KONGUNADU COLLEGE OF ENGINEERING AND TECHNOLOGY

NAMAKKAL- TRICHY MAIN ROAD, THOTTIAM

DEPARTMENT OF MECHANICAL ENGINEERING

SEMESTER-III

QUESTION BANK

Subject Name : CE8394-FLUID MECHANICS AND MACHINERY

UNIT- I FLUID PROPERTIES AND FLOW CHARACTERISTICS

PART – A

1. Define fluids.
2. What are the properties of ideal fluid?
3. What are the properties of real fluid?
4. Define density and specific weight.
5. Define Specific volume and Specific Gravity.
6. Define Surface tension and Capillarity.
7. Define Viscosity and what is the effect due to temperature on liquid and gases. (Apr/May 2017)
8. Define kinematic viscosity.
9. Define Relative or Specific viscosity.
10. Define Compressibility.
11. Define Newton's law of Viscosity. (Nov/Dec 2012)
12. What is cohesion and adhesion in fluids?
13. State momentum of momentum equation?
14. What is momentum equation? (Nov/Dec 2012)
15. Why is it necessary in winter to use lighter oil for automobiles than in summer? To what property does the term lighter refer?
16. If the pressure on the fluid is increased from 75 bar to 140 bar, the volume of liquid decreases by 0.15%. Find the bulk modulus of elasticity of the liquid.
17. At a certain point in flowing caster oil, the shear stress is 2 N/m^2 and velocity gradient is 0.25/sec. The mass density of the oil is $800kg/m^3$. Find the kinematic viscosity of oil in stokes.
18. State Pascal's law.
19. Doesviscosityvarywith pressure and temperature?(Nov/Dec 2013, May/June 2016, Nov/Dec 2016)
20. State momentum of momentum equation?
21. What is momentum equation?
22. What is importance of kinematic viscocity?(Nov/Dec 2015)
23. Define incompressible fluid. (Nov/Dec 2015)

24. Calculate mass density and specific volume of 1 litre of liquid which weighs 7N. (Apr/May 2015)

25. What is the use of control volume (Apr/May 2015)

26. how does a rewood viscometer work ? (May/June 2016)

27. Calculate the capillary rise in a glass tube of 2.5 mm diameter, when immersed in (i)water, and (ii)mercury.Take surface tension σ = 0.0725 N/mfor water and σ = 0.52 N/m for a mercury in contact with air. The specific gravity of mercury is given as 13.6 and angle of contact 130^{o} (Nov/Dec 2016&Apr/May 2017)

28.Brief on consequences of pascal's law. (Nov/Dec 2017)

29.Diffrentiate between steady and unsteady flow.(Nov/Dec 2017)

PART – B

1. 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 m/s requires a force of 98.1 N to maintain the speed. Determine the dynamic viscosity of the oil and the kinematic viscosity of the oil in stokes if the specific gravity of the oil is 0.95.

2. A 400 mm diameter shaft is rotating at 200 r.p.m. in a bearing of length 120 mm. If the thickness of oil film is 1.5 mm and the dynamic viscosity of the oil is 0.7 N.s/m^2 determine: (i) Torque required to overcome friction in bearing (ii) Power utilised in overcoming viscous resistance. **(Nov/Dec 2016)**

3. A vertical cylinder of diameter 180 mm rotates concentrically inside another cylinder of diameter 181.2 mm. Both the cylinders are 300 mm high. The space between the cylinders is filled with a liquid. Determine the viscosity of the fluid if a torque of 20 Nm is required to rotate the inner cylinder at 120 r.p.m.

4. Find the surface tension in a soap bubble of 40 mm diameter when the inside pressure is 2.5 N/m^2 above atmospheric pressure.

5. Calculate the capillary rise in a glass tube of 4 mm diameter, when immersed in (i)water, and (ii)mercury.the temperature of the liquid is 20ºC and the values of the surface tension of water and mercury at 20ºC in contact with air are 0.073575 N/m respectively. The angle of contact for water is zero that for mercury 130^{o}. Take density of water at 20ºC as equal to 998 kg/m^3.

