical Engineering. Third Edition, Academic Press Series in Biomedical Engineering, 2012
2. Willian B.Blesser, "A System Approach to Biomedicine", McGraw Hill Book Co., New York, 2009
3. Manfreo Clynes and John H.Milsum, "Biomedical Engineering System", McGraw Hill and Co., New York , 2001
4. Richard Skalak and ShuChien, "Hand Book of Biomedical Engineering", McGraw Hill and Co. New York, 1998

18BM2014	REAL TIME EMBEDDED SYSTEMS	L	T	P	C
		3	0	0	3

Course Objective:
To impart knowledge on

1. Basic concepts of Embedded Systems
2. Various techniques used for designing an embedded system.
3. Real time system with an examples

Course Outcomes:
At the end of this course, students will demonstrate the ability to

1. Discuss the basics of embedded systems and its hardware units
2. Identify the various tools and development process of embedded system
3. Demonstrate the various I/O interfacing with microcontroller
4. Create the programming for embedded system design
5. Summarize the real time models, languages and operating systems
6. Design a real time embedded system for biomedical applications

Module 1: System Design (7 Hours)
Embedded system, Processor embedded into a system, Embedded hardware units and devices in a system, Embedded software in a system, Embedded system architecture, Classifications, Skills required for an embedded system designer. Typical application scenario ofembedded systems

Module 2: Embedded Systems Design, Development Process and Tools (8 Hours)
Complex systems and microprocessor, Design process and metrics in embedded system, Design challenges, Optimising the design metrics, Issues related to embedded software development, Hardware software co-design, Embedded system design technology, Embedded software development process and tools, Host and Target machine, Linking and Locating Software, Getting embedded software into the target system, Design process and design examples.

Module 3: Real World Interfacing (8 Hours)
Study of microcontroller, Processor and memory organization, Switch, Keypad and LED interfacing, Seven segment display interfacing, Data Acquisition system, A/D, D/A converters, Timers, Counters, Actuators.

Module 4: Programming Concepts (7 Hours)
Programming in assembly language and high level language, C program elements, Embedded C programming- Simple programs, High level language descriptions of software for embedded system, Java based embedded system design.

Module 5: Techniques for Embedded Systems (8 Hours) State Machine and state Tables in embedded system design, Simulation and Emulation of embeddedsystems.Real time models, Language and Operating Systems-Tasks and task states, operating system services, RTOS functions, Interrupt routine in RTOS environment.

Module 6: Applications (7 Hours)
Body temperature measurement, Speed control of DC motor. Stepper motor control. Embedded system in biomedical application- Wireless sensor technologies, Body sensor network, Patient monitoring system.

Text Books

1. RajKamal, "Embedded Systems Architecture, Programming and Design", Tata McGrawHill ,Second Edition, 2008
2. Tim Wilhurst, "An Introduction to the Design of Small Scale Embedded Systems,Palgrave, 2004.

Reference Books

1. Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2005.
2. Frank Vahid, Tony Givargis, "Embedded Systems Design", Wiley India, 2006
3. Khandpur R.S, "Hand-book of Biomedical Instrumentation", Tata McGraw Hill, 2nd Edition, 2003.
4. G. Baura, "A Biosystems Approach to Industrial Patient Monitoring and Diagnostic Devices", Morgan& Claypool, IEEE, 2008.

18BM2015	MEDICAL DIAGNOSTICS AND THERAPEUTIC EQUIPMENT II	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Pulmonary analyzers and aid equipments and their functions on respiratory system
2. Physiotherapy and electrotherapy equipments
3. Instruments dealing with kidney and bones, sensory measurements and special equipments

Course outcome:

At the end of this course, students will demonstrate the ability to

1. Describe the principle involved in clinical and optical equipments
2. Identify the various therapeutic devices for pulmonary diseases.
3. Apply the appropriate therapeutic device related to kidney ailment.
4. Demonstrate the functions and applications of electrotherapy and lasers
5. Assess the merits and demerits of the diagnostic equipments for basic senses.
6. Design new therapeutic devices for particular application based on given specifications.

Module 1: Clinical and Optical Equipments (8 Hours)

Clinical equipment's, glucometer, hemoglobin monitor, Ultrasound scanner, holter monitor, multi parameter monitor, capsule endoscopy, foot scanner., Optical Method - Colorimeter, Spectro photometer, Flame photometer – Chromatography – Mass Spectrometer - Electrical hazard – Micro- and Macro- shock - Patient safety procedures.

Module 2: Pulmonary Analyzers and Optical Equipments (8 Hours)

Regulation of Breathing - Pulmonary gas flow measurements - Pulmonary volume measurements - Respiratory gas analyzers – Nitrogen Gas Analyzer, Oxygen Analyzer - Humidifier, IPPB Unit - Anesthesia machine.

Module 3: Instruments Dealing With Kidney (7 Hours)

Regulation of Water and Electrolyte Balance – Artificial Kidney – Hemo dialysis - Crafts for dialysis - Peritoneal dialysis - Dialyzers – different types.

Module 4: Electrotherapy Equipment and Therapeutic Lasers (7 Hours)

High frequency heat therapy, Principle, Short wave diathermy, Microwave diathermy, Ultrasonic therapy, Lithotripsy, Therapeutic IR radiation, Therapeutic UV Lamps. Basic principles of Biomedical LASERS: Applications of lasers in medicine, CO2 laser, He-Ne laser, Nd-YAG and Ruby laser.

Module 5: Sensory Instrumentation (8 Hours)

Mechanism of Hearing, Sound Conduction System - Basic Audiometer, Pure tone audiometer, Audiometer system Bekesy – Hearing Aids - Ophthalmoscope – Tonometer - Measurement of Basal Skin response and Galvanic skin response - Instruments for testing Motor responses - Experimental Analysis of Behavior - Biofeedback Instrumentation.

Module 6: Special Equipments (7 Hours)

Endoscopy – Laparoscopy - Cryogenic Equipment - Automated drug delivery system – Components of drug infusion system – Implantable infusion systems, BMD Measurements – SXA – DXA - Quantitative ultrasound bone densitometer

Text Books

1. Geoddes L.A, and Baker L.E, "Principles of Applied Biomedical Instrumentation", John Wiley, 3rd Edition, 1975, Reprint 1989.

2. Khandpur R.S, “Hand-book of Biomedical Instrumentation”, Tata McGraw Hill, 2nd Edition, 2003.

Reference Books

1. Stuart MacKay R, “Bio-Medical Telemetry: Sensing and Transmitting Biological Information from Animals and Man”, Wiley-IEEE Press, 2nd Edition, 1968.
2. John G, Webster, “Medical Instrumentation application and design”, JohnWiley, 3rd Edition, 1997.
3. Carr Joseph J, Brown, John M, “Introduction to Biomedical equipment technology”, John Wiley and sons, New York, 4th Edition, 1997.
4. Rajarao C, and Guha S.K, “Principles of Medical Electronics and Biomedical Instrumentation”, Universities press (India) Ltd, First Edition, Orient Longman ltd, 2001.

18BM2016	BIOMEDICAL INSTRUMENTATION LABORATORY	L	T	P	C
		0	0	2	1

Course objective:

To impart knowledge on

1. Recording of bio signals and analyzing.
2. Preamplifiers used for amplifying the bio signals.
3. Measurements and monitoring of physiological parameters.

Course outcome:

At the end of this course, students will demonstrate the ability to

1. Illustrate the working procedure of medical instruments.
2. Identify the suitability of diagnostic and therapeutic equipment for specific applications.
3. Analyze the performance of various biomedical equipment and infer their safety aspects.
4. Apply appropriate measurement techniques.
5. Design portable instruments capable of recording bio signals.
6. Evaluate the performance of medical instruments.

List of Experiments:

1. Real time acquisition of ECG and its analysis
2. Analysis of EEG signal using 10-20 electrode system
3. EMG signal acquisition and Analysis
4. Audiometer
5. Acquisition of Heart sounds using PCG
6. Pulse oximeter
7. Dialyzer
8. Spirometer
9. TENS
10. Real time patient monitoring system
11. Surgical Diathermy – study
12. Defibrillator Models – Study

18BM2017	EMBEDDED BASED BIOMEDICAL SYSTEMS LABORATORY	L	T	P	C
		0	0	2	1

Course Objective:

To impart knowledge on

1. To impart knowledge on the integration of hardwae circuits with software
2. To introduce the concepts of programming in an IDE and download it into a processor
3. To learn about the practical aspects of data acquistion and analysis

Course Outcome:

At the end of this course, students will demonstrate the ability to

1. Design interfacing circuits to acquire real time data and process it using software
2. Develop real time embedded systems for biomedical applications
3. Apply communication protocols for data transmission
4. Create an embedded C program for various I/O interfacing
5. Implement timer concept for providing real time delay
6. Integrate the sensor with microcontroller for embedded system design

List of Experiments:

1. Bit wise port access
2. Interfacing Running Display

3. Interfacing of byte wise input output module
4. Heart rate measurement using timer (for 60 sec)
5. Study of timer interrupt for pulse rate measurement
6. Interfacing temperature sensor
7. Relay Interface
8. Interfacing rehabilitation devices
9. Position control
10. Interfacing communication protocols- I^2C
11. Wave generation for nerve and muscle stimulator
12. Real time application-Simulation

18BM2018	BIOELECTRONICS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Basic structural and functional elements of human cell.
2. Organs and structures involving in system formation and functions.
3. Origin of bioelectric signals and its acquisition.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Analyze the ionic activity in cells and generation of action potential.
2. Illustrate briefly the basic functions of bioelectrodes
3. Demonstrate the medical sensors based on the basic transduction principles.
4. Interpret the cardiac action potentials for diagnostic purpose
5. Recognize briefly the basic components and functions of EEG.
6. Describe briefly the basic methods of various bioelectric signal acquisition

Module 1: Biopotential (7 Hours)

Cell membrane: Structure, Excitable cells, Nernst potential, Resting membrane potential, Polarized state, Goldman Hodgkin Katz equation, Action potential , Propagation of nerve impulses, Refractory period, Hodgkin Huxley model of squid gait axon membranes, Modes of transport of substances across the cell membranes.

Module 2: Bioelectrodes (7 Hours)

Electrode electrolyte interface, Half-cell potential, Polarisable and Non-polarisable electrodes - Skin electrode interface – Bio-electrodes: Surface- Micro-. Needle electrodes - Equivalent circuits of electrodes , pH, pO2, pCO2 - Ion sensitive Field effect Transistors.

Module 3: Electrical Activity of the heart (7 Hours)

Cardiac muscle, Action potentials in cardiac muscle, SA node, Origin and propagation of rhythmical excitation & contraction, refractoriness, regular and ectopic pace makers, Electrocardiogram - Einthoven triangle, Standard 12-lead configurations - ECG Machine, Arrhythmias.

Module 4: Electrical Activity of the brain (8 Hours)

Electrical activity of brain – Sleep stages, Brain waves, waveforms & measurements, Evoked potentials, 10-20 electrodes placement system for EEG - EEG machine.

Module 5: Bioelectric Signal Acquisition (8 Hours)

Bioelectric signals (EMG, EOG & ERG, PPG, PCG) and their characteristics – Electrodes for EMG, PPG, PCG, Heart sound and characteristics, EMG Machine.

Module 6: Biomedical Instruments and measurement of physiological parameters (8 Hours)

Transducer and measurement of physiological events, Resistive transducer – metallic strain gauges, catheter type transducer, catheter tip transducer, Capacitive transducer, Temperature transducers, Pressure transducer-measurement of Blood pressure – Blood flow – Cardiac output measurement – Heart rate – Respiration rate – Measurement of lung volume – Oximeters – Audiometer.

Text Books:

1. Arthur C. Guyton : Textbook of Medical Physiology, Prism Books (Pvt) Ltd &W.B.Saunders Company, 12th edition, 2012
2. Khandpur R S: Handbook of Medical Instrumentation, Tata McGraw Hill, New Delhi.2004.

Reference Books:

1. Electronics in Medicine and Biomedical Instrumentation by Nandini K. Jog PHI Second Edition 2013.
2. Hermann K P. Neubert, Instrument Transducer – An Introduction to their performance and design, 1975.

3. Harry N, Norton, Biomedical sensors – fundamentals and application, 1982
4. L.A. Geddes, L.E.Baker, Principles of applied Biomedical Instrumentation,Third edition,2008.

18BM2019	BIOMEDICAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Fundamentals of anatomy and human physiology system and its functions.
2. Concepts of physiological parameters measurement.
3. Various medical instruments for biomedical applications.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Identify the need of understanding human anatomy and physiology system
2. Select the suitable acquisition method for analysing biomedical signal and vital parameters measurement.
3. Apply the knowledge of biomedical instruments to practical applications
4. Categorize the parameter monitoring techniques based on the application and relevance.
5. Design the various structure for patient safety
6. Develop systems for real time bio signal acquisition and processing.

Module 1: Anatomy and Physiology of Human Body (8 Hours)

The cell and its electrical activity– Principle physiological system: Cardiovascular System, Nervous system, Respiratory system, Muscular system – Origin of bioelectric signal – Bioelectric signals: ECG, EMG, EEG, EOG and their characteristics.

Module 2: Measurement of Physiological Parameters (8 Hours)

Physiological transducers – Measurement of Blood pressure – Blood flow – Cardiac output measurement – Heart rate – Respiration rate – Measurement of lung volume – Oximeters – Audiometer.

Module 3: Therapeutic Equipments and Patient Safety (8 Hours)

Electro Surgical unit: Short wave and microwave diathermy – Laser surgical unit – Defibrillators – Pacemaker – Heart Lung machine – Dialyser – Anesthesia machine – Ventilators – Nerve stimulators – Total artificial heart (TAH) – Patient Safety: Electric Shock Hazards, Leakage Current

Module 4: Clinical Laboratory Instruments (7 Hours)

Clinical Flame photometer – Spectrophotometer – Colorimeter – Chromatography–Blood Gas Analyzer – Blood pH Measurement– Measurement of Blood pCO2– Blood pO2 Measurement– Blood Cell Counters: Types and Methods of cell counting

Module 5: Imaging Technique (7 Hours)

X– ray – C.T. scan – MRI instrumentation – Ultrasound scanner – Vector cardiograph – Echo cardiograph – Angiography

Module 6: Telemetry (7 Hours)

Wireless telemetry, Single channel and multichannel telemetry system– Multi patient Telemetry – Implantable Telemetry systems

Text Books

1. Khandpur. R. S., "Handbook of Biomedical Instrumentation", Prentice Hall of India, New Delhi, 2004.
2. Cromwell, "Biomedical Instrumentation and Measurements", Prentice Hall of India, New Delhi, 2007.

Reference Books:

1. Arthur C. Guyton : Textbook of Medical Physiology, Prism Books (Pvt) Ltd &W.B.Saunders Company, 12th edition, 2012
2. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology",Pearson Education India, Delhi, 2004.
3. Jacobson B and Webster J G Medical and Clinical Engineering – Prentice Hall of India New Delhi 1999
4. John. G. Webster. "Medical Instrumentation, Application and Design"Fourth Edition. Wiley &sons, Inc, New York.2011.

18BM2020	HOSPITAL MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. To understand the need and significance of Clinical Engineering and Health Policies.
2. To familiarize the training strategies, quality management policies and information technology used in health care.
3. To know the needs of managerial training to hospital staffs

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Identify the need for clinical engineering in healthcare system.
2. Evaluate the use of various health policies.
3. Describe how high quality training is delivered for technical staff.
4. Demonstrate the quality management concept in health care.
5. Debate the concepts of quality and safety.
6. Apply the concept of information technology in medicine.

Module 1: Need and scopes of clinical engineering (8 Hours)

Clinical engineering program, Educational responsibilities, Role to be performed by them in hospital, Staff structure in hospital

Module 2: National health policies (7 Hours)

Need for evolving health policy, Health organization in state, Health financing system, Health education, Health insurance, Health legislation.

Module 3: Training and management of technical staff in hospital (8 Hours)

Difference between hospital and industrial organization, Levels of training, Steps of training, Developing Training program, Evaluation of training, Wages and salary, Employee appraisal method.

Module 4: Codes and quality management in health care (8 Hours)

Quality management in hospitals and clinical laboratories, Necessity for standardization and Quality management, NABH and NABL standards, FDA, Joint Commission of Accreditation of hospitals

Module 5: Standards in health care (7 Hours)

ICRP and other standard organization, Methods to monitor the standards, Overview of Medical Device regulation and regulatory agencies.

Module 6: Computers and information technology in medicine and Healthcare (7 Hours)

Computer application in ICU, Picture Archival System (PACS) for Radiological images department, Clinical laboratory administration, Patient data and medical records, Communication, Simulation

Text Books:

1. R.C. Goyal, "Handbook of Hospital Personal Management", Prentice Hall of India, 2008.
2. Joseph. F. Dyro, " Clinical Engineering Management", Academic Press Series in Biomedical Engineering, 2004.

Reference Books:

1. Antony Kelly, "Strategic Maintenance planning", Butterworths London, 2006.
2. Cesar A. Caceres and Albert Zara, "The Practice of Clinical Engineering", Academic Press, 1977.
3. Webster, J.G. and Albert M. Cook, "Clinical Engineering Principles and Practices", Prentice HallInc. Englewood Cliffs, 1979.
4. Webster J.C. and Albert M.Cook, "Clinical Engineering Principle and Practice", Prentice Hall Inc., Englewood Cliffs, New Jersey, 1979.

18BM3001	ADVANCED BIOMEDICAL INSTRUMENTATION DESIGN	L	T	P	C
		3	0	0	3

Course Objectives:

The student should be made to:

1. Understand the fundamentals of human physiology system and its functions.
2. Learn the fundamental concepts of physiological parameters measurement.
3. Apply the concepts of various instrumentation techniques for biomedical applications.

Course Outcomes:

At the end of this course, students will be able to

1. Identify the basic functions of various human physiological systems
2. Demonstrate an interfacing circuit for real time bio signal acquisition

3. Construct the suitable instrumentation technique for a specific illness
4. Categorize the medical devices based on its biomedical applications
5. Assess the various parameters, constraints in methodology for effective diagnosis
6. Design of advanced biomedical equipments for various diseases and ensure patient safety

Module 1: Introduction To Human Physiology: (7 Hours) Circulatory system – cardio vascular system-central nervous system – respiratory system – muscular skeletal system – digestive system – excretory system – sensory organs – voluntary and involuntary action.

Module 2: Biopotentials And Their Measurements(8 Hours) cell and its structure – resting potentials – action potentials – bioelectric potentials – measurement of potentials and their recording – Electrode theory – bipolar and Unipolar electrode-surface electrode – electrode impedance –equivalent circuit for extra cellular electrodes- micro electrodes. basic principles of ECG, EEG, EMG.

Module 3: Advanced Medical Instrumentation: (7 **Hours**) Design of instrumentation system for physiological measurements-temperature, pressure, strain, weight, angle measurements using encoder, flow measurements. Sensor selection for speed, location and acceleration measurement. Case study.

Module 4: Cardiovascular System And Instrumentation (8 **Hours**) Design of instrumentation system for Blood pressure measurement, selection of sensors, design specifications, blood flow measurements, phonocardiography, Cardiac pacemakers, heart lung machines, Tread Mill, Test design of interfacing circuits. Design of interface system. Case study.

Module 5: Respiratory System And Instrumentation: (7 Hours) Mechanics of breathing, regulation of respiration, design of instrumentation system for respiratory system, selection of transducers, artificial respiration therapy, artificial mechanical ventilation, troubleshooting and maintenance of ventilators. Design of interfacing circuits. Case study.

Module 6: Neurological Instrumentation System: (8 Hours) Neurophysiology**,** design of EEG amplifiers, wireless EEG**,** Bispectral Index EEG measurements for depth of anesthesia monitoring.

Reference Books:

1. Joseph J Carr, John M Brown, "Introduction to medical equipment technology", Pearson education publisher, New Delhi, 2013.
2. Steven Schreiner, Joseph D. Bronzino, Donald R. Peterson, **"**Medical Instruments and Devices: Principles and Practices**",** CRC Press, 2017.
3. John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, New York, 2009.
4. Joseph D. Bronzino, "The Biomedical engineering handbook", Vol I, CRC press, 2000.
5. Myer Kutz, "Standard Handbook of Biomedical Engineering& Design", McGraw Hill Publisher,UK,2003.
6. Leslie Cromwell, "Biomedical Instrumentation and measurement", Prentice hall of India, New Delhi, 2007.

18BM3002	ADVANCED MEDICAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

Course Objective

The student should be made to:

1. Know the basic concepts of Bio signal Processing
2. Learn about the filtering techniques used in Medical Signal Processing
3. Understand the Applications of Signal Processing for Diagnosis.

Course Outcome:

Upon the completion of this course, the student will be able to:

1. Summarize the basic concepts of digital signal processing techniques.
2. Identify the nature of Biomedical signals.
3. Apply the Filtering Techniques.
4. Analyze the Noise Cancellation Techniques for Biosignals.
5. Understand various Techniques for Detection of Events.
6. Develop systems for Biosignal Acquisition and Analysis

Module 1: Overview of Digital Signal Processing And Applications(7 Hours) - Sampling and aliasing , Signal reconstruction, Signal conversion systems, convolution - Correlation - FFT - decimation in time algorithm, Decimation in Frequency algorithm

Module 2: Introduction to biomedical signals: (8 **Hours**) Nature of biomedical signals - Examples of biomedical signals-EEG, EMG,ECG, VMG, VAG, evoked potentials, Event Related Potentials, Speech Signal, Bioacoustic signals - Objectives and Difficulties of Biomedical Signal Analysis

Module 3: Filtering Techniques:(7 Hours) Random Noise, Structured Noise, and Physiological Noise Time domain filtering – Synchronous averaging, Moving average filters, Frequency domain filters – Design of Butterworth filters- optimal filtering.

Module 4: Noise Cancellation in Bio Signals: (8 **Hours**) Adaptive noise cancellation-LMS and RLS algorithms in adaptive filtering – Application: Motion Artifacts in ECG, Powerline Interference in ECG, Maternal Interference in ECG.

Module 5: Analysis of Biosignals: (7 **Hours**) Cardiological Signal Processing - Methods in Recording ECG , Waves and Intervals of ECG - ECG Data Acquisition , ECG Parameters and Their Estimation - ECG QRS Detection Technique - Template Matching Technique - Differentiation Based QRS Detection Technique - Simple QRS width Detection Algorithm - High Speed QRS detection Algorithm - Estimation of R-R Interval - Estimation of ST Segment - Analysis of PCG signal - Analysis of EMG signal and EEG Signal.

Module 6: Applications: (8 **Hours**) Adaptive Segmentation of ECG and PCG signals - Time varying analysis of heart rate variability - Detection of Coronary Artery Disease - Analysis of Ectopic ECG beats.

Reference Books:

1. Rangaraj M. Rangayyan, "Biomedical signal analysis", John Wiley & Sons.Inc. 2002
2. Monson H.Hayes, "Statistical Digital signal processing", John Wiley & Sons.Inc 1996
3. Arnon Cohen, "Biomedical Signal Processing" Vol I and II,CRC Press, Florida, 1988.
4. D.C.Reddy, "Biomedical Signal Processing: Principles and Techniques, Tata McGraw Hill Pub, Third reprint 2007.
5. Sanjit K.Mitra "Digital Signal Processing", A Computer Based Approach", Tata McGraw-Hill, New Delhi, fourth edition 2011.
6. John G. Proakis and Dimitris G.Manolakis, "Digital Signal Processing, Algorithms and Applications", PHI of India Ltd., New Delhi, fourth Edition, 2007.

