II B. Tech I Semester Regular/Supplementary Examinations, December, 2023
FLUID MECHANICS
(Civil Engineering)

Time: 3 hours Max. Marks: 70

Answer any **FIVE** Questions each Question from each unit
All Questions carry **Equal** Marks
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UNIT-I

1 a) In a horizontal pipe where oil with a specific gravity of 0.8 is flowing, a U-tube differential gauge is connected to two sections, A and B. The mercury in the gauge is deflected by 60 cm, with the level closer to section A being lower. [9M]
(i) Determine the pressure difference between sections A and B.
(ii) Provide explanations for convective and local acceleration in the context of fluid mechanics.

b) What is the concept of a flow net, and what are its practical applications and uses in engineering and geotechnical analysis? [5M]

OR

2 a) What are the modes of measuring pressure? How can you convert the pressure in KPa into the liquid columns and vice versa? [7M]

b) A square plate measuring 0.9 m × 0.9 m is placed on an inclined plane with an angle of inclination of 20 degrees. The plate, which has a weight of 392.4 N, is lubricated with a 1.5 mm thick oil film as it slides down the inclined plane at a constant velocity of 0.2 m/s. Calculate the dynamic viscosity of the oil. [7M]

UNIT-II

3 a) Derive Euler's equation of motion along a streamline and subsequently integrate it to derive Bernoulli's equation. Please also outline all the assumptions involved in the process. [7M]

b) A horizontal pipe with a diameter of 35 cm is transporting water at a rate of 350 liters per second. The pipe takes a right-angle bend in the clockwise direction. The water entering the bend has a pressure of 200 kN/m². Illustrate the configuration. Disregarding frictional losses, determine the magnitude and direction of the resultant force exerted on the pipe. [7M]

OR

4 a) Explain the difference between surface forces and body forces in fluid dynamics and provide examples of each. [7M]

b) A plate of 600 mm length and 400 mm wide is immersed in a fluid of specific gravity 0.9 and kinematic viscosity 10-4 m^2/s. The fluid is moving with a velocity of 6 m/s. Determine (i) boundary layer thickness and (ii) shear stress at the end of the plate. Also find the drag force on one side of the plate. [7M]

UNIT-III

5 a) Explain Reynold's experiment and its significance in fluid dynamics. What does the Reynolds number indicate? [7M]
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	b)	Assume water is flowing through a converging-diverging nozzle. The inlet diameter is 0.04 meters, and the throat diameter is 0.02 meters. If the pressure at the inlet is 300,000 Pa and the velocity is 10 m/s, calculate the velocity at the throat and the pressure at the throat. Assume incompressible flow	[7M]
		OR	
6	a)	Explain the Hagen-Poiseuille formula and its applications in fluid flow. What factors influence the flow rate in a cylindrical pipe according to this formula?	[7M]
	b)	For a turbulent flow over a flat plate, the velocity of the fluid at a distance of 0.02 meters from the plate's surface is 2 m/s. Calculate the boundary layer thickness at this point. Use the appropriate equations for turbulent boundary layers.	[7M]
		UNIT-IV	
7	a)	Explain how the pressure differential across an orifice is related to the flow rate. Provide the equation for flow rate measurement using an orifice meter.	[7M]
	b)	Given the following data for a Pitot tube measurement: stagnation pressure = 102 kPa, static pressure = 98 kPa, and fluid density = 1000 kg/m³. Calculate the velocity of the fluid.	[7M]
		OR	
8	a)	Discuss the advantages and disadvantages of using electronic flow measurement methods compared to traditional mechanical flow measurement devices	[7M]
	b)	A Venturi meter is used to measure the flow rate of a gas. The throat diameter is 6 cm, the pipe diameter is 12 cm, and the pressure difference is 8 kPa. Calculate the flow rate of the gas.	[7M]
		UNIT-V	
9	a)	Describe Prandtl's significant contributions to boundary layer theory. How did his work revolutionize our understanding of fluid flow near solid surfaces?	[7M]
	b)	Calculate the boundary layer thickness on a curved surface with a radius of 0.4 meters when subjected to a flow velocity of 20 m/s, considering the dynamic viscosity of the fluid (μ) as 0.02 Ns/m^2.	[7M]
		OR	
10	a)	Enumerate and elucidate the key characteristics of the boundary layer along a thin flat plate. How do these characteristics change along the plate's length.	[7M]
	b)	Determine the critical Reynolds number for a flat plate in water, given that the plate's length is 1.5 meters, the water velocity is 2 m/s, and the kinematic viscosity of water (ν) is 1 x 10^{-6} m^2/s.	[7M]

