KNOWLEDGE INSTITUTE OF TECHNOLOGY

(Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai)

Kakapalayam (PO), Salem – 637504.

FLUID MECHANICS & MACHINERY

QUESTION BANK

Department of Mechanical Engineering

PART A

UNIT – I

1. Define density or mass density.

   Density of a fluid is defined as the ratio of the mass of a fluid to its volume.

   Density, ρ = mass/volume (Kg/m^3)

   $\rho_{water} = 1000\ Kg/m^3$

2. Define specific weight or weight density.

   Specific weight or weight density of a fluid is defined as the ratio between the weight of a fluid to its volume.

   Specific weight, γ = weight/volume (N/m^3)

   $\gamma = \rho g$

   $\gamma_{water} = 9810\ N/m^3$

3. Define specific volume.

   Specific volume of a fluid is defined as the volume of fluid occupied by an unit wt or unit mass of a fluid.

   Specific volume v_s = volume/ wt ----- for liquids – $v_s = 1/\rho g$

   Specific volume v_s = volume/ mass ----- for gases - $v_s = 1/\rho$

4. Define dynamic viscosity.

   Viscosity is defined as the property of fluid which offers resistance to the movement of one layer of fluid over another adjacent layer of the fluid.

   μ – dynamic viscosity or viscosity or coefficient of viscosity ($N\text{-}s/m^2$)

   $1\ N\text{-}s/m^2 = 1\ Pa\text{-}s = 10$ Poise

5. Define Kinematic viscosity.

   It is defined as the ratio between the dynamic viscosity and density of fluid.

   $\nu = \mu/\rho$ (m^2/s)

   $1\ m^2/s = 10000$ Stokes (or) 1 stoke = $10^{-4}\ m^2/s$

6. Types of fluids.

   Ideal fluid, Real fluid, Newtonian fluid, Non-Newtonian fluid, Ideal Plastic fluid.

7. Define Compressibility.

   It is defined as the ratio of volumetric strain to compressive stress.

   Compressibility, β = (d Vol/ Vol) / dp (m^2/N)

8. Define Surface Tension.

Surface tension is defined as the tensile force acting on the surface of the liquid in contact with a gas or on the surface between two immiscible liquids such that the contact surface behaves like a membrane under tension. Unit = **(N/m)**

$\boldsymbol{\sigma_{water} = 0.0725}$ **N/m** $\boldsymbol{\sigma_{Mercury} = 0.52}$ **N/m**

9. Define Capillarity.

Capillarity is defined as a phenomenon of rise or fall of a liquid surface in a small tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid. The rise of liquid surface is known as capillary rise while the fall of liquid surface is known as capillary depression.

Capillary Rise or fall, $h = (4\sigma \cos\theta) / \rho g d$

$\theta = 0$ **for glass tube and water** $\theta = 130^{o}$ **for glass tube and mercury**

10. Define Vapour Pressure.

When vaporization takes place, the molecules start accumulating over the free liquid surface exerting pressure on the liquid surface. This pressure is known as Vapour pressure of the liquid.

11. Define Control Volume.

A control volume may be defined as an identified volume fixed in space. The boundaries around the control volume are referred to as control surfaces. An open system is also referred to as a control volume.

12. List the types of fluid flow.

- Steady and unsteady flow
- Uniform and non-uniform flow
- Laminar and Turbulent flow
- Compressible and incompressible flow
- Rotational and ir-rotational flow
- One, Two and Three dimensional flow

13. Define Steady and Unsteady flow.

Steady flow

Fluid flow is said to be steady if at any point in the flowing fluid various characteristics such as velocity, density, pressure,etc do not change with time.

$$\partial v/\partial t = 0 \qquad \partial p/\partial t = 0 \qquad \partial \rho/\partial t = 0$$

Unsteady flow

Fluid flow is said to be unsteady if at any point flowing fluid any one or all characteristics which describe the behaviour of the fluid in motion change with time.

$$\partial v/\partial t \neq 0 \qquad \partial p/\partial t \neq 0 \qquad \partial \rho/\partial t \neq 0$$

14. Define Uniform and Non-uniform flow.

Uniform flow

When the velocity of flow of fluid does not change both in direction and magnitude from point to point in the flowing fluid for any given instant of time, the flow is said to be uniform.

$$\partial v/\partial s = 0 \quad \partial p/\partial s = 0 \quad \partial \rho/\partial s = 0$$

Non-uniform flow

If the velocity of flow of fluid changes from point to point in the flowing fluid at any instant, the flow is said to be non-uniform flow.

$$\partial v/\partial s \neq 0 \quad \partial p/\partial s \neq 0 \quad \partial \rho/\partial s \neq 0$$

15. Mention about Laminar and Turbulent flow.

Laminar flow

A flow is said to be laminar if Reynolds number is less than 2000 for pipe flow. Laminar flow is possible only at low velocities and high viscous fluids. In laminar type of flow, fluid particles move in laminas or layers gliding smoothly over the adjacent layer.

Turbulent flow

In Turbulent flow, the flow is possible at both velocities and low viscous fluid. The flow is said to be turbulent if Reynolds number is greater than 4000 for pipe flow. In Turbulent type of flow fluid, particles move in a zig – zag manner.

16. Define Compressible and incompressible flow

Compressible flow

The compressible flow is a type of flow in which the density of the fluid changes from point to point i.e. the density is not constant for the fluid. It is expressed in kg/sec.

$\rho \neq$ constant

Incompressible flow

The incompressible flow is a type of flow in which the density is constant for the fluid flow. Liquids are generally incompressible. It is expressed in m^3/s.

$\rho =$ constant

17. Define Rotational and Ir-rotational flow.

Rotational flow

Rotational flow is a type of flow in which the fluid particles flow along stream lines and also rotate about their own axis.

Ir-rotational flow

If the fluid particles are flowing along stream lines and do not rotate about their own axis is called as ir-rotational flow

18. Define One, Two and Three dimensional flow.

One dimensional flow

The flow parameter such as velocity is a function of time and one space co- ordinate only. **$u = f(x)$, $v = 0$ & $w = 0$.**

Two dimensional flow

The velocity is a function of time and two rectangular space co-ordinates.

$u = f_1(x,y)$, $v = f_2(x,y)$ & $w = 0$.

Three dimensional flow

The velocity is a function of time and three mutually perpendicular co-ordinates.

