**Fluid Mechanics & Machinery**

# UNIT- I

## PART – A

1. Define fluids.

   Fluid may be defined as a substance which is capable of flowing. It has no definite shape of its own, but confirms to the shape of the containing vessel.

2. What are the properties of ideal fluid?

   Ideal fluids have following properties

   i) It is incompressible
   ii) It has zero viscosity
   iii) Shear force is zero

3. What are the properties of real fluid?

   Real fluids have following properties

   i) It is compressible
   ii) They are viscous in nature
   iii) Shear force exists always in such fluids.

4. Define density and specific weight.

   Density is defined as mass per unit volume ($kg/m^3$)
   Specific weight is defined as weight possessed per unit volume ($N/m^3$)

5. Define Specific volume and Specific Gravity.

   Specific volume is defined as volume of fluid occupied by unit mass ($m^3/kg$)
   Specific gravity is defined as the ratio of specific weight of fluid to the specific weight of standard fluid.

6. Define Surface tension and Capillarity.

   Surface tension is due to the force of cohesion between the liquid particles at the free surface.
   Capillary is a phenomenon of rise or fall of liquid surface relative to the adjacent general level of liquid.

7. Define Viscosity.

   It is defined as the property of a liquid due to which it offers resistance to the movement of one layer of liquid over another adjacent layer.

8. Define kinematic viscosity.

   It is defined as the ratio of dynamic viscosity to mass density. ($m^2/sec$)

9. Define Relative or Specific viscosity.
   It is the ratio of dynamic viscosity of fluid to dynamic viscosity of water at 20°C.
10. Define Compressibility.
   It is the property by virtue of which fluids undergoes a change in volume under the action of external pressure.
11. Define Newtonian law of Viscosity.
   According to Newton's law of viscosity the shear force F acting between two layers of fluid is proportional to the difference in their velocities du and area A of the plate and inversely proportional to the distance between them.
12. What is cohesion and adhesion in fluids?
   Cohesion is due to the force of attraction between the molecules of the same liquid.
   Adhesion is due to the force of attraction between the molecules of two different liquids or between the molecules of the liquid and molecules of the solid boundary surface.
13. State momentum of momentum equation?
   It states that the resulting torque acting on a rotating fluid is equal to the rate of change of moment of momentum
14. What is momentum equation
   It is based on the law of conservation of momentum or on the momentum principle It states that,the net force acting on a fluid mass is equal to the change in momentum of flow per unit time in that direction.

PART-B ( 16 Marks)

1. a) What are the different types fluids? Explain each type. (8)

   b) Discuss the thermodynamic properties of fluids (8)

2. a) One litre of crude oil weighs 9.6 N. Calculate its Specific weight, density and specific volume. (8)

   b) The Velocity Distribution for flow over a flat plate is given by $u=(2/3)y-y^2$, Where u is the point velocity in metre per second at a distance y metre above the plate. Determine the shear stress at y=0 and y=15 cm. Assume dynamic viscosity as 8.63 poises (8)

3. a) A plate, 0.025 mm distant from a fixed plate, moves at 50 cm/s and requires a force of 1.471 N/ $m^2$ to maintain this speed. Determine the fluid viscosity between plates in the poise. (8)

   b) Determine the intensity of shear of an oil having viscosity =1.2 poise and is used for lubrication in the clearance between a 10 cm diameter shaft and its journal bearing. The clearance is 1.0 mm and Shaft rotates at 200 r.p.m (8)

4. a) Two plates are placed at a distance of 0.15mm apart. The lower plate is fixed while the upper plate having surface area 1.0 $m^2$ is pulled at 0.3 nm/s. Find the force and power required to maintain this speed, if the fluid separating them is having viscosity 1.5 poise. (8)

b) An oil film of thickness 1.5 mm is used for lubrication between a square plate of size 0.9m *0.9m and an inclined plane having an angle of inclination $20^0$ . The weight of square plate is 392.4 N and its slides down the plane with a uniform velocity of 0.2 m/s. find the dynamic viscosity of the oil. (8)

