Department	Mechanical Engineering		Program	B. Tech	
Subject Name	Applied Thermodynamics -II		Subject Code	MEC 704	
Semester	7th	Credits	4	Teacher Incharge/Mentor	Prof. (Dr. Adnan Qayoum)
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UNIT 1

Links to the Resources:

1. http://nptel.ac.in/courses/112105123/
2. https://www.youtube.com/watch?v=SUVVheK0rf4
3. https://www.youtube.com/watch?v=BBQ2o0LcmnQ

Text Book Recommended

Fundamentals of Compressible Flow by **S.M.Yahya**

LECTURE 01:

Definitions and Basic Relations. **Page No. 1-15**

1. Fluid
2. System
3. Boundary
4. Control volume
5. State
6. Process
7. Cycle property
8. Continuum
9. Pure substances
10. Pressure
11. Density, equilibrium
12. Temperature
13. Energy
14. Work
15. Heat
16. zeroth law of Thermodynamics
17. First law of Thermodynamics
18. Specific heat of gases
19. Internal energy and enthalpy
20. Ideal gas
21. Equations of state
22. Real gases

LECTURE 02

1. Second law of Thermodynamics **Page No. 15-29**
2. Reversible and irreversible flow
3. Adiabatic process
4. Change of entropy
5. Third law of thermodynamics
6. Isentropic process
7. Bulk modulus of density
8. Coefficient of compressibility
9. Fluid velocity
10. Streamline
11. Steam tube
12. Incompressible flow and compressible flow
13. Steady flow and unsteady flow
14. Flow process and non flow process
15. Viscosity and Reynolds number
16. Mach number
17. Laminar and Turbulent flow
18. Coefficient of skin friction

LECTURE 03:

The Energy Equations **Page. No. 43-48**

1. Energy equation for non flow process
2. Energy Equation for Flow process
3. The adiabatic energy equation
4. Stagnation velocity of sound
5. 5 Stagnation pressure, density and State

LECTURE 04

Various Regions of Flow **Page No 48-58**

1. Reference Velocities
2. Bernoulli Equation
3. Effect of Mach number on Compressibility
4. Numerical Problems **Page No. 59-64 (Prob.No.2.1, 2.2, 2.3,2.4,2.5, 2.6, 2.7)**

LECTURE 05

Isentropic Flow with variable area **Page No 81-98**

1. Comparison of isentropic and adiabatic process
2. Mach Number variation
3. Stagnation and critical states
4. Area ratio as function of mach number
5. Impulse function
6. Mass flow rate

LECTURE 06

Flow through Nozzles **Page No 99-106**

1. Flow through diffusers
2. Use of gas tables

Numerical Problems **Page No. 107-118**
(4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7)

Questions and problems (4.1,4.2,4.3)

LECTURE 07

Wave Motion **Page No. 119-131**

1. Wave propagation in an elastic solid medium
2. Propagation of infinitesimal waves(sound wave)

LECTURE 08

Flow with Normal Shock Wave **Page No. 158-190**

1. Development of a shock wave
2. Rarefaction wave
3. Prandtl-Meyer relation
4. Mach number downstream of the normal shock wave
5. Static pressure ratio across the shock
6. Temperature ratio across the shock
7. Density ratio across the shock(The Rankine –Hugoniot equation)
8. Stagnation pressure ratio across the shock
9. Change in entropy across the shock
10. Impossibility of a shock in subsonic flow

11. Strength of a shock wave
12. Determination of Mach number of supersonic flow
13. Table and chart for normal shock wave
14. Supersonic wind tunnel
15. Moving normal shock wave

Numerical Problems **Page No. 204-207 (Problem no's 6.4, 6.5)**

LECTURE 09

1. 1. Flow in Constant Area Duct with Friction **Page No.256-272**
2. The Fanno curves
3. Fanno Flow equations
4. Solution of Fanno Flow equations
5. Variation of flow property
6. Variation of Mach number with duct length
7. Tables and chart for Fanno flow