Code No: R2021013 | **R20** | SET - 2

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UNIT-I

1	a)	Determine the capillary rise in a glass tube with a 3mm diameter when submerged in water at a temperature of 20°C. Given that the surface tension of water at this temperature is 0.0075 kg/m, calculate the percentage increase in capillary rise that occurs when the diameter of the glass tube is reduced to 2mm.	[8M]
	b)	Describe the factors that influence fluid motion and provide examples of how specific gravity, viscosity, and surface tension impact fluid flow.	[6M]

OR

2	a)	Describe the U-tube differential manometer and the inverted U-tube differential manometer, including their working principles and applications.	[7M]
	b)	Calculate the pressure difference in pascals between two points in a fluid column, one located 3 meters below the surface and the other 8 meters below the surface.	[7M]

UNIT-II

3	a)	Describe the equation of continuity for one-dimensional, two-dimensional, and three-dimensional flows in fluids.	[7M]
	b)	A horizontal pipe with a diameter of 50 cm carries oil at a rate of 500 liters per second. The pipe takes a 60-degree bend in the counterclockwise direction. The oil entering the bend has a pressure of 300 kN/m². Create a diagram of the setup. Neglecting frictional losses, calculate the magnitude and direction of the resultant force on the pipe.	[7M]

OR

4	a)	Discuss Bernoulli's equation and its various forms, highlighting its significance in fluid dynamics.	[7M]
	b)	Analyze the flow in a pipe that features a sudden contraction from 20cm to 10cm in diameter. Calculate the velocity change and pressure change at the contraction point	[7M]

UNIT-III

5	a)	Differentiate between hydrodynamically smooth and rough flows. What role does roughness play in fluid transport?	[7M]
	b)	A fluid with a dynamic viscosity of 0.02 Pa·s flows over a smooth, rotating cylinder with a radius of 0.1 meters. The cylinder is rotating at 200 revolutions per minute. Calculate the drag force acting on the cylinder.	[7M]

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6	a)	What is the Darcy-Weisbach equation, and how is it used to calculate head loss in fluid flow through pipes?	[7M]
	b)	Water is flowing through a hydro dynamically rough, porous medium with a permeability of 1×10^{6} m^2. If the pressure drop across the porous medium is 2,000 Pa, calculate the volumetric flow rate of water	[7M]

UNIT-IV

7	a)	Describe the concept of a stepped notch in flow measurement. How does it differ from conventional notches, and what advantages does it offer?	[7M]
	b)	A Venturi meter with a throat diameter of 15 cm and a pipe diameter of 30 cm is used to measure the flow rate of a liquid. The pressure difference between the throat and the pipe is 20 kPa. Calculate the flow rate and the Reynolds number for the fluid.	[7M]

OR

8	a)	Define a broad-crested weir and an ogee weir. Discuss their specific applications and differences in terms of flow measurement.	[7M]
	b)	Calculate the flow rate of water through a triangular notch with a head of 30 cm and a weir coefficient of 1.5. Also, determine the velocity of the flow at the notch.	[7M]

UNIT-V

9	a)	Discuss the Von Kármán momentum integral equation and its relevance in boundary layer analysis. How does it aid in solving practical engineering problems?	[7M]
	b)	Calculate the drag force experienced by a sphere with a diameter of 0.1 meters moving through oil with a velocity of 0.5 m/s. Consider the kinematic viscosity of oil as 1×10^{-4} m^2/s.	[7M]