18BM3003	APPLIED MEDICAL IMAGE PROCESSING	L	T	P	C
		3	0	0	3

Course Objectives:

The student should be made to:

1. Learn the fundamentals of medical image processing
2. Understand various medical image processing techniques
3. Apply the methodologies for clinical applications

Course Outcomes:

Upon the completion of this course, the student will be able to:

1. Describe the fundamentals to represent the images as per the given requirement
2. Discuss the segmentation method for a given clinical application
3. Explain the spatial transformation and its use for medical application
4. Distinguish between various rendering techniques on medical images
5. Assess the effect of image registration with respect to clinical application
6. Discuss the techniques for reconstruction of CT images

Module 1: Image Representation: (7 Hours) Pixels and voxel**s,** gray scale and color representation, image file formats, DICOM, other formats- intensity transform functions, and the dynamic range, windowing, histogram and histogram operations, dithering and depth, filtering and Fourier transform.

Module 2: Segmentation: (8 Hours) The segmentation problem, Region of interest and centroid, theresholding, region growing, sophisticated segmentation methods, morphological operations, evaluation of segmentation results-Clinical applications.

Module 3: Spatial Transforms: (7 Hours) Discretization**,** interpolation and volume regularization, translation and rotation, reformatting, tracking and image guided therapy

Module 4: Rendering And Surface Models: (8 **Hours**) Visualization, orthogonal and perspective projection, and their view point, raycasting, surface based rendering-Clinical applications.

Module 5: Registration: (7 Hours) Fusing information, registration paradigm, merit functions, optimization strategies-camera calibration, registration to physical space-evaluation of registration results - Clinical applications.

Module 6: CT Reconstruction: (8 Hours) Introduction-Radon transform-algebraic reconstruction-Fourier transform and filtering-filtered back projection-Clinical applications.

Reference Books:

1. Wolfgang Birkfellner, "Applied medical Image Processing- A basic course", Second Edition, CRC Press, 2014.

2. Rafael C. Gonzales, Richard E. Woods, “Digital Image Processing”, Third Edition, Pearson Education, 2010.
3. Anil Jain K. “Fundamentals of Digital Image Processing”, PHI Learning Pvt. Ltd., 2011.
4. William K. Pratt, “Introduction to Digital Image Processing”, CRC Press, 2013.
5. Chris Solomon, Toby Breckon, “Fundamentals of Digital Image Processing – A practical approach with examples in Matlab”, Wiley-Blackwell, 2010.
6. Jayaraman, “Digital Image Processing”, Tata McGraw Hill Education, 2011.

18BM3004	ADVANCED HEALTHCARE SYSTEM DESIGN	L	T	P	C
		3	0	0	3

Course Objectives:

The student should be made to:

1. Understand the needs for wearable devices and the technology
2. Learn the concepts in digital health care and digital hospitals
3. Apply the tools in design, testing and developing digital health care equipment

Course Outcomes:

At the end of this course, students will be able to

1. Identify the available technology for wearable healthcare devices
2. Interpret the need for digital methods of handling medical records
3. Modify the tools and methods for work flow
4. Compare various standards for inter-operability of devices
5. Decide quality and safety standards for developing healthcare systems
6. Formulate advanced strategies for innovation to societal needs.

Module 1: Wearable Devices And M-Health Care: (7 Hours) Introduction to mobile health care-devices-economy-average length of stay in hospital, outpatient care, health care costs, mobile phones, 4G, smart devices, wearable devices, Uptake of e-health and m-health technologies. Standards, system Design and case study.

Module 2: Digital Radiology: (8 Hours) Digital radiology for digital hospital, picture archiving and communication, system integration, digital history of radiology, medical image archives, storage and networks.

Module 3: E-Health: (7 Hours) Health care networking, Medical reporting using speech recognition, physiological tests and functional diagnosis with digital methods, tele-consultation in medicine and radiology.

Module 4: Modality: (8 Hours) Multimodality registration in daily clinical practice. Mobile healthcare. Case study.

Module 5: Digital Health: (7 Hours) Requirements and best practices, Laws and regulations in Digital health, Ethical issues, barriers and strategies for innovation.

Module 6: Standards For Inter Operability: (8 Hours) Selection and Implementation in e-Health project, design of medical equipments based on user needs. Security and privacy in digital health care.

Reference Books:

1. Wlater Hruby, “ Digital revolution in radiology – Bridging the future of health care, second edition, Springer, New York. 2006.
2. Christoph Thuemmler, Chunxue Bai, “Health 4.0: How Virtualization and Big Data are Revolutionizing Healthcare”, Springer, 1st ed. 2017.
3. Samuel A. Fricker, Christoph Thümmler , Anastasius Gavras, “Requirements Engineering For Digital Health”, Springer, 2015.
4. Rick Krohn (Editor), David Metcalf, Patricia Salber, “Health-e Everything: Wearables and The Internet of Things for Health, ebook. 2013.
5. Khandpur,R.S,”Handbook of Biomedical Instrumentation ”,Second Edition. Tata Mc Graw Hill Pub. Co., Ltd. 2003
6. John, G. Webster. Medical Instrumentation: Application and Design. Second Edition. Wiley Publisher, New Delhi. 2013.

18BM3005	CLINICAL INSTRUMENTATION LABORATORY	L	T	P	C
		0	0	4	2

Course objectives

The student should be made:

1. To enable the students to know about the measurements and recording of Bioelectric and Bio Chemical Signals.
2. To work with signal interface for monitoring
3. To study the different preamplifiers used for amplifying the Bio Signals

Course Outcomes:

Upon completion of the course, the student should be able to:

1. Demonstrate the design of biosignal amplifiers
2. Identify the interfacing methodology
3. Analyse the signal by feature extraction
4. Experiment the physiological parameters and its effects
5. Indicate the functions of surgical equipments
6. Perform biochemical measurements

LIST OF EXPERIMENTS

1. Operational Amplifier-various amplifier configurations
2. Study of Timer circuit, Study of FSK modulation and demodulation
3. Design and testing of Bio-Amplifiers
4. Record and analyze the ECG signal
5. Record and analyze the EMG signal.
6. Record and analyze the EEG signal.
7. Record and analyze the PPG signal.
8. Recording of various physiological parameters using patient monitoring system
9. Study and analysis of functioning and safety aspects of surgical diathermy
10. Study and analysis of functioning of ultrasound imaging scanner
11. Respiration rate measurement using spirometer
12. Blood count measurement using blood cell counter
13. Blood pH measurement using pH meter
14. Bio-chemical measurements

18BM3006	BIOSENSORS AND MEMS LABORATORY	L	T	P	C
		0	0	4	2

Course Objectives:

The student should be made to:

1. Acquire, record, analyze MEMS sensors for specific applications
2. Study the design of micro devices, fabrication and testing methods
3. Impart knowledge about the application development

Course Outcomes:

At the end of this course, students will be able to

1. Examine the functions, performance of MEMS sensors in medical applications
2. Classify the methods in thin film and 3D printing process.
3. Illustrate the appropriate design standards and constrains
4. Experiment the performance of sensors in simulation tools
5. Assess the functions of new microsensors and test the performance.
6. Integrate the MEMS sensors for developing medical applications.

LIST OF EXPERIMENTS

1. Design, selection and testing the performance of microsensor for medical applications
2. Design, selection and testing the performance of biochemical sensor
3. Design and testing the performance of strain sensor for biomechanics applications
4. Design and testing the performance of angle sensor for biomechanics applications
5. Study the methodologies of PVD and CVD process for developing medical application
6. Study the methodology of thin film process and develop medical application
7. Testing of thin film devices using, XRD, optical, electrical and SEM.
8. Fabrication and testing of 3D bioprint models for prosthetics and implants
9. Design of MEMS device and analysis using simulation tools Comsol, MatLab
10. System integration for biomedical application for human Gait analysis.

18BM3007	MEDICAL IMAGE PROCESSING LABORATORY	L	T	P	C
		0	0	4	2

Course objectives

The student should be made to:

1. Work with various medical image data
2. Have experience in MatLab for image processing
3. Process medical images using various methods

Course Outcomes:

Upon completion of the course, the student should be able to:

1. Demonstrate the manipulation of images for the specified requirement
2. Identify the region of interest using segmentation and morphological operations
3. Modify the image geometry for specific purpose
4. Show the effect of rending on given image
5. Indicate the results of fusion and registration of images
6. Demonstrate image reconstruction using the given data

List of Experiments:

13. Basic operations on medical images
14. Enhancement of medical images
15. Image segmentation using thresholding and region based methods
16. Morphological operations on medical images
17. Translation and rotation of medical images
18. Image reformatting and tracking
19. Volume rendering
20. Surface rendering
21. Methods for medical image fusion
22. Image registration methods
23. Radon Transform
24. Image reconstruction

18BM3008	HOSPITAL TRAINING	L	T	P	C
		0	0	4	2

Course objectives

The student should be made to:

1. Work and testing of various medical equipments
2. Have experience in hospital work environment
3. Assess various methods of quality in medical devices

Course Outcomes:

Upon completion of the course, the student should be able to:

1. Demonstrate the functions of medical equipments
2. Identify the specifications, operating procedure, and maintenance log
3. Modify the applications for specific purpose
4. Experiment the effect of human factors on design of medical devices
5. Access the regulations, standards and certification of devices
6. Integrate the functions, analyse the data and develop methodologies

List of Experiments:

1. Study and testing of the instruments for vital sign monitoring
2. Study and testing of the instruments for respiration monitoring
3. Study and testing of the anesthesia machine
4. Study and testing of the instruments for post operative care
5. Study and testing of the equipments in ICU, ICCU, HDU, NICU
6. Study and testing of the equipments in operation theatre
7. Study and testing of the equipments for minimally access surgery
8. Study and testing of the equipments in dentistry
9. Study and testing of the equipments in urology
10. Study and testing of the equipments for chemotherapy
11. Study and testing of the equipments for physiotherapy
12. Study and testing of the equipments for podiatry
13. Study on Equipments for waste handling and regulations

14. Study on quality standards, medical record and certification
15. Handling of power sources, water and general maintenance practices

18BM3009	MEDICAL SENSORS AND MEMS TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

The student should be made to:

1. Understand the in depth and quantitative view of medical sensors and its characteristics
2. Knowledge of the current state of the art to micro sensor fabrication methods
3. Apply the tools to design and development of sensors for the medical applications

Course Outcome:

At the end of this course, students will be able to

1. Identify the principle of medical sensors and its interfacing circuits
2. Classify the micro sensor materials, synthesis, fabrication and its characterization
3. Choose the design tools to test and develop products to required specifications
4. Infer the most relevant challenges facing in the fabrication process
5. Judge a sensor based on standard performance criteria and environmental impact
6. Construct the micro system for appropriateness for an application and user.

Module 1: Classification Of Medical Sensors: (**7 Hours**) Sensors for Pressure Measurement- Sensors for Motion and Force Measurement- Sensors for Flow Measurement -Temperature Measurement- Sensors for speed, torque, vibration- smart sensors, design of interface system.

Module 2: Microsystem Design: (8 **Hours**) Technological Breakthrough, Dielectrics for Use in MEMS Applications, Piezoelectric Thin Films for MEMS Applications, Modeling of Piezoelectric MEMS, Interface Circuits for Capacitive MEMS Gyroscope, Advanced MEMS Technologies for Tactile Sensing and Actuation, MEMS-Based Micro Hot-Plate Devices, Inertial Sensor. Design of microsystem for sensing and control. Case study.

Module 3: Material For MEMS And NEMS: (7 Hours) Working principle of Microsystems, materials for MEMS and Microsystems, micromachining, System modeling, Properties of materials, Synthesis, selection and characteristics of materials.

Module 4: Fabrication Methods: (8 Hours) Clean room, microfabrication methods, Lithography, epitaxy, sputtering, deposition, surface and bulk micromachining. Case study.

Module 5: Microsensors And Actuators: (7 Hours) Mechanical sensors and actuators – beam and cantilever, piezoelectric materials, thermal sensors and actuators- micromachined thermocouple probe, Peltier effect, heat pumps, thermal flow sensors, micro gripper microlens, microneedle, micropumps-Testing of the performance using software tools.

Module 6: Software Tools: (8 Hours) Modeling and design, using MatLab, Design of sensors, pressure sensor, vibration sensor, actuators Analysis using solvers, MatLab, Comsol, mechanical solver, electrical solver.

Reference Books:

1. Vikas Choudhary, Krzysztof Iniewski, “MEMS: Fundamental Technology and Applications”, CRC Press, UK, 2017.
2. Tatsuo Togawa; Toshiyo Tamura; P. Ake Oberg, “Biomedical Sensors and Instruments”, CRC Press,UK 2011.
3. Octavian Adrian Postolache and Subhas Chandra Mukhopadhyay, “Sensors for Everyday Life: Healthcare Settings (Smart Sensors, Measurement and Instrumentation), CRC Press, 2017.
4. Gabor Harsanyi, “Sensors In Biomedical Applications: Fundamentals, Technology & Applications”, CRC Press, USA, 2000.
5. Tai Ran Hsu, “MEMS and Microsystems Design and Manufacture”, Tata McGraw Hill Publishing Company, New Delhi, 2002.
6. Marc J. Madou ‘Fundamentals of Microfabrication: The Science of Miniaturization’, CRC Press, 2002.

18BM3010	HUMAN COMPUTER INTERFACE	L	T	P	C
		3	0	0	3

Course objectives:

The student should be made to:

1. Understand the fundamentals of EEG signal acquisition techniques
2. Learn the feature extraction methods

3. Design EEG based robotic application

Course outcomes:

At the end of this course, students will be able to

1. Identify the data acquisition methods for EEG signal
2. Classify the types of signals and its components
3. Choose the design tools to develop simulation models
4. Classify the signals to develop the applications
5. Assess the systems based on the design specifications
6. Construct the applications for medical diagnosis and robots

Module 1: Human Computer Interaction: (7 Hours) Introduction to theories within cognitive and perceptual psychology, human decision making and actions in computer supported situations. Design and construction, Interaction between human and computerized technical systems.

Module 2: Introduction To Brain Computer Interfaces: (8 **Hours**) Concept of BCI, Invasive and Non-invasive Types, EEG Standards, Signal Features, Spectral Components, EEG Data Acquisition, Pre-processing, Hardware and Software, Artifacts, Methods to Remove, Near Infrared BCI.

Module 3: BCI Approaches: (7 **Hours**) Movement Related EEG Potentials, Mental States, Visual Evoked Potential. P300 virtual platform.

Module 4: EEG Feature Extraction Methods: (8 Hours) Time/Space Methods, Fourier Transform, Wavelets, AR models, Band pass filtering, PCA, Laplacian Filters, Linear and Non-linear Features.

Module 5: EEG Feature Translation Methods: (7 **Hours**) LDA, Regression, Memory Based Vector Quantization, Gaussian Mixture Modeling, Hidden Markov Modeling.

Module 6: BCI Controlled Robots: (8 **Hours**) Case Study of Problems in BCI, Case Study of Brain Actuated Control applications.

Reference Books:

1. Chang S. Nam (Editor), Anton Nijholt (Editor), Fabien Lotte, " Brain–Computer Interfaces Handbook: Technological and Theoretical Advances", CRC Press, UK. 2018.
2. Maureen Clerc, Laurent Bougrain, Fabien Lotte, "Brain Computer Interfaces 2: Technology and Applications", Wiley Publisher, 2016.
3. Rajesh P. N. Rao, "Brain-Computer Interfacing: An Introduction", 1st Edition, Cambridge University Press, 2018.
4. Andrew Webb, "Statistical Pattern Recognition", Wiley International, Second Edition, 2002.
4. R.Spehlmann, "EEG Primer", Elsevier Biomedical Press, 1981.
5. Bishop C.M, "Neural Networks for Pattern Recognition", Oxford, Clarendon Press, 1995.

18BM3011	HUMAN ASSIST DEVICES	L	T	P	C
		3	0	0	3

Course Objective:

The student should be made to:

1. Introduce the Fundamental terms and concepts of human assist devices
2. Learn various assist device functions and characteristics.
3. Apply design tools for modeling and analysis of assist devices

Course Outcomes:

At the end of this course, students will be able to

1. Identify the requirements for human assist devices
2. Classify the systems based on applications
3. Relate soft tools for analysis and design of devices for specific applications
4. Infer the merits of human assist system and its influence to environment.
5. Choose the methodologies in measurement systems and conditions
6. Combine instrumentation techniques for development of assist devices to human needs

Module 1: Heart Lung Machine And Artificial Heart: (7 **Hours**) Condition to be satisfied by the H/L System. Different types of Oxygenators, Pumps, Pulsatile and Continuous Types, Monitoring Process, Shunting, The Indication for Cardiac Transplant, Driving Mechanism, Blood Handling System, Functioning and different types of Artificial Heart, Mock test setup for assessing its Functions.

Module 2: Cardiac Assist Devices: (8 **Hours**) Synchronous Counter pulsation, Assisted through Respiration Right Ventricular Bypass Pump, Left Ventricular Bypass Pump, Open Chest and closed Chest type, Intra Aortic Balloon Pumping, Arterial Pumping, Prosthetic Cardio Valves, Principle and problem, Biomaterials for implantable purposes, its characteristics and testing. Case study.

Module 3: Artificial Kidney: (7 **Hours**) Indication and Principle of Hemodialysers, Membrane, Dialysate, Different types of hemodialysers, Monitoring Systems, Wearable Artificial Kidney, Implanting Type- Modeling and analysis. Case study.

Module 4: Prosthetic And Orthodic Devices: (8 Hours) Hand and Arm Replacement - Different Types of Models Externally Powered Limb Prosthesis Feedback in Orthodic System, Functional Electrical Stimulation, Haptic Devices

Module 5: Respiratory And Hearing Aids: (7 **Hours**) Intermittent positive pressure, Breathing Apparatus Operating Sequence, Electronic IPPB unit with monitoring for all respiratory parameters. Types of Deafness, Hearing Aids- Construction and Functional Characteristics.

Module 6: Sensory Augmentation And Substitutions: (8 Hours) Classification of Visual Impairments, Prevention and cure of visual impairments, Visual Augmentation, Tactile vision substitution, auditory substitution and augmentation, tactile auditory substitution, Assistive devices for the visual impaired

Reference Books:

1. Kolff W.J, "Artificial Organs", John Wiley and Sons, New York, 1979.
2. Andreas.F.Vonracum,"Hand book of biomaterial evalution",Mc-MillanPublishers, 1980.
3. Albert M.Cook, Webster J.G., "Therapeutic Medical Devices", Prentice Hall Inc., New Jersey, 1982.
4. John. G. Webster – Bioinstrumentation - John Wiley & Sons (Asia) Pvt Ltd, 2004.
5. Muzumdar A., "Powered Upper Limb Prostheses: Control, Implementation and Clinical Application, "Springer, 2004.
6. Rory A Cooper, "An Introduction to Rehabilitation Engineering, Taylor & Francis, CRC Press, UK. 2006.

18BM3012	COGNITIVE TECHNOLOGY FOR BIOMEDICAL ENGINEERS	L	T	P	C
		3	0	0	3

Course objectives

The student should be made to:

1. Learn the various soft computing frame works
2. Be familiar with design of various neural networks and fuzzy logic
3. Learn genetic programming and hybrid systems

Course Outcomes:

Upon completion of the course, the student should be able to:

1. Identify various soft computing frame works
2. Interpret various neural networks and fuzzy logic methods
3. Relate genetic programming and hybrid soft computing
4. Select computing techniques for biomedical applications
5. Assess hybrid techniques
6. Design diagnostic and therapeutic methods

Module 1: Introduction To Artificial Neural Networks: (7 Hours) Characteristics- learning methods – taxonomy – Evolution of neural networks- McCulloch-Pitts neuron - linear separability - Hebb network - supervised learning network: perceptron networks - adaptive linear neuron, multiple adaptive linear neuron.

Module 2: Types Of Neural Networks:(8 Hours) BPN, RBF, TDNN- associative memory network: auto-associative memory network, hetero-associative memory network, BAM, hopfield networks, iterative autoassociative memory network & iterative associative memory network – unsupervised learning networks: Kohonen self organizing feature maps, LVQ – CP networks, ART network. Case studies on biomedical applications.

Module 3: Fuzzy Logic: (7 Hours) Membership functions: features, fuzzification, methods of membership value assignments- Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - formation of rules-decomposition of rules, fuzzy inference systems-overview of fuzzy expert system-fuzzy decision making. Case studies on biomedical applications.

Module 4: Genetic Algorithm: (8 Hours) Genetic algorithm and search space - general genetic algorithm, operators - Generational cycle, stopping condition, constraints. Classification, genetic programming, multilevel optimization, real life problem, Advances in GA. Case studies on biomedical applications.

Module 5: Hybrid Soft Computing Techniques: (7 Hours) Neuro-fuzzy hybrid systems - genetic neuro hybrid systems - genetic fuzzy hybrid and fuzzy genetic hybrid systems - simplified fuzzy ARTMAP. Case studies on biomedical applications.

Module 6: Applications: **(8 Hours)** A fusion approach of multispectral images with SAR, optimization of traveling salesman problem using genetic algorithm approach, soft computing based hybrid fuzzy controllers. Case studies on biomedical applications.

Reference Books:

1. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications" Pearson Education, 2010.
2. S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.
3. J.S.R.Jang, C.T. Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", Pearson Education 2004.
4. S.Rajasekaran and G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd., 2006.
5. George J. Klir, Ute St. Clair, Bo Yuan, "Fuzzy Set Theory: Foundations and Applications", Prentice Hall, New Delhi. 1997.
6. Simon Haykin, "Neural Networks Comprehensive Foundation", Second Edition, Pearson Education, 2005.

18BM3013	FINITE ELEMENT METHODS FOR BIOMEDICAL ENGINEERS	L	T	P	C
		3	0	0	3

Course Objectives:

The students should be made to**:**

1. Understand the concepts of finite element methods for biomechanical analysis
2. Study beam elements and scalar problem in two dimension
3. Create applications to field problems

Course Outcomes:

At the end of this course, the students should be able to:

1. Define finite element formulation
2. Identify boundary conditions and mesh elements
3. Relate finite element analysis in biomechanical research
4. Select the tools and develop the models
5. Assess the models and observe the performance
6. Create physiological model for biomedical applications

Module 1: Introduction To Modeling: (7 Hours)

Historical Background, Mathematical Modeling of field problems in Engineering, Governing Equations, Natural and Essential Boundary conditions - Basic concepts of the Finite Element Method. One Dimensional Second Order Equations, Discretization, element types- Linear and Higher order Elements Derivation of Shape functions and Stiffness matrices and force vectors Assembly of Matrices - solution of problems from solid and bio mechanics- Structural, stress, and strain analysis of the human body and/or artificial implants.

Module 2: Beam Elements And Scalar Problem In Two Dimention (8 Hours)

Fourth Order Beam Equation Transverse deflections - Natural frequencies of beams and Longitudinal vibration. Second Order 2D Equations involving Scalar Variable Variational formulation Finite Element formulation Triangular elements Shape functions and element matrices and vectors. Application to Field Problems in Bio mechanics, Quadrilateral elements.

Module 3: Applications To Field Problems: (7 Hours)

Higher order elements. Natural co-ordinate systems Isoparametric elements Shape functions for isoparametric elements One, two and three dimensions Serendipity elements Numerical integration and application to plane stress problems transformation in coordinates- Jacobian of transformation- order of convergence- numerical integration example problems- shape functions in natural coordinates- rectangular elements- Lagrange family- Serendipity family rectangular prisms- tetrahedral elements.

