

GOVERNMENT ENGINEERING COLLEGE, BHUJ
MECHANICAL ENGINEERING DEPARTMENT

Academic Year 2025-2026 (Even Term)

Problem Based Learning

Fluid Mechanics (BE BE04000161)

Sr. No	Name of the activity	No. of hours	Evaluation Criteria	Mark
1	Technical Video based learning Fluid Mechanics NPTEL: Introduction to Fluid Mechanics, IIT Kharagpur (Prof. Suman Chakraborty) https://nptel.ac.in/courses/112105269	Duration of video = 10 h	Report based on the video learning outcomes	5
2	Numerical Assignment Writing (As per attachment)	Duration = 20 h	Based on the assignment Submission	10
3	Poster/chart/power point preparation on technical topics (As per attached List)	Duration = 6 h	Based on poster/chart preparation and presentation skills	10
4	Real world case studies-based learning	Duration = 10hrs.	Based on in-depth study, technical depth, data collected, fact finding and report Submission	5

Reporting Faculty : Prof P K Jaradi

Date: 02/05/2026 Onwards (Room No 133)

Attachment – 1 : Assignment

Attachment – 2 : Poster preparation topic

Assignment 1: Properties of Fluids & Fluid Statics

Estimated Time: 4 Hours

Alignment: CO-1 (Explain properties of fluids and principles of fluid statics). Covering Unit 1 and Unit 2.

Questions:

1. **Fluid Properties (Viscosity):** A flat plate with an area of 0.2 m^2 is pulled at a velocity of 0.5 m/s over a stationary base plate. The gap between the plates is 0.8 mm and is filled with a biodiesel blend acting as a lubricant. If the force required to maintain the motion is 15 N , determine the dynamic viscosity and kinematic viscosity of the biodiesel blend. (Assume the specific gravity of the blend is 0.88).
2. **Capillarity:** Calculate the capillary rise of water in a glass tube of 2.5 mm diameter when submerged vertically in water. Take the surface tension of water as 0.0725 N/m and the angle of contact as 0° . How would this value change if the fluid was an automotive brake fluid with a higher surface tension?
3. **Pressure Measurement:** A U-tube differential manometer connects two pressure pipes, A and B. Pipe A contains a coolant fluid (Specific Gravity = 1.05) at a pressure of $1.2 \times 10^5 \text{ N/m}^2$, and Pipe B contains oil (Specific Gravity = 0.9) at a pressure of $2.0 \times 10^5 \text{ N/m}^2$. The manometer liquid is mercury. Find the difference in the mercury level if pipe B is positioned 0.5 m higher than pipe A.
4. **Hydrostatic Forces:** A circular plate of 2 m diameter is submerged vertically in a liquid of specific gravity 0.95 such that its top edge is 1 m below the free surface. Calculate the total hydrostatic pressure force on the plate and the depth of the center of pressure.
5. **Buoyancy:** A solid cylinder of diameter 3 m and height 2 m floats in water with its vertical axis perpendicular to the surface. If the specific gravity of the cylinder material is 0.65 , determine its metacentric height and state whether its equilibrium is stable.

Assignment 2: Fluid Kinematics & Fluid Dynamics

Estimated Time: 4 Hours

Alignment: CO-2 (Apply continuity, momentum, and energy equations to solve engineering problems). Covering Unit 3 and Unit 4.

