B. E. CIVIL ENGG. 2ND YR 1ST SEMESTER SUPPLEMENTARY EXAMINATION 2024

FLUID MECHANICS

Time: Three Hours **Full Marks: 100**

ANSWER any FIVE questions, ensuring all parts of each question are addressed together. Symbols should be explained with sketches where applicable. Relevant data may be assumed with justifications.

1. (i) Discuss the causes of dynamic viscosity and classify different categories of fluids with a neat schematic diagram. Explain Newtonian and non-Newtonian fluids with examples.

   (ii) Consider two identical rotating discs (30 cm diameter), separated by a 3 mm thick oil film with a viscosity of 3.8 Poise. The first disc rotates at 1450 rpm, while the second rotates at 1398 rpm. Illustrate the setup with a schematic diagram and calculate the frictional torque and power transferred from one disc to the other.

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2. (i) State and prove Pascal's law, and derive the basic equation of hydrostatics.

   (ii) Imagine two small vessels connected to a U-tube manometer filled with mercury (relative density 13.56), while the connecting tubes contain alcohol (relative density 0.82). One vessel sits 2 meters lower in elevation than the other. Determine the pressure difference between the vessels when the steady difference in the mercury meniscus is 225 mm.

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3. (i) Define the center of buoyancy, metacenter, and center of pressure. Consider a circular plate with a diameter of 3 meters submerged in water, with its maximum depth below the free surface being 2 meters and the minimum depth being 1 meter. Calculate the total hydrostatic thrust exerted on the front surface of the plate and determine the position of the centre of pressure.

   (ii) Given a fluid flow described by the velocity field $V = 3xy^2\mathbf{i} + 2xy\mathbf{j} + (2zy + 3t)\mathbf{k}$, determine the magnitudes and directions of (i) translational velocity, (ii) rotational velocity, and (iii) vorticity of a fluid element at the coordinates (1, 2, 1) and at time $t = 3$. Additionally, ascertain whether the flow is irrotational.

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4. (i) Derive Euler and Bernoulli equations of fluid motion with a neat sketch, using proper symbols and assumptions.

   (ii) In a pipe of 0.25 m diameter with a pressure head of 7.6 m and maximum flow of 8.1 m^3/min, find the minimum throat diameter for a venturi meter to ensure the pressure head does not become negative.

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5. (i) Obtain the expression of the velocity profile and discharge in terms of pressure gradient for laminar fully developed flow through a circular pipe with an appropriate schematic diagram. Establish the relation between friction factor and Reynolds number (Re), specifying necessary assumptions.

   (ii) Calculate the Reynolds number for a fluid of density 900 kg/m^3 and dynamic viscosity 0.038Pa.s flowing in a 50 mm diameter pipe at a rate of 2.5 litre/s. Estimate the mean velocity above which laminar flow would be unlikely.

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6. (i) Water flows through a pipe with a diameter of 0.9 m, which is later connected to a reducer leading to a pipe with a diameter of 0.6 m. Given a gauge pressure of 412.02 kN/m^2 and an initial velocity of 2 m/s at the entrance of the reducer, calculate the resultant thrust exerted on the reducer. Assume a frictional loss of head of 1.5 meters. Illustrate the problem with a schematic diagram and identify the principles applied to solve it.

   (ii) Consider a trapezoidal channel conveying water at a consistent depth of 2 meters. The channel has a bottom width of 6 meters and side slopes of 2 horizontal to 1 vertical. Determine the necessary bottom slope to accommodate a discharge of 65 m^3/s, assuming a Manning's roughness coefficient of 0.025. Additionally, assess whether the flow in the channel is tranquil or rapid.

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