Module 4: Isoparametric Formulation And Miscellaneous Topics (8 Hours)

Introduction to elasticity equations stress strain relations plane problems of elasticity element equations Plane stress, plane strain and axisymmetric problems stress-strain-time or constitutive equations for soft connective tissue components Modelling and force analysis of musculoskeletal systems Stress calculations

Module 5: Non-Linear Analysis (7 Hours)
Introduction to Non-linear problems - some solution methods- computational procedure- simple material nonlinearity, stress stiffening, contact interfaces- problems of gaps and contact- geometric non-linearity- modeling considerations.
Module 6: Impact Analysis: (8 Hours) Mechanical properties of biological and commonly used biomedical engineering materials - Critical reviews of finite element analysis in biomechanical research.

Reference Books:

1. J N Reddy, "Finite element methods", Tata Mc GrawHill, 2003.
2. Seshu, "Text Book of finite element analysis", Prentice Hall, New Delhi, 2003.
3. Connie McGuire, "Finite Element Analysis: Biomedical Aspects", NY Research press, 2015.
4. Moratal D., "Finite Element Analysis from Biomedical Applications to Industrial Developments", InTech Publisher, 2014.
5. King-Hay Yang, "Basic Finite Element Method as Applied to Injury Biomechanics", Elsevier Academic Press. 2017.
6. Suvranu De and Farshid Guilak, "Computational Modeling in Biomechanics", Springer, 2010.

18BM3014	REHABILITATION ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:
The student should be made to:
1. Know about various types of disability and its rehabilitation models
2. Understand the integration of sensor and actuators to combat disability
3. Build rehabilitation robots for training and applications in rehabilitation

Course Outcomes:
At the end of this course, students will be able to
1. Describe the basic terminology in rehabilitation and models for societal applications
2. Classify the sensors and actuators for particular applications.
3. Discover the new methodology and systems for societal needs related to disability
4. Compare the devices and methods under various environmental conditions
5. Criticize the design, performance, cost, user need and affordability
6. Develop the products based on cost effectiveness, user needs, environment friendly

Module 1: Introduction To Rehabilitation: (7 Hours) Introduction, models, Health, disability, quality of life, Safety standards, Community based rehabilitation, independence, mobility, reforms.
Module 2: Transducer And Actuators For Rehabilitation: (8 Hours) Linear and Angular displacement transducer, velocity Strain, Force measurement, Motion sensor-accelerometer, Proximity sensor, optical encoder Electrical actuators for rehabilitation, electromechanical mechanism, Pneumatic actuators, Hydraulic actuators.
Module 3: Technology And Disability: (7 Hours) Design of upper limb, Design of lower limb,prosthetics design, and design parameters.
Module 4: Robots In Rehabilitation: (8 **Hours**) Physiology basics of neuromotor recovery, neurorehabilitation, robots assisted rehabilitation therapy, actuator design methods and controllers. Exoskeleton applications for upper and lower limb. rehabilitation robotics,Mobility and navigation.
Module 5: Rehabilitation Training And Assessment: (7 Hours) Assessment methods, computational models**,** interactive training, software tools, Personal and patient transportation system, Design of Smart wheel chair, Gait training, wearable robotic systems,robots in activities for daily living.
Module 6: Control Of Exoskeleton: (8 Hours) EMG based controls. Modeling, simulation and control of exoskeleton.

Reference Books:

1. Barbara Gibson, "Rehabilitation: A Post-critical Approach", Rehabilitation Science in Practice Series, First Edition, 2016.
2. Myer Kutz, "Standard Handbook of Biomedical Engineering& Design", McGraw Hill Publisher,UK,2003.
3. Roberto Colombo (Editor), Vittorio Sanguineti, "Rehabilitation Robotics: Technology and Application",1st Edition, Elsevier, UK, 2018.
4. Volker Dietz, Tobias Nef, William Zev Rymer, "Neuro Rehabilitation technology", Springer, London, 2012.

5. Clarence W. de Silva, "Sensors and Actuators: Engineering System", CRC Press, UK, 2016.
6. **Xie**, Shane, "Advanced Robotics for Medical Rehabilitation: Current State of the Art and Recent Advances, 2016.

18BM3015	MACHINE LEARNING	L	T	P	C
		3	0	0	3

Course Objective

The student should be made to:

1. Learn the concept of machine learning.
2. Analyse recent advances in machine learning algorithms
3. Explore supervised and unsupervised learning paradigms towards applications

Course Outcomes

After completion of course, students would be able to:

1. Describe features that can be used for a particular machine learning approach
2. Classify contrast pros and cons of various machine learning techniques
3. Illustrate various methods for developing the application
4. Infer various machine learning approaches and paradigms.
5. Choose the methods towards challenges
6. Create solution to human problems in healthcare domain

Module 1: Supervised Learning: (7 Hours) Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naive Bayes Linear models: Linear Regression, Logistic Regression, Generalized Linear Models Support Vector Machines, Nonlinearity and Kernel Methods-Beyond Binary Classification: Multi-class/Structured Outputs, Ranking

Module 2: Unsupervised Learning: (8 Hours) Clustering: K-means/Kernel K-means, Dimensionality Reduction: PCA and kernel PCA, Matrix Factorization and Matrix Completion, Generative Models (mixture models and latent factor models)

Module 3: Evaluating Algorithms: (7 Hours) Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods, Boosting, Bagging, Random Forests.

Module 4: Sparse Modeling And Estimation: (8 **Hours**) Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning.

Module 5: Scalable Machine Learning: (7 **Hours**) Online and Distributed Learning, A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference

Module 6: Recent Trends: (8 **Hours**) Various learning techniques of Machine Learning and classification methods for IoMT applications. Various models for IoMT, and applications.

Reference Books:

1. Kevin Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning", Springer 2009.
3. Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 2007.
4. Arvin Agah, "Medical Applications of Artificial Intelligence", CRC Press, 2017.

18BM3016	ROBOTICS IN SURGERY	L	T	P	C
		3	0	0	3

Course objectives:

The student should be made to:

1. Understand the fundamentals of robotics and its degree of freedom
2. Learn the various sensor and actuators required for its functions
3. Apply the machine learning concepts in medical applications

Course outcomes:

At the end of this course, students will be able to

1. Identify the fundamental concepts in robotic systems
2. Interpret the types of sensors and actuators for its applications
3. Choose the design tools to develop artificial intelligence techniques
4. Classify the conditions required for testing and control of autonomous robots
5. Judge the safety aspects to human and environment
6. Construct the robots for assisting in surgery

Module 1: Introduction To Robotics: (7 **Hours**) Degrees of freedom, path planning, Lagrange equation of motion, kinetics, payload, Links and Joints.
Module 2: Sensors And Actuators: (8 **Hours**) Gripper, tactile sensor, Sensor for vision and motion, proximity switches, controllers. Path planning, path tracking.
Module 3: Programmable Controller: (7 **Hours**) Artificial intelligence, machine vision, design of controllers based on embedded system, feedback control design. Human machine interface. Case studies
Module 4: Human-Robot Interaction: (8 **Hours**) Human factors: perception, motor skills, social aspect of interaction, safety, Haptic robots, collision detection, autonomous robots.
Module 5: Medical Robotics: (7 **Hours**) surgical robotics, robot supported diagnostics, micro-robots, nanorobots at the cell level, Robots in medical applications. case study.
Module 6: Surgical Robot: (8 **Hours**) Configuration, kinematics and workspace, design of intraocular robot surgery, Laparoscopic robotic surgery, applications of smart materials. Case study.

Reference Books:

1. Mohsen Shahinpoor, Siavash Gheshmi, "Robotic Surgery: Smart Materials, Robotic Structures, and Artificial Muscles", CRC Press, 2015.
2. Jacob Rosen, Blake Hannaford, Richard. M. Satava, "Surgical Robotics", Systems Applications and Visions", Springer, 2011.
3. Farid Gharagozloo, Farzad Najam, "Robotic surgery", McGraw Hill Publishers, US, 2009.First edition.
4. Bruno Siciliano and Lorenzo Sciavicco, "Robotics: Modeling, Planning and Control", Springer, 2010.
4. Bruno Siciliano, Oussama Khatib, "Springer Handbook of Robotics", Springer, 2008.
5. M. Tavakoli, R.V. Patel, M. Moallem, A. Aziminejad, Haptics for Teleoperated Surgical Robotic Systems, World Scientific, 2008.

18BM3017	TELEHEALTH TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:
The student should be made to:
1. Introduce the concept of telemedicine
2. Understand the Benefits and Limitations of Telemedicine.
3. Know Security and Standards and their use in Telemedicine Applications

Course Outcomes:
At the end of this course, students will be able to
1. Justify the need of telemedicine
2. Comprehend the various types of information
3. Realize the various data acquisition and storage system
4. Describe the issues in data handling and strategic Planning
5. Describe the role of Internet in telemedicine
6. Apply telemedicine in different fields like cardiology, oncology, pathology etc.

Module 1: Introduction To Telemedicine: (7 **Hours**) Data types, Data acquisition Systems, Display Systems, Data Storage Systems, Communication Networks.
Module 2: Multimedia Data Exchange And Telemedicine Quality Control: (8) Networking Architecture, Protocol Hierarchies for Multimedia communication, Media Coding.
Module 3: Internet In Telehealth Care: (7 Hours) Security, Quality of Service, Personal Communication, Medical Data Sharing, Telemedicine Needs, E-mail applications, World Wide Web, Teleworking, Teleteaching, Organizational Environment – Teleworking design and development.
Module 4: Data Handling: (8 Hours) Data security and privacy, Mechanism of security, Security on Internet, security and legal issues, Liability and legal aspects, Main Deontological applications, Contract scenarios, legal protection.
Module 5: Planning And Other Social Aspects: (7 Hours) Constraints for use of telehealth care, Costs/benefits, Planning for implementation, Forces affecting technology transfer, Scenarios for technology transfer, Technology transfer requirements, Strategy of telehealth care.
Module 6: Healthcare Applications: (8 Hours) Teleradiology, Telepathology, Telecytology, Telecardiology, Teleoncology, Teledermatology, Tele-Home care, Telesurgery Telepsychiatry, Primary Care, Telephonic Medicine.

Reference Books:

1. Olga Ferrer-Roca, M.Sosa Ludicissa, "Handbook of Telemedicine", IOS press 2002.
2. A.C.Norris, "Essentials of Telemedicine and Telecare", John Wiley & Sons, 2002.
3. E-Health, Telehealth, and Telemedicine: A Guide to Startup and Success By Marlene Maheu, Pamela Whitten, Ace Allen E-Health, 2001.
4. Current Principles and Practices of Telemedicine and E-health, Rifat Latifi, IOS Press, 2008.
5. Steven F. Viegas, Kim Dunn, "Telemedicine: Practicing in the Information Age, 2000.
6. Richard Wootton, John Craig, Victor Patterson, "Introduction to Telemedicine, second edition, 2013.

18BM3018	HOSPITAL AND EQUIPMENT MANAGEMENT	L	T	P	C
		3	0	0	3

Course objectives:

The student should be made to:

1. Understand the fundamentals of health care delivery services
2. Learn the procedures in maintenance of equipments
3. Apply the design principles in engineering systems

Course outcomes:

At the end of this course, students will be able to

1. Identify the principle of organizational structures and regulatory services
2. Classify the types of codes followed and applications
3. Modify the design to develop support systems
4. Infer the most challenges in environment and market trends
5. Evaluate the systems based on the safety criteria to environment
6. Create the methodology for new equipments to user needs

Module 1: Health And Hospital Management: (7 Hours) Health organisation of the country, the State, the Cities and the Region, Management of Hospital Organisation, Nursing Sector, Medical Sector, Central Services, Technical Department, Definition and Practice of Management by Objective, Transactional Analysis Human Relation in Hospital, Importance of Team Work, Legal aspect in Hospital Management. Case study: Health survey.

Module 2: Regulatory And Voluntary Guidelines And Health Care Codes: (8 Hours) FDA Regulation, Joint Commission of Accreditation for Hospitals, National Fire Protection Association Standard, ISO, NABL, ISO:13485, ISO:14791, risk management, Environmental regulation. Case study on risk management.

Module 3: Healthcare Supply Chain Management: (7 Hours) Essentials of healthcare supply chain management, designing sustainable health care supply chain, performance metrics, emerging trends in healthcare supply chain management.

Module 4: Clinical Engineering: (8 Hours) Role to be performed in Hospital, Manpower & Market, Professional Registration, Maintenance of Hospital support system, surveillance network, electric power management, Medical gas production, waste disposal, inventory control. Case study: RF ID tag for inventory.

Module 5: Safety Equipments: (7 **Hours**) Operation of safety devices, personnel safety equipments, Gas mask, Radiation measurements, equipment safety systems, elements of basic first aid, fire fighting, Case study: Safety Awareness.

Module 6: Equipment Maintenance Management: (8 Hours) Organizing the maintenance operation, biomedical equipment procurement procedure, proper selection, compatibility, testing and installation, purchase and contract procedure, trained medical staff, on proper use of equipment and operating instructions. Maintenance of job planning, preventive maintenance, maintenance budgeting, contract maintenance.

Reference Books:

1. Hokey Min, "Healthcare Supply Chain Management: Basic Concepts and principles", Business expert press, NewYork, 2014.
2. Keith Willson, Keith Ison, Slavik Tabakov, "Medical Equipment Management", CRC Press, 2013.
3. Webster.J.G. and Albert M.Cook, "Clinical Engineering Principles and Practices Prentice Hall Inc., Englewood Cliffs, New Jersey, 1979.
4. 4.Robin Guenther, Gail Vittori, "Sustainable Healthcare Architecture", Wiley, 2013.
5. Sharma D K, R.C.Goyal, "Hospital administration and human Resource Management in Hospital", Prentice Hall of India, New Delhi, 2017.

6. Syed Amin Tabish “Hospital and Health services Administration Principles and Practices” Oxford Press, New Delhi, 2001.

18BM3019	PHYSIOLOGICAL CONTROL SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:

The student should be made to:

1. Learn the modeling techniques of physiological systems.
2. Understand physiology and control techniques
3. Study the various regulatory systems of the human body.

Course Outcomes:

At the end of this course, students will be able to

1. Describe the concepts of modeling and simulation
2. Differentiate characteristics of physiological systems
3. Show various concepts of biofeedback methods
4. Categorize adaptive and learning techniques
5. Criticize various control methodology for medical device applications
6. Design the biomedical systems useful for community

Module 1: Modeling Of Physiological Systems: (7 **Hours**)

Systems Analysis, examples of physiological control systems, differences between engineering and physiological control systems. Generalized system properties, mathematical approach, electrical analogs, linear models, lung mechanics, muscle mechanics, distributed parameter versus lumped parameter models

Module 2: Analysis of Physiological Models (8 Hours)

Static and dynamic analysis of physiological systems: regulation of cardiac output, blood glucose regulation, chemical regulation of ventilation, electrical model of neural control mechanism, sleep apnea, respiration.

Module 3: Biofeedback In Physiological System (7 Hours)

Circulatory System: respiration system, cardiovascular measurements, EEG and EMG, Pupil reflux. Blood pressure, heart rate. Case study.

Module 4: Stability Analysis: (5 Hours) Routh-Hurwitz, Root locus, Lyapnov methods.

Module 5: Control Techniques: (10 **Hours**) Introduction to adaptive control, Direct and indirect adaptive control, Model reference adaptive control, Parameter convergence, Persistence of excitation Adaptive back stepping, Adaptive control of nonlinear systems, Composite adaptation. Case study.

Module 6: Advanced Controllers: (8 **Hours**) Robust adaptive control Neural Network-based control Reinforcement learning-based control, Repetitive learning control, Predictive control, Robust adaptive control.

Reference Books:

1. Physiological control systems: Analysis, Simulation and estimation, IEEE Press Series on Biomedical Engineering, 2018.
2. John Enderly, Joseph Bronzino, “Introduction to Biomedical Engineering”, Third Edition, Academic Press Series in Biomedical Engineering, 2012.
3. William B.Blesser, “A System Approach to Biomedicine”, McGraw Hill Book Co., New York, 2009.
4. Manfreo Clynes and John H.Milsum, “Biomedical Engineering System”, McGraw Hill and Co., New York, 2001.
5. J.J.E. Slotine, and W. Li, “Applied Nonlinear Control”, Prentice-Hall, 1991.
6. P. Ioannou& B. Fidan, “Adaptive Control Tutorial”, SIAM, Philadelpia, PA, 2006

18BM3020	ERGONOMICS IN HOSPITAL	L	T	P	C
		3	0	0	3

Course Objectives:

The student should be made to:

1. Introduce the Fundamental terms and concepts of human factors
2. Learn principles and optimize human well-being and overall performance.
3. Apply methodology for human stress related issues in hospital work area.

Course Outcomes:

At the end of this course, students will be able to

1. Identify the problems in posture and work efficiency
2. Classify the workspace and related systems
3. Choose signal processing techniques for analysis and feature extraction.
4. Relate the anthropometric concepts to human system and environment.
5. Assess the methodologies in measurement systems and conditions
6. Construct instrumentation techniques for development of user friendly systems

Module 1: Ergonomics In Healthcare: (7 **Hours**) Human factors and ergonomics in health care, ergonomic challenges in patient safety, work system design in healthcare, effect of workplace on healthcare workers, healthcare work schedule. Human error in healthcare, error reduction strategies.

Module 2: Human–Machine System: (8 Hours) Human machine interaction**,** human technological system, manual, mechanical, automated system, human system reliability, human system modeling, Human Output And Control, material handling, motor skill, human control of systems, controls and data entry devices, hand tools and devices,

Module 3: Workplace Design: (7 Hours) Applied anthropometry, workspace design and seating, design of computer worktable, case studies. Physical environment in healthcare. Environmental conditions. Workplace design.

Module 4: Measurement System: (8 Hours) Physical stress and fatigue measurement using EMG and EEG. Assessment and evaluation tools for musculoskeletal disorder and patient handling techniques. Design of assessment system: Case study.

Module 5: Ergonomics Methodologies: (7 Hours) Cognitive work analysis in healthcare, risk management for medical products, analysis of workflow, simulation based trainings, Information technology design and development, programmes and implementation models, patient safety and ergonomics for patient safety.

Module 6: Ergonomics Applications In Hospital: (8 **Hours**) Human factors and ergonomics in ICU, emergency department, pediatrics, home care, primary care, anesthesia, medication safety, infection prevention, surgical excellence. Case study.

Reference Books:

1. Pascale Carayon, "Handbook of Human Factors and Ergonomics in Health Care and Patient Safety, Second Edition, CRC Press, UK. 2017.
2. Alan Hedge**, "**Ergonomic Workplace Design for Health, Wellness, and Productivity, CRC Press, 2016.
3. Bridger R S, "Introduction to Ergonomics", Taylor and Francis, London, 2003.
4. Vincent G. Duffy, Advances in Human Factors and Ergonomics in Healthcare, Advances in Human Factors and Ergonomics Series, 2017.
5. Mccormic.E.J., and Sanders.M.S, "Human factors in Engineering and Design", McGraw Hill, New Delhi, 1993.
6. Webster, "Medical Instrumentation Application and Design", Wiley India Pte Ltd, New Delhi, 2014.

18BM3021	MEDICAL ETHICS AND SAFETY	L	T	P	C
		3	0	0	3

Course Objectives:

The student should be made to:

1. Provide a source of useful ideas, concepts, and techniques
2. Improve performance to avoid patient injury, achieving efficacious treatment
3. Reduce Medical error and controlling health care costs.

Course Outcomes:

At the end of this course, students will be able to

1. Identify the mechanical and electrical safety standards of medical equipment
2. Understand device specific safety goals
3. Interpret reasonable, acceptable and effective remedies and counter measure
4. Select the clinical suitability to the impact of the device on the environment
5. Device more reliable medical equipment incorporating safety goals
6. Combine new techniques for device management

Module 1: Reliability And Safety Testing: (7 **Hours**) Reliability – Types of reliability – Reliability optimization & assurance – Reliability's effect on medical devices – The concept of failure – Causes of failure – Types of Failures in Medical devices – Safety testing – Device specific safety goals,

Failure assessment and Documentation – Visual inspection: External & Internal visual inspection – Measurement – Safety parameters, Function test

Module 2: Medical Devices Handling, Environmental Safety: (8 **Hours**) Safe medical devices – Handling and operation – Medical Application safety – Usability – Clinical assessment – Environmental safety.

Module 3: Electrical Safety: (7 **Hours**) Safety Mechanics – Electrical Safety – Biological aspect – Limitation of Voltages - Macroshock and Microshock – Earth and Protection – Leakage currents – Magnetic fields and compatibility – Basic assumptions in safety technology – Safety classes.

Module 4: Medical Devices Standards: (8 Hours) Medical Standards and Regulations – Device classification – Registration and listing – Declaration of conformance to a recognized standard – Investigational Device Exemptions – Institutional Review Boards – IDE format – Good laboratory practices – Good manufacturing practices.

Module 5: Ethical Theories & Moral Principles: (7 Hours) Theories-Deontology& Utilitarianism, Casuist theory, Virtue theory, The Right Theory. Principles - Non-Maleficence, Beneficence, Autonomy, Veracity, Justice. Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research, Bioethical issues in Human Genetics & Reproductive Medicine.

Module 6: Introduction To Medical Ethics: (8 Hours) Definition of Medical ethics, Scope of ethics in medicine, American medical Association code of ethics, CMA code of ethics- Fundamental Responsibilities, The Doctor and the Patient, The Doctor and the Profession, Professional Independence, The Doctor and Society.

Reference Books:

1. Norbert Leitgeb "Safety of Electro-medical Devices Law – Risks – Opportunities" Springer Verlog, 2010.
2. Bertil Jacobson and Alan Murray, "Medical Devices Use and Safety", Elsevier, 2007.
3. Richard Fries, "Reliable Design of Medical Devices – Second Edition", CRC Press, Taylor & Francis Group, 2006.
4. Robert M Veatch, "Basics of Bio Ethics", Second Edition. Prentice- Hall, Inc. 2003
5. Domiel A Vallero, "Biomedical Ethics for Engineers", Elsevier Pub.1st edition, 2007
6. Erich H. Loewy, "Textbook of Medical Ethics", Springer; 2014.

18BM3022	EMBEDDED SYSTEMS AND IoT IN HEALTH CARE	L	T	P	C
		3	0	0	3

Course objective

The student should be made to:

1. Teach the internet concepts and design methodology
2. Teach fundamentals of embedded system
3. Teach importance of embedded and IoT in health care.

Course outcome:

At the end of this course, students will be able to

1. Acquire the knowledge & concepts of IoT.
2. Explain the basic concepts of IoT Protocols.
3. Illustrate the concepts of embedded system for health care applications.
4. Categorize the importance of digital health
5. Criticize the ethical issues in health care
6. Develop an application based on IoT in health care

Module 1: Internet Concepts And Infrastructure: (7 Hours)

Broad Band Transmission facilities, Open Interconnection standards, Local Area Networks, Wide Area Networks, Network management, Network Security, Cluster computers. Internet concepts, Capabilities and limitations of the internet. Interfacing Internet server applications to corporate databases HTML and XML Web page design through programming and the use of active components.

Module 2: Design Methodology And Protocols: (8 **Hours**) Introduction, Characteristics, Physical design, Protocols, Logical design, Enabling technologies, IoT Levels, Domain Specific IoTs, IoT vs M2M. IOT design methodology, IoT systems management, IoT Design Methodology Specifications Integration and Application Development.

Module 3: Embedded Systems: (7 **Hours**) Generic Embedded Systems Structure- Components of Embedded Systems- Sensors and Actuators-importance of Analog/Digital Conversion- Embedded

system based physiological monitoring system- Health care innovations using embedded system. Evolution of digital health- challenges and opportunities of digital health- importance of digital health.