Questions:

1. **Continuity Equation:** In a 2D incompressible flow, the fluid velocity components are given by $u = 3x$ and $v = -3y$. Show whether this flow satisfies the continuity equation. Determine the stream function ψ for this flow field.
2. **Bernoulli's Theorem Application:** Water flows through a horizontal pipeline that tapers from a 300 mm diameter at section 1 to a 150 mm diameter at section 2. The pressure at section 1 is

- 40 kPa and the velocity is 2 m/s. Assuming no energy losses, calculate the pressure at section 2.
3. **Venturimeter:** A horizontal venturimeter with an inlet diameter of 200 mm and a throat diameter of 100 mm is used to measure the flow of oil (Specific Gravity = 0.85). The discharge through the venturimeter is 60 lps. If the coefficient of discharge C_d is 0.97, find the reading of the oil-mercury differential manometer.
 4. **Pitot Tube:** A pitot-static tube is placed in the center of a 250 mm pipe to measure the velocity of an exhaust gas flow. The stagnation pressure head is 8 mm of water, and the static pressure head is 2 mm of water. If the coefficient of the pitot tube is 0.98 and the density of the gas is 1.2 kg/m^3 , determine the velocity of the gas.
 5. **Momentum Equation:** A 45° reducing bend is connected in a pipeline. The diameter at the inlet and outlet of the bend are 600 mm and 300 mm respectively. Find the force exerted by water on the bend if the pressure at the inlet is 8.829 N/cm^2 and the flow rate is 600 lps
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Assignment 3: Laminar & Turbulent Flow Analysis

Estimated Time: 4 Hours

Alignment: CO-3 (Analyze laminar and turbulent flows in pipes and channels). Covering Unit 6 and Unit 7.

Questions:

1. **Reynolds Number & Flow Regime:** Jatropha oil (Specific Gravity = 0.92, dynamic viscosity = 0.035 Pa.s) flows through a 50 mm diameter pipe. Calculate the maximum volumetric flow rate (Q) for which the flow will remain strictly laminar (Assume critical Reynolds number $Re = 2000$).
 2. **Hagen-Poiseuille Flow:** For the laminar flow of the Jatropha oil calculated in Question 1, determine the pressure drop over a 15 m length of the horizontal pipe. Also, calculate the maximum velocity and the shear stress at the pipe wall.
 3. **Darcy-Weisbach & Friction:** Water flows through a rough pipe of diameter 400 mm and length 2500 m at a rate of $0.4 \text{ m}^3/\text{s}$. If the kinematic viscosity of water is $1 \times 10^{-6} \text{ m}^2/\text{s}$ and the absolute roughness is 0.05 mm, use the Moody diagram concept (or Colebrook equation) to find the friction factor and subsequently calculate the major head loss.
 4. **Minor Losses:** An engine cooling system features a sudden expansion in a pipe from 50 mm to 100 mm diameter. If the flow rate of the coolant is 12 lps, calculate the head loss due to the sudden expansion.
 5. **Pipes in Series & Parallel:** Two pipes of lengths 1000 m and 800 m, and diameters 300 mm and 200 mm respectively, are connected in series. Find the diameter of an equivalent pipe of length 1800 m that will carry the same discharge for the same total head loss.
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Assignment 4: Dimensional Analysis & Similitude

Estimated Time: 4 Hours

Alignment: CO-4 (Apply dimensional analysis and similitude to engineering and automotive model studies). Covering Unit 5.

Questions:

1. **Rayleigh's Method:** The power P required by a centrifugal pump depends on the impeller diameter D , rotational speed N , fluid density ρ , and dynamic viscosity μ . Use Rayleigh's method to find the dimensional relationship.
 2. **Buckingham π Theorem:** The aerodynamic drag force (FD) on an automotive vehicle depends on the vehicle's frontal area A , velocity V , fluid density ρ , and fluid dynamic viscosity μ . Using Buckingham's π theorem, derive a dimensionless expression for the drag force.
 3. **Dimensionless Numbers:** Define the physical significance of the Reynolds number, Froude number, and Mach number. Provide one specific automotive or mechanical engineering application where each number is the primary similarity criterion.
 4. **Similitude (Wind Tunnel):** A 1:10 scale model of an automobile is tested in a wind tunnel. The prototype is designed to travel at 100 km/hr in air at 20 °C. To achieve dynamic similarity (Reynolds number matching), what must be the air velocity in the wind tunnel if the air temperature and pressure are the same for both model and prototype?
 5. **Model Laws:** A spillway model is built to a scale of 1:36. If the velocity of flow over the model is 1.5 m/s and the discharge is 2.0 m³/s, calculate the corresponding velocity and discharge for the prototype using Froude model laws.
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Assignment 5: Compressible Flow Fundamentals

Estimated Time: 4 Hours

Alignment: CO-5 (Demonstrate fundamentals of compressible flow). Covering Unit 8.