OR

10	a)	Differentiate between laminar and turbulent boundary layers. What factors influence the transition from laminar to turbulent flow in a boundary layer?	[7M]
	b)	Determine the skin friction coefficient on a flat plate for turbulent boundary layer flow with a Reynolds number of 2×10^{6} and the dynamic viscosity of air (μ) as 1.85×10^{-5} Ns/m^2.	[7M]

Code No: R2021013 **R20** SET - 3

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UNIT-I

1 a) Explain Pascal's law and its practical applications, including hydraulic systems and the transmission of pressure in confined fluids. [6M]

b) Determine the specific weight, density, and specific gravity of one liter of crude oil, knowing that it has a weight of 9.6 N. [8M]

OR

2 a) An L-shaped object has a horizontal arm that is 2 meters long and a vertical arm that is 3 meters long. The horizontal arm is submerged in water, and the vertical arm is in the air. Calculate the hydrostatic force on the horizontal arm and find the location of the center of pressure.. [7M]

b) A vacuum pump reduces the pressure in a container to 50 kPa below atmospheric pressure. Calculate the absolute pressure inside the container in pascals. [7M]

UNIT-II

3 a) Explain the classification of flows into steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, and irrotational flows, providing examples for each. [7M]

b) Given a stream function for a flow field, $\psi = 4x - 2y$, find the velocity components (u and v) and the equation of the streamline passing through a specific point. [7M]

OR

4 a) Differentiate between surface forces and body forces in fluid dynamics, providing examples of each. [7M]

b) For a two-dimensional flow, the velocity potential is given by $\varphi = 2x^2 - 3y$. Determine the velocity components (u and v) and calculate the flow rate through a line segment. [7M]

UNIT-III

5 a) Explain minor losses in pipe flow. How do they affect the overall energy balance in a piping system? [7M]

b) Water is flowing through a 100-meter-long pipe with a diameter of 0.2 meters at a flow rate of 0.5 m^3/s. Calculate the head loss using the Darcy-Weisbach equation, assuming a friction factor (f) of 0.02. [7M]

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6 a) How does the friction factor vary with the Reynolds number in pipe flow? Describe the Moody's Chart and its significance in pipe flow analysis. [7M]

b) In a pipeline system, there are two 90-degree elbows, a sudden contraction, and a gate valve. Calculate the total head loss due to minor losses if the flow rate is 0.02 m^3/s. Use K-values for each component: Elbows (K=0.5), Contraction (K=1.2), Gate Valve (K=0.6). [7M]

UNIT-IV

7 a) Define the terms "small orifice" and "large orifice" in the context of flow measurement. How do these classifications affect flow measurement accuracy? [7M]

b) For a stepped notch with a total head of 40 cm and 8 steps, calculate the flow rate if the weir coefficient is 4.0. Additionally, determine the depth of flow over each step. [7M]

OR

8 a) Explain the principles behind flow measurement over rectangular, triangular, and trapezoidal notches. Provide real-world examples where these notches might be used. [7M]

b) Determine the flow rate of a viscous oil (dynamic viscosity = 0.1 Pa·s) through a standard sharp-edged orifice with a diameter of 20 cm when the pressure drop across the orifice is 30 kPa. The fluid density is 800 kg/m^3. [7M]

UNIT-V

9 a) Explain the term "boundary layer separation." What are the causes and consequences of boundary layer separation in fluid flow? [7M]

b) Calculate the local shear stress distribution along the surface of a submerged cylindrical object with a radius of 0.2 meters and a flow velocity of 10 m/s at a location 0.1 meters from the front of the object. [7M]