6. A pipe (1) 450 mm in diameter branches in to two pipes (2 and 3) of diameters 300 mm and 200 mm respectively. If the average velocity in 450 mm diameter pipe is 3m/s. Find (i) Discharge through 450 mm diameter pipe; (ii) Velocity in 200 mm diameter pipe if the average velocity in 300mm pipe is 2.5 m/s.

7. A 6m long pipe is inclined at an angle of 20^{o} with the horizontal. The smaller section of the pipe which is at lower level is of 100 mm dia and the larger section is of 300 mm dia. If the pipe is uniformly tapering and the velocity of the water at the smaller section is 1.8m/s. Determine the difference of pressures between two sections.

8. A 30 cm x 15 cm venturimeter is provided in a vertical pipe line carrying oil of specific gravity 0.9, the flow being upwards. The difference in elevation of the throat section and entrance section of the venturimeter is 30 cm. The differential U tube mercury manometer shows a gauge deflection of 25 cm. Calculate: (i) the discharge of oil. (ii) The pressure difference between the entrance section and the throat section. Take C_d=0.98 and specific gravity of mercury as 13.6.

9. A horizontal venturimeter with inlet and throat diameter 300 mm and 100 mm respectively is used to measure the flow of water. The pressure intensity at inlet is 130 kN/m^2 while the vacuum pressure head at throat is 350 mm of mercury. Assuming that 3% head lost between the inlet and throat. Find the value of coefficient of discharge for the venturimeter and also determine the rate of flow.

10. 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 and C_d = 0.6.

11. Derive Euler's equation of motion.

12. Determine the viscous drag torque and power absorbed on one surface of collar bearing of 0.2m ID and 0.3 m OD with a oil film thickness of 1mm and viscosity of 30 centi-poise if it rotates at 500 rpm **(Nov/Dec 2015)**

13. The water level in the tank is 20m above the ground. The hose is connected to the bottom of tank, and the nozzle is at the end of hose is pointed straight up. The tank is at sea level and the water surface is open to atmosphere. In the line leading from the tank to the nozzle is a pump, which increases the pressure of water. If the water jet rises to the height of 27m from the ground, determine the minimum pressure rise applied by the pump to the water line. **(Apr/May 2015)**

14. A hollow cylinder of 150mm OD with its weight equal to the buyont forces is to be kept floating vertically in the liquid with a surface tension of 0.45N/m^2. The contact angle is 60°. Determine the additional force required. **(Apr/May 2015)**

15. At a certain location, wind at a temperature of 30 °C is blowing steadily at 15 m/s .Determine the mechanical energy of air per unit mass and the power generation potential of a wind turbine with 40 m diameter blades at that location. Also determine the actual electric power generation assuming an overall efficiency of 35%. **(May/June 2016)**

16. In cold climates the water pipes may freeze and burst if proper precautions are not taken. In such an occurrence, the exposed part of a pipe on the ground ruptures, and water shoots up to 34 m. Estimate the gage pressure of water in pipe. State your assumptions and discuss if the actual pressure is more or less than the value you predicted. **(May/June 2016)**

17. Derive Reynolds transport theorem **(Nov/Dec 2016)**

18. Derive Bernoullis equation with basic assumptions **(Nov/Dec 2016&Apr/May 2017)**

19. (a) Calculate the dynamic viscosity of an oil which is used for lubrication between a square plate of size 0.8m x 0.8 m in an inclined plane with an angle of inclination 30° to the horizontal. The weight of the square plate is 300 N and it slides down the inclained plane with an uniform velocity of 0.3m/s. The thickness of the oil flim is 1.5mm(b)An oil of sp.gravity 0.8 is flowing through venturimeter having inlet dia 20cm and throtdia 10cm. The oil – mercury differential manometer shows a reading of 25cm. Calculate the discharge of oil through the horizontal venturimeter. Take C_d = 0.98 **(Apr/May 2017)**