Questions:

1. **Mach Number & Speed of Sound:** Exhaust gas leaves an internal combustion engine manifold at a temperature of 600 °C. Calculate the speed of sound in this gas and determine the velocity of the gas if the flow is at a Mach number of 0.85. (Assume the gas constant $R = 287 \text{ J/kgK}$ and the specific heat ratio $\gamma = 1.33$).
2. **Stagnation Properties:** Air flows through a turbocharger intake duct at a velocity of 250 m/s a static pressure of 90 kPa and a static temperature of 15°C. Calculate the stagnation pressure and stagnation temperature. (Assume air properties: $R = 287 \text{ J/kg.K}$, $\gamma = 1.4$, $C_p = 1005 \text{ J/kgK}$).
3. **Isentropic Flow in Nozzles:** Air enters a converging-diverging nozzle from a reservoir where the pressure is 500 kPa and the temperature is 400 K. If the flow is isentropic, calculate the pressure, temperature, and velocity at the throat where the Mach number is 1.0.
4. **Compressibility Regimes:** Based on the compressibility of fluids, classify the flow regimes corresponding to Mach numbers $M < 0.3$, $0.8 < M < 1.2$, and $M > 1.2$. Explain why flow behaves fundamentally differently in the supersonic regime compared to the subsonic regime.
5. **Mass Flow Rate Formulation:** Derive the expression for the mass flow rate in a 1D isentropic flow in terms of the stagnation pressure (P_0), stagnation temperature (T_0), Mach number (M), and cross-sectional area (A).

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Subject Code: BE04000161

Subject Name: Fluid Mechanics

Notes:

Design a physical 2ft x 3ft (24" x 36") poster.

A poster needs to be highly specific, focusing on a single process, a visual comparison, a real-world cutaway diagram, or a specific case study.

A good ratio for this size is roughly 60% visuals (diagrams charts photos) and 40% text (bullet points short explanations and equations).

