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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Third Semester, B.E. - Mechanical Engineering

Semester End Examination; March / April - 2022

Fluid Mechanics

Time: 3 hrs *Max. Marks: 100*

***Note**: Answer **FIVE** full questions, selecting **ONE** full question from each unit.*

UNIT - I

1 a. Explain the following properties of fluids, state their units of measurements in S.I.
i) Weight density
ii) Specific volume
iii) Dynamic viscosity
iv) Kinematic Viscosity — 8

b. Explain briefly the phenomenon of capillarity. Obtain an expression for capillary rise of a liquid. — 6

c. Two horizontal flat plates are placed 0.15 mm apart and the space between them is filled with an oil of viscosity 1 poise. The upper plate of area 1.5 m^2 is required to move with speed of 0.5 m/s relative to the lower plate. Determine the necessary force and power required to maintain this speed. — 6

2 a. State and prove Pascal's Law. Discuss its applications in brief. — 8

b. A cubical block weighing 4.5 N and having a 40 cm edge is allowed to slide down an inclined plane surface making an angle of 30º with the horizontal on which there is a uniform layer of oil 0.005 cm thick. If the expected steady state velocity of the block is 12.5 cm/s, determine the viscosity of the oil. Also express the kinematic viscosity in stokes, if the oil has a mass density of 800 kg/m^3. — 6

c. An open tank contains water up to a depth of 2 m and above it an oil of sp. Gr. 0.9 for a depth of 1 m. Find the pressure intensity,
i) At the interface of the two liquids
ii) At the bottom of the tank — 6

UNIT - II

3 a. Explain the terms centre of buoyancy, meta-centre and meta-centric height. — 6

b. Determine the difference of pressure between pipes *A* and *B* when connected to an inverted U-tube differential manometer containing oil of specific gravity 0.8 as the manometric liquid. The pipe *A* conveys water and fluid of specific gravity 0.9 flows through the pipe *B*. The position of manometric liquid in the manometer limbs is as indicated in Figure 3b. If $P_B = 5 \times 10^4$ N/m^2 and the barometer reading is 730 mm of mercury, find the pressure in pipe *A* in meters of water absolute. — 8

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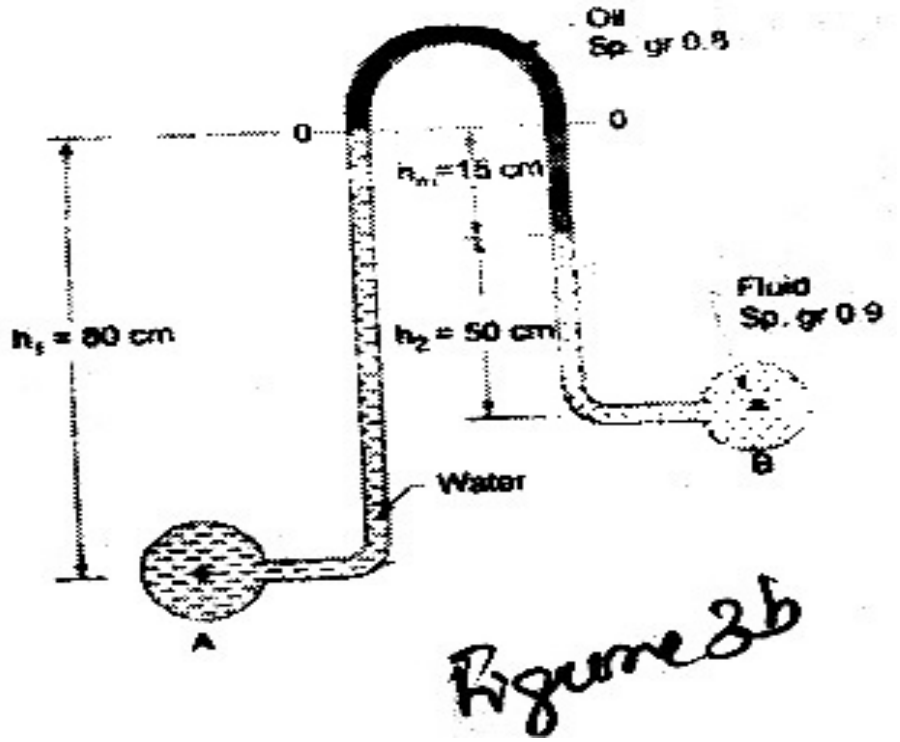

c. Explain briefly the stability criteria of submerged and floating bodies. 6

4 a. State the principle of pressure measurement by manometer. Explain the difference between a simple and differential manometer with a neat sketch. 8

b. A hollow cylinder closed at both ends has an outside diameter of 1.25 m, length 3.2 m and specific weight 75 kN/m^3. If the cylinder is to float just in stable equilibrium in sea water, find its minimum permissible thickness. Presume that sea water weighs 10 kN/m^3. 12

UNIT - III

5 a. Define and distinguish between: 4

i) Uniform and non-uniform flow ii) Steady and unsteady flow

b. Derive the general three-dimensional equation of continuity and deduce from it the continuity equation for one dimensional frictionless flow. 8

c. The velocity potential for a two-dimensional flow is $\phi = x(2y - 1)$. Determine the velocity at the point (4, 5). Also obtain the value of stream function at this point *P*. 8

6 a. Derive the Euler's equation of motion along a stream line and hence derive the Bernoulli's equation. 10

b. A 30 cm x 15 cm venturimeter is provided in a vertical pipeline carrying oil of specific gravity 0.9 the flow being upwards. The difference in elevations of the throat section and entrance section of the venturimeter is 30 cm. The differential U-tube mercury manometer shows a gauge deflection of 25 cm. Calculate; 10

i) The discharge of oil

ii) The pressure difference between the entrance section and the throat section.

Take the discharge co-efficient as 0.98 and specific gravity of mercury as 13.6.

Contd... 3

UNIT - IV

7 a. What are the coefficients of drag and lift? Briefly explain. 4

b. Flow takes place over a flat plate exposed parallel to free stream. Draw a picture of laminar and turbulent boundary layers and the transition zone separating them and explain them in detail. 8

c. Determine the displacement thickness and momentum thickness in terms of the nominal boundary layer thickness 'δ' in respect of the following velocity profile in the boundary layer on a flat plate; $\frac{u}{U_0} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$. 8

8 a. Explain the total energy line (energy gradient line) and the hydraulic gradient line for fluid flow through a piping system. 10

b. Water flows through a 30 cm diameter pipe and the flow causes a measured lost head of 15 m in 350 m of pipe length. Calculate;

i) The shear stress at the walls

ii) The shear stress at 5 cm from the centre line of the pipe

iii) The friction velocity

iv) The average velocity for friction coefficient '*f*' value of 0.0125 in the Darcy equation $h_f = \frac{4flv^2}{2gd}$ 10

UNIT - V

9 a. Derive a Hagen-Poseuille equation. 10

b. Explain the following:

i) Critical Reynolds number 10

ii) Laminar uni-directional flow between stationary parallel plates

10 a. The resulting force '*F*' of a supersonic plane during flight can be considered as dependent upon the length of aircraft '*l*', velocity '*V*', air viscosity 'μ', air density 'ρ' and Bulk modulus of air '*K*'. Express the functional relationship between these variables and the resisting force. 12

b. Define the following:

i) Fundamental quantities

ii) Derived quantities 4

iii) Repeating variables

iv) Dimensional homogeneity

c. Explain the significance of dimensional analysis applied to fluid flow problems. 4

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