$u = f_1(x,y,z)$, $v = f_2(x,y,z)$ & $w = f_3(x,y,z)$.

19. Write the Bernoulli's equation applied between two sections

$$P_1 / \rho g + v_1^2/2g + z_1 = P_2/ \rho g + v_2^2/2g + z_2$$

$p/\rho g$ = pressure head
$v^2/2g$ = kinetic head
Z = datum head

20. State the assumptions used in deriving Bernoulli's equation

- Flow is steady
- Flow is laminar;
- Flow is irrotational;
- Flow is incompressible;
- Fluid is ideal.

21. List the instruments works on the basis of Bernoulli's equation.

- Venturi meter
- Orifice meter
- Pitot tube.

22. Define Impulse Momentum Equation (or) Momentum Equation.

The total force acting on fluid is equal to rate of change of momentum. According to Newton's second law of motion, **$F = ma$**

$F\,dt = d(mv)$

UNIT – II

1. Mention the range of Reynold's number for laminar and turbulent flow in a pipe.
   If the Reynold,s number is less than 2000, the flow is laminar. But if the
   Reynold's number is greater than 4000, the flow is turbulent flow.

2. What does Haigen-Poiseulle equation refer to?
   The equation refers to the value of loss of head in a pipe of length 'L' due to
   viscosity in a laminar flow.

3. What is Hagen poiseuille's formula?

   $$(P_1-P_2) / \rho g = h_f$$

   (OR)

   $$h_f = 32\ \mu \bar{U} L / \rho g D^2$$

   The expression is known as Hagen poiseuille formula.

Where P_1-P_2 / ρg = Loss of pressure head, Ū= Average
μ = Coefficient of viscosity, D = Diameter of pipe,
L = Length of pipe

4. Give the expression for the coefficient of friction in viscous flow?
   Coefficient of friction between pipe and fluid in viscous flow **f =16/ Re**
   Where, f = Re = Reynolds number

5. What are the factors to be determined when viscous fluid flows through the circular pipe?
   The factors to be determined are:
   i. Velocity distribution across the section.
   ii. Ratio of maximum velocity to the average velocity.
   iii. Shear stress distribution.
   iv. Drop of pressure for a given length.

6. Define kinetic energy correction factor?

Kinetic energy factor is defined as the ratio of the kinetic energy of the flow per sec based on actual velocity across a section to the kinetic energy of the flow per sec based on average velocity across the same section. It is denoted by (α).

K. E factor (α) = K.E per sec based on actual velocity / K.E per sec based on Average velocity

7. Define momentum correction factor (β):

It is defined as the ratio of momentum of the flow per sec based on actual velocity to the momentum of the flow per sec based on average velocity across the section.

β= Momentum per sec based on actual velocity/Momentum Per sec based on average velocity

8. Define Boundary layer.

When a real fluid flow passed a solid boundary, fluid layer is adhered to the solid boundary. Due to adhesion fluid undergoes retardation thereby developing a small region in the immediate vicinity of the boundary. This region is known as boundary layer.

9. What is mean by boundary layer growth?

At subsequent points downstream of the leading edge, the boundary layer region increases because the retarded fluid is further retarded. This is referred as growth of boundary layer.

10. Classification of boundary layer.

(i) Laminar boundary layer, (ii) Transition zone, (iii) Turbulent boundary layer.

11. Define Laminar boundary layer.

Near the leading edge of the surface of the plate the thickness of boundary layer is small and flow is laminar. This layer of fluid is said to be laminar boundary layer.

The length of the plate from the leading edge, upto which laminar boundary layer exists is called as laminar zone. In this zone the velocity profile is parabolic.

12. Define transition zone.

After laminar zone, the laminar boundary layer becomes unstable and the fluid motion transformed to turbulent boundary layer. This short length over which the changes taking place is called as transition zone.

13. Define Turbulent boundary.

Further downstream of transition zone, the boundary layer is turbulent and continuous to grow in thickness. This layer of boundary is called turbulent boundary layer.

14. Define Laminar sub Layer

In the turbulent boundary layer zone, adjacent to the solid surface of the plate the velocity variation is influenced by viscous effects. Due to very small thickness, the velocity distribution is almost linear. This region is known as laminar sub layer.

15. Define Boundary layer Thickness.

It is defined as the distance from the solid boundary measured in y-direction to the point, where the velocity of fluid is approximately equal to 0.99 times the free stream velocity (U) of the fluid. It is denoted by δ.

16. List the various types of boundary layer thickness.
Displacement thickness(δ*), Momentum thickness(θ), Energy thickness(δ**)

17. Define displacement thickness.
The displacement thickness (δ) is defined as the distance by which the boundary should be displaced to compensate for the reduction in flow rate on account of boundary layer formation.

18. Define momentum thickness.
The momentum thickness (θ) is defined as the distance by which the boundary should be displaced to compensate for the reduction in momentum of the flowing fluid on account of boundary layer formation.

19. Define energy thickness
The energy thickness (δ**) is defined as the distance by which the boundary should be displaced to compensate for the reduction in kinetic energy of the flowing fluid on account of boundary layer formation.

20. What is meant by energy loss in a pipe?
When the fluid flows through a pipe, it looses some energy or head due to frictional resistance and other reasons. It is called energy loss. The losses are classified as; Major losses and Minor losses

21. Explain the major losses in a pipe.
The major energy losses in a pipe is mainly due to the frictional resistance caused by the shear force between the fluid particles and boundary walls of the pipe and also due to viscosity of the fluid.

22. Explain minor losses in a pipe.
The loss of energy or head due to change of velocity of the flowing fluid in magnitude or direction is called minor losses. It includes: sudden expansion of the pipe, sudden contraction of the pipe, bend in a pipe, pipe fittings and obstruction in the pipe, etc.

23. State Darcy-Weisbach equation **OR** What is the expression for head loss due to friction?

$$\mathbf{h_f = 4flv^2 / 2gd}$$

where, h_f = Head loss due to friction (m), L = Length of the pipe (m),
d = Diameter of the pipe (m), V = Velocity of flow (m/sec)
f = Coefficient of friction

24. 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.

25. Write the expression for loss of head due to sudden enlargement of the pipe.

$$h_{exp} = (V_1 - V_2)^2 / 2g$$

Where, h_{exp} = Loss of head due to sudden enlargement of pipe.
V_1 = Velocity of flow at pipe 1; V_2 = Velocity of flow at pipe 2.