5.a) Assuming the bulk modulus of elasticity of water is 2.07 x$10^6$ kN/$m^2$ at standard atmospheric condition determine the increase of pressure necessary to produce one percent reduction in volume at the same temperature. (8)

b) Calculate the capillary rise in glass tube of 3mm diameter when immersed in mercury, take the surface tension and angle of contact of mercury as 0.52 N/m and $130^0$ respectively. Also determine the minimum size of the glass tube, if it is immersed in water, given that the surface tension of water is 0.0725 N/m and Capillary rise in tube is not exceed 0.5mm. (8)

6.a) Calculate the pressure exerted by 5kg of nitrogen gas at a temperature of $10^0$ CWhen the volume is 0.4 $m^3$ .Also find the volume when the pressure is 3*$10^5$ N/ $m^2$ and the temp is $10^0$ C. Assume the ideal law is applicable. (8)

b) Calculate the capillary effect in glass tube 5mm diameter, when immersed in (1) water and (2) mercury. The surface tension of water and mercury in contact with air are 0.0725 N/m and 0.51 N/m respectively . The angle of contact of mercury of mercury is 130° (8)

7. a) Explain all three Simple manometers with neat sketch. (8)

b) Explain Differential manometer With Neat sketch. (8)

8. A U-tube differential manometer is connected two pressure pipes A and B. Pipe A contains Carbon tetrachloride having a specific gravity 1.594 under a pressure of 11.772 N/ $Cm^2$ and pipe B contain oil of specific gravity 0.8 under pressure 11.72 N/ $Cm^2$ . The pipe A lies 2.5 m above pipe B. Find the difference of pressure measured by mercury as a fluid filling U-tube (16)

# UNIT-II

## PART-A

1. Mention the general characteristics of laminar flow.
   - There is a shear stress between fluid layers
   - 'No slip' at the boundary
   - The flow is rotational
   - There is a continuous dissipation of energy due to viscous shear
2. What is Hagen poiseuille's formula ?

   $P_1 - P_2 / \rho g = h_f = 32 \mu UL / \_gD^2$

   The expression is known as Hagen poiseuille formula .

   Where $P_1 - P_2 / \_g$ = Loss of pressure head   U = Average velocity

   $\mu$ = Coefficient of viscosity   D = Diameter of pipe

   L = Length of pipe
3. What are the factors influencing the frictional loss in pipe flow ?

   Frictional resistance for the turbulent flow is

   i. Proportional to $v_n$ where v varies from 1.5 to 2.0 .

   ii. Proportional to the density of fluid .

   iii. Proportional to the area of surface in contact .

   iv. Independent of pressure .

   v. Depend on the nature of the surface in contact .

4. What is the expression for head loss due to friction in Darcy formula ?

   $h_f = 4fLV^2 / 2gD$

   Where f = Coefficient of friction in pipe   L = Length of the pipe

   D = Diameter of pipe   V = velocity of the fluid
5. What do you understand by the terms a) major energy losses , b) minor energy losses

   Major energy losses : -

   This loss due to friction and it is calculated by Darcy weis bach formula and chezy's formula .

   Minor energy losses :-

   This is due to

   i. Sudden expansion in pipe .   ii. Sudden contraction in pipe .

   iii. Bend in pipe .   iv. Due to obstruction in pipe .
6. Give an expression for loss of head due to sudden enlargement of the pipe :-

   $he = (V1-V2)^2 /2g$

   Where he = Loss of head due to sudden enlargement of pipe .

   V1 = Velocity of flow at section 1-1

   V2 = Velocity of flow at section 2-2
7. Give an expression for loss of head due to sudden contraction : -

   $hc = 0.5\ V^2/2g$

   Where hc = Loss of head due to sudden contraction .

   V = Velocity at outlet of pipe.

8. Give an expression for loss of head at the entrance of the pipe : -

   hi =0.5V2/2g

   where hi = Loss of head at entrance of pipe .

   V = Velocity of liquid at inlet and outlet of the pipe .

9. Define the terms a) Hydraulic gradient line [HGL], b) Total Energy line [TEL]

   a) Hydraulic gradient line :-

   Hydraulic gradient line is defined as the line which gives the sum of pressure head and datum head of a flowing fluid in apipe with respect the reference line .

   b) Total energy line :-

   Total energy line is defined as the line which gives the sum of pressure head , datum head and kinetic head of a flowing fluid in a pipe with respect to some reference line .