20.A U tube manometer is used to measure 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 the water and mercury is in the left limb.Calculate the pressure of water in the mainline if the difference in level of mercury in the limbs is 10.5 cm and free surface of mercury is in level with centreof pipe.If the pressure of water in the pipe is reduced by (i) 10000N/m^2 and (ii) 12000 N/m^2. Find the new difference if level of mercury. **(Nov/Dec 2017)**

21. A conical bearing of Outer radius 0.5 m and inner radius 0.3 m runs on a conical support with a uniform clearance between surfaces. Oil with viscocity 33 centi poise is used. The support is rotated at 450 rpm. Determine the clearance if power required was 1400 W. **(May/June 2016)**

22.A hydraulic lift shaft of 450 mm diameter moves in a cylinder of 451 mm diameter with the length of engagement of 3m. The interface is filled with oil of kinematic viscocity of 2.5 x 10^{-4} m^2/s and the density of 900 kg/m^3. Determine the uniform velocity of movement of the shaft if the drag resistance was 320 N. **(May/ June 2016)**

23. Water flows at a rate of 200 lit/s upwards through a tapered vertical pipe . The diameter of bottom is 240 mm and the top is 200 mm length is 5m , the pressure at the bottom is 8 bar and pressure at the top is 7.3 bar. Determine the head loss through the pipe. Express as the function of exit velocity head. **(Nov/Dec 2015)**

24. In a vertical pipe carring water, pressure gauges inserted at points x and y where the pipe diameters are 0.2m and 0.1m respectively. The point y is 2.25m below x and when the flowrate down the pipe is 0.025m^3/s, the pressure at y is 15686 N/m^2 greater than that at x. Assuming the losses in the pipe between x and y can be expressed as (k . v^2/2g) where v is velocity at x find the value of k. If the gauge at x and y are replaced by tubes with water and connected to U-Tube containing mercury of relative density 13.6 Calculate the difference in the levels of two limbs of the U-tube. **(Nov/Dec 2017)**

UNIT- II FLOW THROUG CIRCULAR CONDUITS

PART – A

1. Mention the general characteristics of laminar flow.
2. What is Hagen poiseuille’s formula?(Nov/Dec 2012)
3. What are the factors influencing the frictional loss in pipe flow?
4. What is the expression for head loss due to friction in Darcy formula?
5. What do you understand by the terms a) major energy losses, b) minor energy losses
6. Give an expression for loss of head due to sudden enlargement of the pipe:
7. Give an expression for loss of head due to sudden contraction: (Apr/May 2015)
8. Give an expression for loss of head at the entrance of the pipe:
9. Define the terms a) Hydraulic gradient line [HGL], b) Total Energy line [TEL] (Nov/Dec 2015)
10. What is sypon ? Where it is used?
11. What are the basic educations to solve the problems in flow through branched pipes?
12. What is Dupuit’s equation or equivalent pipe equation?(Nov/Dec 2013&Apr/May 2017)
13. Define kinetic energy correction factor?
14. What is Hydraulic mean depth?
15. What do you understand by the transmission efficiency of a pipe?
16. Obtain a condition for maximum efficiency and prove that it is 66.7%?
17. Differentiate Laminar & Turbulent Flow
18. What do you meant by viscous flow?
19. State the Relationship between Shear stress and pressure gradient.
20. What is an equivalent pipe? State the assumptions made in finding the equivalent length of a compound pipe.(Apr/May 2015& Apr/May 2017)
21. Brief on Darcy’s weibach’s equation. (May/June 2016)
22. What is the condition for maximum power transimission w.r.t head available ? (May/June 2016)
23. Find the displacement thickness for the velocity distribution is given by $\frac{u}{U} = \left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$ (Nov/Dec 2016)
24. Draw the velocity distribution and shear stress distribution for the flow through circular pipes. (Nov/Dec 2016)
25. Define boundary layer. (Apr/May 2017)
26. State significance of Navier – stokes equation. (Nov/Dec 2017)
27. What is meant by roughness Reynolds number.(Nov/Dec 2017)

PART – B

1. Derive an expression for Darcy–Weisbach formula to determine the head loss due to friction. Give the expression for relation between friction factor 'f'and Reynolds's number 'Re'for laminar and turbulent flow.