26. Write the expression for loss of head due to sudden contraction.

$$h_{con} = 0.5\, V^2/2g$$

h_{con} = Loss of head due to sudden contraction. V = Velocity at outlet of pipe.

27. Write the expression for loss of head at the entrance of the pipe.

$$h_i = 0.5V^2/2g$$

h_i = Loss of head at entrance of pipe. V = Velocity of liquid at inlet of the pipe.

28. Write the expression for loss of head at exit of the pipe.

$$ho = V^2/2g$$

where, ho = Loss of head at exit of the pipe.
V = Velocity of liquid at inlet and outlet of the pipe.

29. Give an expression for loss of head due to an obstruction in pipe

Loss of head due to an obstruction = $V^2 / 2g \left(A / Cc (A-a) - 1 \right)^2$

Where, A = area of pipe, a = Max area of obstruction,
V = Velocity of liquid in pipe A-a = Area of flow of liquid at section 1-1

30. What is compound pipe or pipes in series?

When the pipes of different length and different diameters are connected end to end, then the pipes are called as compound pipes or pipes in series.

31. What is mean by parallel pipe and write the governing equations.

When the pipe divides into two or more branches and again join together downstream to form a single pipe then it is called as pipes in parallel. The governing equations are:

$$Q_1 = Q_2 + Q_3 \qquad h_{f1} = h_{f2}$$

32. Define equivalent pipe and write the equation to obtain equivalent pipe diameter.

The single pipe replacing the compound pipe with same diameter without change in discharge and head loss is known as equivalent pipe.

$$L = L_1 + L_2 + L_3$$

$$(L/d^5) = (L_1/d_1)^5 + (L_2/d_2)^5 + (L_3/d_3{}^5)$$

33. What is meant by Moody's chart and what are the uses of Moody's chart?

The basic chart plotted against Darcy-Weisbach friction factor against Reynold's Number (Re) for the variety of relative roughness and flow regimes. The relative roughness is the ratio of the mean height of roughness of the pipe and its diameter (ε/D).

Moody's diagram is accurate to about 15% for design calculations and used for a large number of applications. It can be used for non-circular conduits and also for open channels.

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

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

HGL = Sum of Pressure Head and Datum head

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.

TEL = Sum of Pressure Head, Datum head and Velocity head

UNIT III

1. Define dimensional analysis.

Dimensional analysis is a mathematical technique which makes use of the study of dimensions as an aid to solution of several engineering problems. It plays an important role in research work.

2. Write the uses of dimension analysis?

- It helps in testing the dimensional homogeneity of any equation of fluid motion.
- It helps in deriving equations expressed in terms of non-dimensional parameters.
- It helps in planning model tests and presenting experimental results in a systematic manner.

3. List the primary and derived quantities.

Primary or Fundamental quantities: The various physical quantities used to describe a given phenomenon can be described by a set of quantities which are independent of each other. These quantities are known as fundamental quantities or primary quantities. Mass (M), Length (L), Time (T) and Temperature (θ) are the fundamental quantities.

Secondary or Derived quantities: All other quantities such as area, volume, velocity, acceleration, energy, power, etc are termed as derived quantities or secondary quantities because they can be expressed by primary quantities.

4. Write the dimensions for the followings.

Dynamic viscosity (μ) – $ML^{-1}T^{-2}$, Force (F) - MLT^{-2},
Mass density (ρ) – ML^{-3}, Power (P) -$ML^{2}T^{-3}$

5. Define dimensional homogeneity.
An equation is said to be dimensionally homogeneous if the dimensions of the terms on its LHS are same as the dimensions of the terms on its RHS.

6. Mention the methods available for dimensional analysis.
Rayleigh method, Buckinghum π theorem

7. State Buckingham's π theorem.
It states that "if there are 'n' variables (both independent & dependent variables) in a physical phenomenon and if these variables contain 'm' functional dimensions and are related by a dimensionally homogeneous equation, then the variables are arranged into n-m dimensionless terms. Each term is called π term".

8. List the repeating variables used in Buckingham π theorem.
Geometrical Properties – l, d, H, h, etc,
Flow Properties – v, a, g, ω, Q, etc,
Fluid Properties – ρ, μ, γ, etc.

9. Define model and prototype.
The small scale replica of an actual structure or the machine is known as its Model, while the actual structure or machine is called as its Prototype. Mostly models are much smaller than the corresponding prototype.

10. Write the advantages of model analysis.
- Model test are quite economical and convenient.
- Alterations can be continued until most suitable design is obtained.
- Modification of prototype based on the model results.
- The information about the performance of prototype can be obtained in advance.

11. List the types of similarities or similitude used in model anlaysis.
Geometric similarities, Kinematic similarities, Dynamic similarities

12. Define geometric similarities
It exists between the model and prototype if the ratio of corresponding lengths, dimensions in the model and the prototype are equal. Such a ratio is known as "Scale Ratio".

13. Define kinematic similarities
It exists between the model and prototype if the paths of the homogeneous moving particles are geometrically similar and if the ratio of the flow properties is equal.

14. Define dynamic similarities
It exits between model and the prototype which are geometrically and kinematically similar and if the ratio of all forces acting on the model and prototype are equal.

15. Mention the various forces considered in fluid flow.
    - Inertia force
    - Viscous force
    - Gravity force
    - Pressure force
    - Surface Tension force
    - Elasticity force

16. Define model law or similarity law.

    The condition for existence of completely dynamic similarity between a model and its prototype are denoted by equation obtained from dimensionless numbers. The laws on which the models are designed for dynamic similarity are called Model laws or Laws of Similarity.

17. List the various model laws applied in model analysis.
    - Reynold's Model Law
    - Froude's Model Law
    - Euler's Model Law
    - Weber Model Law
    - Mach Model Law

18. State Reynold's model law

    For the flow, where in addition to inertia force the viscous force is the only other predominant force, the similarity of flow in the model and its prototype can be established, if the Renold's number is same for both the systems. This is known as Reynold's model law. $\mathbf{Re_{(p)} = Re_{(m)}}$

19. State Froude's model law

    When the forces of gravity can be considered to be the only predominant force which controls the motion in addition to the force of inertia, the dynamic similarities of the flow in any two such systems can be established, if the Froude number for both the system is the same. This is known as Froude Model Law. $\mathbf{Fr_{(p)} = Fr_{(m)}}$

20. State Euler's model law

    In a fluid system where supplied pressures are the controlling forces in addition to inertia forces and other forces are either entirely absent or in-significant the Euler's number for both the model and prototype which known as Euler Model Law.