10. What is sypon ? where it is used :_

    Sypon is along bend pipe which is used to transfer liquid from a reservoir at a higher elevation to another reservoir at a lower level .

    Uses of sypon : -

    1. To carry water from one reservoir to another reservoir separated by ahill ridge .
    2. To empty a channel not provided with any outlet sluice .

11. What are the basic educations to solve the problems in flow through branched pipes?

    i. Continuity equation .

    ii. Bernoulli's formula .

    iii. Darcy weisbach equation .

12. What is Dupuit's equation ?

    $L_1/d_1^5+L_2/d_2^5+L_3/d_3^5 = L\ /\ d^5$

    Where

    $L_1, d_1$ = Length and diameter of the pipe 1

    $L_2, d_2$ = Length and diameter of the pipe 2

    $L_3, d_3$ = Length and diameter of the pipe 3

**PART-B**

1. a) Derive an expression for the velocity distribution for viscous flow through a circular pipe. (8)

   b) A main pipe divides into two parallel pipes, which again forms one pipe. The length and diameter for the first parallel pipe are 2000m and 1m respectively, while the length and diameter of second parallel pipe are 2000 and 0.8 m respectively. Find the rate of flow in each parallel pipe, if total flow in the main is 3 m³/s. The coefficient of friction for each parallel pipe is same and equal to 0.005. (8)

2. a) Two pipes of 15 cm and 30 cm diameters are laid in parallel to pass a total discharge of 100 liters/ second. Each pipe is 250 m long. Determine discharge through each pipe. Now these pipes are connected in series to connect two tanks 500 m apart, to carry same total discharge. Determine water level difference between the tanks. Neglect minor losses in both cases, f=0.02 $f_n$ both pipes. (8)

b) A pipe line carrying oil of specific gravity 0.85, changes in diameter from 350 mm at position 1 to 550 mm diameter to a position 2, which is at 6 m at a higher level. If the pressure at position 1 and 2 are taken as 20 $N/cm^2$ and 15 $N/cm^2$ respectively and discharge through the pipe is 0.2 $m^3/s$. determine the loss of head. (8)

3. Obtain an expression for Hagen- Poisulle flow. Deduce the condition of maximum velocity. (16)

4. A flat plate 1.5 m X 1.5 m moves at 50 km / h in a stationary air density 1.15 $kg/m^3$. If the coefficient of drag and lift are 0.15 and 0.75 respectively, determine (i) the lift force (ii) the drag force (iii) the resultant force and (iv) the power required to set the plate in motion. (16)

5. a). The rate of flow of water through a horizontal pipe is 0.3 $m^3/s$. The diameter of the pipe is suddenly enlarged from 25 cm to 50 cm. The pressure intensity in the smaller pipe is 14$N/m^2$. Determine (i) Loss of head due to sudden enlargement. (ii)Pressure intensity in the large pipe and iii)Power lost due to enlargement. (8)

b) Water is flowing through a tapering pipe of length 200 m having diameters 500 mm at the upper end and 250 mm at the lower end, the pipe has a slope of 1 in 40. The rate of flow through the pipe is 250 lit/ sec. the pressure at the lower end and the upper end are 20 $N/cm^2$ and 10 $N/cm^2$ respectively. Find the loss of head and direction of flow (8)

6. A horizontal pipe of 400 mm diameter is suddenly contracted to a diameter of 200 mm. The pressure intensities in the large and small pipe is given as 15 $N/cm^2$ and 10 $N/cm^2$ respectively. Find the loss of head due to contraction, if Cc=0.62, determine also the rate of flow of water. (16)

7. Determine the length of an equivalent pipe of diameter 20 cm and friction factor 0.02 for a given pipe system discharging 0.1$m^3/s$. The pipe system consists of the following:

(i) A 10 m line of 20 cm dia with f=0.03
(ii) Three 90º bend, k=0.5 for each
(iii) Two sudden expansion of diameter 20 to 30 cm
(iv) A 15 m line of 30 cm diameter with f=0.025 and
(v) A global valve, fully open, k=10. (16)

## UNIT III

### PART-A

1. What are the types of fluid flow?
    - Steady & unsteady fluid flow
    - Uniform & Non-uniform flow
    - One dimensional, two-dimensional & three-dimensional flows
    - Rotational & Irrotational flow