Sr No	Enrollment No	Toipcs for Poster Presentation
1	240150119002	Viscosity & Temperature: A comparative graph and diagram showing how engine oil behaves in cold weather vs. extreme engine heat.
2	240150119003	The Physics of Capillarity: A diagram showing cohesive vs. adhesive forces, explaining why meniscus shapes differ between water and mercury.
3	240150119004	Cavitation in Water Pumps: A visual sequence showing vapor bubble formation and collapse on a pump impeller blade, including damage photos.
4	240150119005	Anatomy of a Hydraulic Jack: A cross-sectional cutaway diagram applying Pascal's Law to a garage floor jack, mapping the force multiplication.
5	240150119006	U-Tube vs. Bourdon Gauge: A side-by-side mechanical breakdown of how a fluid-based manometer works compared to a mechanical pressure gauge.
6	240150119008	Submarine Buoyancy Control: A schematic showing the ballast tank filling/purging sequence to demonstrate Archimedes' principle.
7	240150119009	Metacenter and Ship Stability: A diagram of a ship hull tilting, showing the shifting Center of Buoyancy and the restoring torque.
8	240150119012	Visualizing Flow Types: A side-by-side illustrated comparison of steady vs. unsteady and uniform vs. non-uniform flow.
9	240150119013	Streamlines, Pathlines, and Streaklines: A visual tracing guide explaining the difference using a car moving through a smoke tunnel.
10	240150119014	The Continuity Equation in Action: A large diagram of a tapering pipe showing flow velocity increasing as the cross-sectional area decreases.
11	240150119015	Bernoulli's Principle on an Airfoil: A pressure map diagram of an airplane wing showing high-velocity/low-pressure areas generating lift.
12	240150119016	Venturimeter vs. Orifice Meter: A visual comparison of flow profiles, highlighting the severe flow separation and higher head loss in the orifice meter.
13	240150119017	Inside the Pitot-Static Tube: A cross-section of an aircraft probe, mapping how stagnation and static pressures are routed to the airspeed indicator.
14	240150119019	V-Notch vs. Rectangular Weirs: A 3D illustration of open-channel flow over both notch types, showing the different nappe formations.
15	240150119020	Jet Impingement on a Pelton Wheel: A vector diagram showing a high-speed water jet striking a split bucket and reversing direction.
16	240150119021	The Reynolds Experiment: A detailed illustration of Osborne Reynolds' original dye-injection glass tube setup, showing the transition states.
17	240150119022	Velocity Profiles in a Pipe: A large visual comparison of the parabolic curve of laminar flow versus the flattened profile of turbulent flow.
18	240150119023	Shear Stress Distribution: A diagram mapping the zero shear stress at the pipe center to maximum shear stress at the pipe wall.
19	250153119001	How to Read the Moody Chart: A step-by-step graphical guide mapping Relative Roughness and Reynolds Number to find the friction factor.
20	250153119002	Commercial Pipe Roughness: Microscopic visualizations of the inner walls of PVC, cast iron, and concrete pipes, explaining their impact on flow.

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21	250153119004	Flow Separation at Sudden Expansions: A detailed diagram showing eddy currents, turbulence, and minor head loss where a pipe suddenly widens.
22	250153119005	The Cost of Pipe Fittings: A bar chart and diagram comparing the minor head loss coefficient (K) across 90-degree elbows, 45-degree bends, and T-junctions.
23	250153119006	HGL vs. TEL: A large piping system diagram mapping the Hydraulic Grade Line falling below the Total Energy Line due to velocity head.
24	250153119007	Equivalent Pipe Networks: A visual flowchart showing how to convert a complex system of parallel and series pipes into one single equivalent pipe.
25	250153119009	Anatomy of a Water Hammer: A 4-step visual sequence showing the pressure shockwave reflecting back and forth when a valve is slammed shut.
26	250153119011	Deconstructing the Reynolds Number (Re): A visual breakdown of the ratio: Inertial Forces (momentum) vs. Viscous Forces (friction).
27	250153119012	Deconstructing the Froude Number (Fr): A visual breakdown showing how gravity forces dominate surface waves and ship wake formation.
28	250153119013	Deconstructing the Mach Number (Ma): A visual breakdown of object speed versus the local speed of sound.
29	250153119014	The 3 Pillars of Similarity: A visual checklist explaining Geometric (shape), Kinematic (motion), and Dynamic (force) similarity in scale modeling.
30	250153119015	Wind Tunnel Testing: A diagram showing a 1:10 scale car model in a wind tunnel, explaining how to match the Reynolds number for accurate data.
31	250153119016	Spillway Scale Modeling: An illustration of a dam spillway prototype next to a laboratory model, showing how the Froude number dictates the water flow rate.
32	250153119018	Aerodynamic Drag Coefficient (Cd): A visual comparison chart of the airflow and Cd values for a flat plate, a sphere, a modern sedan, and a teardrop shape.
33	250153119019	The Speed of Sound in Different Media: A comparative bar chart showing how sound travels at vastly different velocities through air, water, and steel.
34	250153119020	The Sound Barrier: Visualizations of sound wave propagation in subsonic, Mach 1, and supersonic flight, showing the formation of the Mach cone.
35	250153119022	The Converging-Diverging Nozzle: A flow map showing how a nozzle shape must first contract (subsonic) and then expand (supersonic) to accelerate a gas past Mach 1.