ARYA COLLEGE OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT
III Semester, B.Tech. (II Year)
3CE4-06: FLUID MECHANICS
GUESS PAPER

Chapter-1,2: Fluids, Properties of Fluid

Q. Define the following fluid properties: Density, Weight Density, Specific weight, Specific Volume and Specific Gravity of a fluid.
Q. Explain the terms (a) dynamic viscosity, and (b) kinematic viscosity. Give their dimensions.
Q. Differentiate between:- (a) liquids and gases (b) real fluids and ideal fluids (c) specific weight and specific volume of a fluid.
Q. State the Newton's law of viscosity and give examples of its application.
Q. Define Newtonian and Non-Newtonian fluid.
Q. Why does the viscosity of a gas increases with the increase in temperature while that of a liquid decreases with increase in temperature?
Q. Define surface tension. Prove that the relationship between surface tension and pressure inside a droplet of liquid in excess of outsides pressure of given by $P = \frac{4\sigma}{d}$
Q. Explain the phenomenon of capillarity. Obtain an expression for capillarity rise of a liquid.

Q. Define Fluid. What is fluid Continuum?
Q. Convert 1 $kg/s - m$ dynamic viscosity in poise.

Q. Calculate the dynamic viscosity of oil, which is used for lubrication between a square plate of size $0.8\ m\ X\ 0.8\ m$ and an inclined plane with angle of inclination 30^0. The weight of the square plate is $300\ N$ and it slides down the inclined plane with a uniform velocity of $0.3\ m/s$. The thickness of oil film is $1.5\ mm$.

Q. Determine the viscosity of a liquid having kinematic viscosity 6 stokes and specific gravity 1.9.

Q. A vertical gap 2.2 cm wide of infinite extent contains a fluid of viscosity 2.0 Ns/m^2 and specific gravity 0.9. A metallic plate $1.2\ m\ X\ 1.2\ m\ X\ 1.2\ cm$ is to be lifted up with a constant velocity of $0.15\ m/s$, through the gap. If the plate is in the middle of the gap, find the force required. The weight of the plate is $40N$.

Q. The space between two square flat parallel plates is filled with oil. Each side of the plate is $60\ cm$. The thickness of the oil film is $12.5\ mm$. The upper plate, which moves at 2.5 metre per sec requires a force of $98.1\ N$ to maintain the speed. Determine:
(i) the dynamic viscosity of the oil in poise, and
(ii) the kinematic viscosity of the oil in stokes if the specific gravity of the oil is 0.95.

Q. The dynamic viscosity of an oil, used for lubrication between a shaft and sleeve is $6\ poise$. The shaft is of diameter $0.4\ m$ and rotates at $190\ r.p.m.$ Calculate the power lost in the bearing for a sleeve length of $90\ mm$. The thickness of oil film is $1.5\ mm$.

Q. Two large plane surfaces are 2.4 cm apart. The space between the surfaces is filled with glycerin. What force is required to drag a very thin plate of surface area 0.5 square metre between the two large plane surfaces at a speed of 0.6 m/s, if :
(i) the thin plate is in the middle of the two plane surfaces, and
(ii) the thin plate is at a distance of 0.8 cm from one of the plane surfaces? Take the dynamic viscosity of glycerin = $8.10 \times 10^{-1}\ Ns/m^2$.

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Q. What is the bulk modulus of elasticity of a liquid which is compressed in a slender from volume of 0.0125 m^3 at 80 N/cm^2 pressure to a volume of 0.0124 m^3 at 150 N/cm^2 pressure.

Q. The Pressure outside the droplet of water of diameter 0.04 mm is 10.32 N/cm^2 (atmospheric pressure) calculate the pressure within the droplet if surface tension is give as 0.0725 N/m of water.

Q. Calculate the capillary effect in millimetres in a glass tube 4 mm dia when immerged in (i) Water (ii) Mercury. The temperature of the liquid is 20˚C and the value of surface tension of water and mercury 20˚C in contact with air are 0.073575 N/m and 0.51 N/m. Respectively the angle of contact of water is zero and that of 4 mercury is 130˚. Take Density of water at 20˚C as equal to 998 kg/m^3.

Chapter 3,4: Principles of Fluid Statics, Buoyancy

Q. What do you understand by hydrostatic law?

Q. State and prove the Pascal law.

Q. What do you understand by Hydrostatic law?

Q. What is the difference between Gauge pressure and Vacuum Pressure?

Q. Differentiate between:-
i) Absolute and gauge pressure
ii) Simple manometer and Differential manometer.
iii) Piezometre and pressure gauge.