2. Name the different forces present in fluid flow
    - Inertia force
    - Viscous force
    - Surface tension force
    - Gravity force
3. When in a fluid considered steady?
   In steady flow, various characteristics of following fluids such as velocity, pressure, density, temperature etc at a point do not change with time. So it is called steady flow.
4. Give the Euler's equation of
   motion? (dp/p)+gdz+vdv=0
5. What are the assumptions made in deriving Bernouillie's equation?
   1.The fluid is ideal
   2.The flow is steady.
   3.The flow is incompressible.
   4.The flow is irrotational.
6. What is bernouillie's equation for real fluid?
   (p1/pg)+(v12/2g)+z1=(p2/pg)+(v22/2g)+z2+h
   l
   where hl is the loss of
   energy (p/pg)-Pressure
   energy. (v2/2g)=Kinetic
   energy.
   z-Datum energy.
7. State the application of Bernouillie's equation ?
   It has the application on the following measuring devices.
   1.Orifice meter.
   2.Venturimeter.
   3.Pitot tube.
8. State the methods of dimensional analysis.
   1.Rayleigh's method
   2.Buckingham's Π theorem

9. State Buckingham's Π theorem
   It states that if there are 'n' variables in a dimensionally homogeneous equation and if these variables contain 'm' fundamental dimensions (M,L,T), then they are grouped into (n-m), dimensionless independent Π-terms.

10. State the limitations of dimensional analysis.

1. Dimensional analysis does not give any due regarding the selection of variables.
2. The complete information is not provided by dimensional analysis.
3. The values of coefficient and the nature of function can be obtained only by experiments or from mathematical analysis.

11. Define Similitude

Similitude is defined as the complete similarity between the model and prototype.

12. State Froude's model law

Only Gravitational force is more predominant force. The law states 'The Froude's number is same for both model and prototype'.

## PART-B

1. a) Explain types of fluid flow. (8)

   b) Explain all dimensional number. (8)

2. Derive continuity equation of differential form. Discuss whether the equation is valid for a steady or unsteady flow, viscous or in viscid flow, compressible or incompressible flow.

3. State the Bernoulli's theorem for steady flow of an incompressible fluid. Derive an expression for Bernoulli's equation. (16)

4. Water is flowing through a pipe having diameter 300 mm and 200 mm at the bottom end is 24.525 $N/cm^2$ and the pressure at the upper end is 9.81 $N/Cm^2$. Determine the difference in datum head if the rate of flow through pipe is 40 lit/s. (16)

5. A pipe line 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 pressure at A and B which is 4 m at a higher level. If the pressures at A and B are 9.81 $N/Cm^2$ and 5.886 N/Cm2 respectively and the discharge is 20 litres/s determine the loss of head and direction of flow. (16)

6. The frictional torque T of a disc diameter D rotating at a speedN in a fluid of Viscosity μ and density ρ in a turbulent flow is given by $T=D^5N^2 \rho\Phi(\mu/D^2N\rho)$. Prove this Buckingham's Π theorem. (16)

7. A liquid of specific gravity 0.85 is flowing through in an inclined venturimeter of 250 mm x 115mm size. the difference of pressures between the main and throat is measured by a liquid of specific gravity 0.65 contained in an inverted U- tube which gives a reading of 275mm. If the loss of head between the main and throat is 0.3 times the Kinetic head of the pipe, determine the rate of flow of liquid.