21. State Weber's model law

    When surface tension effect predominates in addition to inertia force then the dynamic similarity is obtained by equating the Weber's number for both model and its prototype, which is called as Weber Model Law.

22. State Mach's model law

    If in any phenomenon only the forces resulting from elastic compression are significant in addition to inertia forces and all other forces may be neglected, then the dynamic similarity between model and its prototype may be achieved by equating the Mach's number for both the systems. This is known Mach Model Law.

23. Classify the hydraulic models.

    The hydraulic models are classified as:
    - Undistorted model

- Distorted model

24. Define undistorted model

An undistorted model is that which is geometrically similar to its prototype, i.e. the scale ratio for corresponding linear dimensions of the model and its prototype are same.

25. Define distorted model

Distorted models are those in which one or more terms of the model are not identical with their counterparts in the prototype.

26. Define Scale effect

An effect in fluid flow that results from changing the scale, but not the shape, of a body around which the flow passes.

27. List the advantages of distorted model.

- The results in steeper water surface slopes and magnification of wave heights in model can be obtained by providing true vertical structure with accuracy.
- The model size can be reduced to lower down the cast.
- Sufficient tractate force can be developed to produce bed movement with a small model.

28. Write the dimensions for the followings.

Quantities	Symbol	Unit	Dimension
Area	**A**	**m^2**	**L^2**
Volume	**V**	**m^3**	**L^3**
Angle	**A**	**Deg. Or Rad**	**$M^0L^0T^0$**
Velocity	**v**	**m/s**	**LT^{-1}**
Angular Velocity	**ω**	**Rad/s**	**T^{-1}**
Speed	**N**	**rpm**	**T^{-1}**
Acceleration	**a**	**m/s^2**	**LT^{-2}**
Gravitational Acceleration	**g**	**m/s^2**	**LT^{-2}**
Discharge	**Q**	**m^3/s**	**L^3T^{-1}**
Discharge per meter run	**q**	**m^2/s**	**L^2T^{-1}**
Mass Density	**ρ**	**Kg/m^3**	**ML^3**
Sp. Weight or Unit Weight	Υ	**N/m^3**	**$ML^{-2}T^{-2}$**
Dynamic Viscosity	**μ**	**$N\text{-}s/m^2$**	**$ML^{-1}T^{-1}$**
Kinematic viscosity	ν	**m^2/s**	**L^2T^{-1}**
Force or Weight	**F or W**	**N**	**MLT^{-2}**
Pressure or Pressure intensity	**p**	**N/m^2 or Pa**	**$ML^{-1}T^{-2}$**

Modulus of Elasticity	**E**	**N/m^2 or Pa**	**$ML^{-1}T^{-2}$**
Bulk Modulus	**K**	**N/m^2 or Pa**	**$ML^{-1}T^{-2}$**
Workdone or Energy	**W or E**	**N-m**	**ML^2T^{-2}**
Torque	**T**	**N-m**	**ML^2T^{-2}**
Power	**P**	**N-m/s or J/s or Watt**	**ML^2T^{-3}**

UNIT IV

1. Define the term negative slip in reciprocating pump.

The difference between theoretical discharge and actual discharge is called the slip of the pump. Slip = Qthe. - Qact , % of slip = (Qthe. - Qact) x 100 / Qthe.

Negative slip occurs when delivery pipe is short suction pipe is long and pump is running at high speed.

2. What are the advantages of multistage pump?

It is more efficient than having a single stage pump. The inlet pressure to the second stage is higher than the inlet pressure at the first stage, and so on. The pressure increases in steps, rather than all at once.

3. What is meant by multistage pump?

A pump in which the head is developed by multiple impellers operating in series.

4. Define cavitation. What are the effects of cavitation?

Cavitation is the formation of vapour cavities in a liquid – i.e. small liquid-cavitation-free zones ("bubbles" or "voids") – that are the consequence of cavitational forces acting upon the cavitational liquid. It usually occurs when a liquid is subjected to rapid changes of pressure that cause the formation of cavities where the pressure is relatively low. When subjected to higher pressure, the voids implode and can generate an intense shockwave.

5. Define specific speed of centrifugal pump.

The net suction specific speed is mainly used to see if there will be problems with cavitation during the pump's operation on the suction side. It is defined by centrifugal and axial pumps' inherent physical characteristics and operating point.

6. What are the function of foot valve in a centrifugal pump?

Foot valves are used to maintain hydraulic pressure to keep the water flow in accordance with the given settings or configurations. There are instances where the pressure can actually pop the valve out and cause major leakage; thus, it is important to use the right kind of material in the tubing to be able to support the force within the valve.

7. What is positive displacement pump?

Positive Displacement Pumps has an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pumps as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant given each cycle of operation.

8. What is and dynamic pump?

A centrifugal pump is a rotodynamic pump that uses a rotating impeller to increase the pressure and flow rate of a fluid. Centrifugal pumps are the most common type of pump used to move liquids through a piping system.

9. Give the necessary precautions to be taken against cavitation in centrifugal pumps

1. The pressure of the flowing liquid in any part of the hydraulic system should not be allowed to fall below its vapour pressure.
2. The special materials or coatings such as aluminium, bronze and stainless steel, which are cavitation resistant materials should be used.

10. What is priming?

Priming is a process of filling up water in the casing and suction pipe of a centrifugal pump for the removal of air before starting it.

11. Why priming is important in centrifugal pump?

If the pump is started with air in the casing and suction pipe, there will be only a negligible pressure difference across the impeller. This will not be sufficient to create enough vacuum to suck the water into the casing from the sump. Therefore priming is very important in centrifugal pumps. The pumps can be primed in several ways.

1. Manual Priming 2. Priming by vacuum 3. Self Priming

12. Define cavitation.

Cavitation is defined as the phenomenon of formation of vapour bubbles of a flowing liquid in a region where the pressure of the liquid falls below its vapour pressure and the sudden collapsing of these vapour bubbles in a region of higher pressure.

