Total Number of printed pages = 12

**19/4th Sem/UFET 403**



**2022**

# FLUID MECHANICS

Full Marks – 100

Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer *all* the questions.

1. Choose the correct answer : 1×15=15

   (i) The absolute viscosity μ of a fluid is primarily a function of

   (a) Density (b) Temperature

   (c) Pressure (d) Velocity

   (ii) The absolute pressure in a tank is measured to be 45 kPa. If the atm. pressure is 95 kPa, the vacuum pressure in the tank is

   (a) 45 kPa (b) 140 kPa

   (c) 130 kPa (d) 50 kPa

[Turn over

(iii) In a velocity field with velocities u, v and w along the x, y and z-directions respectively, the convective acceleration of fluid in the y-direction is given by

(a) $u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}$ $u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}$

(b) $u\frac{\partial u}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial w}{\partial z}$ $u\frac{\partial u}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial w}{\partial z}$

(c) $u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}$ $u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}$

(d) $v\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+v\frac{\partial u}{\partial z}$ $v\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+v\frac{\partial u}{\partial z}$

(iv) The velocity vector in a fluid flow is given by $V = 2x^3i - 10yj$. The velocity (m/s) of the fluid particle at (2, 1) is

(a) 18.9 (b) 20.9

(c) 26.0 (d) 6.0

(v) The Reynolds number is not a function of

(a) Fluid density

(b) Characteristic length

(c) Surface roughness

(d) Fluid viscosity



(vi) What is the unit of dynamic viscosity of a fluid ?

(a) dyne/cm$^2$ (b) dyne s/cm$^2$

(c) gram cm/s (d) gram s/cm

(vii) Hydrostatic law of pressure is given as

(a) $\frac{dP}{dz}\frac{dP}{dz} = 0$ (b) $\frac{dP}{dz}\frac{dP}{dz}$ = Constant

(c) $\frac{dP}{dz}\frac{dP}{dz} = \rho V$ (d) $\frac{dP}{dz}\frac{dP}{dz} = \rho g$

(viii) The velocity distribution in laminar flow through a circular pipe follows the

(a) Parabolic (b) Linear

(c) Circular (d) Logarithmic law

(ix) Consider a fluid is flowing through a GI pipe. If the flow is found to be fully developed laminar flow and the maximum velocity is recorded to be 4 m/s. Find the mean velocity through the pipe.

(a) 2 m/s (b) 4 m/s

(c) 6 m/s (d) 8 m/s

(x) Loss of head due to friction in a turbulent flow through a pipe varies

(a) Directly as the average velocity

(b) Directly as the square of the average velocity

(c) Inversely as the square of the average velocity

(d) Inversely as the square of internal diameter of the pipe

(xi) The coefficient of friction '$C_f$' in terms of shear stress '$\tau_o$' is given by (Note : friction factor and coefficient of friction are not same)



(a) $C_f = \frac{\rho V^2}{2\tau_0}$ $f = \frac{\rho V^2}{2\tau_0}$ (b) $C_f = \frac{2\tau_0}{\rho V^2}$ $f = \frac{2\tau_0}{\rho V^2}$

(c) $C_f = \frac{\tau_0}{\rho V^2}$ $f = \frac{\tau_0}{\rho V^2}$ (d) $C_f = \frac{2\rho V^2}{\tau_0}$ $f = \frac{2\rho V^2}{\tau_0}$

(xii) Which one of the following pumps is not a positive displacement pump ?

(a) Reciprocating pump

(b) Centrifugal pump

(c) Lobe pump

(d) Screw pump



(xiii) Assertion (A) : Pump lifts water from a lower level to a higher level.

Reason (R) : In pump, mechanical energy is converted into pressure energy.

