CE 6303 MECHANICS OF FLUIDS L T P C

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QUESTION BANK

UNIT I FLUID PROPERTIES AND FLUID STATICS

PART - A

1. Define fluid and fluid mechanics.
2. Define real and ideal fluids.
3. Define mass density and specific weight.
4. Distinct b/w statics and kinematics.
5. Define viscosity.
6. Define specific volume.
7. Define specific gravity.
8. Distinct b/w capillarity and surface tension.
9. Calculate the specific weight, density and specific gravity of 1 liter liquid which weighs 7N.
10. State Newton's law of viscosity.
11. Name the types of fluids.
12. Define compressibility.
13. Define kinematic viscosity.
14. Find the kinematic viscosity of oil having density 981 kg/m^3. The shear stress at a point in oil is 0.2452N/m^2 and velocity gradient at that point is 0.2/sec.
15. Determine the specific gravity of a fluid having 0.05 poise and kinematic viscosity 0.035 stokes.
16. Find out the minimum size of glass tube that can be used to measure water level if the capillary rise is restricted to 2 mm. Consider surface tension of water in contact with air as 0.073575 N/m.
17. Write down the expression for capillary fall.
18. Explain vapour pressure and cavitation.
19. Two horizontal plates are placed 1.25 cm apart. The space between them is being filled with oil of viscosity 14 poises. Calculate the shear stress in oil if upper plate is moved with a velocity of 2.5 m/s.
20. State Pascal's law.
21. What is mean by absolute and gauge pressure and vacuum pressure?
22. Define Manometer and list out it's types.
23. Write short notes on 'Differential Manometers'.
24. Define centre of pressure and total pressure.
25. Define buoyancy and centre of buoyancy.

26. Define Meta centre.
27. Define Hydro static Pressure.
28. A differential manometer is connected at the two points A and B. At B pressure is $9.81 N/cm^2$(abs). Find the absolute pressure at A.

PART – B

1. Calculate the capillary effect in millimeters a glass tube of 4mm diameter, when immersed in (a) water (b) mercury. The temperature of the liquid is 20^o C and the values of the surface tension of water and mercury at 20^o C in contact with air are 0.073575 and 0.51 N/m respectively. The angle of contact for water is zero that for mercury 130^o. Take specific weight of water as 9790 N/m^3.
2. If the velocity profile of a liquid over a plate is a parabolic with the vertex 202 cm from the plate, where the velocity is 120 cm/sec. calculate the velocity gradients and shear stress at a distance of 0, 10 and 20 cm from the plate, if the viscosity of the fluid is 8.5 poise.
3. A 15 cm diameter vertical cylinder rotates concentrically inside another cylinder of diameter 15.10 cm. both cylinders are 25 cm high. The space between the cylinders is filled with a liquid whose viscosity is unknown. If a torque of 12.0 Nm is required to rotate the inner cylinder at 100 rpm determine the viscosity of the fluid.
4. The dynamic viscosity of oil, used for lubrication between a shaft and sleeve is 6 poise. The shaft is of diameter 0.4 m and rotates at 190 rpm. Calculate the power lost in the bearing for a sleeve length of 90mm. the thickness of the oil film is 1.5 mm.
5. If the velocity distribution over a plate is given by $u=2/3\ y - y^2$ in which U is the velocity in m/s at a distance y meter above the plate, determine the shear stress at y = 0 and y = 0.15 m.
6. Derive Pascal's law.
7. Derive expression for capillary rise and fall.
8. Two large plane surfaces are 2.4 cm apart. The space between the gap is filled with glycerin. What force is required to drag a thin plate of size 0.5 m between two large plane surfaces at a speed of 0.6 m/sec. if the thin plate is (i) in the middle gap (ii) thin plate is 0.8 cm from one of the plane surfaces? Take dynamic viscosity of fluid is 8.1 poise.
9. Calculate the capillary rise in a glass tube of 2.5 mm diameter when immersed vertically in (a) water (b) mercury. Take surface tension = 0.0725 N/m for water and = 0.52 N/m for mercury in contact with air. The specific gravity for mercury is given as 13.6 and angle of contact of mercury with glass = 130^o.
10. The diameters of a small piston and a large piston of a large piston of a hydraulic jack at 3 cm and 10 cm respectively. A force of 80 N is applied on the small piston. Find the load lifted by the large piston when:
    a. The pistons are at the same level

b. Small piston in 40 cm above the large piston.

