

Air Breathing Engines - Video course

COURSE OUTLINE

- Gas dynamics
 - Introduction
 - Fundamental Ideas
 - Normal shocks
 - Rayleigh flow
 - Fanno flow
 - Quasi 1D flows
 - Oblique shocks
 - Prandtl-Meyer waves
- Propulsion
 - Thrust
 - Modes of Propulsion
 - Operation of a Basic Gas Turbine Engine
 - Turbojet, Afterburning Turbojet and Turbofan Engine
 - Detailed Analysis of the parts of a Gas Turbine Engine
 - Intake – Subsonic
 - Compressor Aerodynamics
 - Combustor
 - Emissions
 - Turbine Aerodynamics
 - Cooling, Materials & Metallurgy
 - Nozzles
 - Turbofan Engine
 - Emerging Trends
 - Ramjet & Turboramjet Engine
 - Supersonic Intakes
 - Scramjet Engine
 - Thrust Equation
 - Thermodynamic Analysis
 - Thrust Calculations , Turbojet, Turbofan, Ramjet Engine

COURSE DETAIL

Lecture	Topics and contents
1	Introduction - Compressibility of Fluids; Compressible and Incompressible Flows; Perfect Gas Equation of State; Calorically Perfect Gas
2	One Dimensional Flows – Basics Governing Equations; Acoustic Wave Propagation Speed; Mach Number; Reference States – sonic state
3	One Dimensional Flows – Basics (cont'd) Reference States – stagnation state; T-s and P-v Diagrams in Compressible Flows
4	Normal Shock Waves - Governing Equations; Mathematical Derivation of the Normal Shock Solution
5	Normal Shock Waves - (cont'd) Illustration of the Normal Shock Solution on T-s and P-v diagrams; Worked example
6	Normal shock waves - (cont'd) Further Insights into the Normal Shock Wave Solution
7	Flow with Heat Addition - Rayleigh Flow Governing Equations; Illustration on T-s and P-v diagrams
8	Flow with Heat Addition - Rayleigh Flow (cont'd) Thermal Choking and Its Consequences

NPTEL

<http://nptel.iitm.ac.in>

Mechanical Engineering

Pre-requisites:

- Freshman level Thermodynamics

Additional Reading:

1. Mechanics and Thermodynamics of Propulsion by P. G. Hill and C. R. Peterson, Third Edition, Addison Wesley, 1991.
2. Elements of Gas Turbine Propulsion by J. D. Mattingly, McGraw-Hill Series in Aeronautical and Aerospace Engineering, 1996.
3. Aerothermodynamics of Gas Turbine and Rocket Propulsion by G. C. Oates, Third edition, AIAA Education Series, 1997.
4. Aerothermodynamics of Aircraft Engine Components by G. C. Oates, AIAA Education Series, 1985.
5. Gas Turbine Theory by H. I. H. Saravanamuttoo, G. F. C. Rogers and H. Cohen, Fifth edition, Pearson Education, 2004.

Hyperlinks:

1. <http://www.grc.nasa.gov/WWW/K-12/airplane/>
2. <http://www.rolls-royce.com/>

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9	Flow with Heat Addition - Rayleigh Flow (cont'd) Worked example
10	Flow with Friction - Fanno Flow Governing Equations; Illustration on T-s diagram
11	Flow with Friction - Fanno Flow (cont'd) Friction Choking and Its Consequences; Worked example
12	Quasi One Dimensional Flows - Governing Equations; Impulse Function and Thrust; Area Velocity Relation
13	Quasi One Dimensional Flows - (cont'd) Geometric Choking; Area Mach number Relation for Choked Flow; Mass Flow Rate for Choked Flow
14	Quasi One Dimensional Flows - (cont'd) Flow Through A Convergent Nozzle; Flow Through A Convergent Divergent Nozzle
15	Quasi One Dimensional Flows - (cont'd) Worked example; Supersonic Wind Tunnels and Intakes; Worked example
16	Quasi One Dimensional Flows - (cont'd) Interaction between Nozzle Flow and Fanno, Rayleigh Flows; Worked examples
17	Oblique Shock Waves Introduction ; Governing Equations; q-b-M curve
18	Oblique Shock Waves - (cont'd) Worked examples; Detached Shocks
19	Oblique Shock Waves - (cont'd) Reflected Shocks - Reflection from a Wall
20	Prandtl Meyer Flow - Propagation of Sound Waves and the Mach Wave; Prandtl Meyer Flow Around Concave and Convex Corners
21	Prandtl Meyer Flow - Prandtl Meyer Solution; Reflection of Oblique Shock From a Constant Pressure Boundary ; Worked example
22	Basic ideas in aircraft propulsion Thrust ; Modes of Propulsion
23	Turbojet engine Operation of a turbojet and afterburning turbojet engine
24	Turbojet engine - (cont'd) Component analysis – intake and compressor
25	Turbojet engine - (cont'd) Component analysis – combustor, turbine and nozzle
26	Turbofan engine
27	Turbofan engine - (cont'd) Component analysis – Fan
28	Turbofan engine Emerging trends
29	Ramjet and turboramjet engines Operation of a Ramjet Engine and a Turboramjet Engine
30	Ramjet and turboramjet engines Component analysis – Supersonic Intake

31	Ramjet and turboramjet engines Component analysis – Supersonic Intake
32	Scramjet engines
33	Thermodynamics of jet engines Thrust Equation for a Turbojet and Turbofan Engine; T-s diagram of a Turbojet Engine
34	Thermodynamics of jet engines Component efficiencies; T-s diagram of a Turbofan Engine
35	Thrust calculations Turbojet and Turbofan engine
36	Thrust calculations (cont'd) Turbojet and Turbofan engine (cont'd)
37	Thrust calculations (cont'd) Afterburning Turbojet and Ramjet Engine
38	Thrust calculations (cont'd) Worked example
39	Thrust calculations (cont'd) Worked example
40	Thrust calculations (cont'd) Worked example

References:

1. Fundamentals of Gas Dynamics by V. Babu, ANE Student Edition, 2008.
2. Fundamentals of Propulsion by V. Babu ANE Student Edition, 2009.