Choose the correct answerT:

(a) Both A and R are individually true, and R is the correct explanation of A

(b) Both A and R are individually true, but R is not the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

(xiv) If $Q_{th}$ and $Q_{act}$ are the theoretical and actual discharge of a pump, then the slip of a pump can be expressed as

(a) $Q_{th} + Q_{act}$ (b) $Q_{th} / Q_{act}$

(c) $Q_{th} - Q_{act}$ (d) $Q_{th} \times Q_{act}$

(xv) A plate, 0.025 $\times 10^{-3}$m distant from a fixed plate moves at 0.60 m/s and requires shear stress of 2 N/m$^2$ to maintain this speed. The fluid viscosity between the plates is

(a) $8.33 \times 10^{-5}$ Ns/m$^2$

(b) $9.33 \times 10^{-5}$ Ns/m$^2$

(c) $10.33 \times 10^{-5}$ Ns/m$^2$

(d) None of these.



2. Answer any *six* of the following : 5×6=30

(a) Define the term 'viscosity' ? State Newton's law of viscosity. Distinguish between the Newtonian and Non-Newtonian fluids. 1+2+2=5

(b) How can you measure atmospheric pressure of a location using a barometer ? Define the unit of pressure 'standard atmosphere'. 3+2=5

(c) Distinguish between Lagrangian and Eulerian descriptions of fluid flow. What are the stream line, path line and streak line ? 2+3=5

(d) What is a pitot-tube ? How will you determine the velocity of a fluid flow at any point with the help of pitot-tube ? 1+4=5

(e) Distinguish between the laminar and turbulent flows? What is Reynold's number? Define critical Reynold's number. 2+2+1=5

(f) Mention the main components of a centrifugal pump. What do you mean by static head and manometric of a centrifugal pump? 2+3=5

(g) Explain the working of a single acting reciprocating pump with schematic diagram. 5

3. Answer any *two* of the following: 5×2=10

(a) Derive the following continuity equation using mass conservation principle, where the symbols have their usual meanings.

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \nabla) = 0.$$

(b) Derive Bernoulli's equation for the flow of an incompressible frictionless fluid from consideration of linear momentum.

(c) Derive Chezy's formula for loss of head due to friction in a pipe. What are the minor energy losses that occur when a fluid flow through a pipe?

4. Answer any *three* of the following : 5×3=15

(a) Determine the pressure difference between the points A and B as shown in Fig.1. The specific gravity of liquids at 20°C are given in the following Table 1.



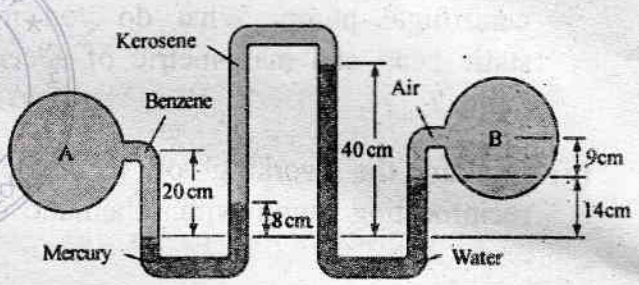


Fig.1

Table 1

| Sl. No. | Liquids | Density (kg/m³) |
|---|---|---|
| 1 | Benzene | 880.734 |
| 2 | Kerosene | 803.771 |
| 3 | Mercury | 13.568 |
| 4 | Water | 997.961 |
| 5 | Air | 1.223 |

(b) A 30 cm diameter pipe (section 1), conveying water, branches two pipes (sections 2 and 3) of diameters 20 cm and 15 cm respectively as shown in Fig. 2. If the average velocity

in the 30 cm diameter pipe is 2.5 m/s, find the discharge in this pipe. Also, determine the velocity in 15 cm pipe if the average velocity in 20 cm diameter pipe is 2 m/s.