2. A 30 cm diameter pipe of length 30 cm is connected in series to a 20 cm diameter pipe of length 20 cm to convey discharge. Find the equivalent length of pipe of diameter 25 cm, assuming that the Friction factor remains the same and the minor losses are negligible. **(Nov/Dec 2012)**

3. An oil of viscosity 9 poise and specific gravity 0.9 is flowing through a horizontal pipe of 60 mm diameter. If the pressure drop in 100 m length of the pipe is 1800 kN/m^2, determine . i. The rate of flow of oil. ii. The centre-line velocity, iii. The total frictional drag over 100 m length, iv. The power required to maintain the flow, v. The velocity gradient at the pipe wall, vi.The velocity and shear stress at 8 mm from the wall.

4. The velocity distribution in the boundary layer is given by $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$,δ being boundary layer thickness. Calculate the following: i.Displacement thickness, ii. Momentum thickness, and iii. Energy thickness.

5. The rate of flow of water through a horizontal pipe is 0.25 m^3/sec. The diameter of the pipe is suddenly enlarged from 200 mm to 400 mm. The pressure intensity in the smaller pipe is 11.772 N/cm^2. Determine (i) loss of head due to sudden enlargement (ii) pressure intensity in the large pipe and (iii) power lost due to enlargement.

6. Three pipes of diameters 300 mm, 200 mm and 400 mm and lengths 450 m, 255 m and 315 m respectively are connected in series. The difference in water surface levels in two tanks is 18 m. Determine the rate of flow of water if coefficients of friction are 0.0075, 0.0078 and 0.0072 respectively considering.

7. A piping system consists of three pipes arranged in series; the lengths of the pipes are 1200 m, 750 m, and 600 m and diameters 750 mm, 600 mm and 450 mm respectively. (1) Transform the system to an equivalent 450 mm diameter pipe and (2) Determine an equivalent diameter for the pipe 2550 m long.

8. For sudden expansion in a pipe flow, workout the optimum ratio between the diameter of the pipe before expansion and the diameter of the pipe after expansion, so that the pressure rise is maximum.

9. Water is supplied to the inhabitants of a college campus through a supply main. The following data is given:Distance of the reservoir from the campus = 3000 m, number of inhabitants = 4000, Consumption of water per day of each inhabitant = 180 litres. Loss of head due to friction = 18m, Co efficient of friction for the pipe, f=0.007; If half of the daily supply is to be pumped in 8 hrs, Find the size of the supply main.

10. The rate of flow of water through a horizontal pipe is 0.25 m^3/s. 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/cm^2. Determine the loss of head due to sudden enlargement and pressure intensity in the large pipe.

11. Two reservoirs whose water surface elevations differ by 12 m are connected by the following horizontal compound pipe system starting from the high level reservoir. Take L_1 = 200 m, D_1 = 0.2 m, $f_1 = 0.008$ and L_2 = 500 m, D_2 = 0.3 m, f_2 = 0.006. Considering all head losses and assuming that all changes of section are abrupt, compute the discharge through the system. Find the equivalent length of a 0.25 m diameter pipe if minor losses are neglected and friction factors are assumed to be the same. Sketch HGL and TEL.