13. What are the effects of cavitation?

1. The metallic surfaces are damaged and cavities are formed on the surfaces.
2. Due to sudden collapse of vapour bubble, considerable noise and vibration are produced.
3. The efficiency of a turbine decreases.

14. What is a reciprocating pump?

If the mechanical energy is converted into hydraulic energy (or pressure energy) by sucking the liquid into a cylinder in which a piston is reciprocating (moving backwards and towards) which exerts the thrust on the liquid and increases its hydraulic energy, the pump is known as reciprocating pump.

15 How will you classify the reciprocating pumps?

According to the contact of water

(i) Single-acting pump – In this type the water is contact with one side of the piston.

(ii) Double acting pump – The water is contact with both sides of the piston.

16. Distinguish between centrifugal pump and reciprocating pump.

Centrifugal pumps	**Reciprocating Pumps**
1.The discharge is continuous and smooth	1.The discharging is fluctuating and pulsating
2.It can handle large quantity of liquid	2.handles small quantity of liquid
3.It is used for large discharge through small heads	It is meant for small discharge at high heads
4.Cost of centrifugal pump is less as compared to reciprocating pump.	4.Cost of reciprocating pump is approximately four times the centrifugal pump.
5.Runs at high speeds.	5.Runs at low speed.
6.Efficiency is high	6.Efficiency is low
7.Needs smaller area and cost of installation is less.	7.Needs large floor area and installation is cost is high
8.Low maintenance cost	8.High maintenance cost
9.It can be used for lifting highly viscous liquids	9.Used only for lifting pure water or less viscous fluids.

17. What are the different types of impellers?

The rotating part of a centrifugal pump is called impeller.

Types of Impellers

1. Shrouded or closed impellers
2. Semi-open impeller
3. Open impeller

18. What are the functions of casing?

1. To provide space for the water coming out of the impeller and to transfer it to the delivery pipe at constant velocity.
2. To maintain a uniform velocity of flow throughout casing.
3. To convert a larger portion of kinetic energy into pressure energy flowing through the casing.
4. To reduce the loss of head by maintaining a uniform velocity in the casing and impeller.
5. To increase the efficiency by eliminating the loss of head.

19. What is the difference between single stage and multi stage pumps?

Single stage centrifugal pump

This pump has one impeller mounted to the shaft and is usually a low lift pump.

Multi stage centrifugal pump

This pump has two or more impellers mounted to the same shaft and enclosed in the same casing.

UNIT V

1. What is draft tube? What are their uses?

In a Reaction turbine such as a Francis turbine or Kaplan turbine, a diffuser tube is installed at the exit of the runner, known as Draft Tube

The primary function of the **draft tube** is to reduce the velocity of the discharged water to minimize the loss of kinetic energy at the outlet.

2. Define specific speed of a turbine.

The *specific speed* value (radian/second) for a *turbine* is the *speed* of a geometrically similar *turbine* which would produce one unit of the *specific speed of a turbine* is given by the manufacturer (along with other ratings) and will always refer to the point of maximum efficiency.

3. Why draft tube is used in a reaction turbine?

In an Impulse turbine the available head is considerably high and there is no significant effect on the efficiency if the turbine is placed a couple of meters above the tailrace. But in the case of Reaction turbines, if the net head is low and if the turbine is installed above the tailrace, there can be appreciable loss in available pressure head

A draft tube at the end of the turbine increases the pressure of the exiting fluid at the expense of its velocity. This means that the turbine can reduce pressure to a higher extent without fear of back flow from tail race

4. What is meant by governing of turbines?

Steam turbine governing is the procedure of controlling the flow rate of steam into a steam turbine so as to maintain its speed of rotation as constant. The variation in load during the operation of a steam turbine can have a significant impact on its performance. In a practical situation the load frequently varies from the designed or economic load and thus there always exists a considerable deviation from the desired performance of the turbine

5. Write the equation for specific speed for pumps and also for turbine.

Pump

$$N_s = \frac{n\sqrt{Q}}{(gH)^{3/4}}$$

where:

N_s is specific speed (unitless)
n is pump rotational speed (radians per second)
Q is flowrate (m^3/s) at the point of best efficiency
H is total head (m) per stage at the point of best efficiency
g is acceleration due to gravity (m/s^2)

Turbine

$n_s = n\sqrt{P}/H^{5/4}$(dimensioned parameter), n= rpm [7]

where:

N= Wheel speed (rpm)

- P= Power (kW)
- H= Water head (m)

6. Classify turbines based on head.

Classification of Hydraulic turbines:

i) Based on type of energy at inlet to the turbine:

- **Impulse Turbine** : The energy is in the form of kinetic form. e.g: Pelton wheel, Turgo wheel.
- **Reaction Turbine** : The energy is in both Kinetic and Pressure form. e.g: Tubular, Bulb, Propellar, Francis turbine.

ii) Based on direction of flow of water through the runner:

- **Tangential flow :** water flows in a direction tangential to path of rotational, i.e. Perpendicular to both axial and radial directions.
- **Radial inward flow**
- **Radial outward flow** e.g : forneyron turbine.
- **Axial flow :** Water flows parallel to the axis of the turbine. e.g: Girard, Jonval, Kalpan turbine.
- **Mixed flow :** Water enters radially at outer periphery and leaves axially. e.g : Modern francis turbine.

iii) Based on the head under which turbine works:

- High head, impulse turbine. e.g : Pelton turbine.
- Medium head,reaction turbine. e.g : Francis turbine.
- Low head, reaction turbine. e.g : Kaplan turbine, propeller turbine.

iv) Based on the specific speed of the turbine:

- Low specific speed, impulse turbine. e.g : pelton wheel
- Medium specific speed, reaction turbine. e.g : francis wheel
- High specific speed, reaction turbine. e.g : Kaplan and Propeller turbine.

v) Based on the name of the originator:

- Impulse turbine - Pelton wheel, Girard, Banki turbine
- Reaction turbine - Forneyron, Jonval, Francis, Dubs, Deriaze, Thomson kalpan, Barker, Moody, Nagler, Bell.

7. What is a Turbine?

Turbine is defined as the hydraulic machine which convert hydraulic energy in to mechanical energy.

