GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Aeronautical
Subject Code: BE04001051
Subject Name: Fundamentals of Fluid Mechanics

w.e.f.Academic Year:	2024-25
Semester:	4
Category of the Course:	Basic Science Course

Prerequisite:	• Basic knowledge of Engineering Physics (mechanics, pressure, forces). • Fundamental concepts from Engineering Mathematics (differentiation, integration, differential equations). • Basic exposure to Engineering Graphics (visualization of aerodynamic domains) and Engineering Mechanics (statics & dynamics).
Rationale:	Aeronautical Fluid Mechanics is a core course that introduces the fundamentals of fluid behavior essential for aircraft performance, propulsion, and aerodynamic design. Understanding fluid properties, governing equations, and flow behavior equips students to analyze and design aircraft wings, fuselages, nozzles, diffusers, intakes, and environmental control systems. This course enables students to: • Understand properties and governing principles of aeronautical fluid flow. • Apply fundamental equations to flows over airfoils, through ducts, intakes, and nozzles. • Analyze laminar and turbulent boundary layers, pipe/duct flows, and aerodynamic forces. • Interpret dimensional analysis, similarity laws, and wind-tunnel scaling for aircraft models. • Understand basics of compressible flow relevant to aircraft propulsion and high-speed aerodynamics. The course bridges theory with aerospace applications, forming the foundation for advanced subjects such as Aerodynamics, Propulsion, CFD, Aircraft Performance, and Aerospace Vehicle Design.

Course Outcomes: At the end of the course, students will be able to:

Sr. No.	CO statement	Marks% weightage
CO-1	Explain properties of fluids and principles of fluid statics.	**22%**
CO-2	Apply continuity, momentum, and energy equations to solve engineering problems.	**29%**
CO-3	Analyze laminar and turbulent flows in pipes and channels.	**27%**
CO-4	Apply dimensional analysis and similitude to engineering and automotive model studies.	**11%**
CO-5	Demonstrate fundamentals of compressible flow and conduct fluid mechanics experiments relevant to aeronautical engineering..	**11%**

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Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

Content:

Sr.No.	Content	Total Hrs
1	**Unit 1: Properties of Fluids** : Concept of fluids and continuum. Properties: density, specific weight, specific gravity. Viscosity: dynamic & kinematic – relevance to aircraft lubrication systems. Surface tension & capillarity – fuel systems, wing de-icing fluids. Compressibility, bulk modulus, vapor pressure – cavitation in pumps, aircraft fuel pumps. Applications in aerospace fluids: hydraulic fluids (Skydrol), aviation fuels, coolant and lubrication systems.	5
2	**Unit 2: Fluid Statics:** Pressure concepts and measurement. Pascal's Law – applications in aircraft hydraulic systems (landing gear, brakes, actuators). Manometers and pressure gauges used in aircraft instrumentation. Hydrostatic forces on plane & curved surfaces. Buoyancy, stability of floating/submerged bodies – seaplanes & UAV float design. Aircraft applications: pitot-static pressure measurement, fuel tank pressure management.	5
3	**Unit 3: Fluid Kinematics**: Types of flow: steady/unsteady, laminar/turbulent, uniform/non-uniform. Flow visualization: streamlines, streaklines, pathlines – smoke flow visualization in wind tunnels. Velocity & acceleration fields. Continuity equation for 2D/3D flows. Aeronautical applications: flow through intakes, bypass ducts, wing flow visualization, airframe ventilation.	5
4	**Unit 4: Fluid Dynamics :** Euler's equation of motion – assumptions and applicability. Bernoulli's equation – derivation, limitations. Applications: • Pitot-static tubes for air speed measurement. • Venturi meters in carburetion/intake systems. • Nozzles & diffusers in gas turbine engines. Momentum equation – force on bends, jets, thrust calculations. Aeronautical applications: lift generation, pressure distribution on airfoils, thrust augmentation.	7

