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

FLUID MECHANICS

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

Assume any relevant data** if necessary **with suitable justifications.
***SYMBOLS** should be **properly described** along with the **necessary SKETCHES** whenever applicable.*
Symbols used in this question paper carry their usual meanings.

Answer any FIVE Questions.
All the parts of a question** must be **answered together.

1. (i) With the help of a neat schematic diagram, establish the relation between the rate of shear deformation of a fluid element and the velocity gradient.

   (ii) Classify fluids on the basis of their viscous characteristics.

   (iii) Two rotating discs of identical 30 cm diameter are separated by a 3mm thick oil film having viscosity of 3.8 Poise. The rotational speeds of the two discs are 1450 rpm and 1398 rpm respectively. Draw a schematic of the situation and evaluate the frictional torque and power exerted by one disc to the other.

   [6+4+10]

2. (i) Derive the basic equation of hydrostatics. Hence obtain the equation for hydrostatic pressure variation for a compressible fluid considering isothermal condition.

   (ii) Two small vessels are connected to a U-tube manometer containing mercury (relative density 13.56) and the connecting tubes are filled with alcohol (relative density 0.82). The vessel at the higher pressure is 2m lower in elevation than the other. What is the pressure difference between the vessels when the steady difference between mercury meniscus is 225mm? Represent the problem schematically.

   [10+10]

3. (i) What is meant by centre of pressure? A circular plate 3m in diameter is submerged in water. Its greatest and least depths from the free surface are 2m and 1m respectively. Find the total hydrostatic thrust on the front surface of the plate and the position of the centre of pressure.

   (ii) The velocity field in a fluid flow is given by $V = 3xy^2\ i + 2xy\ j + (2zy + 3t)\ k$. Find the magnitudes and directions of (i) translational velocity, (ii) rotational velocity, and (iii) vorticity of a fluid element at (1, 2, 1) and at time t = 3. (iv) Is it irrotational flow?

   [10+10]

4. (i) With a neat sketch and usual symbols, derive the Continuity equation for a three-dimensional fluid flow. How you can use it for one-dimensional unsteady compressible flow and two-dimensional steady incompressible flow?

   (ii) A venturi meter is to be fitted in a pipe of 0.25 m diameter where the pressure head is 7.6 m of flowing liquid and the maximum flow is 8.1 m^3/min. Find the least diameter of the throat to ensure that the pressure head does not become negative. Take $C_d = 0.96$.

   [10+10]

5. (i) With an appropriate schematic diagram obtain the expression of the velocity profile and discharge in terms of pressure gradient for a laminar fully developed flow through a circular pipe. Please specify the necessary assumptions, if any. Establish the relation between the maximum velocity and average velocity of flow.

   (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 the rate of 2.5L/s. Estimate the mean velocity above which laminar flow would be unlikely.

   [15+5]

6. (i) A pitot-static tube placed in the centre of a 200 mm pipe line, has one orifice pointing upstream and the other perpendicular to it. If the pressure difference between the two orifices is 40mm of water when the discharge through the pipe is 1365 litres per minute, calculate the coefficient of the pitot tube. Take the mean velocity in the pipe to be 83% of central velocity.

(ii) Water flows through a 0.9 m diameter pipe at the end of which there is a reducer connecting to a 0.6 m diameter pipe. If the gauge pressure at the entrance of the reducer is 412.02 kN/m^2 and the velocity is 2 m/s, determine the resultant thrust on the reducer, assuming that the frictional loss of head in the reducer is 1.5 m. Draw the schematic of the problem. What principles are used to solve this problem?

[6+14]

7. (i) Stating the appropriate flow conditions/assumptions, obtain Manning's equation for open channel flow (along with a neat sketch indicating all the forces).

(ii) Water flows at a uniform depth of 2m in a trapezoidal channel having a bottom width 6 m, side slopes 2 horizontal to 1 vertical. If it has to carry a discharge of $65m^3/s$, compute the bottom slope required to be provided. Take Manning's n = 0.025. Also find the state of flow (whether tranquil or rapid).

[12+8]

8. Write short notes on the following (ANY FOUR)

i) Laminar and turbulent flow
ii) Metacentre and stability
iii) Stream function and velocity potential
iv) Minor losses in flow through pipes.
v) Pipes in series.
vi) Hydraulic Jump

[5×4 = 20]