B. MECHANICAL 1ST YR 2ND SEMESTER EXAMINATION 2018

FLUID MECHANICS - I

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

All the parts of a question should be answered together.
Assume any relevant data if necessary with suitable justifications.
Notations should be properly described along with the necessary sketches whenever applicable.
Symbols used in the questions carry their usual meanings.

Module: 1 (25 Marks)

1. Answer **ANY FIVE** **[5x5 = 25]**

Write a short notes on the following.

i) Continuum Hypothesis and Knudsen number
ii) U-tube Manometer.
iii) Stability of floating body
iv) Eulerian and Lagrangian description of fluid flow
v) Classification of fluid flow
vi) Streamline, Streakline and Pathline
vii) Orifice Meter.
viii) Reynolds Experiment on laminar-turbulent flow
ix) Losses in flow through pipes.
x) Hardy-Cross Method of pipe network analysis.
xi) Economic Channel Section
xii) Hydraulic Jump

Module: 2 (30 Marks)

Answer **ANY THREE**

2. (i) Derive the expression of pressure distribution for fluid containing in a vessel subjected to uniform horizontal and vertical accelerations.

(ii) Using area moment of Inertia and a simple plane, derive an expression for the depth of Centre of Pressure of submerged flat surface. From it, establish that the centre of pressure is always located below the centre of gravity of the plane. **[4+(5+1)]**

3. With the neat sketch and usual symbols, derive the general form of Continuity equation. How to use it for one-dimensional unsteady compressible flow and for two-dimensional steady in compressible flow? **[7+(1+2)]**

4. Using the Hagen-Poiseuille's velocity profile, derive the expressions of Hagen-Poiseuille's pressure drop for flow through pipe. Mention all the assumptions and flow geometry/situations for the applicability of Hagen-Poiseuille equations. **[10+2]**

5. Stating the flow condition/assumption, derive Chezy's equation for open channel flow (along with a neat sketch indicating all the forces). **[2+6]**

Module: 3 (36 Marks)

Answer **ANY FOUR**

6. A shaft of diameter 0.4 m rotates at 400 rpm inside a bearing of sleeve length 100 mm. To avoid the solid friction, a lubrication oil of dynamic viscosity 3 poise is utilized.
   (i) Calculate the frictional force and the power lost in the bearing if the thickness of the oil film is 1.5 mm.

(ii) Mention what kind of fluid you have considered for this problem. If the oil is replaced by some dilatant or pseudo-plastic lubricant then the power loss would increase or decrease? Give your opinion. **[6+3]**

7. A circular opening of 3 m diameter, located in a vertical side of a rectangular tank, is closed by a disk of 3 m diameter. The disk is supported along its horizontal diameter in such a way that it can rotate about the horizontal axis. The head of the water above the horizontal diameter is 4 m. Find (i) the force acting on the disk and (ii) the torque required to close the opening. **[4+5]**

OR

Find the resultant thrust acting on the face of a tainter gate of 90° sector of radius 5m as shown in the figure 1. Take width of the gate to be unity.

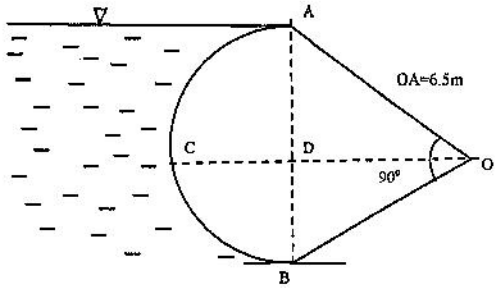

Fig.1

[9]

8. Stream function, $\psi = 2xy$, is given for a two-dimensional incompressible flow in Cartesian coordinate system. Test the feasibility of this flow. Confirm whether the flow is rotational or irrotational. If applicable, find the expression of velocity potential function ϕ. **[2+3+4]**

9. A bend in a pipeline conveying water gradually reduces from 0.6 m to 0.3 m diameter and deflects the flow through an angle of 60°. At the larger end the gauge pressure is 171.675 kN/m^2. (i) Determine the magnitude and direction of the force exerted on the bend when the flow is 876 litres/second. (ii) Which principle is used to solve this problem? **[7+2]**

10. A mild steel pipeline of 150 mm diameter and 1 km long transports water at a rate of 200 m^3/hr. The pipeline consists two gate valves fully open (k = 0.2), two 90° elbows (k = 0.9) and discharges freely into air at the end. In addition considering the entry loss, determine (i) the total head loss in the system and (ii) the power lost due to the fluid friction. (Assume hydrodynamically smooth pipe and use suitable friction coefficient correlation). **[7+2]**

OR

A pipe 60 mm diameter and 450 m long slopes upwards at 1 in 50. An oil of viscosity 0.9 Ns/m^2 and specific gravity 0.9 is required to be pumped at the rate of 5 litres/s. (i) Is the flow laminar? (ii)What pressure difference is required to attain this condition? (iii) What is power of the pump required assuming an overall efficiency of 65%? (iv) What is the centre-line velocity and the velocity gradient at pipe wall?

[9]

11. A channel of trapezoidal section, having side slopes 3 horizontal to 2 vertical, is to carry a flow of 10m^3/s on a longitudinal slope of 1 in 5000. The channel is to be lined for which the value of friction coefficient in Manning's formula is n = 0.012. (i) Find the dimensions of the economic section of the channel. (ii) Also find the conveyance of the channel and identify the state of flow whether torrential or tranquil. **[6+3]**

Module: 4 (9 Marks)

Answer **ANY ONE**

12. (i) A pitot-static tube placed in the centre of a 200 mm pipeline, has one orifice pointing upstream and the other perpendicular to it. If the pressure difference between the two orifices is 40 mm 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) A right-angled V-notch was used for measuring a discharge of 30 litres/sec. An error of 2 mm was made while measuring the head over notch. Calculate the percentage error in the discharge. Take Cd = 0.62. **[5+4]**

OR

12.OR. A venturi meter is installed in a vertical pipe that carries Petrol (of specific gravity 0.78) upward at a rate of 0.029 m^3/s. The inlet and throat diameters of the meter are respectively 150 mm and 75 mm. The throat is 225 mm above the inlet and Cd = 0.96.

(i) Find the pressure difference between the inlet and the throat.
(ii) What Reading will be recorded by a mercury U-tube manometer when connected between the inlet and the throat?
(iii) Sketch the problem with appropriate symbols used in the solution.
(iv) On which principle this device works. **[5+1+2+1]**

OR

12.OR. An inverted differential manometer is connected to two pipes A and carrying water under pressure is shown in the figure 2. The fluid in the manometer is oil of specific gravity 0.75. Determine the pressure difference between A and B.

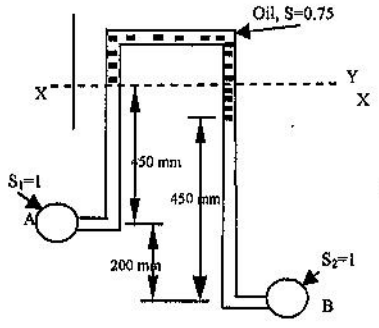

Fig. 2

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