Q. Show that the distance between the meta-centre and centre of buoyancy is given by $BM = \frac{I}{V}$

Q. What do you mean vacuum pressure?

Q. What is the difference between U-tube differential manometers and inverted U-tube differential manometers? Where are they used?

Q. Explain briefly the working principle of Bourdon Pressure Gauge with a neat sketch.

Q. Define total pressure and centre of pressure.

Q. Derive an expression for the force exerted on a sub-merged vertical plane surface by the static liquid and locate the position of centre of pressure.

Q. Prove that the total pressure forces exerted by a static liquid on an inclined plane sub-merged surface is the same as the force exerted on a vertical plane surface as long as the depth of the centre of gravity of the surface is unaltered.

Q. Explain how you would find the resultant pressure on a curved surface immersed in a liquid.

Q. Define the term: Buoyancy, Meta-centre, centre of buoyancy, Meta centric Height, Gauge Pressure, Atmospheric Pressure and absolute pressure.

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Q. What are the condition of equilibrium of a floating body and a sub-merged body?

Q. How will you determine the meta-centric height of floating body experimentally? Explain with neat sketch.

Q. An open tank contains water upto 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, and (ii) at the bottom of the tank.

Q. The diameters of a small piston and a large piston of a hydraulic jack are 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 is 40 cm above the large piston.
The density of the liquid in the jack is given as 1000 kg/m^3.

Q. 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 mercury and is open to atmosphere. The contact between water and mercury is in the left limb. Determine the pressure in the main line, is the difference in level of mercury in the limb of u-tube is 10 cm and the free surface of mercury is in level with the center of the pipe if the pressure of water in pipe line is reduce the 9810 N/m^2 calculate the new difference in the level of mercury. Sketch the arrangement.

Q. A single column manometer is connected to a pipe containing a liquid of sp. gr. 0.9 as shown in fig. Find the pressure in the pipe if the area of the reservoir is 100 times the area of the tube for manometer reading shown in fig. The specific gravity of mercury is 13.6.

Q. A differential manometers is connected at the two point A and B as shown fig. At B air pressure is 9.81 N/cm^2(abs). Find the absolute pressure at A.

Q. An inverted U-tube manometer is connected to two horizontal pipes A and B through which water is flowing. The vertical distance between the axe s of these pipes is 30 cm. When an oil of specific gravity 0.8 is used as a gauge fluid, the vertical heights of water columns in the two limbs of the inverted manometer (when measured from the respective centre lines of the pipes) are found to be same and equal to 35 cm. Determine the difference of pressure between the pipes.

Q. A rectangular plane surface is 2 m wide and 3 m deep. It lies in vertical plane is water. Determine the total pressure and position of centre of pressure on the plane surface when its upper edge is horizontal and (a) coincidence with water surface (b) 2.5m below the free water surface.

Q. 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 height of 1.5 m above the top of the gate whereas on the downstream side water is available up to high touching the top of the gate. Find the resultant forces acting on the gate and position. Find also the force acting horizontally at the top of the gate which is capable of opening it. Assume that the hinged at the bottom.

Q. A rectangular plane surface 2m wide and 3m deep lies in water in such a way that its plane marks an angle of 30˚ with the free surface of water. Determine the total pressure and position of center of pressure when the upper edge is 1.5m below the free water surface.

Q. A cylindrical gate of 4 m diameter 2 m long has water on its both sides as shown in fig. Determine the magnitude, location and direction of the resultant force exerted by the water on the gate. Find also the least weight of the cylinder so that it may not be lifted away from the floor.

Q. A rectangular pontoon 10 m long,7 m broad and 2.5 m deep weighs 686.7 kN. It carries on its upper deck an empty boiler of 5 m diameter weighing 588.6 kN. The centre of gravity of the boiler and the pontoon are at their respective centres along a vertical line. Find the meta-centric height. Weight density of sea water is $10.104\ kN/m^3$.

Q. Find the magnitude and direction of the resultant force due to the water acting on roller gate of cylindrical form of 4m diameter when the gate is placed on the dam in such a way that water is just going to spill. Take the length of the gate as 8m.

Chapter 5: Kinematics of Flow

Q. Explain the terms:
(i) Path line, (ii) Streak line, (iii) Stream line, and (iv) Stream tube.

Q. Distinguish Between :-
(i) Steady and un-steady flow, (ii) Uniform and non-uniform flow, (iii) Compressible and incompressible flow, (iv) Rotational and irrotational flow, and (vi) Laminar and Turbulent flow.

Q. Define the equation of continuity. Obtain an expression for continuity equation for a three dimensional flow.

Q. What do you understand by the terms: (i) Total acceleration, (ii) Convective acceleration, and (iii) Local acceleration?