The density of the liquid in the jack is given as 1000 kg/m^3.

11. A U - Tube manometer is used to measure the pressure of water in a pipe line, which is in excess of atmospheric pressure. The right limb of the manometer contains water and mercury is in the left limb. Determine the pressure of water in the main line, if the difference in level of mercury in the limbs. U tube is 10 cm and the free surface of mercury is in level with over the centre of the pipe. If the pressure of water in pipe line is reduced to 9810 N/m^2, Calculate the new difference in the level of mercury. Sketch the arrangement in both cases.
12. A vertical sluice gate is used to cover an opening in a dam. The opening is 2 m wide and 1.2 m high. On the upstream of the gate, the liquid of sp. Gr 1.45, lies up to a height of 1.5 m above the top of the gate, whereas on the downstream side the water is available up to a height touching the top of the gate. Find the resultant force acting on the gate and position of centre of pressure. Find also the force acting horizontally at the top of the gate which is capable of opening it. Assume the gate is hinged at the bottom.

UNIT II FLUID KINEMATICS AND DYNAMICS

PART – A

1. What are the types of fluid flows?
2. Differentiate steady and unsteady flow?
3. Differentiate uniform and non – uniform flow?
4. Differentiate laminar and turbulent flow?
5. Differentiate compressible and incompressible flow?
6. Differentiate rotational and irrotational flow?
7. Differentiate one dimensional and two dimensional flow?
8. Differentiate local and convective acceleration?
9. Define velocity potential function?
10. Define stream function?
11. What is equipotential line?
12. Give the relation between stream function and velocity potential function?
13. State Bernouillie's equation.
14. Give the Euler's equation of motion.
15. Write the expression rate of flow through venturimeter.
16. For what purpose orifice meter is used? Define it?
17. Define pitot tube and give its working principle?
18. State momentum equation and impulse momentum equation?
19. What do you mean by vorticity?
20. Differentiate forced and free vertex flows with examples?

21. Write the equation for motion for vertex flow and forced vortex flow.
22. What are the assumptions made in deriving Bernouillie's equation and state its applications.
23. Write the expression for rate of floe through venturimeter.

PART – B

1. Derive continuity equation from principle of conservation of mass.
2. The velocity component for a two dimensional incompressible flow are given by u =3x – 2y and v = -3y – 2x. Show that the velocity potential exists. Determine the velocity potential function and stream function.
3. Water flows through a pipe AB 1.2 m diameter at 3 m/s and then passes through a pipe BC 1.5 m diameter. At C, the pipe branches. Branch CD is 0.8 m in diameter and carries one – third of the flow in AB. The flow velocity in branch CE is 2.5 m/s. find the volume rate of flow in AB, the velocity in CD, the velocity in BC and the diameter of CE.
4. A fluid flow field is given by $V = x^2yi+y^2zj – (2xyz+yz^2)k$ prove that it is a case of possible steady incompressible flow. Calculate the velocity and acceleration at the point (2, 1, 3).
5. Derive the continuity equation for a three dimensional incompressible flow.
6. Derive the Euler's equation of motion and deduce that to Bernouillie's equation.
7. The water is flowing through a taper pipe of length 100 m having diameters 600 mm at the upper and 300 mm at the lower end, at the rate of 50 litres /s. the pipe has a slope of 1 in 30. Find the pressure at the lower end if the pressure at the higher level is 19.62 N/cm^2.
8. An oil of sp .Gr. 0.8 is flowing through a venturimeter having inlet diameter 20 cm and throat diameter 10 cm. the oil mercury differenyial manometer shows a reading of 25 cm. Calculate the discharge of oil through the horizontal venturimeter, Take $C_D = 0.98$.
9. 250 litres/s of water is flowing in a pipe having a diameter of 300 mm. of the pipe is bent by 135^o, find the magnitude and direction of the resultant force on the bend. The pressure of water flowing is 39.24 N/cm^2.
10. A vertical wall is of 8 m height. A jet of water is coming out from a nozzle with a velocity of 20 m/s. The nozzle is situated at a distance of 20 m from the vertical wall. Find the angle of projection of the nozzle to the horizontal so that the jet of water just clears the top of the wall.