# UNIT-IV

## PART-A

1. Define hydraulic machines.
   Hydraulic machines which convert the energy of flowing water into mechanical energy
2. Give example for a low head, medium head and high head turbine.
   Low head turbine – Kaplan turbine
   Medium head turbine – Modern Francis turbine
   High head turbine – Pelton wheel
3. What is impulse turbine? Give example.
   In impulse turbine all the energy converted into kinetic energy. From these the turbine will develop high kinetic energy power. This turbine is called impulse turbine. Example: Pelton turbine
4. What is reaction turbine? Give example.
   In a reaction turbine, the runner utilizes both potential and kinetic energies. Here portion of potential energy is converted into kinetic energy before entering into the turbine. Example: Francis and Kaplan turbine.
5. What is axial flow turbine?
   In axial flow turbine water flows parallel to the axis of the turbine shaft.
   Example: Kaplan turbine
6. What is mixed flow turbine?
   In mixed flow water enters the blades radially and comes out axially, parallel to the turbine shaft. Example: Modern Francis turbine.
7. What is the function of spear and nozzle?
   The nozzle is used to convert whole hydraulic energy into kinetic energy. Thus the nozzle delivers high speed jet. To regulate the water flow through the nozzle and to obtain a good jet of water spear or nozzle is arranged.
8. Define gross head and net or effective head.
   Gross Head: The gross head is the difference between the water level at the reservoir and the level at the tailstock.
   Effective Head: The head available at the inlet of the turbine.
9. Define hydraulic efficiency.
   It is defined as the ratio of power developed by the runner to the power supplied by the water jet.
10. Define mechanical efficiency.
    It is defined as the ratio of power available at the turbine shaft to the power developed by the turbine runner.
11. Define volumetric efficiency.
    It is defied as the volume of water actually striking the buckets to the total water supplied by the jet.
12. Define over all efficiency.
    It is defined as the ratio of power available at the turbine shaft to the power available from the water jet.

**PART-B**

1. Obtain en expression for the work done per second by water on the runner of a – pelton wheel. Hence derive an expression for maximum efficiency of the pelton wheel giving the relationship between the jet speed and bucket speed. (16)

2. a) A pelton wheel is having a mean bucket diameter of 1 m and is running at 1000 rpm. The net head on the pelton wheel is 700 m. If the side clearance angle is 15º and discharge through nozzle is 0.1 $m^3/s$, find (1) power available at nozzle and (2) hydraulic efficiency of the turbine. Take $C_v$=1 (8)

   b) A turbine is to operate under a head of 25 m at 200 rpm. The discharge is 9 $m^3/s$. If the efficiency is 90% determine, Specific speed of the machine power generated and type of turbine. (8)

3. A pelton turbine is required to develop 9000 KW when working under a head of 300 m the impeller may rotate at 500 rpm. Assuming a jet ratio of 10 And an overall efficiency of 85% calculate (1) Quantity of water required. (2) Diameter of the wheel (3) Number of jets (4) Number and size of the bucket vanes on the runner. (16)

4. An Outward flow reaction turbine has internal and external diameters of the runner as 0.5 m and 1.0 m respectively. The turbine is running at 250 rpm and rate of flow of water through the turbine is 8 $m^3/s$. The width of the runner is constant at inlet and out let and is equal to 30 cm. The head on the turbine is 10 m and discharge at outlet6 is radial, determine (1) Vane angle at inlet and outlet. (2) Velocity of flow at inlet and outlet. (16)

5. The Nozzle of a pelton Wheel gives a jet of 9 cm diameter and velocity 75 m/s. Coefficient of velocity is 0.978. The pitch circle diameter is 1.5 m and the deflection angle of the bucket is 170º. The wheel velocity is 0.46 times the jet velocity. Estimate the speed of the pelton wheel turbine in rpm, theoretical power developed and also the efficiency of the turbine. (16)

6. a)A turbine is to operate a head of a 25 m at 200 rpm; the available discharge is 9$m^3/s$ assuming an efficiency of 90%. Determine (1) Specific speed (2) Power generated (3) Performance under a head of 20 m (4) The type of turbine (8)

   b) A vertical reaction turbine under 6m head at 400 rpm the area and diameter of runner at inlet are 0.7 $m^2$ and 1m respective the absolute and relative velocities of fluid entering are 15ºand 60º to the tangential direction. Calculate hydraulic efficiency.. (8)

7. A Francis turbine has an inlet diameter of 2.0 m and an outlet diameter of 1.2m. The width of the blades is constant at 0.2 m. The runner rotates at a speed of 250 rpm with a discharge of 8 $m^3/s$ .The vanes are radial at the inlet and the discharge is radially outwards at the outlet. Calculate the angle of guide vane at inlet and blade angle at the outlet. (16)

8. A Kaplan turbine develops 20000KW at a head of 35 m and at rotational speed of 420 rpm. The outer diameter of the blades is 2.5 m and the hub diameter is 0.85m. If the overall efficiency is 85% and the hydraulic efficiency is 88%. Calculate the discharge, the inlet flow angle and the blade angle at the inlet. (16)