Module 4: Ethical Issues In Health Care: (8 Hours) Ethical implications of digital health technologies- privacy, confidentiality and security of personal health data-ethical framework and guidelines in digital health, principles of biomedical ethics.

Module 5: IoT In Health Care Applications: (7 Hours)

IoT based health care- physiological parameter monitoring system- future challenges in health care-health care echo system with IoT- IoT for personalized health care- wearable device characteristics-analysis of power aware protocols.

Module 6: Standards For E-Health Applications: (8 **Hours**) Social network analysis in health care embedded health care system for senior resident using IoT.

Reference Books:

1. Eugene C. Nelson, Paul B. Batalden, Marjorie M. Godfrey, Quality By Design: A Clinical Microsystems Approach John Wiley & sons 2007.
2. Samuel A. Fricker, Christoph Thuemmler, Anastasius Gavras, Requirements Engineering for Digital Health, Springer 2015.
3. Klaus Pohl, Harald Honninger, Reinhold Achatz, Manfred Broy, Model-Based Engineering of Embedded Systems: The SPES 2020 Methodology, Springer 2012
4. Adrian Mc Ewen, Hakim Cassimally, "Designing the Internet of Things", Wiley, 2013.
5. Andrew S Tanenbaum, "Computer Networks", Pearson Education Pvt Ltd, New Delhi, 4th Edition, 2012.
6. Stallings, William, "Data and computer communications", Pearson Education Pvt Ltd, New Delhi, 2007

18BM3023	NANO TECHNOLOGY AND APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

The student should be made to:

1. To know basic nanotechnological principles and characterization methods
2. To understand the essential features of biology and nanotechnology
3. Create the new areas of bio nanotechnology and nanomedicine.

Course Outcomes:

The student will be able to:

1. Define the newest findings in the area of nanomedicine
2. Classify the materials for nano therapeutics
3. Show the advanced methods of nano synthesis
4. Explain the characteristics of nanoparticles in diagnosis
5. Choose nanotechnology in appropriate medical applications
6. Implement the perspectives in own research

Module 1: Introduction of Nanoparticles (7 Hours)

Overview of nanotechnology from medical perceptive, different types of nanobiomaterials and nanostructure interactions. Synthesis, characterization, and properties smart nanomaterials, Surface modification.

Module 2: Biofunctionalization Of Nanomaterials: (8 Hours) Nanocarriers, liposomes, polymer capsules, polymer nanoparticles.

Module 3: Protein As Nanostructures: (7 Hours) Protein based nanostructures building blocks and templates Proteins as transducers and amplifiers nanobioelectronic devices and polymer nanocontainers microbial production of inorganic nanoparticles magnetosomes.

Module 4: DNA as nanostructures: (8 Hours) DNA based nanostructures Topographic and Electrostatic properties of DNA Hybrid conjugates of gold nanoparticles DNA oligomers use of DNA molecules in nanomechanics

Module 5: Nanoparticles In Diagnosis: (7 Hours) Introduction to nanoparticles in diagnostics nuclear imaging, optical imaging, PET, Micro PET, cardio vascular disease studies, imaging and therapy of thrombosis, emerging Ethical issues and toxicology of nanomaterials.

Module 6: Nanotherapeutics: (8 Hours) Nanoparticles as carriers in drug delivery- design, manufacture and physiochemical properties, transport across biological barriers, nanotechnology in

Cancer therapy, lung infectious disease, bone treatment, nano particles for oral vaccination and skin disease.

Reference Books:

1. CM, Niemeyer, C.A. Mirkin, "Nano biotechnology Concepts, Applications and Perspectives", Wiley, 2004.
2. Challa, S.S.R. Kumar, Josef Hormes, Carola Leuschaer., "Nanofabrication towards Biomedical Applications, Techniques, Tools, Applications and Impact" Wiley, 2005.
3. Harry F. Tibbals, Medical Nanotechnology and Nanomedicine, CRC Press, 2010.
4. Nicholas A. Kotov, "Nanoparticles Assemblies and Superstructures", CRC, 2006.
5. T. Pradeep, "Nano: The Essentials", McGraw Hill education 2007.
6. Vinod Labhasetwar, Diandra L. Leslie-Pelecky, "Biomedical Applications of Nanotechnology", John Wiley & Sons, 2007.

18BM3024	BIOMEDICAL ENGINEERING ENTREPRENEURSHIP	L	T	P	C
		3	0	0	3

Course Objectives

The student should be made to:

1. To learn fundamentals of entrepreneurship
2. To apply the methods of entrepreneurship in medical field
3. To evaluate the medical devices and market trends

Course Outcomes

At the end of this course, students will be able to

1. Describe the role of biomedical engineers in entrepreneurship
2. Interpret the background for biomedical engineers in entrepreneurship
3. Acquire the skills and techniques required towards innovation
4. Categorize the resources and funding agencies
5. Judge the right product based on market needs
6. Compile and quantify the opportunities and challenges

Module 1: Scope For Biomedical Engineering Entrepreneurship: (7 Hours)
Fundamentals and models, Advancements in biomedical field, Supporting societies and professional activities. Impact of innovation in medical devices. Case study.

Module 2: Venture: (8 Hours) Assessing the venture, Establish venture invention, market research, presenting the business plan, case study.

Module 3: Regulations: (7 Hours) Certification, ISI, CE, UL, NABL and FDA regulations, ISO:13485, ISO:14791, risk management, Environmental regulation. Case study on risk management. Case study.

Module 4: Identifying The Grants: (8 Hours) Identify and organize support for product development, funding agencies, collaborative initiatives, and angel investors.

Module 5: Impact of Globalization: (7 **Hours**) Medical product manufacturing, marketing, leadership, quality management.

Module 6: Environmental Awareness: (8 Hours) Environmental regulations, safety, safe disposal, preventing pollution, preventing health hazards.

Reference Books:

1. Jen-Shih Lee "Biomedical Engineering Entrepreneurship", World Scientific Publishing, USA. 2010.
2. Brant Cooper, Patrick Vlaskovits, "The Lean Entrepreneur", Wiley, 2nd edition, New Jersy, 2016.
3. Nathan Furr, Jeff Dyer, "The Innovator's Method: Bringing the Lean Start-up into Your Organization", Harvard Business Press, Boston, 2014.

18BM3025	BUSINESS ANALYTICS	L	T	P	C
		3	0	0	3

Course objective

The student should be made to:

1. Understand the role of business analytics
2. Analyze data using statistical and data mining techniques
3. Understand relationships underlying business processes of an organization

Course outcomes

At the end of this course, students will be able to

1. Define the parameters data analytics
2. Interpret the use technical skills in modeling to support business decision-making
3. Relate the ability of data and deep analytics.
4. Translate data into clear, actionable insights and critical thinking
5. Understanding business analytics to formulate and solve business problems
6. Create and support managerial decision making.

Module 1: Business Analytics: (7 **Hours**) Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools, Statistical Notation, Descriptive statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Module 2: Trendiness And Regression Analysis: (8 **Hours**) Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Module 3: Organization Structures: (7 **Hours**) Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Module 4: Forecasting Techniques: (8 Hours) Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Module 5: Decision Analysis: (7 **Hours**) Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Module 6: Recent Trends: (8 **Hours**) Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Reference Books:

1. Michael Minelli, Michele Chambers, Ambiga Dhiraj "Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
2. Dara G. Schniederjans, Christopher M. Starkey, Marc J. Schniederjans, "Business analytics Principles, Concepts, and Applications", Pearson education Press, 2014.
3. James Evans, Business Analytics", Persons Education, 2016.

18BM3025	ENERGY AUDITING AND MANAGEMENT FOR HOSPITAL	L	T	P	C
		3	0	0	3

Course Objectives:

Students will be able to:

1. Understand the need and concepts for energy auditing
2. Know about different audit instruments used in practice
3. Identify the energy sources and optimal utility of electrical energy

Course Outcomes:

At the end of this course, students will be able to:

1. Acquire the background required for engineers to meet the role of energy managers
2. Classify the techniques required to implement energy management
3. Identify and quantify the energy intensive business activities in a hospital
4. Perform Basic Energy Audit in an hospital complex
5. Identify the methods of alternate energy sources for hospitals
6. Construct the optimal utility concepts for efficient hospital systems

Module 1: Introduction To Energy Audit: (7 Hours) System Approach: End use approach to efficient use of Electricity, Electricity tariff types Energy auditing: Types and objectives - audit

instruments, ECO assessment and Economic methods, Specific energy analysis-Minimum energy paths-consumption models-Case study.

Module 2: Energy Efficient Controls: (8 Hours) Electric motors and starting efficiency-Motor Efficiency and Load Analysis Energy efficient /high efficient Motors-Case study Load Matching and selection of motors, Variable speed drives; Pumps and Fans-Efficient Control strategies-Optimal selection and sizing Optimal operation and Storage; Case study.

Module 3: Transformer Loading/Efficiency Analysis: (7 **Hours**) Feeder, cable loss evaluation, case study Reactive Power management-Capacitor, Sizing-Degree of Compensation-Capacitor losses Location-Placement, Maintenance. Case study.

Module 4: Peak Demand Controls- Methodologies: (8 **Hours**) Types of Industrial loads-Optimal Load, scheduling-case study, Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes Electronic ballast-Power quality issues-Luminaries, case study.

Module 5: Alternate Energy Sources For Hospitals: (7 **Hours**) Diesel based Power generating units- Solar based power plants, solar panel, wind mill, power storage. Biomass plant, gasifier.

Module 6: Cogeneration: (8 **Hours**) Methods, and Schemes Optimal operation of cogeneration plants-case study Electric loads of Air conditioning &Refrigeration, Energy conservation measures-Cool storage, Types-Optimal operation. Case study.

Reference Books:

1. Anthony J. Pansini, Kenneth D. Smalling, "Guide to Electric Load Management", Pennwell Pub; 1998.
2. Howard E. Jordan, "Energy-Efficient Electric Motors and Their Applications., Plenum Pub 2nd edition, 1994.
3. Y P Abbi and Shashank Jain, "Handbook on Energy Audit and Environment Management" TERI, 2006.
4. Desai, Ashok V., "Non Conventional Energy", Wiley Eastern Ltd., 1990.
5. Challal, D. S., "Food, Feed and Fuel from Biomass", IBH Publishing Co. Pvt. Ltd., 1991.
6. C. Y. WereKo-Brobby and E. B. Hagan, "Biomass Conversion and Technology", John Wiley & Sons, 1996.

LIST OF COURSES

S.No	Course Code	Name of the Course	Credits
1.	17BM2001	Health and Hospital Management	3:0:0
2.	17BM2002	Biomedical Sensors and Transducers	3:0:0
3.	17BM2003	Biomedical Sensors and Transducers Laboratory	0:0:2
4.	17BM2004	Medical Electronics	3:0:0
5.	17BM2005	Bio Signal Conditioning Circuits	3:0:0
6.	17BM2006	Bio Signal Conditioning Circuits Laboratory	0:0:2
7.	17BM2007	Biocontrol systems	3:0:0
8.	17BM2008	Medical Diagnostic Equipment	3:0:0
9.	17BM2009	Biomechanics Prosthesis and Orthosis	3:0:0
10.	17BM2010	Bio Signal Processing Laboratory	0:0:2
11.	17BM2011	Medical Therapeutic Equipment	3:0:0
12.	17BM2012	Biomedical Instrumentation Laboratory	0:0:2
13.	17BM2013	Modelling of Physiological systems	3:0:0
14.	17BM2014	Medical Imaging Techniques	3:0:0
15.	17BM2015	Digital Image Processing for Medical Applications	3:0:0
16.	17BM2016	Embedded Biomedical Instrumentation Systems	3:0:0
17.	17BM2017	Embedded Biomedical Instrumentation Systems Laboratory	0:0:2
18.	17BM2018	Bio Virtual Instrumentation Laboratory	0:0:2
19.	17BM2019	Medical Image Processing Laboratory	0:0:2
20.	17BM2020	Surgical Assist Systems	0:0:1
21.	17BM2021	Sensory and Motor Rehabilitation	3:0:0
22.	17BM2022	Medical Equipment, Maintenance and Troubleshooting	3:0:0
23.	17BM2023	Biomedical Optics	3:0:0
24.	17BM2024	Biometric systems	3:0:0
25.	17BM2025	Radiation and Nuclear Medicine	3:0:0
26.	17BM2026	Patient and Device Safety	3:0:0
27.	17BM2027	ICU and Operation Theatre Equipment	3:0:0
28.	17BM2028	Graphical System Design for Biomedical Engineers	3:0:0
29.	17BM2029	Wearable Systems and Digital Health Care	3:0:0
30.	17BM2030	Bio-MEMS Technology	3:0:0
31.	17BM2031	Soft Computing Techniques	3:0:0
32.	17BM3001	Advanced Medical Instrumentation	3:0:0
33.	17BM3002	Medial Image Computing	3:0:0
34.	17BM3003	Soft Computing Techniques for Biomedical Engineers	3:0:0
35.	17BM3004	Medical Sensors and MEMS Technology	3:0:0
36.	17BM3005	Modeling and Identification of Physiological Systems	3:0:0
37.	17BM3006	Rehabilitation Engineering	3:0:0
38.	17BM3007	Medical Ethics	3:0:0
39.	17BM3008	Embedded system and IoT in health care	3:0:0
40.	17BM3009	Diagnostic and Therapeutic Laboratory	0:0:2
41.	17BM3010	Medical sensors, Interfacing & MEMS Laboratory	0:0:2
42.	17BM3011	Embedded System and IoT Laboratory	0:0:2
43.	17BM3012	Ambulatory Services	3:0:0
44.	17BM3013	Telehealth Technology	3:0:0
45.	17BM3014	Hospital and Equipment Management	3:0:0
46.	17BM3015	Robotics in Surgery	3:0:0
47.	17BM3016	Speech Signal Processing	3:0:0
48.	17BM3017	Hospital Automation	3:0:0
49.	17BM3018	Human Assist Devices	3:0:0

50.	17BM3019	Human Computer Interfaces	3:0:0
51.	17BM3020	Ergonomic in Hospitals	3:0:0
52.	17BM3021	Finite Element Modeling in Biomedical Engineering	3:0:0

17BM2001 HEALTH AND HOSPITAL MANAGEMENT

Credits: 3:0:0

Course Objectives:

- To understand the need and significance of Clinical Engineering and Health Policies.
- To familiarize the training strategies, quality management policies and information technology used in health care.
- To know the needs of managerial training to hospital staffs

Course Outcomes:

- Identify the role of the manager in healthcare and how organisations and people work within the healthcare system.
- Evaluate and use measurement tools for quality and safety.
- Describe how high quality services can best be designed, configured and delivered.
- Demonstrate a strategic leadership role as an advocate for improved healthcare delivery.
- Debate internal and external catalysts for quality and understand the core concepts of quality and safety.
- Apply the plans to manage people, finances and organisational resources.

Unit I - Need and scopes of clinical engineering: Clinical engineering program, Educational responsibilities, Role to be performed by them in hospital, Staff structure in hospital

Unit II - National health policies: Need for evolving health policy, Health organization in state, Health financing system, Health education, Health insurance, Health legislation.

Unit III - Training and management of technical staff in hospital: Difference between hospital and industrial organization, Levels of training, Steps of training, Developing Training program, Evaluation of training, Wages and salary, Employee appraisal method.

Unit IV - Standards, codes and quality management in health care: Quality management in hospitals and clinical laboratories, Necessity for standardization and Quality management, NABH and NABL standards, FDA, Joint Commission of Accreditation of hospitals, ICRP and other standard organization, Methods to monitor the standards, Overview of Medical Device regulation and regulatory agencies.

Unit V - Computers and information technology in medicine and Healthcare: Computer application in ICU, Picture Archival System (PACS) for Radiological images department, Clinical laboratory administration, Patient data and medical records, Communication, Simulation

Reference Books

1. R.C. Goyal, "Handbook of Hospital Personal Management", Prentice Hall of India, 2008.
2. Joseph. F. Dyro, " Clinical Engineering Management", Academic Press Series in Biomedical Engineering, 2004.
3. Antony Kelly, "Strategic Maintenance planning", Butterworths London, 2006.
4. Cesar A. Caceres and Albert Zara, "The Practice of Clinical Engineering", Academic Press, 1977.
5. Webster, J.G. and Albert M. Cook, "Clinical Engineering Principles and Practices", Prentice HallInc. Englewood Cliffs, 1979.
6. Webster J.C. and Albert M.Cook, "Clinical Engineering Principle and Practice", Prentice Hall Inc., Englewood Cliffs, New Jersey, 1979.

17BM2002 BIOMEDICAL SENSORS AND TRANSDUCERS

Credits: 3:0:0

Course Objectives:

- To provide introduction to the field of medical sensors and an in depth and quantitative view of device design and performance analysis.
- To provide knowledge on the principle and operation of different medical transducers.
- To introduce the application of sensors and transducers in the physiological parameter measuring system.

Course Outcomes:

- Identify the calibration procedure for the basic instruments involved in physiological parameter measurement.
- Interpret the errors in measurement by analyzing the performance characteristics of the sensors.
- Demonstrate the appropriate sensor approach which is most likely to meet a specific biosensor application.
- Apply the suitable design criteria for developing a medical sensor for a particular application.
- Develop advanced medical sensors based on the basic transduction principles.
- Predict the qualitative performance of advanced medical sensors.

Unit I - Science of Measurement: Generalized Instrumentation System, General Properties of Input Transducer. Static Characteristics: Accuracy, Precision, Resolution, Reproducibility, Sensitivity, Drift, Hysteresis, Linearity, Input Impedance and Output Impedance. Dynamic Characteristics: First Order and Second Order Characteristics, Time Delay, Error Free Instrument, Transfer Functions. Design Criteria, Generalized Instrument Specifications.
Unit II - Different Transduction Principles: Temperature transducers, thermo resistive transducers, thermoelectric, p-n junction, chemical thermometry. Displacement transducers, potentiometric, resistive strain gauges, inductive displacement, and capacitive displacement transducer. Pressure transducer, indirect method, measurement of blood pressure using sphygmomanometer, instrument based on Korotkoff sound, strain gauge and LVDT transducers, capacitive and piezo-electric type, catheter tip transducers, measurement of intracranial pressure, catheter tip, implantable type.
Unit III - Biological Sensors: Study of various corpuscles like Pacinian, functions and modelling, Chemoreceptor, hot and cold receptors, baro- receptors, sensors for smell, sound, vision, osmolality and taste.
Unit IV - Biosensors: Introduction, Advantages and limitations, various components of Biosensors, Biocatalysts based biosensors, bio-affinity based biosensors & microorganisms based biosensors, biologically active material and analyte. Types of membranes used in biosensor constructions.
Unit V - Bio potential Electrodes and Bio Chemical Sensors: Electrodes Electrolyte Interface, Half-Cell Potential, Polarization, Polarizable and Non Polarizable, Electrodes, Calomel Electrode, Electrode Circuit Model, Electrode Skin-Interface and Motion Artifact. Body Surface Electrodes. Ion exchange membrane, electrodes, oxygen electrodes, CO_2 electrodes enzyme electrode, construction, ISFET for glucose, urea etc. Electrolytic sensors, optical sensor, fiber optic sensors. Biosensors in clinical chemistry, medicine and health care.

Reference Books

1. Medical Instrumentation-Application and Design by John G. Webster, 2013
2. Transducers for Biomedical Measurements: Principles and Applications, Richard S.C. Cobbold, John Wiley & Sons, 2004.
3. Electronics in Medicine and Biomedical Instrumentation by Nandini K. Jog PHI Second Edition 2013.
4. Instrument Transducer – An Intro to their performance and design, Hermann K P. Neubert. 4. Biomedical sensors – fundamentals and application by Harry N, Norton.
5. Biomedical Transducers and Instruments, Tatsuo Togawa, Toshiyo Tamma and P. Ake Öberg.

17BM2003 BIOMEDICAL SENSORS AND TRANSDUCERS LABORATORY

Credits: 0:0:2

Course Objectives:

- To introduce the practical aspects of various medical transducers and their characteristics.
- To impart knowledge in measurement of Resistance, Inductance and Capacitance using bridges.
- To improve the skills in calibrating analog meters.

Course Outcomes:

- Understand the method of calibration of basic instruments.
- Analyze the performance characteristics of different sensors.
- Demonstrate the appropriate sensor approach which is most likely to meet a specific biosensor application.
- Apply the suitable design criteria for developing a medical sensor for a particular application.
- Develop advanced medical sensors based on the basic transduction principles.

- Predict the qualitative performance of advanced medical sensors.

Description:

This laboratory introduces the different biomedical transducers, their working and determination of their characteristics.

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.

17BM2004 MEDICAL ELECTRONICS

Credits: 3:0:0

Course Objectives:

- To furnish information on the mechanisms of current flow in semi-conductors.
- To yield understanding about the basic operations of diode, transistor and their medical applications.
- To provide knowledge about advanced semiconductor devices and their significant practical applications in medical field.

Course Outcomes:

- Identify various electronic medical equipments
- Generalize the amplifiers and semiconductor applications for biosignal acquisitions.
- Apply the concepts of electronic circuits to biomedical applications.
- Categorize various application of oscillators, pulse circuits etc.
- Design practical circuits for acquisition and analysis of biomedical signals.
- Build simple circuits for biomedical signal and analysis.

Unit I - Introduction to biomedical instrumentation: Overview of medical electronic equipments, types of medical equipments, transduction of bioelectric potentials, concepts of bio-impedance.
Unit II - Introduction to semiconductor devices: PN junction diodes-VI characteristics, rectifiers, power supply design, Zener diodes, Regulators, LED, LCD, Laser diodes, Special purpose diodes and their medical applications
Unit III - BJT and its medical applications: Construction, Characteristics, Hybrid model. Transistor as amplifier, Transistor as a switch, Opto-coupler & its medical application.
Unit IV - Junction field effect transistor and its medical applications: JFET, MOSFET and its classification, Power MOSFET, MOS as a charge transferring Device – CCD, Uni-junction transistor. Medical application of MOSFET.
Unit V - Oscillators and other special purpose amplifiers: Differential amplifiers: CM and DM, feedback amplifiers, Oscillators – LC, RC, crystal and their medical application, Pulse circuits for medical devices.

Reference Books

1. Khandpur. R. S.,"Handbook of Biomedical Instrumentation", Tata McGraw-Hill, Second edition, 2003.
2. Robert L. Boylestad, Louis Nashelsky, "Electronic Devices and Circuit Theory", Prentice Hall, Sixth edition, 2009.
3. David A Bell, "Electron Devices and Circuits", Prentice Hall Of India, Fifth edition, 2007.
4. Millman and Halkias, "Electronic devices and Circuits", Tata McGraw Hill, First edition, 1994.
5. Thomas L. Floyd, "Electron Devices ", Charles & Messil Publications, Tenth edition, 2009.

17BM2005 BIO SIGNAL CONDITIONING CIRCUITS

Credits: 3:0:0

Course Objectives:

- To understand bioelectric amplifiers
- To discuss filters and circuits
- To introduce application of signal conditioning in biomedical field

Course Outcomes:

- Identify the origin and characteristics of various biosignals and its acquisition.
- Identify the application of signal condition circuits for biomedical field.
- Recognize various bioamplifier for biosignal acquisitions using opamps.

- Analyze and deign bio filters and isolation circuits used in medical signal conditioning.
- Apply the concepts in designing various medical equipments using different ICs
- Interface bioelectric signals with embedded systems using digital interfaces.