8. How will you classify turbines?

1. According to the type of energy at inlet: (a) Impulse turbine and (b) Reaction turbine.
2. According to the direction of flow through runner: (a) Tangential flow turbine (b) Radial flow turbine (c) Axial flow turbine (d) Mixed flow turbine.
3. According to the head at the inlet of turbine: (a) High head turbine, (b) Medium head turbine and (c) Low head turbine.
4. According to the specific speed of the turbine: (a) Low specific speed turbine, (b) Medium specific speed turbine and (c) High specific speed turbine.

9. Differentiate between reaction and impulse turbines. Give Examples.

At the inlet of a turbine if the energy available is kinetic energy and pressure energy then the turbine is said to be a reaction turbine whereas if the energy available at the inlet of the turbine is only kinetic energy then the turbine is impulse type.

Reaction turbine

Fourneyron, Thomson, Francis, Propeller, Kaplan

Impulse turbine

Pelton wheel, Jonval turbine, Turgo-impulse wheel, Givard turbine.

10. Differentiate between radial flow, tangential flow and axial flow turbines. Give examples.

Axial flow turbine	Tangential flow turbine	Radial flow turbine
The flows of water through the runner along the direction parallel to the axis of rotation of the turbine.	The loss of water along the tangent of the runner.	The water flows in the radial direction through the runner.
Example: Kaplan turbine, propeller turbine, Jonval turbine	*Example:* Pelton turbine	*Example:* Thomson turbine Givard radial flow turbine, Fourneyron turbine.

11. What are the ranges of specific speed of Pelton, Francis and Kaplan turbines?

Specific Seed	Type of Turbine
10 to 35	Pelton wheel with single jet
35 to 60	Pelton wheel with two or more jets
60 to 300	Francis turbine
300 to 1000	Kaplan or Propeller turbine

12. Define speed ratio, jet ratio and flow ratio.

Speed ratio

It is the ratio of tangential velocity of wheel at inlet to $\sqrt{2gH}$, where H is head on turbine.

$$\text{Speed ratio} = \frac{U_1}{\sqrt{2gH}}$$

Jet ratio

It is defined as the ratio of the pitch diameter (D) of the pelton wheel to the diameter of the jet (d)

$$m = \frac{D}{d} = 12 \text{ for most cases}$$

Flow ratio:

The ratio of the velocity of flow at inlet to the velocity.

$$\text{Flow ratio} = \frac{Vf_1}{\sqrt{2gH}}$$

13. Explain the term Hydraulic efficiency.

Hydraulic efficiency of the turbine is the ratio of the power developed by the runner (i.e. Water Horse Power, W.H.P) to the net power supplied by the water at the entrance to the turbine.

14. Explain the term Mechanical efficiency.

Mechanical efficiency of the turbine is the ratio of the power obtained from the shaft of the turbine (i.e. Shaft of Brake Hose Power S.H.P or B.H.P) to the power developed by the runner (i.e. W.H.P)

15. Explain the term Overall efficiency

Overall efficiency is defined as the ratio of power available at the shaft of the turbine to the power supplied by the water at the inlet of the turbine.

16. Explain the term Volumetric efficiency.

Volumetric efficiency is the ratio of the quantity of water actually striking the runner and the quantity of water supplied to the turbine.

17. What are the functions of surge tank?

1. To relieve the penstock from excessive pressure due to sudden closing of valve in the turbine and thus eliminates water hammer effect.
2. To store the rejected water, when the load is less.
3. To supply sudden requirement of water initially to the turbine when the load is increased.

18. Define the term "Governing of a turbine"

Governing of a turbine is defined as the operation by which the speed of the turbine is kept constant under all conditions of working. It is done by Oil Pressure Governor.

19. What are the ranges of Head (m) for Pelton, Francis and Kaplan turbine

Head (m)	Types of Turbine
300 or more	Pelton wheel (single jet)
200 to 300	Pelton wheel (multiple jet)
30 to 200	Francis turbine
Below 30	Kaplan or Propeller

20. Explain Unit speed, Unit Quantity and Unit Power of a turbine.

Unit Speed

It is defined as the speed of a turbine working under a unit head.

$$N_u = \frac{N}{\sqrt{H}}$$

Unit Quantity

It is defined as the discharge passing through a turbine, which is working under a unit head.

$$Q_u = \frac{Q}{\sqrt{H}}$$

Unit Power

It is defined as the power developed by a turbine working under a unit head.

$$\hat{P}_u = \frac{P}{H^{3/2}}$$

21. What is the basic difference between a Propeller turbines and Kaplan turbine?

A Propeller turbine is one in which the vanes are fixed to the hub and they are not adjustable. On the other hand if the vanes are adjustable, the turbine is known a Kaplan turbine.

22. What is a Surge tank? Name different types of Surge tanks.

Surge tanks are storage reservoirs fitted at some opening of a long penstock nearer to the turbine.

Types of surge tanks

1. Simple surge tank
2. Restricted office surge tank
3. Differential surge tank.

PART B & C

UNIT I

1. A drainage pipe is tapered in a section running with full of water. The pipe diameters at the inlet and exit are 1000 mm and 500 mm respectively. The water surface is 2 m above the centre of the inlet and exit is 3 m above the free surface of the water. The pressure at the exit is 250 mm of Hg vacuum. The friction loss between the inlet and exit of the pipe is 1/10 of the velocity head at the exit. Determine the discharge through the pipe.

2. A pipe of 300 mm diameter inclined at 30° to the horizontal is carrying gasoline (specific gravity =0.82). A Venturimeter is fitted in the pipe to find out the flow rate whose throat diameter is 150 mm. The throat is 1.2 m from the entrance along its length. The pressure gauges fitted to the Venturimeter read 140 kN/m2 and 80 kN/m2 respectively. Find out the coefficient of discharge of Venturimeter if the flow is 0.20 m3/s.

3. Explain the properties of a hydraulic fluid.

4. A 0.5 m shaft rotates in a sleeve under lubrication with viscosity 5 poise at 200 rpm. Calculate the power lost for a length of 100 mm if the thickness of the oil is 1 mm.

5. (i) Derive Bernoulli's theorem and state its limitations.
(ii) A horizontal Venturimeter with inlet diameter 200 mm and throat diameter 100 mm is employed to measure the flow of water. The reading of the differential manometer connected to the inlet is 180 mm of mercury. If Cd = 0.98, determine the rate of flow.