Numerical Problems **Page No.282, 283,284 &297 (Problem no's 8.1, 8.4, 8.5)**

LECTURE 10

Flow in Constant Area Duct with Heat Transfer **Page No.300-317**

1. The Rayleigh Line
2. Fundamental Equation
3. Rayleigh Flow relation
4. Variation of flow property
5. Maximum Heat Transfer
6. Tables and chart for Rayleigh Flow

Numerical Problems **Page No.317-319 (Problem no's 9.1,9.2)**

Text Book Recommended for Lectures 11 to 12
Gas Turbine Theory by **HIH Saravanamuttoo, GFC Rogers and H Cohen** Fifth Edition 2001

LECTURE 11
Centrifugal Compressors **Page No.151-167**

1. Principle of operation
2. Work done in pressure rise
3. The diffuser

Numerical Problems **Page No.157-167(Example No.4.1, 4.2)**

LECTURE 12

Compressibility Effects **Page No.167-179**

1. Non dimension quantities for plotting compressor characteristics
2. Compressor characteristics

Numerical Problems **Page No.157-167(Example No.4.1, 4.2)**

Tutorial Problems:

Q1. The following data refer to the eye of a single-sided impeller.

Inner radius	6·5 cm
Outer radius	15·0 cm
Mass flow	8 kg/s
Ambient conditions	1·00 bar, 288 K
Speed	270 rev/s

Assuming no pre-whirl and no loses in the intake duct; calculate the blade inlet angle at root and tip of the eye, and the Mach number at the tip of the eye. [48-20°' 25·43°, 0·843]

Q2. An aircraft engine is fitted with a single-sided centrifugal compressor. The aircraft flies with a speed of 230 m/s at an altitude where the pressure is 0·23 bar and the temperature 217 K. The intake duct of the impeller eye contains fixed vanes which give the air pre-whirl of25° at all radii. The inner and outer diameters of the eye are 18 and 33 cm respectively, the diameter of the impeller periphery is 54 cm and the rotational speed 270 rev /s. Estimate the stagnation pressure at the compressor outlet when the mass flow is 3-60 kg/s.

Neglect losses in the inlet duct and fixed vanes, and assume that the isentropic efficiency of the compressor is 0-80. Take the slip factor as 0-9 and the power input factor as 1·04.

[1·75 bar]

Q3. The following design data apply to a double-sided centrifugal compressor:

Outer diameter of impeller	50 cm
Speed	270 rev/s
Mass flow	16·0 kg/s
Inlet temperature	288 K
Inlet pressure	1·01 bar
Isentropic efficiency of impeller only	0.90
Radial gap of vane less space	4·0 cm
Axial depth of vaneless space	5-0 cm
Slip factor	0-9
Power input factor	1-04

(a) Calculate the stagnation pressure and temperature at the outlet of the impeller, assuming no pre-whirl.

(b) Show that the radial outlet velocity at the impeller tip is about 96 mj s and hence find the Mach number and air leaving angle at the impeller tip. (In calculating the circumferential area at the tip, the thickness of the impeller disc may be neglected.)

(c) Assuming isentropic diffusion in the vaneless space, find the correct angle of the leading edges of the diffuser vanes, and also find the Mach number at this radius.

[(a) 4·40 bar, 455 K (b) 1-01, 14-08° (c) 12·40°, 0·842]

Q4. A single-sided centrifugal compressor is to deliver 14 kg/ s of air when operating at a pressure ratio of 4: I and a speed of 200 rev/s. The inlet stagnation conditions may be taken as 288 K and 1·0 bar. Assuming a slip factor of0-9, a power input factor of 1·04 and an overall isentropic efficiency of 0·80, estimate the overall diameter of the impeller.
If the Mach number is not to exceed unity at the impeller tip, and 50 per cent of the losses are assumed to occur in the impeller, find the minimum possible axial depth of the diffuser.
[68-9 cm, 5·26 cm]

Any other information:
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