UNIT III FLOW THROUGH PIPES

PART – A

1. What do you mean by viscous flow?
2. What is Hagen Poisuille's formula?
3. Define Kinetic energy correction factor?
4. Define momentum correction factor?

5. Define hydraulic gradient line.
6. Define the major energy loss and minor energy loss.
7. Define water hammer in pipes.
8. Define incompressible flow.
9. Write down the examples of laminar flow/viscous flow.
10. What are the characteristics of laminar flow?
11. Write down chezy's formula.
12. Write down the formula for finding the head loss due to entrance of pipe h_i?
13. Write down the formula for efficiency of power transmission through pipes?
14. Give an expression for loss of head due to sudden enlargement of the pipes.
15. Give an expression for momentum integral equation of the boundary layer?
16. Differentiate between steady flow and uniform flow.
17. A crude of oil of kinematic viscosity of 0.4 stoke is flowing through a pipe of diameter 300mm at the rate of 300 liters/sec.Find the head lost due to friction for a length of 50m of the pipe.
18. Find the type of flow of an oil of relative density 0.9 and dynamic viscosity 20 poise, flowing through a pipe of diameter 20 cm and giving a discharge of 10lps.
19. Give an expression for co efficient of friction in terms of shear stress.
20. Give an expression for loss of head due to sudden contraction.
21. Give an expression for loss of head at the entrance of the pipes.
22. Derive an expression for drop of pressure for a given length of a pipe.
23. Define Darcy formula.
24. What are the factors influencing the frictional loss in pipe flow.
25. Give the formula average velocity.
26. Give the formula for velocity distribution.
27. What are the factors to the determined when viscous fluid flows through the circular pipe?

PART - B

1. Find the head lost due to friction in a pipe of diameter 300 mm and length 50 m, through which water is flowing at a velocity of 3 m/s using (i) Darcy formula, (ii) Chezy's formula for which C = 60.
2. An oil of sp.Gr 0.9 and viscosity 0.06 poise is flowing through a pipe of diameter 200 mm at the rate of 60 litres/sec./ find the head lost due to friction for a 500 m length of pipe. Find the power required to maintain this flow.
3. The rate of flow of water through a horizontal pipe is 0.25 m^3/s. The diameter of the pipe which is 200 mm is suddenly enlarged to 400 mm. The pressure intensity in the smaller is 11.772 N/cm^2. Determine: (i) loss of head due to sudden enlargement, (ii) pressure intensity in the large pipe, (iii) power lost due to enlargement.
4. A horizontal pipe line 40 m long is connected to a water tank at one end discharges freely into the atmosphere at the other end. For the first 25 m of its length from the tank, the

pipe is 150 mm diameter and its diameter is suddenly enlarged to 300 mm. The height of water level in the tank is 8 m above the centre of the pipe. Considering all losses of head which occur, determine the rate of flow. Take f = 0.01 for both sections of the pipe.

5. A pipe line, 300 mm in diameter and 3200 m long is used to pump up 50 kg per second of oil whose density is 950 kg/m^3 and whose kinematic viscosity is 2.1 stokes. The centre of the pipe line at the upper end is 40 m above than that at the lower end. The discharge at the upper end is atmospheric. Find the pressure at the lower end and draw the hydraulic gradient and the total energy line.
6. A siphon of diameter 200 mm connects two reservoirs having a difference in elevation of 15 m. The total length of the siphon is 600 mm and the summit is 4 m above the water level in the upper reservoir. If the separation takes place at 2.8 m of water absolute, find the maximum length of siphon from upper reservoir to the summit. Take f = 0.004 and atmospheric pressure = 10.3 m of water.
7. The difference in water surface levels in two tanks, which are connected by three pipes in series of lengths 300 m, 170 m and 210 m and of diameters 300 mm, 200 mm and 400 mm respectively, is 12m. Determine the rate of flow of water if co – efficient of friction are 0.005, 0.0052 and 0.0048 respectively, considering: (i) minor losses also (ii) neglecting minor losses.
8. A main pipe is divided into two parallel pipes which again forms one pipe. The length and diameter for the first parallel pipe are 2000 m and 1.0 m respectively, while the length and diameter of 2^{nd} parallel pipe are 2000 m and 0.8 m. Find the rate of flow in each parallel pipe, if total flow in the main is 3 m^3/s. The co efficient of friction for each parallel pipe is same and equal to 0.005.
9. A pipe of diameter 20 cm and length 2000 m is connects two reservoirs, having difference of water levels as 20 m. determine the discharge through the pipe.