6. Derive continuity equation from basic principles.

7. Derive Euler's equation of motion for flow along a stream line. What are the assumptions involved.

8. A horizontal pipe carrying water is gradually tapering. At one section the diameter is 150 mm and flow velocity is 1.5 m/s. If the drop in pressure is 1.104 bar at a reduced section, determine the diameter of that section. If the drop is 5 kN/m2, what will be the diameter — Neglect losses?

9. State Bernoulli theorem for steady flow of an incompressible fluid. Derive an expression for Bernoulli equation and state the assumptions made.

10. (i)A 15 cm diameter vertical pipe is connected to 10 cm diameter Vertical pipe with a reducing socket. The pipe carries a flow of 100 1/s. At point 1 in 15 cm pipe gauge pressure is 250 KPa. At point 2 in the 10 cm pipe located 1.0 m below point 1 the gauge pressure is 175 KPa.
(1) Find whether the flow is upwards / downwards.

(2) Head loss between the two points
(ii) Differentiate Venturimeter and Orificemeter.

11. A pipe 300m long has a slope of 1 in100 and tapers from 1m diameter at the high end to 0.5m at the low end. The quantity of water flowing is 5400 m^3/min. If the pressure at the high end is 49033 N/m², find the pressure at the low end. What is the change in pressure if the head loss between the two sections is 0.45m of water?

12. 250 litres/sec of water is flowing in a pipe having a diameter of 300mm. If the pipe is bent by 135° (that is change from initial to final direction is 135°), find the magnitude and direction of the resultant force on the bend. The pressure of water flowing is 39.24N/cm².

13. The diameter of a pipe gradually reduces from 1m to 0.7m. The pressure intensity at centre line of 1m section 7.848kN/m² and the rate of flow of water through the pipe is 600 liters/sec. Find the intensity of pressure at the centre line of 0.7m section. Also determine the force exerted by flowing water on transition of the pipe.

14.a) State the momentum equation. How will you apply momentum equation for determining the force exerted by a flowing fluid on a pipe bend?
b) Define Moment of Momentum equation. Where this equation is used?

UNIT II

1. The velocity distribution in the boundary layer is given by **u/U =y/δ**, where u is the velocity at a distance y from the plate u=U at y =δ, δ being boundary layer thickness. Find the displacement thickness, momentum thickness and energy thickness.

2. Derive an expression for head loss through pipes due to friction.

3. Explain the losses of energy in flow through pipes.

4. Determine the equivalent pipe corresponding to 3 pipes in series with lengths and diametersL1,L2,L3,d1,d2,d3 respectively.

5. The rate of flow of water through a horizontal pipe is 0.25 m3/sec.The diameter of the pipe which is 20 cm is suddenly enlarged to 40 cm. The pressure intensity in the smaller pipe is 11.772 N/cm2. Determine:

Loss of head due to sudden enlargement,
Pressure intensity in larger pipe,
Power loss due to enlargement.

6. An oil of sp.gravity 0.7 is flowing through a pipe of diameter 30 cm at the rate of 500 litres/sec. Find the head lost due to friction and power required to maintain the flow for a length of 1000 m. Take υ= 0.29 stokes.

7. For a town water supply, a main pipe line of diameter 0.4 m is required. As pipes more than 0.35m diameter are not readily available, two parallel pipes of same diameter are used for water supply. If the total discharge in the parallel pipe is same as in the single main pipe, find the diameter of parallel pipe. Coefficient of discharge to be the same for all the pipes.

8. A pipe line 10km, long delivers a power of 50 kW at its outlet ends. The pressure at inlet is 500 kN/m2 and pressure drop per km of pipeline is 50 kN/m. Find the size of the pipe and efficiency of transmission. Take 4f= 0.02.

9. The velocity of water in a pipe 200mm diameter is 5m/s. The length of the pipe is 50m. Find the loss of head due to friction, if f= 0.08.

10.A power transmission pipe 10 cm diameter and 500 m long is fitted with a nozzle at the exit, the inlet is from a river with water level 60 m above the discharge nozzle. Assume f = 0.02, calculate the maximum power which can be transmitted and the diameter of nozzle required

11. Determine the length of an equivalent pipe of diameter 20cm and friction factor is 0.02 for a given pipe system discharging 0.1 m^3/sec. The pipe system consists of the following. i)10m line of 20cm diameter with friction factor 0.03, ii) three 90° bend with k=0.5 for each, iii) two sudden expansion of diameter 20cm to 30cm , iv) a 15cm line of 30cm diameter with friction factor is 0.025 and v) global valve fully open with k=10.

UNIT III

1. What are the criteria for selecting repeating variable in this dimensional analysis?

2. The resisting force(R) of a supersonic flight can be considered as dependent upon the length of the air craft 'l', velocity 'v' , air viscosity 'μ', air density 'ρ' and bulk modulus of air is'k'. Express the functional relationship between these variables and the resisting force.

3. Using Buckingham's π theorem, show that velocity, through a circular pipe orifice is given by *H- head* causing flow; *D-dia* of orifice μ = Coefficient of viscosity ρ = mass density; g = acceleration due to gravity.

4. The efficiency (η of a fan depends on ρ (density), μ (viscosity) of the fluid, W (angular velocity), d (diameter of rotor) and Q (discharge). .Express η in terms of non-dimensional parameters. Use Buckingham's π theorem.

5. Using Buckingham's π- theorem, show that the velocity through a circular orifice in a pipe is given by **$v = \sqrt{(2gH)}\ f\ \{d/H\ ,\ \mu/\rho vH\}$** where v is the velocity through orifice of diameter d and H is the head causing the flow and ρ and μ are the density and dynamic viscosity of the fluid passing through the orifice and g is acceleration due to gravity.

6. Classify Models with scale ratios.

7. Write short notes on the following:

(i) Dimensionless Homogenity with example.
(ii) Euler Model Law.
(iii) Similitude.
(iv) Undistorted and Distorted Models.

8. Explain Reynold's law of similitude and Froude's law of similitude.

9. The efficiency (η of a fan depends on ρ (density), μ (viscosity) of the fluid, W (angular velocity), d (diameter of rotor) and Q (discharge). Express η in terms of non-dimensional parameters. Use Buckingham's π theorem.

10. **(i)** Explain Reynold's law of similitude and Froude's law of similitude.
(ii) Explain different types of similarities.