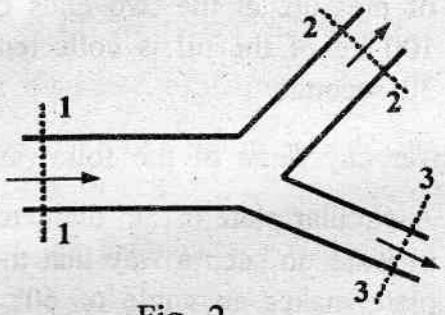


Fig. 2

(c) An orifice-meter with orifice diameter 15 cm is inserted in a pipe of 30 cm diameter. The pressure difference measured by a mercury-oil differential manometer on the two sides of the orifice meter gives a reading of 40 cm of mercury. Find the rate of oil. Given that, specific gravity of oil is 0.8, Coefficient of discharge orifice meter is 0.6.

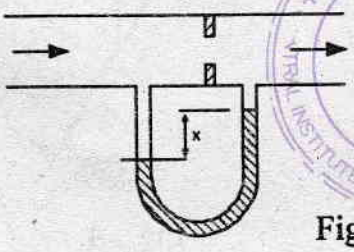




Fig. 3

(d) A crude oil of viscosity 0.97 poise and relative density 0.9 is flowing through a horizontal circular pipe of diameter 100 mm and of length 10m. Calculate the difference of pressure at the two ends of the pipe, if 100 kg of the oil is collected in a tank in 30 seconds

5. Answer any *three* of the following : 10×3=30

(a) A circular plate of 5m diameter is immersed in water in such a way that the plane of the plate makes an angle of 60° with the free surface of the water. Determine the total pressure (hydrostatic force) and position of the centre of pressure ($h_p$) when the upper edge of the plate is 2 m below the free water surface.

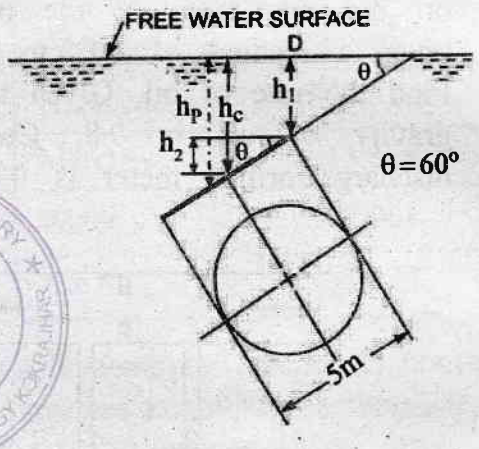




Fig. 4

(b) Balagaon Food Processing Pvt. Ltd. Kokrajhar fitted a venturimeter to an inclined pipe in which water is flowing. The following data are related to the piping system :

Diameter of the pipe = 300 mm

Throat diameter =150 mm

Sp. gravity of liquid used in U-tube manometer = 0.8

Reading of manometer = 400 mm

The loss of head between the inlet and throat is 0.3 times the kinetic head of the pipe.

Find the discharge of the water flowing through the pipe.

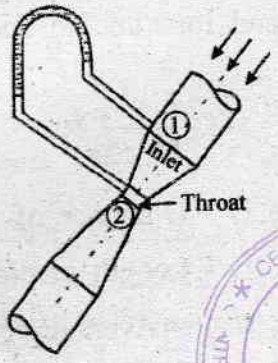


Fig. 5

(c) A student from the Department of FET, CIT Kokrajhar, conducted an experiment for his final year B. Tech Project (BTP). During the investigation, he had connected a horizontal pipe of 1.2 mm diameter and 15m long from a water storage tank to his experimental set-up. If the average velocity of water through the pipe was maintained at 0.9 m/s, and the flow was steady, determine –

(i) Pressure drops

(ii) Head loss

(iii) Pumping power required to overcome the pressure drop. Take,

Density of water, $\rho = 1000$ kg/m$^3$ and

Viscosity of water, $\mu = 1.307 \times 10^{-3}$ kg/m.s

(d) Derive the following Darcy-Weisbach Equation for head loss due to friction in pipe.

$$h_L = f \cdot \frac{L}{D} \cdot \frac{V_{avg}^2}{2g}$$

Where, D = Diameter of pipe

L = Length of pipe at two locations.

$V_{avg}$ = Average velocity of the fluid flow

f = Darcy friction factor

g = Acceleration due to gravity.