## UNIT-V

### PART-A

1. What is meant by Pump?
   A pump is device which converts mechanical energy into hydraulic energy.
2. Mention main components of Centrifugal pump.
   i) Impeller ii) Casing
   iii) Suction pipe,strainer & Foot valve iv) Delivery pipe & Delivery valve
3. What is meant by Priming?
   The delivery valve is closed and the suction pipe, casing and portion of the delivery pipe upto delivery valve are completely filled with the liquid so that no air pocket is left. This is called as priming.
4. Define Manometric head.
   It is the head against which a centrifugal pump work.
5. Define Mechanical efficiency.
   It is defined as the ratio of the power actually delivered by the impeller to the power supplied to the shaft.
7. Define overall efficiency.
   It is the ratio of power output of the pump to the power input to the pump.
9. Define speed ratio, flow ratio.
   Speed ratio: It is the ratio of peripheral speed at outlet to the theoretical velocity of jet corresponding to manometric head.
   Flow ratio: It is the ratio of the velocity of flow at exit to the theoretical velocity of jet corresponding to manometric head.
10. Mention main components of Reciprocating pump.
    # Piton or Plunger
    # Suction and delivery pipe
    # Crank and Connecting rod
11. Define Slip of reciprocating pump. When the negative slip does occur?
    The difference between the theoretical discharge and actual discharge is called slip of the pump.
    But in sometimes actual discharge may be higher then theoretical discharge, in such a case coefficient of discharge is greater then unity and the slip will be negative called as negative slip.
12. What is indicator diagram?
    Indicator diagram is nothing but a graph plotted between the pressure head in the cylinder and the distance traveled by the piston from inner dead center for one complete revolution of the crank.

13. What is meant by Cavitations?

It is defined phenomenon of formation of vapor bubbles of a flowing liquid in a region where the pressure of the liquid falls below its vapor pressure and the sudden collapsing of theses vapor bubbles in a region of high pressure.

14. What are rotary pumps?

Rotary pumps resemble like a centrifugal pumps in appearance. But the working method differs. Uniform discharge and positive displacement can be obtained by using these rotary pumps, It has the combined advantages of both centrifugal and reciprocating pumps.

## PART-B

1. Write short notes on the following (1) Cavitations in hydraulic machines their causes, effects and remedies. (2) Type of rotary pumps. (16)

2 . Draw a neat sketch of centrifugal pump and explain the working principle of the centrifugal pump. (16)

3. Draw a neat sketch of Reciprocating pump and explain the working principle of single acing and double acting Reciprocating pump. (16)

4. A radial flow impeller has a diameter 25 cm and width 7.5 cm at exit. It delivers 120 liters of water per second against a head of 24 m at 1440 rpm. Assuming the vanes block the flow area by 5% and hydraulic efficiency of 0.8, estimate the vane angle at exit. Also calculate the torque exerted on the driving shaft if the mechanical efficiency is 95%. (16)

5. Find the power required to drive a centrifugal pump which to drive a centrifugal pump which delivers 0.04 $m^{3}/s$ of water to a height of 20 m through a 15 cm diameter pipe and 100 m long. The over all efficiency of the pump is 70% and coefficient of friction is 0.15 in the formula $h_f=4flv^2/2gd$. (16)

6. A Centrifugal pump having outer diameter equal to 2 times the inner diameter and running at 1200 rpm works against a total head of 75 m. The Velocity of flow through the impeller is constant and equal to 3 m/s. The vanes are set back at an angle of 30º at out let. If the outer diameter of impeller is 600 mm and width at outlet is 50 mm. Determine (i) Vane angle at inlet (ii) Work done per second on impeller (iii) Manometric efficiency. (16)

7. The diameter and stroke of a single acting reciprocating pump are 200 mm and 400 mm respectively, the pump runs at 60 rpm and lifts 12 liters of water per second through a height of 25 m. The delivery pipe is 20m long and 150mm in diameter. Find (i) Theoretical power required to run the pump. (ii) Percentage of slip. (iii) Acceleration head at the beginning and middle of the delivery stroke. (16)