   If an additional pipe of diameter 20 cm and length 1200 m is attached to the last 1200 m length of the existing pipe, find the increase in the discharge. Take f = 0.015 and neglect minor losses.

10. A pipe line 60 cm diameter bifurcates at a Y- junction into two branches 40 cm and 30 cm in diameter. If the rate of flow in the main pipe is 1.5 m^3/s and mean velocity of flow in 30 cm diameter pipe is 7.5 m/s, determine the rate of flow in the 40 cm diameter pipe.
11. A pipe line of length 2000 m is used for power transmission. If 110.3625 kW power is to be transmitted through the pipe in which water having a pressure of 490.5 N/cm^2 at inlet is flowing. Find the diameter of the pipe and efficiency of transmission if the pressure drop over the length of pipe is 98.1 N/ cm^2. Take f = 0.0065.
12. Find the maximum power transmitted by a jet of water discharging freely out of nozzle fitted to a pie = 300 m long and 100 mm diameter with co efficient of friction as 0.01. the available head at the nozzle is 90 m.

UNIT IV BOUNDARY LAYER

PART – A

1. Define boundary layer.
2. Define momentum thickness.
3. What do you mean by drag lift?
4. What are the different methods of preventing the separation of boundary layers?
5. Differentiate between Laminar boundary and turbulent boundary layer.
6. Define displacement thickness.
7. Define boundary layer thickness.
8. Define energy thickness.
9. Write down the Von Karman momentum integral equation.
10. Write down the boundary conditions for the velocity profiles.
11. Differentiate local co-efficient of drag and average co-efficient of drag.
12. What are the conditions for separation of boundary layer?
13. Draw a diagram for drag force on a plate due to boundary layer.
14. Write down the applications of Von Karman momentum integral equation.
15. What do you mean by Laminar Sub – layer?
16. State Boundary layer theory.
17. Write down the values of boundary layer thickness and drag co – efficient for Blasius's solution.
18. Write down the values of boundary layer thickness and drag co – efficient for velocity profile $u/U = 2\,(y/\delta) - (y/\delta)^2$
19. Write down the values of boundary layer thickness and drag co – efficient for velocity profile $u/U = 2\,(y/\delta) - 2(y/\delta)^3 + (y/\delta)^4$
20. Write down the values of boundary layer thickness and drag co – efficient for velocity profile $u/U = \sin(\pi y/2\delta)$.
21. Write down the values of boundary layer thickness and drag co – efficient for velocity profile $u/U = 3/2\,(y/\delta) - 1/2(y/\delta)^3$.

PART - B

1. Briefly explain the boundary layer definitions.
2. Find the displacement thickness, the momentum thickness and energy thickness for the velocity distribution in the boundary layer given by $u/U = y/\delta$, where u is the velocity at a distance y from the plate and u = U at $y = \delta$, where δ = boundary layer thickness. Also calculate the value of δ^*/θ.
3. Find the displacement thickness, the momentum thickness and energy thickness for the velocity distribution in the boundary layer given by $u/U = 2\,(y/\delta) - (y/\delta)^2$.
4. For the velocity profile $u/U = 2\,(y/\delta) - (y/\delta)^2$, find tghe thickness of boundary layer at the end of the plate and the drag force on one side of a plate 1 m long and 0.8 m wide

when placed in water flowing with a velocity of 150 mm/sec. Calculate the value of co - efficient of drag also. Take μ for water = 0.01 poise.

5. For the velocity profile for laminar boundary layer $u/U = 2 (y/\delta) - (y/\delta)^3 + (y/\delta)^4$ obtain an expression for boundary layer thickness, shear stress, drag force on one side of the plate and co – efficient of drag in term of Reynold number.
6. For the velocity profile for laminar boundary flow $u/U = \sin (\pi y/2\delta)$. Obtain an expression for boundary layer thickness, shear stress, drag force on one side of the plate and co – efficient of drag in terms of Reynold number.
7. For the velocity profile for laminar boundary layer $u/U = 3/2 (y/\delta) - 1/2 (y/\delta)^3$ find the thickness of the boundary layer and the shear stress 1.5 m from the leading edge of a plate. The plate is 2 m long and 1.4 m wide and is placed in water which is moving with a velocity of 200 mm per second. Find the total drag force on the plate if μ for water = 0.01 poise.
8. For the velocity profile for turbulent boundary layer $u/U = (y/\delta)^{1/7}$, obtain an expression for boundary layer thickness, shear stress, drag force on one side of the plate and co – efficient of drag in terms of Reynolds Number. Given the stress (ζ_o) for turbulent boundary layer as

