Hypersonic Aerodynamics - Web course

COURSE OUTLINE

With the advancement of aerospace vehicles, the man's dream is to fly faster and higher. As the speed of vehicle is increased, the aerodynamic environment becomes increasingly hostile.

At speeds of sound (transonic) and higher (supersonic), the aerodynamic loads increase and their distribution change.

When the speed of the vehicle becomes several times higher than the speed of sound (hypersonic), there are additional problem of aerodynamic heating.

At still higher speeds (hypervelocity), the behavior of air begins to change significantly; both physically and chemically.

In this particular course, the contents have been deigned to cover aerodynamic features of hypersonic flows with their basic governing equations and their applications in various flow fields.

Further attempts have been made to familiarize the audience about various 2 of 3 experimental facilities used for simulating nearrealistic hypersonic/hypervelocity flow conditions in the laboratory.

The entire syllabus is aimed to perform two major roles;

Effective classroom text/elective course for undergraduate "aerospace Engineering stream" which can be easily understood by students and instructor.

Professional working tools for scientists/engineers (ISRO, DRDO etc.) in the field of hypersonic and high temperature aerodynamics.

Contents:

Basic Concepts and Fundamentals and Governing Equations; Inviscid and Viscous Hypersonic Flows;; Introduction to high temperature flows, Reentry aerodynamics, radiative gas dynamics, rarified flows; Experimental facilities for hypersonic and hypervelocity flows.

COURSE DETAIL

A Web course shall contain 40 or more 1 hour lecture equivalents.

S.No	Topics	No.of Hours
1	General characteristics of hypersonic flow.	1
2	**Basic governing equations:** concept of equilibrium and nonequilibrium flows, transport properties. Basic conservation equations and species continuity equation, hypersonic shock and expansion relations, hypersonic similarity parameters.	3
3	**Surface pressure distribution in hypersonic flowfield:**	5

NPTEL

http://nptel.iitm.ac.in

Aerospace Engineering

Pre-requisites:

1. Thermodynamics, Fluid Dynamics and Gas Dynamics.

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	Newtonian, modified Newtonian, tangent wedge and coneand shockexpansion techniques. Pressure distribution in separated regions and in reacting flows.	
4	**Approximate and exact methods in hypersonic inviscid flows:** Mach number independence, small disturbance theory, thin shock layer theory. Blast wave theory, method of characteristics, correlation for hypersonic shock wave.	7
5	**Boundary layer and Convective heat transfer:** Self similar and Nonsimilar hypersonic boundary layers. Reference temperature method, hypersonic transition, hypersonic turbulent boundary layer, aerodynamic heating.	5
6	**Viscous Interaction:** Interaction parameter, weak and strong interactions, vorticity interaction, examples of viscous interaction.	4
7	**Stagnation Point Field:** Stagnation point properties, convective and radiative heat flux, shock standoff distance.	3
8	**Aerodynamic forces and moments:** Aerodynamics of typical hypersonic vehicles, dynamic stability, design considerations.	3
9	Introduction to viscous high temperature flows, reentry aerodynamics, radiative gas dynamics, rarified flows.	3
10	**Experimental methods for hypersonic flows:** Impulse facilities, hypersonic wind tunnels, shock tunnels, gun tunnels, freepiston shock tunnels, expansion tubes etc.	6

References:

1. John D. Anderson Jr (1989), Hypersonic and High Temperature Gas Dynamics, McGrawHill
2. John J Bertin (1994), Hypersonic Aerothermodynamics, AIAA Education Series., Washington DC
3. Wallace D. Hayes and Ronald F. Probstein (1959) Hypersonic Flow theory, Academic Press, New York
4. Ernst Heinrich Hirschel (2005) Basics of Aerothermodynamics, SpringerVerlag Berlin

5. Wilbur L. Hankey (1988) Reentry Aerodynamics, AIAA Education series, Washington DC