12. Describe moody's chart.**(Apr/May 2015)**

13. Oil at 27° C (ρ=900 kg/m^3 and μ = 40 centi-poise) is flowing steadily in a 1.25 cm diameter, 40m long. During the flow, the pressure at inlet and exit of pipe is 8.25 bar and 0.97 bar. Determine the flow rate of oil through the pipe if pipe is (a) horizontal (b) inclined 20° upward (c) inclined 20° downward**(Apr/May 2015)**

14. A shell and tube heat exchanger with hundreds of tubes housed in a shell are commonly used in practice for a heat exchange between two fluids. Such a heat exchanger is used in a active solar hot water system transfers heat from a water antifreeze solution flowing through shell and the solar collector to fresh water flowing through the tubes at an average temperature of 60°C at a rate of 15 L/s. The heat exchanger contains 80 brass tubes 1 cm in inner diameter and 1.5 m in length. Disregarding inlet, exit and header losses, determine the pressure drop across a single tube and the pumping power required by the tubeside fluid of the heat exchanger. The density and dynamic viscosity of water at 60°C are ρ = 983.3 kg/m^3 and μ= 0.467 x 10^{-3} kg/ms, respectively. The roughness of brassing tube is 1.5 x 10^{-6} m. **(May/June 2016)**

15. Derive the Hagen poiseuille's formula for the flow through circular pipes**?(Nov/Dec 2016)**

16. (a) A fluid of viscosity 0.7Pa and Sp.gravity 1.3 is flowing through a pipe dia 120mm the Max shear stress at the pipe is 205.2 N/m^2 Determine the pressure gradient, Reynolds number and average velocity.

(b) A crude oil of kinematic viscosity 0.4 Strokes is flowing through a pipe of dia 300mm at the rateof 300 lit/s Find the head loss due to friction for a length of 50m of the pipe. Take the Co-efficient of friction as 0.06**(Apr/May 2017)**

17. For a flow of viscous fluid flowing through a circular pipe under laminar flow conditions show that the velocity distribution is a parabola and also show that the average velocity is half of the max velocity. **(Apr/May 2017)**

18. Water flowing through a 10cm diameter pipe enters a porous section of same diameter which allows a uniform radial velocity V_w through the wall surfaces for a distance of 2m (i) If the entrance average velocity V_1 = 12m/s Find the exit velocity V_2 If V_w= 15cm/s out of the pipe walls; V_w= 10cm/s into the pipe what value of $V_w$will make V_2 = 9m/s (ii) If the entrance average velocity V_1 is 18m/s find the exit velocity V_2 If V_w= 18cm/s out of the pipe walls; V_w=12cm/s into the pipe. What value of $V_w$will make V_2= 12m/s?**(Nov/Dec 2017)**

19.Two reservoirs are connected by a pipeline 600m long. For the first 300m, its diameter is 15cm that reduces suddenly to 7.5cm for the remaining portion. Water discharges into the side of the lower reservoir below the water surface. If the difference in the water level between the two reservoirs is 80m, estimate the discharge considering all losses. Assume C_c= 0.867 and 4f = 0.0268. Determine the viscous drag torque and power absorbed on one surface of collar bearing of 0.2m ID and 0.3 m OD with a oil film thickness of 1mm and viscosity of 30 centi-poise if it rotates at 500 rpm **(Nov/Dec 2015)**

20.An oil of specific gravity 0.80 and kinematic viscosity 15 x 10^{-6} m^2/s, flow in a smooth pipe of 12cm diameter at a rate of 150 litre/min. Determine whether the flow is laminar or turbulent. Also calculate the velocity at the center line and velocity at the radius of 4cm. What is the head loss for a length of 10m? what will be the entry length? Also determine the wall shear. **(Nov/Dec 2015)**

21. Three pipes of diameters 400 mm, 200 mm and 300 mm and lengths 400 m, 300 m and 200 m respectively are connected in series. The difference in water surface levels in two tanks is 16m. If the coefficients of friction of all the pipes are same and equal to 0.005, determine the discharge through the compound pipe neglecting first the minor losses and then including them. **(Nov/Dec 2016)**

