INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

HYPERSONIC AEROTHERMODYNAMICS FOR SPACE VEHICLES								
II Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
BAEE20	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	40	60	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Aerodynamics								

I. COURSE OVERVIEW:

This particular course has been deigned to cover aerodynamic features of hypersonic flows with their basic governing equations and their applications in various flow fields. It also provides a comprehensive training experience in the basic principles, technologies and methodologies pertaining to the multi-disciplined realm of hypersonic flight. Participants will acquire a sound understanding of hypersonic aero physics and the effects of the hypersonic flight environment on vehicle loads and performance, including a consideration of both continuum flow and rarefied flow aerodynamic effects.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The fundamental description of hypersonic flow phenomena, including aerodynamic heating and non-equilibrium real-gas effects.
II. The fundamental features of hypersonic flows, and how these differ from other flows.
III. The importance and influence of non-equilibrium real-gas effects in high temperature flows.
IV. The physical mechanisms causing aerodynamic heating of high-speed vehicles.

III. COURSE OUTCOMES:

After successful completion of the course, students will be able to:

CO 1 Summarize the fundamental aspect of hypersonic flow and their characteristics for solving the hypersonic flow over arbitrary shape.
CO 2 Construct the equation for variation flow properties for shock and expansion waves in hypersonic flow.
CO 3 Make a use of equivalence principle and various theories to model shock interaction in hypersonic flow field.
CO 4 Examine the hypersonic transition and role of hypersonic shock-wave boundary layer interaction
CO 5 Select suitable computational fluid dynamic model to solve hypersonic viscous flow.
CO 6 Intterpret the concept of the aerodynamic heating and thermal protection system.

IV. COURSE CONTENT:

MODULE-I: BASICS OF HYPERSONIC FLOWS (09)

fluid flow regimes, importance and characteristics of hypersonic flow. Historical development and key milestones in hypersonic aerothermodynamics. Challenges and unique features of hypersonic aerodynamics. High temperature flow and communication blackout. Rarefied gas dynamics and its significance at hypersonic speeds.

MODULE-II: HYPERSONIC SHOCK-WAVE AND EXPANSION WAVE (09)

Shockwave definition, types. Basics of hypersonic shock relations, the relationship between Mach number, shock angle, and deflection angle. Shockwave relations in terms of the hypersonic similarity parameter and hypersonic expansion-wave relations.

MODULE-III: INVISCID HYPERSONIC FLOWS (09)

Newtonian flow model, Modified Newtonian theory, Mach-number independence principle, hypersonic small disturbance equation, hypersonic equivalence principle, blast-wave theory.

Shock-shock interactions in hypersonic flow and different types of shock-shock interactions. CFD techniques for hypersonic inviscid flow.

MODULE-IV: VISCOUS HYPERSONIC FLOWS *(09)*

Governing differential equations, boundary layer and it's equation for hypersonic flow, Hypersonic transition, turbulent boundary layer. Hypersonic shock-wave/boundary-layer interactions. Computational methods for simulating hypersonic viscous flow.

MODULE-V: AERODYNAMIC HEATING AND THERMAL PROTECTION SYSTEMS (09)

Aerodynamic heating: sources, mechanism. hypersonic aerodynamic heating and its effects on entropy layer. Types of thermal protection systems (TPS) and their design considerations, Materials used in TPS, Case studies of TPS in hypersonic vehicles.

V. TEXT BOOKS:

1. Ethirajan Rathakrishnan," High Enthalpy Gas Dynamics", Wiley; 1st edition 2015
2. John D. Anderson, "Hypersonic and High Temperature Gas Dynamics", McGraw Hill, 2nd edition, 1989.
3. Bertin, J. J. "Hypersonic Aerothermodynamics, AIAA, Education Series, Washington, D." (1994)

VI. REFERENCE BOOKS:

1. W.D. Hayes, Ronalds F. Probstein, "Hypersonic Flow Theory", Academic Press, 1st edition, 1959.
2. Fletcher, Leroy S., ed. Aerodynamic heating and thermal protection systems. American Institute of Aeronautics and Astronautics, 1978.

VII. WEB REFERENCES:

1. http://www.southampton.ac.uk/engineering/undergraduate/UNITs/sesa6074_hypersonic_and_high_temperature_gas_dynamics.page#aims_and_objectives

VIII. MATERIALS ONLINE

1. Course template.
2. Assignments.
3. Tutorial question bank.
4. Model question paper – I.
5. Model question paper – II.
6. Lecture notes.
7. Power point presentations.