11. The pressure difference ΔP in a pipe of diameter D and length L due to turbulence flow depends on the velocity V, viscosity μ, density ρ and roughness K. Using Buckingham's π theorem, obtain an expression for ΔP. (16 Marks)

12. The discharge Q through an oil ring depends on the diameter D of oil ring, speed N rpm, mass density ρ of oil, absolute viscosity μ of oil, surface tension σ and specific weight w of oil. Show that $Q = ND^3 f [\mu / \rho ND^2 , \sigma / \rho N^2D^3 , w / \rho N^2D]$ (16 Marks)

UNIT IV

1. Show that the work done by a reciprocating pump is equal to the area of the indicator diagram.

2. Classify pumps. Explain the working of a double acting reciprocating pump with a neat diagram.

3. Explain the working principle of reciprocating pump with neat sketch.

4. Define cavitation and discuss its causes, effects and prevention

5. Calculate the work saved by fitting an air vessel for a double acting single cylinder reciprocation pump.

6. The diameter and stroke of a single acting reciprocating pump are 120 mm and 300 mm respectively. The water is lifted by a pump through a total head of 25 m. The diameter and length of delivery pipe are 100 mm and 20 rn respectively. Find out:
(i) Theoretical discharge and theoretical; power required to run the pump if its speed is 60rpm
(ii) Percentage slip, if the actual discharge is 2.35 1/s and
(iii) The acceleration head at the beginning and middle of the delivery stroke.

7. Determine the maximum operating speed in rpm and the maximum capacity in lps of a single-acting reciprocating pump with the following details. Plunger diameter = 25 cm, stroke = 50 cm, suction pipe diameter = 15 cm, length = 9 cm, delivery pipe diameter = 10 cm, length = 36 cm, static suction head = 3 m, static delivery head = 20 m, atmospheric

pressure - 76 cm of mercury, vapour pressure of w A double acting pump with 35cm bore and 40cm stroke runs at 60 strokes per minute. The suction pipe is 10 m long and delivery pipe is 200m long. The diameter of the delivery pipe is 15cm.The pump is situated at a height of 2.5 m above the sump, the outlet of the delivery pipe is 70 m above the pump. Calculate the diameter of the suction pipe for the condition that separation is avoided. Assume separation to occur at an absolute pressure head is 2.5m of water. Find the Horsepower required to drive the pump neglecting all losses other than friction in the pipes assuming friction factor as 0.02.

8. A single acting reciprocating pump running at 50 rpm, delivers 0.01 m3/s of water. The diameter of the piston is 200 mm and stroke length 400 mm. Determine the theoretical discharge of the pump, coefficient of discharge and slip and the percentage slip of the pump.

9. Explain the working of the working of following pumps with the help of neat sketches and mention two, applications of each.
(i) External gear pump (ii) Lobe pump
(iii) Vane pump (iv) Screw pump.

10. Explain the working principle of Gear pump with neat sketch.

11. The length and diameter of a suction pipe of a single acting reciprocating pump are 5m and 10cm respectively. The pump has a plunger of diameter 150mm and stroke of length of 300mm. The centre of the pump is 4m above water surface in the pump. The atmospheric pressure head is 10.3m of water and pump is running at 40rpm.

12. Two geometrical similar pumps are running at the speed of 750rpm. One pump has an impeller diameter of 0.25m and lifts the water at the rate of 30 lit/sec against a head of 20m. Determine the head and impeller diameter of the other pump to deliver half the discharge.

13. i) What is reciprocating pump? Describe the principle and working of a double acting reciprocating pump with a neat sketch.
ii) Define slip, percentage slip and negative slip of a reciprocating pump.

14. A double acting reciprocating pump running at 60rpm is discharging $1.5m^3$ of water per minute. The pump has a stroke length of 400mm. The diameter of the piston is 250mm. The delivery and suction heads are 20m and 5m respectively. Find the power required to drive the pump and the slip of the pump.

15. A double acting reciprocating pump has a bore of 15cm diameter and stroke 30cm long. The piston rod diameter is 25mm. The crank rotation speed is 60rpm. The water is lifted to a height of 20m and the percentage of slip is -2 (negative value). Find the actual discharge of the pump and the power required to lift the water.

UNIT V

1. Give the comparison between impulse and reaction turbine.

2. Write a note on performance curves of turbine.

3. Write a short note on Governing of Turbines.

4. Derive an expression for the efficiency of a draft tube.

5. With the help of neat diagram explain the construction and working of a pelton wheel turbine.

6. Show that the overall efficiency of a hydraulic turbine is the product of volumetric, hydraulic and mechanical efficiencies.

7. Obtain an 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.

8. Explain with the help of a diagram, the essential features of a Kaplan Turbine.

9. A Francis turbine with an overall efficiency of 76% and hydraulic efficiency of 80% is required to produce 150 kW. It is working under a head of 8 m. The peripheral velocity is $\mathbf{0.25\sqrt{2gH}}$ **and** radial velocity of flow at inlet is $\mathbf{0.95\sqrt{2gH}}$**.** The wheel runs at 150 rpm. Assuming radial discharge, determine

(i) Flow velocity at outlet
(ii) The wheel angle at inlet
(iii) Diameter and width of the wheel at inlet.

10. In an inward radial flow turbine, water enters at an angle of 22° to the wheel tangent to the outer rim and leaves at 3 m/s. The flow velocity is constant through the runner. The inner and outer diameters are 300 mm and 600 mm respectively. The speed of the runner is 300 mm. The discharge through the runner is radial. Find the

(i) Inlet and outlet blade angles
(ii) Taking inlet width as 150 mm and neglecting the thickness of the blades, find the power developed by the turbine

11. As inward flow reaction turbine has external and internal diameters as 1m and 0.6m respectively. The hydraulic efficiency of the turbine is 90% when the head on the turbine is 36m. The velocity of flow at outlet is 2.5m/s and discharge at outlet is radial. If the vane angle at outlet is 15° and width of the wheel is 100mm at inlet and outlet, Determine i) the guide blade angle ii) speed of the turbine iii) vane angle of the runner at inlet iv) volume flow rate of turbine v) power developed.

12. A Pelton turbine is required to develop 9000kW when working under a head of 300m the impeller may rotate at 500rpm. Assuming a jet ratio of 10 and an overall efficiency of 85%. Calculate i) quantity of water required ii) diameter of wheel iii) Number of jets iv) Number and size. of bucket on the runner.