5	**Unit 5: Dimensional Analysis & Similitude :** Dimensional homogeneity. Rayleigh's method & Buckingham π-Theorem. Important dimensionless numbers: Re, Fr, We, Eu, Ma – physical significance. Model laws & similarity criteria. Applications: Wind tunnel testing of aircraft models. Helicopter rotor testing. Scale modeling of UAVs.	**5**
6	**Unit 6: Laminar & Turbulent Flow :** Reynolds's experiment – critical Reynolds number, Hagen–Poiseuille equation for laminar flow, Velocity distribution and shear stress in laminar flow, Darcy–Weisbach equation, friction factor – flow resistance, Moody diagram – significance in design of pipes and ducts, Applications: Ducts in air-conditioning systems of aircraft, Fuel and oil flow in aircraft pipelines, Boundary layer behavior on wings.	**6**
7	**Unit 7: Flow in Pipes & Channels :** Energy losses in pipes (major and minor) – sudden expansion, contraction, bends, fittings, Hydraulic Grade Line (HGL) and Total Energy Line (TEL), Pipes in series and parallel – equivalent pipe concept, Basics of water hammer – mitigation in pipelines, Applications: ECS (Environmental Control System), fuel lines, lubrication circuits.	**6**
8	**Unit 8: Introduction to Compressible Flow :** Compressibility and Mach number – classification of flows, Speed of sound in fluids – dependence on medium, Stagnation properties: pressure, temperature, density, 1D isentropic flow relations – nozzle and diffuser analysis, Applications: Jet engines (intake, compressor, turbine, nozzle),Supersonic aircraft aerodynamics, Shock waves (basic exposure).	**6**
	TOTAL	**45**

Suggested Specification table with Marks (Theory): (ForB.E.only)

Distribution ofTheory Marks					
RLevel	ULevel	ALevel	NLevel	ELevel	CLevel
15	**25**	**30**	**20**	**10**	

R: Remembrance; U: Understanding; A: Application; N: Analyze;E: Evaluate;C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

ReferenceBooks:

1. R.K. Bansal – Fluid Mechanics & Hydraulic Machines.
2. P.N. Modi & S.M. Seth – Hydraulics & Fluid Mechanics.
3. F.M. White – Fluid Mechanics, McGraw-Hill.
4. Munson, Young & Okiishi – Fundamentals of Fluid Mechanics, Wiley.

5. Som & Biswas – Introduction to Fluid Mechanics.
6. Anderson, J.D. – Introduction to Flight (Aerodynamic fundamentals).
7. Anderson, J.D. – Modern Compressible Flow (compressible applications).

List ofExperiments:

1. Verification of Pascal's law and hydrostatic pressure.
2. Determination of metacentric height of a floating body.
3. Verification of Bernoulli's theorem.
4. Flow measurement using venturimeter.
5. Flow measurement using orificemeter.
6. Flow measurement using notches (V-notch/rectangular).
7. Coefficient of discharge of an orifice.
8. Reynolds's experiment for laminar and turbulent flow.
9. Determination of friction factor in pipes.
10. Measurement of head losses in fittings.
11. Velocity measurement using pitot tube.
12. Demonstration of model studies (wind tunnel / CFD if available).

Major Equipment:

- Manometers, U-tube differential manometer.
- Flow measuring devices (venturimeter, orificemeter, notches, pitot tube).
- Reynolds apparatus.
- Pipe friction apparatus with fittings.
- Metacentric height apparatus.
- Bernoulli's apparatus.
- Small-scale wind tunnel (if available).

List of Open Source Software/learning website:

1. NPTEL – Fluid Mechanics, Compressible Flow (IITs).
2. MIT OCW – Fluid Mechanics.
3. IIT Bombay Virtual Labs.
4. CFD Online – Tutorials.
5. OpenFOAM (free CFD).
6. ANSYS Student Version.
7. Coursera / edX courses on aerodynamics & CFD.
8. YouTube channels: LearnChemE, NPTEL, Khan Academy.

List of suggested activities for Problem Based Learning:

- Solving numerical problems using MATLAB/Python.
- CFD simulation of flow over an airfoil, duct, or nozzle.
- Mini Project: *Design of an intake duct for a small UAV.*
- Seminar on current trends: boundary layer control, EV cooling, UAV aerodynamics.

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