OR

10 a) How does the boundary layer affect the drag and lift forces experienced by an object moving through a fluid? Discuss the fundamental principles and implications. [7M]

b) Determine the lift force acting on a spinning golf ball with an angular velocity of 3000 rpm when it is hit with a velocity of 45 m/s, considering air density as 1.225 kg/m^3 and the ball's radius as 0.021 meters. [7M]

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UNIT-I

1 a) Explain the concept of micro manometers and their specific applications in situations where high precision pressure measurements are required. [6M]

b) Water has a viscosity of 1.0 mPa·s. Calculate the shear stress when a force of 10N is applied to a plate with an area of 0.02 m^2 moving at a velocity of 0.1 m/s. [8M]

OR

2 a) Discuss the limitations and potential sources of error in pressure measurements using manometers and pressure gauges, and how these limitations can be minimized. [6M]

b) A hydraulic lift system operates with a pressure of 800 kPa. If the area of the smaller piston is 0.01 m^2 and the area of the larger piston is 0.1 m^2, determine the force exerted on the larger piston when a 500 N force is applied to the smaller piston. [8M]

UNIT-II

3 a) A bend in a pipeline carrying water has a gradual reduction in diameter from 0.6 meters to 0.3 meters and diverts the flow through an angle of 60 degrees. At the larger end of the bend, the gauge pressure is 171.675 kN/m^2. Calculate the magnitude and direction of the force applied to the bend when the flow rate is 876 liters per second. [7M]

b) State and derive Euler's equation for fluid flow and explain its practical applications. [7M]

OR

4 a) Describe the concept of laminar and turbulent flows, including the factors that influence the transition between the two flow regimes. [7M]

b) Calculate the net force exerted on a 90-degree pipe bend with a diameter of 25 cm, considering the fluid density, velocity, and the bend's geometry. [7M]

UNIT-III

5 a) Explain the Hazen-Williams formula and its use in calculating the flow rate in pipe systems. [7M]

b) Using the Moody Chart, find the friction factor for a pipe flow with a Reynolds number of 30,000 and a relative roughness (ε/D) of 0.001. Determine whether the flow is laminar or turbulent. [7M]

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6 a) Derive Hagen-Poiseulle equation for laminar flow through circular pipes. [7M]

b) Two pipes are connected in series. The first pipe has a length of 50 meters and a diameter of 0.1 meters, while the second pipe has a length of 30 meters and a diameter of 0.15meters. Determine the total head loss for a flow rate of $0.03m^3/s$. [7M]

UNIT-IV

7 a) Explain the working principle of a Pitot tube and its application in flow measurement. What are its advantages and limitations. [7M]

b) Determine the height of a rectangular weir of length 6 mto be built across a rectangular channel. The maximum depth of water on the up stream side of the weir is 1.8m and discharge is 2000 liters/s. Take Cd = 0.6 and neglect end contractions. [7M]

OR

8 a) Compare and contrast the Venturi meter and Orifice meter as flow measurement devices. Discuss their respective advantages and limitations. [7M]

b) Determine the discharge through a trapezoidal notch with the following dimensions: the width at the top is 1 meter, at the bottom it's 0.40 meters, and the height of the notch is 30 cm. The water head on the notch is 20 cm. You can assume a coefficient of discharge (Cd) of 0.62 for the rectangular portion and 0.60 for the triangular portion. Calculate the discharge. [7M]

UNIT-V

9 a) Elaborate on the methods and techniques for controlling the boundary layer in engineering applications. Provide examples of situations where boundary layer control is crucial. [7M]

b) Describe the key differences between the boundary layer on a flat plate and the boundary layer around submerged objects. What factors make the analysis of the latter more complex? [7M]

OR

10 a) Define the Magnus effect. How does it influence the behavior of spinning objects in a fluid? Provide practical examples where the Magnus effect is significant. [7M]

b) A submarine with a surface roughness length of 0.005 mm is moving through seawater with a velocity of 4 m/s. Calculate the transition Reynolds number for the submarine's surface, considering the kinematic viscosity of seawater as $1.0 \times 10^{-6}\ m^2/s$. [7M]