$$\zeta_o = 0.0225 \rho U^2 (\mu/ \rho U g)^{1/4}.$$

9. Determine the thickness of the boundary layer at the trailing edge of smooth plate of length 4 m and of the width 1.5 m, when the plate is moving with a velocity of 4 m/s in stationary air. Take kinematic viscosity of air as 1.5×10^{-5} m^2/s.
10. For the following velocity profiles, determine whether the flow has or on the verge of separation or will attach with the surface:
    - (i) $u/U = 3/2 (y/\delta) - 1/2 (y/\delta)^3$
    - (ii) $u/U = 2 (y/\delta)^2 - (y/\delta)^3$
    - (iii) $u/U = -2 (y/\delta) + (y/\delta)^2$

UNIT V DIMENSIONAL ANALYSIS AND MODEL STUDIES

PART - A

1. Define dimensional analysis.
2. What are the fundamental dimensions?
3. Give the dimensions of Area and Volume.
4. Derive the dimensions of velocity.
5. Define Model.
6. List out the advantages of model analysis.
7. Define similitude.
8. Define Scale ratio.
9. Define dynamic similarity.
10. Give the types of forces in a moving fluid.
11. Define dimensionless numbers.

12. Define surface tension.
13. Define pressure force.
14. Define Elastic force.
15. Give the types of dimensionless numbers.
16. Define Reynold's number.
17. Define Froude's number.
18. Give the classification of models.
19. What is an undistorted model?
20. What id distorted model?
21. Give the advantages of distorted models.
22. List out the types of model laws.
23. List out the application of Froude's model laws.
24. Define Weber's model laws.

PART - B

1. Explain Buckingham's theorem.
2. The resisting force (R) of a supersonic flight can be considered as dependent upon 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.
3. A ship is 300 m long moves in sea water, whose density is 1030 kg/m^3. A 1:100 model of this to be tested in a wind tunnel. The velocity of air in the wind tunnel around the model is 30 m/s and the resistance of the model is 60 N. Determine the velocity of ship in sea water and also the resistance of the ship in sea water. The density of air is given as 1.24 kg/m^3. Take the Kinematic viscosity of sea water and air as 0.012 stokes and 0.018 stokes respectively.
4. A 7.2 m height and 15 m long spillway discharge 94 m^3/s, under a head of 2.0m. If a 1:9 scale model of this spillway is to be constructed, determine model dimensions, head over spillway model and the model discharge. If model experience a force of 7500 N (764.53 Kgf), determine force on the prototype.
5. A quarter scale turbine model is tested under ahead of 12 m. The full scale turbine is to work under a head of 30 m and to run at 428 rpm. Find N for model. If model develops 100 kW and uses 1100 l/s at this speed, what power will be obtained from full scale turbine assuming its n is 3% better than that of model.
6. Using Buckingham's π theorem, show that the drag force $F_D = \rho L^2V^2\varphi$ (Re,M) which Re $= \rho LV/\mu$; $M = V/C$; ρ = fluid mass density; L = chord length: V= velocity of aircraft; μ = fluid viscosity; C = sonic velocity = $\sqrt{K}/\rho$ where K = bulk modulus of elasticity.
7. The resistance ' R' experienced by apartially, submerged body depends upon the velocity 'V', length of the body 'l', viscosity of fluid 'μ', density of the fluid 'ρ', and gravitational acceleration 'g'; obtain expression for R.
8. Derive the relation using Buckingham's π theorem $F = \rho U^2D^2f(\mu/UD\rho), ND/U)$.

9. State the reasons for construction distorted model of rivers and discuss the various types of distortion in models. What are the merits and demerits of distorted models as compared to undistorted model?
10. In an aeroplane model of size 1/10 of its prototype the pressure drop is 7.5 kN/m^3. The model is tested in water. Find the corresponding pressure drop in the prototype. Take density of air is 1.4 kg/m^3, density of water is 1000 kg/m^3, viscosity of air is 0.00018 poise and viscosity of water is 0.01 poise.