Q. What is discharge?

Q. Define and discuss types of fluid flow.

Q. (a) Define the terms: (i) Velocity Potential Function, and (ii) Stream function.
(b) What are the conditions for flow to be irrotational?

Q. What do you mean by equipotential line and a line of constant stream function?

Q. Define the terms:
(i) Vortex flow, (ii) Forced Vortex Flow, and (iii) Free vortex flow.

Q. Derive an expression for the depth of paraboloid formed by the surface of a liquid contained in a cylindrical tank which is rotated at a constant angular velocity ω about its vertical axis.

Q. A rectangular tank is moving horizontally in the direction of its length with a constant acceleration of $2.4\ m/s^2$. The length, width and depth of the tank are 6 m, 2.5 m and 2 m respectively. If the depth of water in the tank is 1 m and tank is open at the top then calculate:
(i) the angle of the water surface to the horizontal.

(ii) the maximum and minimum pressure intensities at the bottom.
(iii) the total force due to water acting on each end of the tank.

Q. Water flow through a pipe AB 1.2 m diameter at 3 m/s. and then passes through the pipe BC 1.5 m diameter. At C, the pipe branches CD in 0.8 m in diameter 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 and the diameter of CE.

Q. Examine whether the following velocity components represent a physically possible flow?

$$u_r = r\sin\theta\,, u_\theta = 2r\cos\theta.$$

Q. 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 fluid flow. Calculate the velocity and acceleration at the point (2,1,3).

Q. If two dimensional potential flow the velocity potential is given by

$$\emptyset = x(2y - 1)$$

determine the velocity at the point P(4,5). Determine also the value of stream function Ψ at the point P.

Q. A cylindrical vessel 12 cm in diameter and 30 cm deep is filled with water upto the top. The vessel is open at the top. Find the quantity of liquid left in the vessel, when it is rotated about its vertical axis with a speed of (a) 3000 $r.p.m.$ and (b) 600 $r.p.m.$

Q. A vessel, cylindrical in shape and closed at the top and bottom, contains water upto a height of 80 cm. The diameter of the vessel is 20 cm and length of vessel is 120 cm. The vessel is rotated at a speed of 400 $r.p.m.$ about its vertical axis. Find the height of paraboloid formed.

Q. The following cases represent the two velocity components, determine the third component of velocity such that that they satisfy the continuity equation:

(i) $u = x^2 + y^2 + z^2; v = xy^2 - yz^2 + xy$
(ii) $v = 2y^2; w = 2xyz.$

Q. Sketch the stream lines represented by $\Psi = x^2 + y^2$. Also find out the velocity and its direction at point (1,2).

Q. The velocity components in a two-dimensional flow field for an incompressible fluid are as follows:

$$u = \frac{y^3}{3} + 2x - x^2y \text{ and } v = xy^2 - 2y - \frac{x^3}{3}$$

Obtain an expression for the stream function Ψ.

Chapter 6: Fluid Dynamics

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Q. What is Euler's equation of motion? How will you obtain Bernoulli's equation from it?

Q. State Bernoull's theorem.

Q. What is a Venturimeter? Drive an expression for the discharge through Venturimeter.

Q. Define an orifice-meter. Prove that the discharge through an orifice-meter is given by the relation

$$Q = C_d \frac{a_0 a_1}{\sqrt{a_1^2 - a_0^2}} \times \sqrt{2gh}$$

Q. Define moment of momentum equation. Where this equation is used.

Q. State and prove Bernoulli's equation. Also give assumptions, limitations and its applications.

Q. Define the following co-officient: (i) Co-efficient of velocity (ii) Co-officient of counteraction (iii) Co-officient of discharge.

Q. What is the free jet liquid? Derive an expression for the path travelled by free jet issuing from a nozzle.

Q. Explain the classification of orifices and mouthpieces.

Q. Define vena-contracta.

Q. State and derive impulse-momentum equation for steady flow.

Q. Prove that the expression for discharge through an external mouthpiece is given by

$$Q = .855 \times a \times v$$

Q. Obtain an expression for the force exerted by a jet of water on a fixed vertical plate in the directions of the jet.

Q. The water is flowing through a pipe having diameter 20 cm and 10 cm at section 1 and 2 respectively. The rate of flow through pipe is 35 ltr/s. The section 1 is 6 m above datum and section 2 is 4 m above datum. If the pressure at section 1 is 39.24 N/cm^2 find the intensity of pressure at section 2.

Q. A pipeline carrying oil of specific gravity 0.87, changes in diameter from 200 mm diameter at a position A to 500 mm diameter at a position B which is 4 meters at a higher level. If the pressures at A and B are 9.81 N/cm^2 and 5.886 N/cm^2 respectively and the discharge is 200 lit/s, determine the loss of head and direction of flow.

