Reg.No. \_\_\_\_\_\_\_\_\_\_\_\_



**UNIVERSITY**

(Karunya Institute of Technology & Sciences)

(Declared as Deemed-to-be University under Sec.3 of the UGC Act, 1956)

**End Semester Examination – Nov/Dec – 2016**

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|  |  | **Semester :** | **2016-17 ODD** |
| **Code :** | **14AE2034** | **Duration :** | **3hrs** |
| **Sub. Name :** | **INTRODUCTION TO HYPERSONIC FLOWS** | **Max. marks :** | **100** |

**ANSWER ALL QUESTIONS (5 x 20 = 100 Marks)**

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| **Q. No.** | **Sub Div.** | **Questions** | **Course**  **Outcome** | **Marks** |
| 1. | a. | When Flow is called as Hypersonic flow:  (a) M > 3 (b) M \_>5 (c) M > 7 (d) Depends on body geometry | CO 1 | 1 |
| b. | In Hypersonic flow, the viscous effects are limited to thin layer near the wall  limited to entire region between shock and body important in the entire flow field including free-stream. | CO 1 | 1 |
| c. | Define Shock layer. | CO 1 | 2 |
| d. | For air, at which temperture range calorically perfect gas ( constant specific heat )  assumption breaks down? | CO 1 | 2 |
| e. | How hypersonic flow is different from supersonic flow? Discuss various features. | CO 1 | 14 |
| (OR) | | | | |
| 2. | a. | Define Entropy layer. | CO 1 | 1 |
| b. | Under the assumption of Newtonian approximation, what is the expression for pressure distribution? | CO 2 | 2 |
| c. | Write the basic assuptions underlying the Newtonian approximation for pressure distribution. | CO 2 | 2 |
| d. | For air, at which temperture range chemical reactions start playing role. | CO 1 | 2 |
| e. | What is Mach number independence principle? Derive it from euler equations. | CO 2 | 14 |
| 3. | a. | What is underlying assumption of Tangent wedge method for estimating the pressure on the body surface? | CO 2 | 1 |
|  | b. | What is underlying assumption of Tangent cone method for estimating the pressure on the body surface? | CO 2 | 1 |
|  | c. | For a blunt 2D body, which method(s) will you use to estimate pressure on the surface of body? | CO 2 | 2 |
|  | d. | For a blunt Axi-symmetric body, which method(s) will you use to estimate pressure on the surface of body? | CO 2 | 2 |
|  | e. | Estimate the pressure distribution on the sharp cone of half angle θ and length L at zero angle attack using Newtonian approximation. Estimate the drag coefficient of cone taking reference area as base area of the cone. | CO 2 | 14 |
| (OR) | | | | |
| 4. | a. | What are the approximate methods for estimating the pressure on body surface under Hypersonic flow conditions? | CO 2 | 1 |
|  | b. | What is basic difference between Tangent cone and tangent wedge method? | CO 2 | 1 |
|  | c. | For a blunt 2D body, which method(s) will you use to estimate pressure on the surface of body? | CO 2 | 2 |
|  | d. | For a blunt Axi-symmetric body, which method(s) will you use to estimate pressure on the surface of body? | CO 2 | 2 |
|  | e. | Estimate the pressure distribution on the surface of wedge of included angle 2θ and length Lat zero angle of attack using Newtonian approximation. Estimate the drag coefficient of wedge taking reference area as base area of th wedge. | CO 2 | 14 |
| 5. | a. | Define Viscous Shock layer. | CO 1 | 1 |
|  | b. | How lengths normal to flow directions are non-dimensionalised under Hypersonic slender body theory? | CO 1 | 1 |
|  | c. | How velocitiy along flow direction is non-dimensionalised under Hypersonic slender body theory? | CO 2 | 2 |
|  | d. | How pressure is non-dimensionalised under Hypersonic slender body theory? | CO 2 | 2 |
|  | e. | Discuss Hypersonic similarity laws. | CO 2 | 14 |
| (OR) | | | | |
| 6. | a. | Are Euler Equations valid for the flow region between shock and body under hypersonic flow condition? | CO 1 | 1 |
|  | b. | How length along the flow direction is non-dimensionalised under Hypersonic slender body theory? | CO 1 | 1 |
|  | c. | How velocities normal to flow direction are non-dimensionalised under Hypersonic slender body theory? | CO 2 | 2 |
|  | d. | How temperature is non-dimensionalised under Hypersonic slender body theory? | CO 2 | 2 |
|  | e. | Derive the governing equations for Hypersonic Slender body theory. | CO 2 | 14 |
| 7. | a. | What change occurs in the continuity equation between hypersonic inviscid and hyper sonic viscous flow. | CO 1 | 1 |
|  | b. | What change occurs in the momentum equation between hypersonic inviscid and hyper sonic viscous flow. | CO 1 | 1 |
|  | c. | Write the complete conrinuity equation along the length of flat plate ( 2D flow) for hypersonic flow. | CO 2 | 2 |
|  | d. | Write the complete momentum equation along the length of flat plate ( 2D flow) for hypersonic flow. | CO 2 | 2 |
|  | e. | Consider the hypersonic boundary layer over a flat plate without pressure gradient. Using similarity consideration, derive the equation governing the **similar velocity** profile.  Give the boundary conditions for governing equations. | CO 2 | 14 |
| (OR) | | | | |
| 8. | a. | Under hypersonic flow condition, is the momentum equation normal to the wall is same as normal momentum equation in supersonic boundary layer? | CO 1 | 1 |
|  | b. | What change occurs in the energy equation between hypersonic inviscid and hypersonic viscous flow. | CO 1 | 1 |
|  | c. | Write the continuity equation along the length of flat plate ( 2D flow) for hypersonic boundary layer flow. | CO 2 | 2 |
|  | d. | Write the momentum equation along the length of flat plate ( 2D flow) for hypersonic boundary layer flow. | CO 2 | 2 |
|  | e. | Consider the hypersonic boundary layer over a flat plate without pressure gradient. Using similarity consideration, derive the equation governing the **similar temperature** profile.  Give the boundary conditions for governing equations. | CO 2 | 14 |
|  | | **Compulsory:** |  |  |
| 9. | a. | Write the relation between shock wave angle β and flow deflection angle θ for hypersonic flow. | CO 2 | 1 |
|  | b. | What is maximum value of flow deflection angle θmax during expansion under hypersonic flow condtions ? |  | 1 |
|  | c. | What is maximum value of flow deflection angle θmax under hypersonic flow condtions? | CO 2 | 2 |
|  | d. | What is the Mach number after expansion |  | 2 |
|  | e. | Derive Hypersonic Boundary layer equatiuons for laminar flow. Give the Boundary conditions | CO 2 | 14 |