Unit I - Biopotentials and bioelectric currents: Nature of Bio Electricity: Bioelectric Currents, Nernst Potential, Diffusion Potential, Action potential, Detection of Bio electric events, bio-electrode and electrode-skin interface.
Unit II - Operational Amplifiers Basic opamps parameters, Ideal and practical opamp, application of opamp in biomedicine- Adder, subtractor, analog integrator, differentiator, preamplifiers, Transimpedence circuits
Unit III - Active filters and Medical Isolation Amplifiers: First order and second order active filters, Instrumentation amplifier, Types of isolation amplifiers, and optocouplers
Unit IV - Comparators and Digital Interfaces: Comparators, Comparator applications, Multivibrators,555 timers, Astable and monostable, Pacemaker circuits, Aliaisng and sampling, Analog to Digital, Digital to Analog conversion, Biosignal data acquisition systems
Unit V - Special analog circuits and systems used in biomedical Instrumentation: Phase Detectors-Analog and Digital, Voltage Controlled Oscillators, Various VCO ICS, Phase locked loops. Electrical Interface problems and Safety Standards in Bio Potential Measurements.

Reference Books

1. Robert B. Northrop, "Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation", CRC Press, II Edition, New York,2004.
2. Myer Kutz, "Biomedical Engineering and Design Handbook", II Edition, Volume 1, McGraw Hill Professional, 2009.
3. Milman & Hallkias, "Integrated Electronics-Analog and Digital Circuit", McGraw Hill, II Edition, 2011.
4. Robert F. Coughlin, Frederick F. Driscoll, "Operational Amplifiers & Linear Integrated Circuits", Prentice-Hall, 6th Edition,2001.
5. Sergio Franco, "Design with Operational Amplifier and Analog Integrated Circuits", TMH, 3rd Edition, 2002.

17BM2006 BIOSIGNAL CONDITIONING CIRCUITS LABORATORY

Credits: 0:0:2

Course Objectives:
- To understand the design of filters and circuits for bioelectric amplifiers.
- To impart knowledge of the different preamplifiers used for amplifying the bio signals.
- To impart knowledge about the application of signal conditioning in biomedical field.

Course Outcomes:
- Apply and analyze the front end analogue circuit design for ECG, EMG, EEG, etc.
- Identify the method to apply various signal conditioning circuits.
- Apply the basic concepts of filtering and signal acquisitions for bio signals
- Identify the amplifiers for a variety of biomedical sensors.
- Design and build various digital interfaces for embedded applications
- Select suitable circuits to design various biomedical devices

Description:
This laboratory introduces the filter design and circuit design for bioelectric amplifiers.

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

17BM2007 BIOCONTROL SYSTEMS

Credits: 3:0:0

Course Objectives:
To study various
- Bio control systems modeling technique.
- Time response analysis and frequency response analysis.

- Analyze biological control systems.

Course Outcomes:

- Represent the system in various forms.
- Compute the mathematical model of physiological systems.
- Interpret the response of the system in time domain.
- Analyze the frequency response of any system
- Examine the stability of the system.
- Summarize the features of physiological system.

Unit I - Basic structure of control system, Positive and Negative Feedback, transfer functions, modeling of electrical systems, block diagram and signal flow graph representation of systems

Unit II - Difference between engineering and physiological control systems, generalized system properties , models with combination of system elements. Physiological system modeling, Linear model of respiratory mechanics, model of chemical regulation of ventilation, linear model of muscle mechanics, model of regulation of cardiac output, model of Neuromuscular reflex motion

Unit III - Introduction to simulation, Step response of first order and second order systems, determination of time domain specifications of first and second order systems. Definition of steady state error constants and its computation

Unit IV - Frequency response, determination of gain margin and phase margin using Bode plot, use of Nichol's chart to compute resonant frequency and band width.

Unit V - Definition of stability, Routh-Hurwitz criteria of stability, construction of root locus, Nyquist stability criterion, Nyquist plot and determination of closed loop stability

Reference Books

1. Michael. C. K. Khoo, "Physiological control systems", IEEE press, Prentice –Hall of India, 2001.
2. Benjamin C. Kuo, "Automatic control systems", Prentice Hall of India,7th edition, 1995
3. M. Gopal "Control Systems Principles and design", Tata McGraw Hill ,2002
4. John Enderle, Susan Blanchard, Joseph Bronzino, "Introduction to Biomedical Engineering" second edition, Academic Press, 2005.
5. Richard C. Dorf, Robert H. Bishop," Modern control systems", Pearson, 2004.

17EI2008 MEDICAL DIAGNOSTIC EQUIPMENT

Credits: 3:0:0

Course objectives:

- To know the principle of various bio potential recordings equipment.
- To understand the working of equipment used for physiological parameters.
- To learn the diagnostic equipment for clinical and advanced equipment.

Course outcomes:

- Identify the procedures for acquisition of physiological signals
- Demonstrate the functions and applications of diagnostic equipment
- Construct the suitable measurement systems and its signal conditioning circuits
- Compare the techniques for clinical diagnosis and its recent methods
- Assess the merits of the diagnostic equipment based on its applications
- Design the devices for the particular application based on given specifications.

Unit I - Equipment for physiological signals acquisition: Electrocardiography, Electro encephalography, Electro Oculography, Electro myography, Electro gastrography.

Unit II - Vital parameter monitoring system: Measurement of human body temperature, blood pressure monitor, body mass index, Heart rate, respiration rate, oxygen saturation.

Unit III - Equipments for non invasive methods: Pulse oximeter, spirometer, measurements for respiration gas flow, cardiac output, blood flow meter and signal conditioning circuits.

Unit IV - Clinical equipments: Bio-chemical measurement:Blood pH, Blood pO2, Blood pCO2, glucometer, hemoglobin monitor, Photometers, chromatograph.

Unit V - Advanced equipments: Ultrasound scanner, holter monitor, multi parameter monitor, capsule endoscopy, foot scanner.

Reference Books

1. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology",Pearson Education India, Delhi, 2004.
2. Khandpur. R. S., "Handbook of Biomedical Instrumentation", Prentice Hall of India, New Delhi, 2003.
3. Cromwell, "Biomedical Instrumentation and Measurements", Prentice Hall of India, New Delhi, 2007.
4. Webster, "Medical Instrumentation – Application & Design," John Wiley and sons Inc, Netherlands, 2009.
5. Jacobson B and Webster J G Medical and Clinical Engineering – Prentice Hall of India New Delhi 1999

17BM2009 BIOMECHANICS PROSTHESIS AND ORTHOSIS

Credits: 3:0:0

Course Objectives:

- To introduce the fundamental terms and concepts of human system modeling.
- To understand the anthropometric, biomechanical and physiological principles and their use in human well-being and overall performance.
- To acquire knowledge in evaluation of physiological factors and fitness factors for vehicle drivers.

Course Outcomes:

- Recognize the concepts of human system modelling.
- Interpret the human factors that affect the environmental conditions
- Apply the engineering tools in design of prosthetics
- Analyze the data, design, and functions of orthotics and overall performance.
- Evaluate the methods, solutions to human problems for specific needs
- Design the advanced system concepts implement solutions to a human factors problem.

Unit I - Human system modeling: Human control of systems, biomechanics-stress and fatigue measurements of bones, muscles-cognitive stress-stress modeling- signal acquisition and processing-brain and computer interface.
Unit II - Effects of environmental conditions: Human Factors Applications in medical and industrial field, Heat, stress-Human error- accidents analysis- human factors –case study on evaluation of the physiological factors and fitness factors for defense vehicle driver –safety Standards.
Unit III - Prosthesis: Introduction to Prosthesis, -Gait Analysis in Transtibial Amputees, Prosthesis in Knee Disarticulation- Gait Analysis in Transfemoral Amputees, -Prosthesis for Hand Amputation and Wrist Disarticulation-Recent Advances in Prosthesis
Unit IV - Orthotics: Introduction to orthotics, applications, implants, design of orthotics, modeling and analysis, 3D printing, A support, brace, or splint used to support, the function of movable parts of the body.
Unit V - Introduction to robotics: Definition - Classification - History - Robots components - Degrees of freedom - Robot joints coordinates - Reference frames - Workspace - Robot languages - Actuators - Sensors - Sensor characteristics - and electric actuators

Reference Books

1. Subrata Pal, "Text book of Biomechanics", Viva education Private limited, New Delhi. 2009.
2. Saeed B. Niku , "Introduction to Robotics", Pearson Education, 2002.
3. K.S.Fu, Ralph Gonzalez and C.S.G.Lee, "Robotics", TATA McGraw Hill, Aug., 2008.
4. Susan J.Hall, "Basics Bio Mechanics" 5th Edition, McGraw-Hill Publishing Co, Newyork, 2007.
5. Joseph D. Bronzino, "The biomedical engineering handbook", Volume 2, CRC Press, USA, 2000.

17BM2010 BIOSIGNAL PROCESSING LABORATORY

Credits: 0:0:2

Course Objectives:

- To record the bio signals and analyze it.

- To study the different preamplifiers used for amplifying the bio signals.
- To impart knowledge about the measurements and recordings of bioelectric and biochemical signals.

Course Outcomes:

- Recall the fundamentals of signal processing concepts.
- Recognize the morphological features of a signal.
- Apply the signal processing algorithms for real time bio-signals.
- Analyze the characteristics of the signal.
- Design digital filters for bio signal processing.
- Select suitable digital signal processors for processing a signal.

Description:

This laboratory introduces the different digital filters, sampling process and signal processing algorithms suitable for pre-processing the bio signals.

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

17BM2011 MEDICAL THERAPEUTIC EQUIPMENT

Credits: 3:0:0

Course objectives:

- To learn the principles of cardiac assist devices.
- To understand the need and use of extracorporeal devices, and the use of lasers in medicine.
- To enable the students to gain knowledge on the working of therapeutic clinical equipment.

Course outcomes:

- Identify the various therapeutic devices available for specific diseases.
- Demonstrate the functions and applications of cardiac, respiratory and electrotherapy equipment.
- Apply the appropriate therapeutic device for a particular ailment.
- Compare the techniques used in hospitals and its recent advancements.
- Assess the merits and demerits of the therapeutic equipment based on its applications.
- Design new therapeutic devices for particular application based on given specifications.

Unit I - Cardiac Equipment: External and implantable pacemakers, Programmable pacemakers, Power sources, Design of encapsulation and leads, Pacing system analyzers. Cardiac Defibrillators, Basic principles and comparison of different Defibrillators, Energy requirements, Synchronous operation, Implantable Defibrillators, Defibrillator analyzers.

Unit II - Respiratory Equipment: Principles of constant pressure and constant volume ventilators, Basic principles of electromechanical, Pneumatic and electronic ventilators, Nebulizer, Ventilator testing.

Unit III - Electrotherapy Equipment – I: Electro diagnosis, Electrotherapy, Electrodes, Stimulators for Nerve and Muscle, Stimulator for pain relief, Interferential current therapy, Spinal cord stimulator, Diaphragm pacing for artificial ventilation. Functional Electrical Stimulation.

Unit IV - Electrotherapy Equipment – II: High frequency heat therapy, Principle, Short wave diathermy, Microwave diathermy, Ultrasonic therapy, Lithotripsy, Therapeutic IR radiation, Therapeutic UV Lamps.

Unit V - Therapeutic Lasers: Basic principles of Biomedical LASERS: Applications of lasers in medicine, CO_2 laser, He-Ne laser, Nd-YAG and Ruby laser.

Reference Books

1. Khandpur. R.S., "Handbook of Biomedical Instrumentation". Second Edition. TataMc Graw Hill Pub. Co.,Ltd. 2013.
2. John. G. Webster. "Medical Instrumentation, Application and Design".Fourth Edition. Wiley &sons, Inc.,New York.2011.
3. Leslie Cromwell, Fred. J. Weibell & Erich. A. Pfeiffer. "Biomedical Instrumentation and Measurements". Second Edition. Prentice Hall Inc.2000.
4. JohnLow & AnnReed. "Electrotherapy Explained, Principles and Practice". Second Edition. Butterworth Heinemann Ltd. 2000.

5. Joseph. J. Carr, John Michael Brown, "Introduction to Biomedical Equipment Technology", Prentice Hall and Technology, 2008.

17BM2012 BIOMEDICAL INSTRUMENTATION LABORATORY

Credits: 0:0:2

Course Objective:

- To record the bio signals and analyze it.
- To study the different preamplifiers used for amplifying the bio signals.
- To impart knowledge about the measurements and recordings of bioelectric and biochemical signals.

Course Outcome:

- Calibrate medical instruments.
- Identify the suitability of diagnostic and therapeutic equipment for specific applications.
- Analyze the performance of various biomedical equipment and infer their safety aspects.
- Apply appropriate measurement techniques.
- Design portable instruments capable of recording bio signals.
- Evaluate the performance of medical instruments.

Description:

This laboratory introduces the different diagnostic and therapeutic equipment, their working and the methodologies used for analysing and recording bio signals.

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.

17BM2013 MODELLING OF PHYSIOLOGICAL SYSTEMS

Credits: 3:0:0

Course objectives:

- To learn the basic ideas related to modeling.
- Understand different modelling techniques of physiological systems.
- To study the various regulatory systems of the human body.

Course Outcomes:

- Analyze the concepts of modeling
- Differentiate the dynamics of circulatory system
- Perform the modeling for thermal regulatory system
- Design the model for Renal system
- Evaluate the mass-balance concept for respiratory system
- Summarize the mathematical concept for any Physiological system

Unit I - Basics of Physiological Systems: Systems Analysis, examples of physiological control systems, differences between engineering and physiological control systems. Generalized system properties, mathematical approach, electrical analogs, linear models, lung mechanics, muscle mechanics, distributed parameter versus lumped parameter models, static analysis, regulation of cardiac output, blood glucose regulation, chemical regulation of ventilation, electrical model of neural control mechanism

Unit II - Circulatory System: Physical, chemical and rheological properties of blood, problems associated with extra corporeal blood flow, dynamics of circulatory system.

Unit III - Thermal Regulatory System: Parameters involved, Control system model etc. Biochemistry of digestion, types of heat loss from body, models of heat transfer between subsystem of human body like skin core, etc. and systems like within body, body, environment, etc.

Unit IV - Ultra-Filtration System: Transport through cells and tubules, diffusion, facilitated diffusion and active transport, methods of waste removal, counter current model of urine formation in nephron, Modeling Henle's loop.

Unit V - Respiratory System: Modelling oxygen uptake by RBC and pulmonary capillaries, Mass balancing by lungs, Gas transport mechanisms of lungs, oxygen and carbon dioxide transport in blood and tissues

Reference Books

1. David O. Cooney. (2000). Biomedical Engineering Principles. Marcel Decker Pub. Co.
2. Michael C.K.Khoo. (2000). Physiological Control Systems. Prentice Hall of India.
3. John Enderly, Susan Blanchard, Joseph Bronzino. (2005). Introduction to Biomedical Engineering. Second Edition, Academic Press Series in Biomedical Engineering.

17BM2014 MEDICAL IMAGING TECHNIQUES

Credits: 3:0:0

Course Objectives:

- To study the quality assurance test for radiography, method of recording sectional images
- To study the functioning of radio isotopic imaging equipment.
- To study the MRI, image acquisition and reconstruction

Course Outcomes:

- List out the various medical imaging techniques.
- Explain the principle of specific medical imaging techniques.
- Interpret the imaging outputs.
- Identify the suitable medical imaging techniques for specific pathology.
- Devise new ideas to solve certain issues in medical imaging.
- Justify the impact of medical imaging system for diagnosis.

Unit I - ULTRASOUND IN MEDICINE: Production of ultrasound – properties and principles of image formation, capture and display – principles of A-mode, B-mode and M-mode display – Doppler ultra sound and color flow mapping – applications of diagnostic ultra sound.

Unit II - X-RAY COMPUTED TOMOGRAPHY: Principles of sectional imaging – scanner configuration – data acquisition system – image formation principles – conversion of x-ray data in to scan image – 2-D image reconstruction techniques –Iteration and Fourier method – types of CT scanners.

Unit III - MAGNETIC RESONANCE IMAGING: Principles of MRI pulse sequence – image acquisition and reconstruction techniques – MRI instrumentation magnetic gradient system RF coils – receiver system functional MRI – Application of MRI.

Unit IV - RADIO ISOTOPIC IMAGING: Rectilinear scanners – linear scanners – SPECT – PET Gamma camera radio nuclides for imaging – emission computed CT 78.

Unit V - INFRA RED IMAGING: Physics of thermography – imaging systems – pyroelectric Videocon camera clinical thermography – liquid crystal thermography.

Reference Books

1. M. Analoui, J.D. Bronzino, D.R.Peterson, "Medical Imaging: Principles and Practices", CRC Press, 2012.
2. S. Webb, "Physics of medical imaging", Taylor & Francis, 2010.
3. T. Farncombe, K. Iniewski, "Medical Imaging: Technology & Applications", CRC Press, 2013
4. J.S. Benseler, "The Radiology Handbook: A pocket guide to medical imaging", Ohio University Press, 2006
5. R.R.Carlton, A.M.Adler, "Principles of Radiographic Imaging: An Art and a Science", Delmar Cengage Learning; Fifth Eddition, 2012
6. N.B.Smith, A. Webb, "Introduction to Medical Imaging Physics, Engineering and Clinical Applications" CRC Press, 2010
7. M.A. Haidekker, "Medical Imaging Technology", Springer, 2013

17BM2015 DIGITAL IMAGE PROCESSING FOR MEDICAL APPLICATION

Credits: 3:0:0

Course Objectives:

- Learn digital image fundamentals.
- Be exposed to simple image processing techniques.
- Be familiar with image compression and segmentation techniques.

Course Outcomes:

- Describe various concepts of digital image processing
- Select suitable technique for accomplishing specific image processing task
- Illustrate the steps involved in processing digital images
- Analyze the performance of image processing techniques
- Devise new ideas or tools to solve common issues in certain applications
- Assess the impact of digital image processing for medical application

Unit I - Digital image fundamentals: Introduction – Origin – Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels - color models.

Unit II - Image enhancement: **Spatial Domain:** Gray level transformations – Histogram processing – Basics of Spatial Filtering–Smoothing and Sharpening Spatial Filtering – **Frequency Domain:** Introduction to Fourier Transform– Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters.

Unit III - Image restoration and segmentation: Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering **Segmentation:** Detection of Discontinuities–Edge Linking and Boundary detection – Region based segmentation- Morphological processing- erosion and dilation.

Unit IV - Wavelets and image compression: Wavelets – Subband coding - Multiresolution expansions - **Compression:** Fundamentals – Image Compression models – Error Free Compression – Variable Length Coding – Bit-Plane Coding – Lossless Predictive Coding – Lossy Compression – Lossy Predictive Coding – Compression Standards.

Unit V - Image representation and recognition: Boundary representation – Chain Code – Polygonal approximation, signature, boundary segments – Boundary description – Shape number – Fourier Descriptor, moments- Regional Descriptors – Topological feature, Texture - Patterns and Pattern classes - Recognition based on matching.

Reference Books

1. Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", Third Edition, Pearson Education, 2010.
2. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using Matlab", Third Edition Tata McGraw Hill Pvt. Ltd., 2011.
3. Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd., 2011.
4. William K. Pratt, "Introduction to Digital Image Processing", CRC Press, 2013.
5. Chris Solomon, Toby Breckon, "Fundamentals of Digital Image Processing – A practical approach with examples in Matlab", Wiley-Blackwell, 2010.
6. Jayaraman, "Digital Image Processing", Tata McGraw Hill Education, 2011.
7. Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", First Edition, PHI Learning Pvt. Ltd., 2011.

17BM2016 EMBEDDED BIOMEDICAL INSTRUMENTATION SYSTEMS

Credits: 3:0:0

Course Objectives:

- To study the fundamentals of embedded system and its hardware units.
- To study the concepts of various programming models for embedded system design
- To study the development activities of real time biomedical instrumentation system for medical applications

Course Outcomes:

- Identify the basic need of embedded systems and various software development tools
- Classify the different program modelling concepts for real time system design
- Choose the suitable techniques for biomedical instrumentation system application development
- Demonstrate various interfacing issues related to real time embedded applications
- Point out the requirement of RTOS for multitasking execution
- Design embedded based biomedical system for remote applications

Unit I - Introduction to embedded systems: Embedded system, Processor embedded into a system, embedded hardware units – Embedded software in a system – Conversion of assembly language into machine codes – Software tools for designing an embedded systems – Examples of an embedded systems – Complex systems design and processors – Design process in embedded system – Classification of an embedded systems

Unit II - Program modeling concepts: Program modeling concepts –State machine programming model- State Machine and state Tables in embedded design – Modelling for multiprocessor systems – UML modeling – High level language descriptions of S/W for embedded system – Software programming – Object oriented programming – Embedded programming advantages and disadvantages

Unit III - Interfacing techniques for system design: Getting embedded software into a target system, Simulation and Emulation of an embedded system, Software development tools-Overview of analog and digital Interfacing- LED, Seven Segment Display, Switch Interface, Keypad Interface, Data Acquisition system- Analog to Digital and Digital to analog converters, Timer operations. Pressure sensor interfacing, Temperature sensor interfacing and serial communications

Unit IV - Real time multitasking system: Real time languages , OS tasks, Task states, Real time kernel, Preemptive Kernel, Non preemptive kernel, Priority Inversion Problem, Task scheduling, Interrupt Service Routine in RTOS environment.

Unit V - Applications: Computerised versions of ECG, EEG, EMG Acquisitions - Embedded implementation of physiological parameters monitoring system, Role of body sensor networks for biomedical applications, Study of wireless modules for biomedical applications- Case studies in medical signal and image processing, Design of embedded system for classifying and diagnosis of various diseases.

Reference Books

1. RajKamal, "Embedded Systems Architecture, Programming and Design", Tata McGrawHill , Second Edition, 2008.
2. Tim Wilhurst, "An Introduction to the Design of Small Scale Embedded Systems, Palgrave, 2004.
3. Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2005.
4. Frank Vahid, Tony Givargis, "Embedded Systems Design", Wiley India, 2006

17BM2017 EMBEDDED BIOMEDICAL INSTRUMENTATION SYSTEMS LABORATORY

Credits: 0:0:2

Course Objectives:

- To impart the basic knowledge about embedded systems.
- To learn about the Embedded Processors with Real World applications.
- To understand the concepts of embedded programming.

Course Outcomes:

- List different software tools used for system design
- Review the structure of embedded software and download it to the embedded hardware.
- Demonstrate the necessary of embedded hardware and the interface issues related to it.
- Identify the various procedures for designing real time system
- Design a real time biomedical system for real time bio signal acquisitions
- Summarize the programming issues related to biomedical instrumentation system

Description:

This course enables the students to gain practical knowledge in embedded programming, data acquisition and interfacing techniques of medical sensors and instruments with microcontrollers and apply it to real time applications.

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.

17BM2018 BIOVIRTUAL INSTRUMENTATION LABORATORY

Credits: 0:0:2

Course Objectives:

- To study the basic programming concepts of virtual instrumentation.
- To study the various functions available to process and extract features from bio signals.
- To learn about real time data acquisition and medical sensors interfacing concepts.

Course Outcomes:

- Create, edit and debug bio virtual instruments.
- Understand the usage of biomedical tool kit for processing bio signals.
- Develop virtual instrumentation systems for filtering and processing of bio signals.
- Apply computer interfacing principles for bio signal acquisition.
- Interpret the merits of real time processing of data using LabVIEW.
- Appraise the usefulness of LabVIEW in real time data acquisition and processing of bio signals which aids in measurement of physiological data and analysis.