Q. Find the discharge of water flowing through a pipe 30 cm diameter placed in an inclined position where a venturimeter is inserted, having a throat diameter of 15 cm. The difference of pressure between the main and throat is measured by a liquid of sp.gr. 0.6 in an inverted U-tube which gives a reading of 30 cm. The loss of head between the main and throat is 0.2 times the kinetic head of the pipe.

Q. 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 50 cm of mercury. Find the rate of flow of oil of sp.gr. 0.9 when the co-efficient of discharge of the orifice meter = 0.64.

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Q. $250\ lit/s$ of water is flowing in a pipe having a diameter of $300\ mm$. if the pipe is bent by 135^0, find the magnitude and direction of the resultant force on the bend. The pressure of water flowing is $39.24\ N/cm^2$.

Q. A cylindrical tank is having a hemispherical base. The height of cylindrical portion is 5m and diameter is 4m. At the bottom of this tank and orifice of diameter 200 mm is fitted. Find the time required to completely emptying the tank. Take $C_d = 0.6$.

Q. The head of water over an orifice of diameter 100 mm is 10 m. The water coming out from orifice is collected in a circular tank of diameter 1.5 m. The rise of water level in this tank is 1.0 m in 25 seconds. Also the co ordinates of a point on the jet, measured from vena-contracta are 4.3 m horizontal and 0.5 m vertical . Find the co-efficient C_d, C_v and C_c.

Q. A closed vessel contains water upto a height of $1.5\ m$ and over the water surface there is air having pressure $7.848\ N/cm^2$ ($0.8\ kgf/cm^2$) above atmospheric pressure. At the bottom of the vessel there is an orifice of diameter $100\ mm$. Find the rate of flow of water from orifice. Take $Cd = 0.6$.

Q. A rectangular orifice of $2\ m$ width and $1.2\ m$ deep is fitted in one side of a large tank. The water level on one side of the orifice is $3\ m$ above the top edge of the orifice, while on the other side of the orifice, the water level is $0.5\ m$ below its top edge. Calculate the discharge through the orifice if $C_d = 0.64$.

Chapter 7: Laminar Flow Through Pipes

Q. Derive an expression for the velocity distribution for viscous flow through a circular pipe. Also sketch the velocity distribution and shear stress distribution across a section of the pipe.

Q. Derive an expression for Hagen Poiseuille's formula.

Q. What is Laminar flow?

Q. What is Turbulent flow?

Q. Discuss various types of minor losses in pipe flow.

Q. Prove that the maximum velocity in a circular pipe for viscous flow is equal to two times the average velocity of the flow.

Q. Derive an expression for the loss of head of a viscous fluid flowing through a circular pipe.

Q. Show that the difference of pressure head for a given length of the two parallel plates which are fixed and through which viscous fluid is flowing is given by

$$h_f = \frac{12\mu\bar{u}L}{\rho g t^2}$$

Q. Show that the value of the co-efficient of friction for viscous flow through a circular pipe is given by

$$f = \frac{16}{R_e}$$

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Q. Describe Reynolds experiments to demonstrate the two type of flow.

Q. Derive Darcy-Weisbach Equation.

Q. Derive an expression for the loss of head due to : (i) Sudden enlargement and (ii) Sudden contraction of a pipe.

Q. 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 10 m. 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 sec.

Q. A laminar flow is taking place in a pipe of diameter 200 mm. The maximum velocity is 1.5 m/sec. Find the mean velocity and the radius at which this occurs. Also calculate the velocity at 4 cm from the wall of the pipe.

Q. Water at 15^0C flows between two large parallel plates at a distance of 1.6 mm apart. Determine (i) the max velocity (ii) the pressure drop per unit length, and (iii) the shear stress at the walls of the plates if the average velocity is 0.2 m/s. The velocity of water at 15^0C is given as 0.01 $poise$.

Q. Water is flowing through a 200 mm diameter pipe with coefficient of friction $f = 0.04$. The shear stress at a point 40 mm from the pipe axis is 0.00981 N/cm^2. Calculate the shear stress at a pipe wall.

Q. Calculate the discharge in each pipe of the network shown in figure. The pipe network consists of 5 $pipes$. The head loss h_f in a pipe is given by $h_f = rQ^2$. The values of r for various pipes and also the inflow or outflows at nodes are shown in figure.

Q. Calculate (i) the pressure gradient along flow
(ii) The average velocity
(iii) The discharge for an oil of the viscosity 0.02 Ns/m^2 flowing between two stationary parallel plates 1m wide maintained 10m apart. The velocity midway between the plates is 2m/sec.