BMEE323L	Gas Dynamics	L	T	P	C
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Pre-requisite	**BMEE203L , BMEE204L , BMEE204P**	**Syllabus version**			
		1.0			

Course Objectives

1. To introduce students to the basics of compressible flow, with a particular emphasis on a wide range of one-dimensional steady-flow problems.
2. To provide a thorough knowledge of supersonic flow characteristics such as shock waves and expansion fans, as well as their applications in practical systems.
3. To impart the knowledge of compressible flow through a constant area duct with friction.
4. To impart the knowledge of compressible flow through a constant area duct with heat transfer.
5. To familiarize the student with the numerical techniques suited for the design of supersonic nozzles.

Course Outcomes

At the end of the course, the student will be able to

1. Explain the features of compressible flows.
2. Design C-D nozzles by applying the concepts of isentropic compressible flow through variable area duct.
3. Analyse normal shock, oblique shock and their interactions in high-speed flows.
4. Apply the knowledge of Prandtl-Meyer expansion fan and shock-expansion theory.
5. Apply the concepts of Fanno flow and Rayleigh flow towards the design of combustion sections and jet pipes.
6. Apply the concept of Method of Characteristics for the design of jet engine nozzle.

Module:1	**Introduction to compressible fluid flow and control volume analysis**	**4 hours**

Introduction to compressible flow; Coefficient of Compressibility; Speed of sound; Mach number; Stagnation state; Critical state; Classification of flows based on Mach number- Physical significance of Mach number - Effect of Mach number on compressibility- Mach cone - Differences between Incompressible and Compressible flows. Properties of atmosphere - Conservation laws for mass, momentum and energy.

Module:2	**Isentropic Variable area flows**	**6 hours**

Isentropic flow through a variable area duct; Mach number variation; Area ratio as a function of Mach number; Impulse function; Mass flow rate through nozzles and diffusers; Phenomenon of choking; subsonic and supersonic designs; Effect of back pressure; Over-expanded and under-expanded Convergent-Divergent nozzles; T-S and H-S diagrams showing Nozzle and Diffuser process, Supersonic wind tunnels.

Module:3	**Normal shock waves**	**6 hours**

Flow with normal shock waves; Governing equations; Prandtl relation; Impossibility of rarefaction shock; Mach number downstream of the shock; Property variations across the shock; Strength of shock wave; Entropy change and stagnation pressure drop; Rankine-Hugoniot equation; Normal shock waves in Convergent-Divergent nozzles, Moving normal shock waves; Physical features of wave propagation; Shock tube and property relations.

Module:4	**Oblique Shock Waves**	**7 hours**

Oblique shock wave and its governing equations, θ-β-M relations, The Hodograph and Shock Polar, Supersonic flow over wedges and cones, Mach line, Attached and Detached shock, Reflections and interaction of oblique shock waves, Oblique shock wave applications.

Module:5	**Prandtl-Meyer Flows and Shock-Expansion Theory**	**6 hours**

Expansion waves, Prandtl-Meyer flow and its governing equations, Supersonic flow over convex and concave corners, Approximation of continuous expansion waves by discrete waves; Expansion fan interactions and reflections, Shock-Expansion Theory, Lift and drag calculation for Diamond airfoil.

Module:6	**Fanno and Rayleigh Flows**	**7 hours**
Fanno flow governing equations and their closed-form solutions; Fanno curves; Variation of flow properties with duct length; Frictional choking; Applications; Normal shocks in Fanno flow. Rayleigh flow equations; Rayleigh line; Variation of flow properties; Maximum heat transfer, thermal choking; Applications; Normal shocks in Rayleigh flow.		
Module:7	**Method of Characteristics**	**7 hours**
Philosophy of the method of characteristics, MoC for Planar flow, determination of the characteristic lines; compatibility equations, unit processes; Initial value line; Zones of influence and Dependence; Properties of characteristic regions; Centered expansions; Compression turns; Supersonic nozzle design		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book	
1.	Hodge B.K, Koenig C, Compressible Fluid Dynamics with personal computer applications, 2015, 1st edition, Pearson Education India.
Reference Books	
1.	Anderson J.D, Modern Compressible Flow: With Historical Perspective, 2021, 4th Edition. McGrawHill.
2.	Robert D. Zucker, Oscar Biblarz, Fundamentals of Gas Dynamics, 2019, 3rd Edition. John Wiley & Sons Inc.
3.	Oosthuizen, Patrick H, William E. Carscallen, Introduction to compressible fluid flow, 2013, CRC press.
4.	Saad M.A, Compressible Fluid Flow, 1993, 2nd ed. Upper Saddle River, NJ: Prentice-Hall.
5.	Rathakrishnan E, Gas Dynamics, 2017, 6th Edition. Prentice-Hall of India Pvt. Ltd.

Mode of Evaluation: CAT, written assignment, Quiz, FAT.			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022