Description:

This course enables the students to gain practical knowledge in programming techniques, data acquisition and interfacing techniques of virtual instrumentation and apply it to real time environment.

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.

17BM2019 MEDICAL IMAGE PROCESSING LABORATORY

Credits: 0:0:2

Course Objectives:

- To teach about the image processing tool
- To impart hands-on knowledge on various image processing techniques
- To apply for biomedical image applications.

Course Outcomes:

- Describe various components of digital image processing tool
- Select suitable technique for implementing specific image processing task
- Illustrate the steps involved in processing digital images
- Analyze the results of image processing algorithms
- Devise new approach to solve issues in certain applications
- Assess the impact of digital image processing tool for medical application

Description:

This course enables the students to gain practical knowledge in medical image processing techniques, using various algorithms.

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.

17BM2020 SURGICAL ASSIST SYSTEMS

Credits: 3:0:0

Course objectives:

- Understand the need for robotics based assistive devices
- Learn robot kinematics, trajectory control
- Apply control algorithms in controlling robot motion for medical applications

Course Outcomes:

- Identify the concepts of robotics, motion, joints
- Summarize the principles of sensors and actuators for robots
- Use the software tools for designing and analysing the robot motion
- Classify the performance to various sensors to its environment

- Recommend the suitable principles for specific conditions
- Create simple robots for surgical applications

Unit I - Introduction to Robotics: Degree of freedom, path planning, Lagrange equation of motion, kinetics, payload.
Unit II - Robot sensors, actuators: Sensors and actuators, gripper- types, applications. Proximity switches,
Unit III - Mechanism: Lift mechanism for surgery, special lighting controls, ventilator, and heart lung machine.
Unit IV - Controllers: Artificial intelligence, machine vision, design of controllers.
Unit V - Human machine interface: Surgical conditions, types of surgeries by robots, camera, wireless devices, remote monitors, case studies.

Reference Books

1. Jacob Rosen, Blake Hannaford, Richard. M. Satava, "Surgical Robotics- Systems, Applications and Visions", Springer, 2010.
2. Farid Gharagozloo, Farzad Najam, "Robotic surgery", McGraw Hill Publishers, US, 2009,
3. Bruno Siciliano and Lorenzo Sciavicco, "Robotics: Modelling, Planning and Control, Springer, 2010.
4. Bruno Siciliano, Oussama Khatib, "Springer Handbook of Robotics", Springer, 2008.
5. Sebastian Thrun, Wolfram Burgard, "Probabilistic Robotics", Intelligent Robotics and Autonomous Agents series, 2005.

17BM2021 SENSORY AND MOTOR REHABILITATION

Credit: 3:0:0

Course Objectives:

- Know the fundamental rehabilitation concepts for future development and applications.
- Understand orthopedic prosthetics and orthotics in rehabilitation.
- Apply the technology to improve the quality of life of the disabled population.

Course Outcomes:

- Identify the models of rehabilitation
- Interpret the techniques for disabilities related to sensory and motor functions
- Construct the test bench, tools and methods for troubleshooting
- Compare various standards and specifications.
- Decide quality and safety standards in design of devices for user needs
- Formulate advanced methods to solve critical problems related to old aged

Unit I - Rehabilitation concepts: Engineering concepts in sensory rehabilitation, motor rehabilitation. Survey.
Unit II - Sensory Rehabilitation: Rehabilitation of auditory disorders, and vision, measurement system, rehabilitation methods- Hearing aids and other assistive devices. Language disorders, assessment and treatment.
Unit III - Motor Rehabilitation: Limb disorder, fractures, mobility aids, assist devices, types, prosthetics, myoelectric arm.
Unit IV - Cognitive Rehabilitation: Cognitive disorder, assessment, design of communication aids, assist devices for cognitive development, evaluation of improvements.
Unit V - Rehabilitation for Old aged: Assist devices for old aged, assist devices for lifting, standing, movement, monitoring systems, movement sensor, Case study.

Reference Books

1. Horia, Hicholi, Teodorescu L., Lakme C Jain., "Intelligent Systems and Technologies in Rehabilitation Engineering", First Edition. CRC Press. 2000.
2. Bronzino J.D., "The Biomedical Engineering handbook". Second Edition. Vol. II, CRC press, Bocaraton, 2000.
3. Cooper Douglas, A. Hobson, "An Introduction to Rehabilitation Engineering", CRC Press, 2007.
4. Marion A. HershBy Jerome G. Alpiner, Patricia A. McCarthy, "Assistive Technology for Visually Impaired and Blind People", CRC Press, 2005.

17BM2022 MEDICAL EQUIPMENT MAINTENANCE AND TROUBLESHOOTING

Credits: 3:0:0

Course Objectives:

- Understand troubleshooting of electrical and electronic equipment.
- Learn the trouble shooting of medical equipment.
- Apply the tools in design, testing and developing medical equipment

Course Outcomes:

- Identify the reasons for equipment failure.
- Interpret the need for grounding aspects, maintenance and troubleshooting.
- Construct the test bench, tools and methods for troubleshooting
- Compare various standards and specifications.
- Decide quality and safety standards
- Formulate advanced methods to solve critical problems.

Unit I - Testing of electrical equipments: AC, DC power supply, Grounding, shielding, Guarding, insulation testing, insulation resistance measurement, Types of Circuit Breakers, Rating - Testing of circuit breakers – Tranformer testing- Earthing –Earth wires - Earthing of appliances – contactor, relay testing–CT and PT, Panel wiring- Megger-Testing equipments and instruments.

Unit II - Testing of electronic components: Troubleshooting of PCB boards, Calibration of analog and digital sensor probe, Display interface, DC Power supply design, testing, Safe electrical practice, Cables and standard, Fuse.

Unit III - Testing of surgical Equipment: Functions and operating procedure-Testing and maintenance of Heart lung machine, surgical lights, ventilator, patient monitor, anesthesia machine, dialyzer, surgical tools.

Unit IV - Troubleshooting of equipments: X-ray machines, Troubleshooting of ECG recorders, incubator, baby warmer, infusion pumps, annual maintenance, contract requirements, vendor services, quality and safety standards.

Unit V - Life cycle management of medical equipment: Cost of the medical equipment, maintenance cost, replacement analysis, managing equipment service, decision making, extracting optimal benefit from medical equipment over its life cycle. Case study.

Reference Books

1. Shakti Chatterjee, Aubert Miller, "Biomedical Equipment Repair", Cengage Learning Technology & Engineering, 2010.
2. David Herres, "Troubleshooting and Repairing Commercial Electrical Equipment", McGraw Hill Professional edition, 2013.
3. Rao S, "Testing, Commissioning, Operation and Maintenance of Electrical Equipment", Khanna Publishers, New Delhi, 2014.
4. L.Nokes.B.Turton, D.Jennings, T. Flint, "Introduction to Medical Electronics Applications", Butterworth Heinemann, Pub., New Delhi. 1995.
5. Francis Hegarty, John Amoore, "Health care technology management – A systematic approach", CRC Press, USA, 2017.
6. Paul Gill, "Electrical Power Equipment Maintenance and Testing", CRC Press, USA, Second Edition, 2008.
7. Hemant Joshi, "Residential, Commercial and Industrial Electrical Systems: Protection, testing and commissioning", Tata McGraw-Hill Education, New Delhi,2008.
8. Medical Equipment Maintenance Manuel, Ministry of Health and Family Welfare, New Delhi, 2010.

17BM2023 BIOMEDICAL OPTICS

Credit 3:0:0

Course Objective:

- To offer clear understanding of tissue characteristics when it is exposed to optical energy.
- To know about various optical sources and applications of lasers.
- To learn about Holography and its medical applications.

Course Outcomes:

- Recall the principles of optical properties
- Explain the different measurement techniques in medical optics
- Illustrate the concept of biomedical optics in various real life applications
- Analyze the instrumentation involved in biomedical optics
- Apply laser instrumentation in medical diagnosis and therapy
- Discuss the therapeutic applications in the field of medicine

Unit I - Optical properties of the tissues: Refraction, Scattering, Absorption, Light transport inside the tissue, Tissue properties, Laser Characteristics as applied to medicine and biology-Laser tissue Interaction-Chemical-Thermal- Electromechanical – Photoabalative processes.
Unit II - Instrumentation in photonics: Instrumentation for absorption, Scattering and emission measurements, excitation light sources – high pressure arc lamp, LEDs, Lasers, Optical filters, - optical detectors – Time resolved and phase resolved detectors.
Unit III - Laser applications: Lasers in ophthalmology- Dermatology –Dentistry-Urology-Otolaryngology - Tissue welding.
Unit IV - Non thermal diagnostic applications: Optical coherence tomography, Elastography, Laser Induced Fluorescence (LIF)-Imaging, FLIM Raman Spectroscopy and Imaging, FLIM – Holographic and speckle application of lasers in biology and medicine.
Unit V - Therapeutic applications: Phototherapy, Photodynamic therapy (PDT) - Principle and mechanism - Oncological and nononcological applications of PDT - Biostimulation effect – applications-Laser Safety Procedures.

Reference Books

1. Markolf H.Niemz, "Laser-Tissue Interaction Fundamentals and Applications", Springer, 2007
2. Paras N. Prasad, "Introduction to Biophotonics", A. John Wiley and Sons, Inc. Publications, 2004

17BM2024 BIOMETRIC SYSTEMS

Credits: 3:0:0
Course Objective:

- To introduce the basic concepts of fingerprint, iris, face and speech recognition.
- To impart knowledge on the general principles of design of biometric systems and the underlying trade-offs
- To render knowledge on personal privacy and security implications of biometrics based identification technology and the issues realized

Course Outcome:

- Infer the technologies of fingerprint, iris, face and speech recognition.
- Expertise in the general principles of design of biometric systems and the underlying trade-offs.
- Priorities the work on identification and recognition depends on physiological and behavioral characteristics
- Identifying the interfacing technologies for real time biometric applications
- Inculcate knowledge on personal privacy and security implications of
- Biometrics based identification technology and the issues involved.

Unit I - Biometric Fundamentals – Definition: Biometrics versus traditional techniques – Characteristics - Key biometric processes - Verification - Identification - Biometric matching - Performance measures in biometric systems - Assessing the privacy risks of biometrics.
Unit II - Physiological Biometrics Characteristics: Facial scan - Ear scan, Retina scan -
Iris scan - Finger scan - automated fingerprint identification system - Palm print - Hand vascular geometry analysis - DNA - Dental.
Unit III - Behavioural Biometrics Characteristics: Signature scan - Keystroke scan - Voice scan, Gait recognition - Gesture recognition - Video face - mapping the body technology.
Unit IV - Biometric Interfaces: Human machine interface - BHMI structure, Human side interface: Iris image interface - Hand geometry and fingerprint sensor - Machine side interface - Parallel port - Serial port - Network topologies.

Unit V - Biometric Applications: Categorizing biometric applications, Application areas: Criminal and citizen identification – Surveillance - PC/network access - E-commerce and retail/ATM - Costs to deploy - Issues in deployment - Biometrics in medicine - cancellable biometrics.

Reference Books

1. James Wayman, Anil Jain, DavideMaltoni, Dario Maio, "Biometric Systems, Technology Design and Performance Evaluation", Springer, 2005
2. S.Y. Kung, S.H. Lin, M.W.Mak, "Biometric Authentication: A Machine Learning Approach" Prentice Hall, 2005
3. Paul Reid, "Biometrics for Network Security", Pearson Education, 2004.
4. Nalini K Ratha, Ruud Bolle, "Automatic fingerprint Recognition System", Springer, 2003
5. L C Jain, I Hayashi, S B Lee, U Halici, "Intelligent Biometric Techniques in Fingerprint and Face Recognition" CRC Press, 1999.
6. Sanir Nanavati, Michael Thieme, Biometrics Identity Verification in a Networked world, Wiley Computer Publishing Ltd, New Delhi,2003.
7. Paul Reid, "Biometrics for Network Security", Pearson Education, New Delhi, 2004.
8. Ruud M. Bolle et al, "Guide to Biometrics", Springer, USA, 2003.
9. David D Zhang, "Automated Biometrics: Technologies and Systems", Kluwer Academic Publishers, New Delhi, 2005

17BM2025 RADIATION AND NUCLEAR MEDICINE

Credits: 3:0:0

Course Objectives:

- To expose the student to the use of ionizing radiation and its biological effects in the medical field.
- To know about the use of ionizing radiation in medical and industrial applications.
- To understand the biological effects of low and high doses of ionizing radiation.

Course Outcomes:

- Acquire knowledge about radiation activity in the living cells.
- Identify the key principles of nuclear medicine and radioactivity.
- Analyze the working principle of advanced nuclear medicine imaging systems.
- Interpret the effects of ionizing and non-ionizing radiations
- Analyze the effect of microwave on human organs and systems.
- Suggest suitable therapeutic radiation for diseases without any side effects.

Unit I - Action of Radiation in Living Cells: Various theories related to radiation at cellular level. Dna and chromosomal damages. Somatic application of radiation. Radio sensitivity protocols of different tissues of human. Ld50/30 effective radiation on skin, bone marrow, Eye, endocrine glands, and basis of radio therapy. Genetic effects of radiation: Threshold and linear dose, gene control hereditary diseases effect of dose. Effect of microwave: Effects on various human organs and systems.

Unit II - Nuclear Medicine: Basic characteristic and units of radioactivity, ionization chamber, GM tubes, Gas filled detectors, scintillation detectors, semiconductor detectors, Liquid scintillation counter, Statistical aspects of nuclear medicine.

Unit III - Nuclear Medicine Imaging Systems: Rectilinear scanners, Scintillation Camera, principle of operation, collimator, photomultiplier tube, Pulse height Analyser, computerized multi crystal Gamma camera, Principles of PET and SPECT.

Unit IV - Radiation Therapy: Principles of Radiation Therapy, Radio therapy treatment planning Dose in Radiotherapy, Mega voltage therapy, Intensity modulated Radiation therapy, Brachy-therapy, Radiotherapy using radio isotopes

Unit V - Radiobiology and Radiological Protection: Radiation sensitivity of biological materials, Evidence on radiobiological damage from cell survival curve, Radiation effects on humans, Maximum permissible dose equivalent limits, Hazard from ingested radioactivity, substances, ICRP regulations, Quality factor and sievert, Principles of radiological protection, personnel dosimetry.

Reference Books

1. Mary Alice S, Paula J Visconti, E Russell Ritenour, Kelli Haynes," Radiation Protection In medical Radiography,"Elsevier Health Sciences,2014.
2. Glasser O.,"Medical Physics", Volume I,II,III, The year book publishers inc, chicago 1980.
3. Moselly H., "Non ionizing radiation", Adam-hilgar, Bristol 1988.
4. Khan,F.M, Physics for Radiation Therapy, Williams & Wilkins. 2009.
5. Gopal B.Saha, Physics and Radiation biology of Nuclear Medicine. 2006

17BM2026 PATIENT AND DEVICE SAFETY

Credits: 3:0:0

Course Objectives:

- To provide a source of useful ideas, concepts, and techniques that could be selectively applied to reduce an intolerable rate of unacceptable errors, mistakes, goofs, or short comings in expected Medical Device performance.
- To avoid patient injury, achieving efficacious treatment, and controlling health care costs.
- Medical error has proved to be a difficult and recalcitrant phenomenon.

Course Outcomes:

- Identify the mechanical and electrical safety standards of medical equipment
- Understand device specific safety goals
- Interpret reasonable, acceptable and effective remedies and counter measure
- Access the clinical suitability to under the impact of the device on the environment
- Device more reliable medical equipment incorporating safety goals
- Suggest new techniques for device management

Unit I - Reliability and Safety Testing: Reliability – Types of reliability – Reliability optimization & assurance – Reliability's effect on medical devices – The concept of failure – Causes of failure – Types of Failures in Medical devices – Safety testing – Device specific safety goals, Failure assessment and Documentation – Visual inspection: External & Internal visual inspection – Measurement – Safety parameters, Function test

Unit II - Risk Management: Safety and risk management – Risk, Deciding on acceptable risk, Factors important to medical device risk assessment – Risk management – Tools for risk estimation – Liability – Manufacturer's and physician's responsibilities

Unit III - Medical Devices Handling, Environmental & Ecological Safety: Safe medical devices – Handling and operation – Medical Application safety – Usability – Clinical assessment – Environmental safety – Interference with the environment – Environmental conditions, Impact on the environment – Ecological safety

Unit IV - Mechanical and Electrical Safety: Safety Mechanics – Electrical Safety – Biological aspect – Limitation of Voltages - Macroshock and Microshock – Earth and Protection – Leakage currents – Magnetic fields and compatibility – Basic assumptions in safety technology – Safety classes

Unit V - Medical Devices Standards, Regulations & Directives: Medical Standards and Regulations – Device classification – Registration and listing – Declaration of conformance to a recognized standard – Investigational Device Exemptions (IDEs) – Institutional Review Boards (IRBs) – IDE format – Good laboratory practices (GLPs) – Good manufacturing practices (GMPs) – Human factors – Design control – The Medical Devices Directives (MDD) – Definition, Process and choosing the appropriate directive – Active Implantable Medical Devices Directive (AIMDD) – In Vitro Diagnostic Medical Devices Directive (IVDMDD).

Reference Books

1. Norbert Leitgeb "Safety of Electro-medical Devices Law – Risks – Opportunities" Springer Verlog/Wein, 2010.
2. Bertil Jacobson and Alan Murray, "Medical Devices Use and Safety", Elsevier Limited, 2007.
3. Richard Fries, "Reliable Design of Medical Devices – Second Edition", CRC Press, Taylor & Francis Group, 2006.
4. Gordon R Higson, "Medical Device Safety – The regulation of Medical Devices for Public Health and Safety", IOP Publishing Limited, Bristol and Philadelphia, 2002.
5. Shayne Cox Gad, "Safety Evaluation of Medical Devices" Second Edition, Marcel Dekker Inc., 2002.

17BM2027 ICU AND OPERATION THEATRE EQUIPMENT

Credit: 3:0:0

Course Objective:

- To offer clear understanding of various intensive care equipment and their working.
- To understand the necessity of different operation theatre equipment.
- To know about different dialyzers and ventilators.

Course Outcome:

- Apply the knowledge acquired, in designing new monitoring devices for ICU.
- Suggest suitable surgical instruments and operational devices.
- Assist the medical personnel's during emergency situations in the ICU.
- Compare the various techniques for clinical diagnosis, therapy and surgery, and its recent methods
- Assess the merits of the operation theatre equipment based on its applications
- Design the devices for the particular application based on given specifications.

Unit I - ICU Equipment: Suction apparatus, Different types; Sterilizers, Chemical, Radiation, Steam for small and larger units. Automated drug delivery systems, Infusion pumps, closed loop control infusion system, implantable infusion system.
Unit II - Critical Care Equipment: Hemodialysis Machine, Different types of Dialyzers, Membranes, Machine controls and measurements. Heart Lung Machine, different types of oxygenators, peristaltic pumps, Incubators.
Unit III - Operation Theatre Equipment: Surgical diathermy, Instruments for operation. Anesthesia Equipment, Humidification, Sterilization aspects, Boyles apparatus.
Unit IV - Centralised Systems: Centralized Oxygen, Nitrogen, Air supply & Suction. Centralized Air Conditioning, Operation Theatre table & Lighting.
Unit V - Patient Safety: Patient electrical safety, Types of hazards, Natural protective mechanisms against electricity, Leakage current, Inspection of grounding and patient isolation, Hazards in operation rooms, ICCU and IMCUs, Opto couplers and Pulse transformers.

Reference Books

1. Khandpur,R.S,"Handbook of Biomedical Instrumentation ",Second Edition. Tata Mc Graw Hill Pub. Co., Ltd. 2003
2. John, G. Webster. Medical Instrumentation, Application and Design. Second Edition. John Wiley & sons, Inc., NewYork. 2008.
3. Joseph Dubovy, Introduction to Biomedical.Mc Graw Hill Co.1978
4. Terry Bahil.A, Biomedical and Clinical Engineering. Prentice Hall Inc.1981

17BM2028 GRAPHICAL SYSTEM DESIGN FOR BIOMEDICAL ENGINEERS

Credits: 3:0:0

Course Objectives:

- To create knowledge in acquiring data and control an external measuring device by interfacing to a computer.
- To study about the basic of Programming Techniques and its applications.
- To become a performer in designing virtual instruments for various biomedical measurements and applications.

Course Outcomes:

- Understand Computer based instrumentation for real time applications
- Interfacing with real time signals
- Analyzing the application of VIs in medical instrumentation in developing medical instruments
- Perform signal processing operations using virtual instrumentation
- Identify salient traits of a virtual instrument and incorporate these traits in projects.
- Experiment, analyze and document in the laboratory prototype measurement systems using a computer, plug-in DAQ interfaces and bench level instruments.

Unit I - Labview programming principles & environment: Data flow – Definition, and importance of data flow in LabVIEW – Identify programming practices that enforce data flow in block diagram, Virtual instrumentation (VI), and sub-VIs - Identify programming practices that break data flow – Polymorphism - Define polymorphism - Identify benefits of polymorphism - Determine output or intermediate values of data elements in VI that utilizes polymorphic inputs LabVIEW Environment -Front panel window, block diagram, and connector pane - Identify which types of VIs do not have a block diagram - Identify the purpose of the connector pane and icon – Palettes

Unit II - Software constructs & programming functions: Front panel window and block diagram objects - Controls, indicators, IO controls, and refnums - Property Nodes - Data types and data structures - Working with objects and data types on front panel windows – Program control structures and data storage - Flat and Stacked sequence structures - Event structures- Formula Node - Arrays and clusters

Unit III - Data communication & synchronization: Local, global, and shared variables – Data Socket - TCP and UDP – Synchronization – Notifiers – Queues - VI Server - configuring the VI Server - Error handling VIs and functions - Debugging tools and techniques.

Unit IV - Virtual insturmentation (vi) design & subvi design techniques: Simple state machine - User interface event handler - Queued message handler - Producer/consumer (data) and producer/consumer (events) - Functional global variables - Connector panes and connection types - Polymorphic subVIs - Options related to subVIs - Error handling – User interface design and block diagram layout - Modular and hierarchical design - SubVI icons and connector pane layout (standard) - VI properties - Documenting VIs

Unit V - Memory, performance and determinism: Tools for identifying memory and performance issues - Profile memory and performance - Show buffer allocations- VI metrics - Programming practices - Enforcing dataflow -User interface updates and response to user interface controls - Data type selection, coercion, and buffer allocation - Array, string, and loop operations -Local and global variables, Property Nodes.

Reference Books

1. S. Sumathi, P.Surekha, "LabVIEW based Advanced Instrumentation Systems " springer 2007.
2. Gary Jonson, 'Labview Graphical Programming', McGraw Hill, New York, Fourth edition 2006.
3. Lisa K. wells & Jeffrey Travis, 'Labview for everyone', Prentice Hall Inc., First edition 1997.
4. S. Gupta, J.P: Gu.pta, 'PC interfacing for Data Acquisition & Process Control', Instrument Society of America, Second Edition, 1994

17BM2029 WEARABLE SYSTEMS AND DIGITAL HEALTH CARE

Credits: 3:0:0

Course Objectives:

- Understand the needs for wearable devices and the technology
- Learn the concepts in digital health care and digital hospitals
- Apply the tools in design, testing and developing digital health care equipment

Course Outcomes:

- Identify the available technology for wearable devices
- Interpret the need for digital methods of handling medical records
- Construct the tools and methods for work flow
- Compare various standards for inter-operability of devices
- Decide quality and safety standards for developing new devices
- Formulate advanced strategies for innovation to societal needs.

