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Question Paper Code : 80677

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2025.

Third Semester

Mechanical Engineering

CE 3391 — FLUID MECHANICS AND MACHINERY

(Common to : Aeronautical Engineering/Aerospace Engineering/Industrial Engineering/Industrial Engineering and Management/Manufacturing Engineering/Mechanical Engineering (Sandwich)/Mechanical and Automation Engineering/Production Engineering/Safety and Fire Engineering)

(Regulations 2021)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is meant by 'metacentric height'?
2. Write the differential form of the momentum equation for a fluid element.
3. What is the critical Reynolds number for flow in a circular pipe?
4. Differentiate between the Hydraulic Gradient Line (HGL) and the Energy Gradient Line (EGL).
5. What is the purpose of Buckingham Pi theorem?
6. Give one example where a distorted model is used.
7. What is a velocity triangle? Why is it important in rotodynamic machines?
8. State the function of a draft tube in a reaction turbine.
9. Define manometric head and total head in a pump.
10. Define the term priming in a pump.

PART B — (5 × 13 = 65 marks)

11. (a) A differential U-tube manometer contains oil (specific gravity 0.85) and is used to measure the pressure difference between two points, A and B, in a horizontal pipe carrying water ($\rho_w = 1000 \text{ kg/m}^3$). The oil column shows a height difference of $h_1 = 0.25 \text{ m}$ and the water column difference in the opposite limb is $h_2 = 0.15 \text{ m}$. Determine the pressure difference $P_A - P_B$.

Or

- (b) Consider water flowing through a pipe with a velocity field described by

$$\vec{V}(x, y, z) = 2x\hat{i} + 3y\hat{j} \text{ m/s}$$

Where x, y and z are the spatial coordinates in meters. Using the Eulerian approach, determine the velocity of the water at the point $P(2, 1, 0)$. Additionally, employing the Lagrangian approach, find the trajectory of a fluid particle that starts from the origin (0, 0 and 0).

12. (a) A horizontal water pipe of diameter 0.1 m and length 50 m conveys water at a volumetric flow rate of $0.002 \text{ m}^3/\text{s}$. The pipe has a smooth surface, and a sudden enlargement occurs midway along its length. Determine the Reynolds number for the flow and comment on the flow regime. Using the Darcy-Weisbach equation, calculate the major head loss due to friction in the pipe, taking the friction factor from the Moody diagram for smooth pipe conditions. Calculate the minor head loss caused by the sudden enlargement, using the coefficient

$$K = 1 - \left(\frac{d_1}{d_2} \right)^4$$

Finally, draw the Hydraulic Gradient Line (HGL) and Energy Gradient Line (EGL) for the system, clearly showing the effect of both frictional and minor losses.

Or

- (b) Derive an expression for the different types of boundary layer thicknesses for a laminar boundary layer developing over a flat plate.
13. (a) A small ship of length L floats in water, and the drag force F_D acting on it depends on the following variables: the water density ρ , the water viscosity μ , the ship velocity V , and the ship length L .
- (i) Using Rayleigh's method, derive a dimensionless parameter that relates the drag force to the other variables. (6)
- (ii) Apply the Buckingham Pi theorem to determine all the independent dimensionless π -groups for this problem. (7)

Or

- (b) A fluid flows through a horizontal circular pipe of diameter D and length L with a volumetric flow rate Q . The fluid has density ρ and dynamic viscosity μ and gravity acts downward with acceleration g . Identify all the variables that can affect the pressure drop ΔP in the pipe and write their fundamental dimensions.
14. (a) A Pelton wheel has a mean bucket speed of 10 metres per second with a jet of water flowing at the rate of 700 litres/s under a head of 30 metres. The buckets deflect the jet through an angle of 160° . Calculate the power given by water to the runner and the hydraulic efficiency of the turbine. Assume coefficient of velocity as 0.98.

Or

- (b) A Kaplan turbine working under a head of 20 m develops 11772 kW shaft power. The outer diameter of the runner is 3.5 m and hub diameter is 1.75 m. The guide blade angle at the extreme edge of the runner is 35° . The hydraulic and overall efficiencies of the turbines are 88% and 84% respectively. If the velocity of whirl is zero at outlet, determine :
- Runner vane angles at inlet and outlet at the extreme edge of the runner, and (8)
 - Speed of the turbine. (5)
15. (a) The internal and external diameters of the impeller of a centrifugal pump are 200 mm and 400 mm respectively. The pump is running at 1200 r.p.m. The vane angles of the impeller at inlet and outlet are 20° and 30° respectively. The water enters the impeller radially and velocity of flow is constant. Determine the work done by the impeller per unit weight of water.

Or

- (b) The length and diameter of a suction pipe of a single-acting reciprocating pump are 5 m and 10 cm respectively. The pump has a plunger of diameter 15 cm and a stroke length of 35 cm. The centre of the pump is 3 m above the water surface in the pump. The atmospheric pressure head is 10.3 m of water and pump is running at 35 r.p.m. Determine :
- Pressure head due to acceleration at the beginning of the suction stroke, (4)
 - Maximum pressure head due to acceleration, and (4)
 - Pressure head in the cylinder at the beginning and at the end of the stroke. (5)

PART C — (1 × 15 = 15 marks)

16. (a) A body has the cylindrical upper portion of 3 m diameter and 1.8 m deep. The lower portion is a curved one, which displaces a volume of 0.6 m^3 of water. The centre of buoyancy of the curved portion is at a distance of 1.95 m below the top of the cylinder. The centre of gravity of the whole body is 1.20 m below the top of the cylinder. The total displacement of water is 3.9 tonnes. Find the meta-centric height of the body.

Or

- (b) Water flows steadily through a horizontal pipe of length 500 meters and diameter 0.3 meters at a flow rate of $0.2 \text{ m}^3/\text{s}$. The pipe has a Darcy friction factor of 0.025. Assume the flow is incompressible and fully developed.
- (i) Calculate the velocity of flow in the pipe. (3)
 - (ii) Determine the head loss due to friction using the Darcy-Weisbach equation. (3)
 - (iii) Calculate the pressure drop across the pipe length due to friction. (2)
 - (iv) Compute the power loss caused by the pressure drop. (2)
 - (v) Discuss the effect on the head loss if the pipe diameter is reduced to 0.2 meters while keeping the flow rate constant. (5)