Unit I - Wearable devices and m-Health care: Introduction to mobile health care-devices-economy-average length of stay in hospital, outpatient care, health care costs, mobile phones, 4G, smart devices, wearable devices, Uptake of e-health and m-health technologies. Standards.

Unit II - Digital Radiology: Digital radiology for digital hospital, picture archiving and communication, system integration, digital history of radiology, medical image archives, storage and networks.

Unit III - e-Health: Health care networking, Medical reporting using speech recognition, physiological tests and functional diagnosis with digital methods, tele-consultation in medicine and radiology. Multimodality registration in daily clinical practice. Mobile health care.

Unit IV - Digital Health: Requirements and best practices, Laws and regulations in Digital health, Ethical issues, barriers and strategies for innovation.
Unit V - Standards for inter operability: Selection and Implementation in e-Health project, design of medical equipments based on user needs. Security and privacy in digital health care.

Reference Books

1. Wlater Hruby, " Digital revolution in radiology – Bridging the future of health care, second edition, Springer, New York. 2006.
2. Christoph Thuemmler, Chunxue Bai, "Health 4.0: How Virtualization and Big Data are Revolutionizing Healthcare", Springer, 1st ed. 2017.
3. Samuel A. Fricker, Christoph Thümmler , Anastasius Gavras, "Requirements Engineering for Digital Health", Springer 2015th Edition**.**
4. Rick Krohn (Editor), David Metcalf, Patricia Salber, "Health-e Everything: Wearables and the Internet of Things for Health, Part One: Wearables for Healthcare", HIMSS resources.ebook.

17BM2030 BIO-MEMS TECHNOLOGY

Credits: 3:0:0

Course Objective:

- Introduce the concepts of micro electromechanical systems in medical use
- Learn the materials used and the micro manufacturing of devices
- Apply Microsystems and their applications in medical field

Course Outcome:

- Identify the micro fabrication methods
- Summarize the principles of sensors and actuators
- Use the software tools for designing and analysing the sensors
- Classify the performance to various sensors to its environment
- Recommend the suitable principles for specific conditions
- Create simple systems for medical applications

Unit I - MEMS and Microsystem: Introduction, working principles, materials, micro machining.
Unit II - Micro sensor and actuator: Working principles of Beam, cantilever, piezoelectric sensor, thermal sensor, and actuator, Peltier heat pump and magnetic sensor.
Unit III - Micro Optical sensors: principles of micro lens, digital micro mirror, light detector, medical applications.
Unit IV - Micro fluidics: Fluid actuation methods, micro fluid dispenser, micro needle, micro pump.
Unit V - MEMS Biomedical applications: Micro TAS, micro pressure sensor for detecting human blood pressure, micro flow sensor, micro accelerometer, micro gyro. Radio pill micro device, biochip.

Reference Books

1. Tai Ran Tsu, "MEMS and Micro system design and manufacture", Tata McGraw Hill, New Delhi, 2002.
2. N.P.Mahalik, "Micro manufacturing & Nanotechnology", Springer, 2006.
3. SergeyEdwardLysherski.NanoandMicro-electromechanicalsystems.Second Edition.CRCPress.2005.
4. Wanjun Wang, Steven A. Soper, "BioMEMS Technologies and Applications", CRC Press. 2006.
5. Abraham P. Lee, James L. Lee, "BioMEMS and Biomedical Nano technology", Vol.I, Springer, 2006.

17BM3001 ADVANCED MEDICAL INSTRUMENTATION

Credits: 3:0:0

Course Objectives:

- Understand the fundamentals of human physiology system and its functions.
- Learn the fundamental concepts of physiological parameters measurement.
- Apply the concepts of various medical instruments for biomedical applications.

Course Outcomes:

- Identify the basic need of various human physiology system
- Demonstrate an interfacing circuit for real time bio signal acquisition and processing
- Construct the suitable acquisition method for analyzing biomedical signal.
- Categorize the real time system models for biomedical applications
- Evaluate the various structure for patient safety
- Design real time biomedical system for diagnosing various diseases

Unit I - Introduction to Human Physiology: Circulatory system – cardio vascular system-central nervous system – respiratory system – muscular skeletal system – digestive system – excretory system – sensory organs – voluntary and involuntary action.
Unit II - Biopotentials and their Measurements: cell and its structure – resting potentials – action potentials – bioelectric potentials – measurement of potentials and their recording – basic principles of ECG, EEG, EMG– Electrode theory – bipolar and Unipolar electrode-surface electrode – electrode impedance –equivalent circuit for extra cellular electrodes- micro electrodes.
Unit III - Computer based medical instrumentation: Computerised versions of ECG, EEG, EMG, Tread Mill Test ECG– Foetal monitor, cardiac arrthymias and its monitoring through Hotler monitor, Event monitors, Bispectral Index EEG for depth of anesthesia monitoring.
Unit IV - Operation theatre equipment and Critical Care instrumentation: Patient monitors, pulse oximetry, ICU ventilators, suction apparatus, anesthesia equipment, electro surgery, operating microscopes, motorized operation table, infusion pumps and syringe pumps, nerve stimulator, defibrillators, Electrical Safety and other safety aspects of medical equipment.
Unit V - Medical Imaging Techniques and Therapeutic, diagnostic equipment: X-rays – scanning techniques-ultrasound scanner- color Doppler system, CT, MRI scanning techniques – coronary angiogram, nuclear imaging, Specialized Therapeutic and diagnostic equipment Cardiac pacemakers, heart lung machines, haemodialysis, clinical laboratory instrumentation, Audiometer, Phonocardiogram.

Reference Books:

1. John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, New York, 2009.
2. Leslie Cromwell, "Biomedical Instrumentation and measurement", Prentice hall of India, New Delhi, 2007.
3. Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, New Delhi, 2003.
4. Myer Kutz , "Standard Handbook of Biomedical Engineering & Design", McGraw Hill Publisher, UK, 2003.

17BM3002 MEDICAL IMAGE COMPUTING

Credits: 3:0:0

Course Objectives:

- Learn the fundamentals of digital image processing
- Understand various methods of medical image processing techniques
- Apply the methodologies for clinical applications

Course Outcomes:

- Describe various concepts of digital image processing
- Select suitable technique for accomplishing specific image processing task
- Illustrate the steps involved in processing digital images
- Analyze the performance of image processing techniques
- Devise new ideas or tools to solve common issues in certain applications
- Assess the impact of digital image processing for medical application

Unit I - Image representation: Pixels and voxel**s,** gray scale and color representation, image file formats, DICOM, other formats- intensity transform functions, and the dynamic range, windowing, histogram and histogram operations, dithering and depth, filtering and fourier transform.
Unit II - Segmentation: The segmentation problem, Region of interest and centroid, theresholding, region growing, sophisticated segmentation methods, morphological operations, evaluation of segmentation results-Clinical applications.

Unit III - Spatial Transforms: Discretisation**,** interpolation and volume regularization, translation and rotation, reformatting, tracking and image guided therapy- Visualization, orthogonal and perspective projection, and their view point, raycasting, surface based rendering-Clinical applications.
Unit IV - Registration: Fusing information, registration paradigm, merit functions, optimization strategies-camera calibration, registration to physical space-evaluation of registration results- Clinical applications.
Unit V - CT reconstruction: Introduction-Radon transform-algebraic reconstruction-Fourier transform and filtering-filtered back projection-Clinical applications.

Reference Books

1. Wolfgang Birkfellner, "Applied medical Image Processing- A basic course", second edition, CRC Press, 2014.
2. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using Matlab", Third Edition Tata McGraw Hill Pvt. Ltd., 2011.
3. Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd., 2011.
4. William K. Pratt, "Introduction to Digital Image Processing", CRC Press, 2013.
5. Chris Solomon, Toby Breckon, "Fundamentals of Digital Image Processing – A practical approach with examples in Matlab", Wiley-Blackwell, 2010.
6. Jayaraman, "Digital Image Processing", Tata McGraw Hill Education, 2011.
7. Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", First Edition, PHI Learning Pvt. Ltd., 2011.

17BM3003 SOFT COMPUTING TECHNIQUES FOR BIOMEDICAL ENGINEERS

Credits: 3:0:0

Course Objectives:

- Introduce the basic concepts of neural networks and medical applications
- Learn fuzzy logic concept and its applications in biomedicine.
- Apply genetic algorithm, ant colony optimization and particle swam optimization techniques in solving medical engineering problems.

Course Outcomes:

- Identify the basics of machine learning algorithms.
- Demonstrate the application of soft computing.
- Apply the machine learning techniques to solve real world problems, mainly pertaining to medical applications.
- Design new algorithms through cognitive research.
- Develop new hypothesis based on the cognitive technology.
- Evaluate the effectiveness of the algorithms and modify.

Unit I - Introduction to neural networks: Introduction – Biological neurons and their artificial models – Learning, Adaptation and neural network's learning rules – Types of neural networks – Single layer, Multiple layer – Feed forward, Feedback networks, Back propagation– Learning and training.
Unit II - Special networks and applications: Associative memory – BAM – Hopfield network – ART Network – SOM – Case studies: Depth of anesthesia monitoring using neural networks, Bio signal classification, Pattern recognition.
Unit III - Introduction to fuzzy logic: Fuzzy sets – Fuzzy operation – Fuzzy arithmetic – Fuzzy relations – Fuzzy relational equations – Fuzzy measure – Fuzzy functions –Approximate reasoning – Fuzzy propositions –Fuzzy quantifiers – If then rules.
Unit IV - Fuzzy logic control: Structure of fuzzy logic controller – Fuzzification models –Data base – Rule base – Inference engine – Defuzzification module Case studies: Blood pressure monitoring during anesthesia using fuzzy logic, Image processing using fuzzy logic, Home heating system.
Unit V - Soft Computing Techniques and its applications: Fundamentals of genetic algorithm: Evolutionary computation – Search space – Encoding – Reproduction – Elements of genetic algorithm – Ant Colony Optimization techniques, Particle Swam Optimization techniques and its applications, Machine learning Algorithms – Random Forest, ANFIS, Case studies.

Reference Books:

1. Klir G.J. &Folger T.A. 'Fuzzy sets, uncertainty and Information', Prentice –Hall of India Pvt. Ltd.,1993.
2. Zimmerman H.J. 'Fuzzy set theory – and its Applications' – Kluwer Academic Publishers,1994.
3. Kosko, B. 'Neural Networks and Fuzzy Systems', Prentice – Hall of India Pvt. Ltd.,1994.
4. Jacek M Zurada, 'Introduction to Artificial Neural Systems', Jaico Publishing House, 1999.

17BM3004 MEDICAL SENSORS AND MEMS TECHNOLOGY

Credits: 3:0:0

Course Objectives:

- Understand the in depth and quantitative view of medical sensors, its characteristics and applications for wearable and smart sensors
- Overview of the current state of the art to micro sensor fabrication methods micro sensor design, analysis, materials and testing
- Apply the tools to design and development of sensors for the medical applications

Course Outcome:

- Identify the principle of medical sensors and its interfacing circuits for application
- Classify the micro sensor materials and fabrication process
- Apply the design tools to test and develop products to required specifications
- Analyze the most relevant challenges facing the smart sensor research field
- Evaluate a sensor based on standard performance criteria and appropriateness for an application and its impact on environment and user.
- Create the wearable sensor and micro sensor for the particular application,

Unit I - Classification of Medical Sensors: Sensors for Pressure Measurement- Sensors for Motion and Force Measurement- Sensors for Flow Measurement -Temperature Measurement- Sensors for speed, torque, vibration- Wearable Sensors-smart sensors.

Unit II - Introduction to MEMS And Microsystems: Working principle of Microsystems, materials for MEMS and Microsystems, micromachining, System modeling.

Unit III - Fabrication Methods: Properties of materials, Clean room, Fabrication methods, Lithography, epitaxy, sputtering, LIGA.

Unit IV - Microsensors And Acuators: Mechanical sensors and actuators – beam and cantilever, piezoelectric materials, thermal sensors and actuators- micromachined thermocouple probe, Peltier effect, heat pumps, thermal flow sensors, micro gripper microlens, microneedle, micropumps-Testing of the performance using LabVIEW.

Unit V - Design Of Micro System& Software Tools: Modeling and design, using Matlab, Design of sensors, pressure sensor, vibration sensor, actuators Analysis using solvers, Matlab, Intellisuite, mechanical solver, electrical solver.

References

1. Tatsuo Togawa, Toshiyo Tamura, P. Ake Oberg, "Bio-Medical Transducers and Instruments", CRC Press, USA, 2010.
2. Subhas Chandra Mukhopadhyay, Aime Lay Ekuakille, "Advances in biomedical sensing and measurements", Lecture notes in electrical engineering, Springer Verlag, Berlin,
3. Gabor Harsanyi, "Sensors in biomedical applications: fundamentals, technology & applications", CRC Press, USA, 2000.
4. Joseph D. Bronzino, "The biomedical engineering handbook", Volume 2, CRC Press, USA, 2000.
4. Tai Ran Hsu, "MEMS and Microsystems design and manufacture", Tata McGraw Hill Publishing Company, New Delhi, 2002
5. Wanjun Wang, Stephen A.Soper, "BioMEMs: Technologies and applications", CRC Press, New York, 2007.
6. Marc J. Madou 'Fundamentals of micro fabrication: the science of miniaturization', CRC Press, 2002.
7. Nadim Maluf, Kirt Williams. "An introduction to Micro electro mechancial Systems Engineering", Second Edition, Artech House Inc, MA, 2004.

17BM3005 MODELING AND IDENTIFICATION OF PHYSIOLOGICAL SYSTEMS

Credits: 3:0:0

Course Objectives:

- Understand basic ideas related to modeling the physiological system
- Learn the functions of various physiological systems and their characteristics
- Apply the tools to create and analyze the models

Course Outcomes:

- Analyze the concepts of modeling
- Differentiate the dynamics of circulatory system
- Perform the modeling for thermal regulatory system
- Design the model for Renal system
- Evaluate the mass-balance concept for respiratory system
- Identify the model of any Physiological system

Unit I - Basics of Physiological Systems: Systems Analysis, examples of physiological control systems, differences between engineering and physiological control systems. Generalized system properties, mathematical approach, electrical analogs, linear models, lung mechanics, muscle mechanics, distributed parameter versus lumped parameter models, static analysis, electrical model of neural control mechanism.

Unit II - Circulatory and Thermal Regulatory System: Physical, chemical and rheological properties of blood, problems associated with extra corporeal blood flow, dynamics of circulatory system. Parameters involved, Control system model etc. Biochemistry of digestion, types of heat loss from body, models of heat transfer between subsystem of human body like skin core, etc. and systems like within body, body, environment, etc.

Unit III - Ultra Filtration System: Transport through cells and tubules, diffusion, facilitated diffusion and active transport, methods of waste removal, counter current model of urine formation in nephron, Modeling Henle's loop.

Unit IV - Respiratory Systems: Modeling oxygen uptake by RBC and pulmonary capillaries, Mass balancing by lungs, Gas transport mechanisms of lungs, oxygen and carbon dioxide transport in blood and tissues.

Unit V - Identification of Physiological Systems: Non Parametric and parametric identification methods-Numerical Deconvolution, Least Squares Estimation-Correlation functions-frequency domain-optimization techniques, Identification of closed loop systems-case studies.

Reference books:

1. Michael C.K.Khoo, "Physiological control systems", Prentice hall India, 2000.
2. Johnenderly, Susanblanchard, Joseph bronzino. (2005), "Introduction to biomedical
3. Engineering", Second Edition, Academic press series in biomedical engineering.
4. David O Cooney, "Biomedical engineering principles", Marcel decker pub.Co., 2000.

17BM3006 REHABILITATION ENGINEERING

Credits: 3:0:0

Course Objectives:

- To know about various types of assist devices and its applications
- To understand the sensor and actuators and its integration for human assist devices for the disabled subjects
- To develop rehabilitation robots, mobility aids, assist devices for old aged

Course Outcomes:

- Describe the basic terminology in rehabilitation and models for societal applications
- Classify the sensors and actuators for particular applications.
- Discover the new methodology, products and systems for societal needs
- Analyze the performance of devices in various environmental conditions, design aspects
- Evaluate the design, performance, cost and affordability
- Develop the products based on cost effectiveness, user needs, environment friendly

Unit I - Introduction to rehabilitation-terminology, Health, disability, assist device, Assist device models, Safety standards, Community based rehabilitation.
Unit II - Sensors for rehabilitation-linear displacement, Angular displacement, velocity Strain, Force measurement, Motion sensor-accelerometer, Proximity sensor, optical encoder Electrical actuators for rehabilitation, electromechanical mechanism, Pneumatic actuators, Hydraulic actuators.
Unit III - Robots in rehabilitation- Robots in physiotherapy –Rehabilitation of the lower extremity, Robot assisted Gait training –measurements- evaluation.
Unit IV - Mobility aids: wheel chairs – types –wheel chair design, Design of caster-Smart wheel chair, Gyro based wheel chair with integrated controls, Personal and patient transportation system
Unit V - Assistive technology for daily living: Mobility and navigation, Accessible environments, GPS, Text based devices.

References

1. Volker Dietz, Tobias Nef, William Zev Rymer, "Neuro Rehabilitation technology", Springer Verilag, London, 2012.
2. Marion A. Hersh , "Assistive Technology for Visually Impaired and Blind People", CRC Press, 2005.
3. Letha. Y. Griffin, "Rehabilitation of the injured knee", Library of congress cataloging, USA, 1994.
4. Joseph D. Bronzino, "The Biomedical engineering handbook", Vol I, CRC press, 2000.

17BM3007 MEDICAL ETHICS

Credit: 3:0:0

Course Objective:

- Achieve familiarity with some basic ethical framework & understand how these ethical frame works can help us to think through contemporary questions in medical ethics.
- To know about the legal and ethical principles and application of these in medical field.
- Gain knowledge about the medical standards that to be followed in hospitals.

Course Outcomes:

- Identify the fundamental responsibilities of a clinical engineer.
- Develop a life style with ethical values and moral principles.
- Apply the moral values and ethics in their work environment
- Maintain the confidentiality issues in medical practice.
- Suggest standards that are patient centered.
- Evaluate the effect of safety standards.

Unit I - Introduction to medical ethics: Definition of Medical ethics, Scope of ethics in medicine, American medical Association code of ethics, CMA code of ethics- Fundamental Responsibilities, The Doctor and the Patient, The Doctor and the Profession, Professional Independence, The Doctor and Society.
Unit II - Ethical theories & moral principles: Theories-Deontology& Utilitarianism, Casuist theory, Virtue theory, The Right Theory. Principles - Non-Maleficence, Beneficence, Autonomy, Veracity, Justice. Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research, Bioethical issues in Human Genetics & Reproductive Medicine.
Unit III - Hospital accreditation: Accreditation- JCI Accreditation & its Policies. JCA accreditation, FDA regulations, Patient centered standards, Healthcare Organization management standards, NFPA standards, IRPC standards.
Unit IV - Ethics in Hospital safety: Life Safety Standards- Protecting Occupants, Protecting the Hospital From Fire, Smoke, and Heat, Protecting Individuals From Fire and Smoke, Providing and Maintaining Fire Alarm Systems, Systems for Extinguishing Fires Environment of Care Standards-Minimizing EC Risks, Smoking Prohibitions, Managing Hazardous Material and Waste, Maintaining Fire Safety Equipment, Features, Testing, Maintaining, and Inspecting Medical Equipment.
Unit V - Medical Application safety: Environmental safety, Interference with the environment, Ecological safety. Electrical Safety, Limitation of Voltages, Macroshock and Microshock- Earth and Protection, Leakage currents, Magnetic fields and compatibility. Medical Standards and Regulations.

Reference Books

1. Biomedical Ethics: A Canadian Focus. Johnna Fisher (ed.), Oxford University Press Canada. 2009
2. Robert M Veatch, "Basics of Bio Ethics", Second Edition. Prentice- Hall, Inc. 2003
3. Domiel A Vallero, "Biomedical Ethics for Engineers", Elsevier Pub.1st edition, 2007

17BM3008 EMBEDDED SYSTEM AND IoT IN HEALTH CARE

Credits 3:0:0

Course objectives:

- To learn about the Embedded Processors with Real World applications.
- To introduce the concept of biomedical applications in embedded systems.
- To enhance the knowledge in interfacing processes with embedded controllers.

Course outcomes:

- Outline the features of ATmega processor
- Design a biomedical application in an embedded processor.
- Identify IDE for embedded processor
- Write embedded c programming for real time applications
- Compare the features of ATmega processor with other processor
- Specify, analyze and develop prototype using IOT

Unit I - Internet concepts and infrastructure: Broad Band Transmission facilities –Open Interconnection standards –Local Area Networks – Wide Area Networks –Network management – Network Security – Cluster computers. Internet concepts - Capabilities and limitations of the internet -– Interfacing Internet server applications to corporate databases HTML and XML Web page design through programming and the use of active components.
Unit II - Design methodology and protocols: Introduction-Characteristics-Physical design - Protocols – Logical design – Enabling technologies – IoT Levels – Domain Specific IoTs – IoT vs M2M. IOT design methodology -IoT systems management – IoT Design Methodology – Specifications Integration and Application Development.
Unit III - Embedded systems: Generic Embedded Systems Structure- Components of Embedded Systems- Sensors and Actuators-importance of Analog/Digital Conversion- Embedded system based physiological monitoring system- Health care innovations using embedded system
Unit IV - Digital Health: Evolution of digital health-social Technological alignment – laws and regulations for digital health- ethical issues.
Unit V - IOT in health care: IOT based health care- physiological parameter monitoring system- future challenges in health care- health care echo system with IOT- IOT for personalized health care- wearable device characteristics-analysis of power aware protocols and standards for critical e-health applications social network analysis in health care embedded health care system for senior resident using IOT.

Reference:

1. Eugene C. Nelson, Paul B. Batalden, Marjorie M. Godfrey Quality By Design: A Clinical Microsystems Approach John wiley & sons 2007
2. Samuel A. Fricker, Christoph Thuemmler, Anastasius Gavras Requirements Engineering Dor Digital Health springer 2015.
3. Klaus Pohl, Harald Hönninger, Reinhold Achatz, Manfred Broy, "Model-Based Engineering Of Embedded Systems: The SPES 2020 Methodology, Springer, 2012.

17BM3009 DIAGNOSTIC AND THERAPEUTIC LABORATORY

Credits: 0:0:2

Course Objectives:

- To acquire, record and analyze the bio signals
- To study the different preamplifiers used for amplifying the bio signals.
- To impart knowledge about the equipment for diagnosis, therapy and surgical tools

Course Outcomes:

- Identify various sterilization methods in hospitals, equipments for post operative care units, operation theatre and physiotherapy.

- Identify the suitability of diagnostic and therapeutic equipment for specific applications.
- Analyze the performance of various biomedical equipments and their specifications.
- Apply appropriate measurement standards and safe handling of equipments in operation theatre, and surgical equipments
- Design the signal conditioning circuits and develop systems.
- Evaluate the performance of medical instruments.

Description:
This laboratory introduces the different diagnostic and therapeutic equipment, their working principles and the methodologies used for analysing and recording biosignal.

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.

17BM3010 MEDICAL SENSORS, INTERFACING & MEMS LAB

Credits: 0:0:2

Course Objectives:
- To acquire, record and analyse the IC type sensors, MEMS sensors,
- To study the different design tools software for analyzing and comparision.
- To impart knowledge about the equipments for MEMS fabrication methods

Course Outcomes:
- Acquisition, recording and analyse the IC type sensors, MEMS sensors.
- Identify the suitability interfacing circuits for applications.
- Analyze the performance of sensors in simulation tools
- Apply appropriate design standards and constrains
- Design the new sensors test the performance using LabVIEW.
- Evaluate the performance fabrication methods and 3D printing facility.

Description:
This laboratory introduces the different MEMS sensors their conditioning circuits, familiarize MEMS software tools, working and the methodologies used for fabrication of micro devices and 3D printing.

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.

17BM3011 EMBEDDED SYSTEM AND IoT LABORATORY

Credits: 0:0:2

Course Objectives:
- Understand the fundamental concepts in embedded system and design methodology
- Learn the fundamentals of Internet concepts and its applications
- Apply embedded and IoT concepts in health care applications.

Course outcomes:
- Acquire the knowledge and concepts of embedded system.
- Comprehends the challenges in system design
- Apply the concepts of embedded system for health care applications.
- Analyze the functions of digital health.
- Compare Various levels of IoT
- Evaluate future challenges in health care

Description:
This laboratory introduces the fundamentals of embedded based system development, familiarize software tools, design of IoT based applications in health care.

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.

17BM3012 AMBULATORY SERVICES

Credits 3:0:0

Course Objectives:

- Understand the fundamentals of patient monitoring system
- Learn the design of ambulance and transportation systems
- Apply computer based technology in ambulatory services

Course outcomes:

- Identify the principle of patient monitors and its interfacing circuits for application
- Classify the types of services and systems
- Apply the design tools to test and develop lift mechanism for given specifications
- Analyze the most relevant challenges facing the patient safety and protection
- Evaluate the systems based on the criteria and its impact on environment and user.
- Create the smart safety alert systems for the application

Unit I - Patient monitoring systems- artifacts-denoising techniques- Advancements in Wireless patient Monitoring system- Case study.
Unit II - Design of ambulance- Vehicle design- ambulance train- disaster relief squad- regulation for patient transportation- Case study.
Unit III - Lift mechanism- Design of lift mechanism for patient-design of lift in ambulance- computer based systems- Case study.
Unit IV - Design of mobile diagnostic equipment: devices with battery backup- mobile X-ray unit- nursing-medical gas handling-regulations-GPS in ambulance networked services- Case study.
Unit V - Accident care systems- automated alert system- smart safety systems-fire protection –maintenance and regulation-Accreditation for ambulance services- Case study.

Reference Books

1. David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.
2. Andreas F. Molisch, "Wireless Communications, 2nd Edition, John Wiley & sons, USA, 2010.
3. Jochen Schiller, "Mobile Communications", Addison Wesley Publishers, 2000.
4. Yi-Bing Lin and ImrichChlamtac, "Wireless and Mobile Network Architecture", John Wiley and Sons, New Delhi, 2nd Edition, 2001.
5. Feher K., "Wireless Digital Communications", Prentice Hall of India, New Delhi, 1995.

17BM3013 TELEHEALTH TECHNOLOGY

Credits 3:0:0

Course Objectives:

- Understand the development of technology for support telehealth
- Learn the improved healthcare methods to meet greater expectations on the health service
- Apply the design, selection, procurement, installation, management, maintenance, and evaluation of telehealth systems appropriate to present and future needs.

Course Outcomes

- Identify the basics of telemedicine and its application
- Classify the technologies and standards
- Apply principles and methods of evaluation to telehealth projects
- Analyze the most relevant challenges in telemedicine to rural areas
- Evaluate the systems based on the criteria and its impact on environment and user.
- Create the telehealth technologies for future challenges in population

Unit I - Telemedicine And Health: History and Evolution of telemedicine, Functional diagram of telemedicine system, Telemedicine, Tele health, Tele care, Organs of telemedicine, Global and Indian scenario, Ethical and legal aspects of Telemedicine - Confidentiality, Social and legal issues, Safety and regulatory issues, Advances in Telemedicine.

Unit II - Telemedical Technology: Principles of Multimedia - Text, Audio, Video, data, Data communications and networks, PSTN, POTS, ANT, ISDN, Internet, Air/ wireless communications: GSM satellite, and Micro wave, Modulation techniques, Types of Antenna, Integration and operational issues, Communication infrastructure for telemedicine – LAN and WAN technology. Satellite communication. Mobile hand held devices and mobile communication. Internet technology and telemedicine using world wide web (www)-Video and audio conferencing-clinical data– local and centralized.

Unit III - Telemedical Standards: Data Security and Standards: Encryption, Cryptography, Mechanisms of encryption, phases of Encryption. Protocols: TCP/IP, ISO-OSI, Standards to followed DICOM,HL7, H. 320 series (Video phone based ISBN) T. 120, H.324 (Video phone basedPSTN), Video Conferencing, Real-time Telemedicine integrating doctors /Hospitals.

Unit IV - Mobile Telemedicine: Tele radiology: Definition, Basic parts of teleradiology system: Image Acquisition system Display system, Tele pathology, multimedia databases, color images of sufficient resolution, Dynamic range, spatial resolution, compression methods ,Interactive control of color.

Unit V - Telemedical Applications: Telemedicine access to health care services – health education and self care Introduction to robotics surgery, telesurgery. Telecardiology, Teleoncology, Telemedicine in neurosciences, Electronic Documentation, e-health services security and interoperability, Telemedicine access to health care services – health education and self

Reference Books

1. Norris, A.C, "Essentials of Telemedicine and Telecare", . Wiley (ISBN 0-471-53151- 0), 2002
2. Wootton, R., Craig, J., Patterson, V. (Eds.), "Introduction to Telemedicine", Royal Society of Medicine Press Ltd (ISBN 1853156779), 2006 .
3. O'Carroll, P.W., Yasnoff, W.A., Ward, E., Ripp, L.H., Martin, E.L. (Eds), "Public Health Informatics and Information Systems", Springer (ISBN 0-387-95474-0), 2003.
4. Ferrer-Roca, O., Sosa-Iudicissa, M. (editors), "Handbook of Telemedicine", IOS Press (Studies in Health Technology and Informatics, Volume 54). (ISBN 90- 5199-413-3), 2002.
5. Simpson, W. 2006. "Video over IP- A practical guide to technology and applications", Focal Press (Elsevier). ISBN-10: 0-240-80557-7.
6. Bemmel, J.H. van, Musen, M.A. (Eds.) (1997), "Handbook of Medical Informatics", Heidelberg, Germany: Springer. (ISBN 3-540-63351-0)

17BM3014 HOSPITAL AND EQUIPMENT MANAGEMENT

Credits 3:0:0

Course objectives:

- Understand the fundamentals of health care delivery services
- Learn the procedures in maintenance of equipments
- Apply the design principles in engineering systems

Course outcomes:

- Identify the principle of organizational structures and regulatory services
- Classify the types of codes followed and applications
- Apply the design to develop support systems
- Analyze the most challenges in environment and market trends
- Evaluate the systems based on the safety criteria to environment
- Create the methodology for new equipments to user needs

Unit I - Health And Hospital Management: Health organisation of the country, the State, the Cities and the Region, Management of Hospital Organisation, Nursing Sector, Medical Sector, Central Services, Technical Department, Definition and Practice of Management by Objective, Transactional Analysis Human Relation in Hospital, Importance of Team Work, Legal aspect in Hospital Management. Case study: Health survey.

Unit II - Regulatory Requirement And Health Care Codes: FDA Regulation, Joint Commission of Accreditation for Hospitals, National Fire Protection Association Standard, ISO, NABL, Environmental regulation. Case study on ISO.

Unit III - Equipment Maintenance Management: Hospital architecture, Piping, planning of construction, Organising, Maintenance Operations, Maintenance Job Planning, Maintenance Work Measurement and Standards,

Preventive Maintenance, Maintenance Budgeting and Forecasting, Maintenance Training, Contract Maintenance. Case study: Laboratory automation.

Unit IV - Clinical Engineering: Role to be performed in Hospital, Manpower & Market, Professional Registration, Maintenance of Hospital support system, surveillance network, electric power management, Medical gas production, waste disposal, inventory control. Case study: RF id tag for inventory.

Unit V - Hospital Equipments: Operation of safety devices, personnel safety equipments, Gas mask, Radiation measurements, equipment safety systems, elements of basic first aid, fire fighting, Case study: Safety Awareness.

REFERENCES

1. Cesar A.Caceres and Albert Zara, "The Practice of Clinical Engineering, Academic Press, New York, 1977.
2. Webster.J.G. and Albert M.Cook, "Clinical Engineering Principles and Practices Prentice Hall Inc., Englewood Cliffs, New Jersey, 1979.
3. Hans Pfeiff, Vera Dammann (Ed.), "Hospital Engineering in Developing Countries", Report, Eschbom,1986
4. Jacob Kline, Handbook of Bio Medical Engineering, Academic Press Inc.San Deigo,1988
5. R.C.Goyal, "Human Resource Management in Hospital", Prentice Hall of India, 3rd edition, 2000.
6. Syed Amin Tabish "Hospital and Health services Administration Principles and Practices" Oxford Press, New Delhi, 2001.

17BM3015 ROBOTICS IN SURGERY

Credits: 3:0:0

Course objectives:

- Understand the fundamentals of robotics and its degree of freedom
- Learn the various sensor and actuators required for its functions
- Apply the machine learning concepts in medical applications

Course outcomes:

- Identify the fundamental concepts in robotic systems
- Classify the types of sensors and actuators for its applications
- Apply the design tools to develop artificial intelligence techniques
- Analyze the conditions required for testing and control of autonomous robots
- Evaluate the safety aspects to human and environment
- Create the robots for assisting in surgery

Unit I - Introduction to Robotics, degree of freedom, path planning, Lagrange equation of motion, kinetics, payload, Links and Joints,

Unit II - Sensors and actuators: gripper- tactile sensor, Sensor for vision and motion, proximity switches, controllers. Path planning, path tracking, GPS based feedback control.

Unit III - Programmable controller, artificial intelligence, machine vision, design of controllers based on embedded system, human machine interface, case studies

Unit IV - Human-robot interaction, human factors: perception, motor skills, social aspect of interaction, safety, Haptic robots, collision detection, autonomous robots. Applications in physiotherapy.

Unit V - Robotics in surgery: surgical robotics, robot supported diagnostics, micro-robots, nanorobots at the cell level, Robots in medical applications.

Reference Books

1. Jacob Rosen, Blake Hannaford, Richard.M.Satava, "Surgical Robotics", Systems Applications and Visions", Springer, 2011.
2. Farid Gharagozloo, Farzad Najam, "Robotic surgery", McGraw Hill Publishers, US, 2009.First edition.
3. Bruno Siciliano and Lorenzo Sciavicco, "Robotics: Modeling, Planning and Control", Springer, 2010.
4. Bruno Siciliano, Oussama Khatib, "Springer Handbook of Robotics", Springer, 2008.
5. M. Tavakoli, R.V. Patel, M. Moallem, A. Aziminejad, Haptics for Teleoperated Surgical Robotic Systems, World Scientific, 2008
6. Jose L. Pons, Wearable Robots: Biomechatronic Exoskeletons, John Wiley & Sons, 2008.

7. V. Dietz, T. Nef, W.Z. Rymer, "Neurorehabilitation Technology", Springer, 2012
8. E. Burdet, D.W. Franklin, T.E. Milner, "Human Robotics: Neuromechanics and Motor Control", The MIT Press, 2013.

17BM3016 SPEECH SIGNAL PROCESSING

Credits: 3:0:0

Course Objective:

- To introduce the models for speech production
- To develop time and frequency domain techniques for estimating speech parameters
- To introduce concepts of speech compression, recognition, synthesis and speaker identification

Course Outcome

- Qualitatively describe the mechanisms of human speech production.
- Analyse speech signals in the time and frequency domains
- Solve problems regarding parameter estimation in source-filter production models for speech analysis
- Devise methods and systems for efficient quantization and coding of speech signals, speech enhancement and simple pattern-recognition.
- Evaluate the methods used for speech signal analysis and apply suitable methods for practical applications.
- Deign an simple system for speech processing

Unit I - Nature of Speech Signal - Speech production mechanism, Classification of speech, sounds, nature of speech signal, models of speech production. Speech signal processing: purpose of speech processing, digital models for speech signal, Digital processing of speech signals, Significance, short time analysis.
Unit II - Time Domain Methods For Speech Processing - Time domain parameters of speech, methods for extracting the parameters, Zero crossings, Auto correlation function, pitch estimation.
Unit III - Frequency Domain Methods For Speech Processing - Short time Fourier analysis, filter bank analysis, spectrographic analysis, Format extraction, pitch extraction, Analysis - synthesis systems.
Unit IV - Linear Predictive Coding of Speech - Formulation of linear prediction problem in time domain, solution of normal equations, Interpretation of linear prediction in auto correlation and spectral domains.
Unit V - Homomorphic Speech Analysis - Central analysis of speech, format and pitch estimation, Applications of speech processing - Speech recognition, Speech synthesis and speaker verification.

References

1. Theory and Applications of Digital Speech Processing, Rabiner and Schafer, 2011
2. Speech and Audio Signal Processing , Gold and Morgan, Wiley and sons, 2011
3. Daniel Jurafsky & James H.Martin, "Speech and Language Processing", Pearson Education, 2000
4. Thomas F.Quatieri, "Discrete – Time Speech Signal Processing", Pearson Eduation, 2008.

17BM3017 HOSPITAL AUTOMATION

Credits: 3:0:0

Course Objectives

- To introduce the concepts of hospital systems and need for central monitoring
- To learn about power generation, utility and protection system
- To Apply distributed and central monitoring functions in hospital environment

Course outcomes:

- Identify the factors in central power generating and monitoring systems
- Classify the equipment types and its applications
- Apply software tools and digital computer for monitoring of parameters, Medical data handling
- Analyze the sensors and actuators for the automation systems
- Evaluate the methodologies in measurement systems and automation
- Create central monitoring station for hospitals for control and surveillance applications.

Unit I - Hospital system automation: power generator, maintenance, battery-maintenance and troubleshooting, energy conservation and monitoring system- Case study.

Unit II - Medical gas production: Automation in dryer, compressor, air conditioning, lighting, heating systems.
Unit III - Automation in piping: Monitoring of flow -Leakage test- prevention and safety automation.
Unit IV - Instrumentation systems: limit switches, sensors, controllers, control room, central monitoring station- alarm system –regulation and standards. Case study.
Unit V - Office Automation: Tools for data retrieval, RFID in medical record -surveillance system in hospital- case study.

Reference Books

1. Khandpur. R. S., "Handbook of Biomedical Instrumentation", Prentice Hall of India, New Delhi, 2003.
2. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology", Pearson Education India, Delhi, 2008.
3. Curtis Johnson, D., "Process Control Instrumentation Technology", Prentice Hall of India, 2006.
4. John V. Grimaldi and Rollin H. Simonds., Safety Management, All India Travelers Book seller, New Delhi, 1989.
5. N.V. Krishnan, Safety in Industry, Jaico Publisher House, 1996.

17BM3018 HUMAN ASSIST DEVICES

Credits 3:0:0

Course Objective:

- Introduce the Fundamental terms and concepts of human assist devices
- Learn various assist device functions and characteristics.
- Apply design tools for modeling and analysis of assist devices

Course Outcomes:

- Identify the requirements for human assist devices
- Classify the systems based on applications
- Apply soft tools for analysis and design of devices for specific applications
- Analyze the merits of human assist system and its influence to environment.
- Evaluate the methodologies in measurement systems and conditions
- Create instrumentation techniques for development of assist devices to human needs

Unit I - Heart Lung Machine And Artificial Heart: Condition to be satisfied by the H/L System. Different types of Oxygenators, Pumps, Pulsatile and Continuous Types, Monitoring Process, Shunting, The Indication for Cardiac Transplant, Driving Mechanism, Blood Handling System, Functioning and different types of Artificial Heart, Mock test setup for assessing its Functions
Unit II - Cardiac Assist Devices: Synchronous Counter pulsation, Assisted through Respiration Right Ventricular Bypass Pump, Left Ventricular Bypass Pump, Open Chest and closed Chest type, Intra Aortic Balloon Pumping Veno Arterial Pumping, Prosthetic Cardio Valves, Principle and problem, Biomaterials for implantable purposes, its characteristics and testing. Case study.
Unit III - Artificial Kidney: Indication and Principle of Haemodialysis, Membrane, Dialysate, Different types of heamodialysers, Monitoring Systems, Wearable Artificial Kidney, Implanting Type- Modeling and analysis. Case study.
Unit IV - Prosthetic And Orthodic Devices : Hand and Arm Replacement - Different Types of Models Externally Powered Limb Prosthesis Feedback in Orthodic System, Functional Electrical Stimulation, Haptic Devices
Unit V - Respiratory And Hearing Aids: Intermittent positive pressure, Breathing Apparatus Operating Sequence, Electronic IPPB unit with monitoring for all respiratory parameters. Types of Deafness, Hearing Aids- Construction and Functional Characteristics.

Reference Books

1. Kolff W.J., Artificial Organs, John Wiley and Sons, New York, 1979.
2. Andreas.F.Von racum, Hand book of bio material evalution, Mc-Millan publishers, 1980.
3. Albert M.Cook and Webster J.G., Therapeutic Medical Devices, Prentice Hall Inc., New Jersey, 1982
4. Gray E Wnek, Gray L Browlin – Encyclopedia of Biomaterials and Biomedical Engineering – Marcel Dekker Inc New York 2004.
5. John. G . Webster – Bioinstrumentation - John Wiley & Sons (Asia) Pvt Ltd, 2004.

17BM3019 HUMAN COMPUTER INTERFACES

Credits 3:0:0

Course objectives:

- Understand the fundamentals of EEG signal acquisition techniques
- Learn the feature extraction methods
- Apply the design principles in developing EEG based robotic application

Course outcomes:

- Identify the fundamental principles of EEG signal and data acquisition methods
- Classify the types of signals and its components
- Apply the design tools to develop simulation models
- Analyze the signals to develop the applications
- Evaluate the systems based on the design specifications
- Create the applications for medical diagnosis and robots

Unit I - Introduction To Brain Computer Interfaces: Concept of BCI – Invasive and Non-invasive Types – EEG Standards – Signal Features – Spectral Components – EEG Data Acquisition – Pre-processing – Hardware and Software – Artifacts – Methods to Remove – Near Infrared BCI.
Unit II - BCI Approaches: Mu Rhythm – Movement Related EEG Potentials – Mental States – Visual Evoked Potential Based – P300 component.
Unit III - EEG Feature Extraction Methods: Time/Space Methods – Fourier Transform – Wavelets – AR models – Band pass filtering – PCA – Laplacian Filters – Linear and Non-linear Features.
Unit IV - EEG Feature Translation Methods: LDA – Regression – Memory Based – Vector Quantization – Gaussian Mixture Modeling – Hidden Markov Modeling.
Unit V - Case Study: Case Study of Problems in BCI - Case Study of Brain Actuated Control of Mobile Robot.

Reference Books

1. Special Issue on Brain Control Interfaces, IEEE Transactions on Neural Systems and Rehabilitation Engineering, Vol 14, June 2006.
2. Andrew Webb, "Statistical Pattern Recognition", Wiley International, Second Edition, 2002.
3. R.Spehlmann, "EEG Primer", Elsevier Biomedical Press, 1981.
4. Arnon Kohen, "Biomedical Signal Processing", Vol I and II, CRC Press Inc, Florida.
5. Bishop C.M, "Neural Networks for Pattern Recognition", Oxford, Clarendon Press, 1995.
6. Torsten Felzer, "On the possibility of Developing a Brain Computer Interface", Technical Report, Technical University of Darmstadt, Germany, 2001.
7. Wolpaw J.R, N.Birbaumer et al, "Brain control interface for Communication and control", Clinical Neurophysiology, 113, 2002.
8. Jose del R.Millan et al, "Non-invasive brain actuated control of a mobile robot by human EEG", IEEE Transactions on biomedical Engineering, Vol 51, No.6, 2004 June.

17BM3020 ERGONOMICS IN HOSPITALS

Credit 3:0:0

Course Objectives:

- Introduce the Fundamental terms and concepts of human factors
- Learn anthropometric principles and optimize human well-being and overall performance.
- Apply signal acquisition and processing of human stress related issues in hospital work area.

Course Outcomes:

- Identify the problems in posture and work efficiency
- Classify the workspace and related systems
- Apply signal processing techniques for analysis and feature extraction.
- Analyze the anthropometric concepts to human system and environment.
- Evaluate the methodologies in measurement systems and conditions
- Create instrumentation techniques for development of user friendly systems

Unit I - Human–machine system: Definition, human technological system, manual, mechanical, automated system, human system reliability, human system modeling, Human Output And Control, material handling, motor skill, human control of systems, controls and data entry devices, hand tools and devices,
Unit II - Workplace Design: Applied anthropometry, workspace design and seating, design of computer worktable, case studies.
Unit III - Measurement: physical stress and fatigue using EMG and EEG- Modeling of pain. Case study.
Unit IV - Environmental Conditions: Illumination, climate, noise, motion, sound, vibration. Musculoskeletal anatomy, Quantitative models, Case study
Unit V - Human body kinematics: Instrumentation concepts - Instrumentation for the Measurement human body kinematics. Case studies: computer based evaluation of recovery process caused due to limb fractures, cognitive stress to patients.

Reference Books

1. Bridger R S, "Introduction to Ergonomics", Taylor and Francis, London, 2003.
2. Karl Kroemer, Henrike Kroemer, Katrin Kroemer-Elbert, "Ergonomics- How to Design for Ease & Efficiency", Prentice Hall International Editions, 2001.
3. Mark S Sanders, "Human Factors in Engineering and Design", McGraw Hill, NewYork, 1993.
4. Martin Helander, "A Guide to Ergonomics of Manufacturing", Tata McGraw Hill, 1996.
5. Mccormic.E.J., and Sanders.M.S, "Human factors in Engineering and Design", McGraw Hill, New Delhi.

17BM3021 FINITE ELEMENT MODELLING IN BIOMEDICAL ENGINEERING

Credit 3:0:0

Course Objectives:

- Introduce the fundamentals of Finite Element Analysis
- Learn enable the students to formulate the design problems into FEA.
- Apply finite element technology to develop medical applications

Course Outcomes:

- Identify the fundamentals of concepts and FE tools
- Classify the methods for suitable applications
- Apply solver tools for analysis and design for specific applications
- Analyze the medial applications and its influence to environment.
- Evaluate the methodologies to optimize the design and analysis
- Create the medical applications to human needs

Unit I - Introduction: Basic concepts- Historical Background -finite element packages- Boundary Value and Initial Value Problem-Weighted Residual Methods-General Procedure of FEA-Element Types and its Characteristics.
Unit II - Concept of Element Assembly-Bandwidth and its effects- Boundary conditions-Aspect Ratio- Pascal's Triangle- Stiffness matrix -beam element-Shape Function for Spar element, Beam element- Convergence and Continuous criteria.
Unit III - Structural Problems: Equations of elasticity- plane elasticity problems - Bending of elastic plates Heat Transfer Problems.
Unit IV - One Dimensional equation: Heat transfer derivation of finite element equation -Fluid Mechanics problems: incompressible fluid flow-Biomedical Applications.
Unit V - Case studies: FE modeling of blood flow channel, limb, bone, implants, sensors analysis using mechanical solver, electrical solver, electro mechanical solver, Vibration analysis using software tools.

Reference Books

1. David.V.Hutton, "Fundamentals of Finite Element Analysis", Tata McGraw Hill, 2003.
2. Tirupathi, R.Chandrupatla, Ashok. D.Belegundu, "Introduction to Finite Elements in Engineering", Prentice Hall of India, 2004.
3. Rao. S.S., "The Finite Element Method in Engineering", 2/e, Pergamon Press, Oxford, 2001.