22. Water at 15°C is to be discharged from reservoir at a rate of 20L/s using two horizontal cast iron pipes connected in series and a pump between them. The first pipe is 22 m long and has a 6 cm diameter, while the second pipe is 33 m long and has a 4 cm diameter. The water level in the reservoir is 30 m above the centerline of the pipe. The pipe entrance is sharp-edged, losses associated with the connection of pump is negligible. Determine the required pumping head and the minimum pumping power to maintain the indicated flow rate. The density and dynamic viscocity of water at 15°C are ρ= 999.1 kg/m^3 and μ= 1.138 x 10^{-3}kg/ms. The roughness of cast iron pipe is 0.00026 m. **(May/June 2016 & Nov/Dec 2017)**

UNIT III DIMENSIONAL ANALYSIS

PART – A

1. What are the types of fluid flow?
2. Name the different forces present in fluid flow
3. When in a fluid considered steady?
4. Give the Euler's equation of motion?(Nov/Dec 2012)
5. What are the assumptions made in deriving Bernouillie's equation? (Nov/Dec 2015)
6. What is bernouillie's equation for real fluid?
7. State the application of Bernouillie's equation?
8. State the methods of dimensional analysis.
9. State Buckingham's Π theorem. (Nov/Dec 2012, Nov/Dec 2016)
10. State the limitations of dimensional analysis.
11. Define Similitude
12. State Froude's model law
13. What are the factors influencing the frictional lossin pipe flow?
14. What are the factors to the determined when viscous fluid flows through the circularpipe?
15. What are the advantages of dimensional and model analysis? (Apr/May 2015)
16. Define mach number and state it's application. (Nov/Dec 2015)
17. Write the similitude that exist between model and prototype (Apr/May 2017)
18. Define Froude's number.
19. What is Mach number? Mention its field of use.
20. Distinguish between a control and differential control volume.
21. Brief on Euler number. (May/June 2016)
22. What is meant by Kinematic Similarity ? (May/June 2016)
23. write the scale ratio for velocity, pressure intensity using Froude model law. (Nov/Dec 2016)
24. Write the expression for Mach number and state its application.(Apr/May 2017)
25. A piping system involves two pipes of different diameters (but of identical length, material and roughness) connected in parallel. How would you compare the flowrates and pressure drops in these two pipes.(Nov/Dec 2017)
26. The excess pressure Δp inside a bubble is known to be a function of the surface tension and radius. By dimensional reasoning determine how the excess pressure will vary if we double the surface tension and radius. (Nov/Dec 2017)

PART - B

1. The resistance R experienced by a partially submerged body depends upon the velocity V, length of the body l, viscosity of the fluid μ, density of the fluid ρ and gravitational acceleration g, obtain a dimensionless expression for R.

2. Using Buckingham's π theorem, show that the velocity through a circular orifice is given by $V = \sqrt{2gH}\emptyset\left[\frac{D}{H}, \frac{\mu}{\rho VH}\right]$. Where H=Head causing flow, D=Diameter of the orifice, μ=Co-efficient of viscosity, ρ=Mass density & g=Acc. due gravity. **(Apr/May 2017)**

3. The discharge Q of a centrifugal pump depends upon the mass density of fluid (ρ), the speed of the pump (N), the diameter of the impeller (D), the manometric head (H_m) and the viscosity of fluid (μ).Show that $Q = ND^3\emptyset\left(\frac{gH}{N^2D^2}, \frac{\mu}{\rho ND^2}\right)$.

4. A pipe of diameter 1.m is required to transport an oil specific gravity 0.9 and viscosity 3 x 10^{-2} poise at the rate of 3000 liters/s. Tests were conducted on a 15 cm diameter pipe using water at 20°C. Find the velocity and the rate of flow in the model. Viscosity of water at 20°C is 0.01 poise.

5. A model of submarine is scaled down to 1/20 of the prototype and is to be tested in a wind tunnel where free stream pressure is 2 MPa and absolute temperature is 50°C. The speed of the prototype is 7.72 m/s. Determine the free stream velocity of air and the ratio of the drags between model and prototype. Assume kinematic viscosity of sea water as 1.4 x 10^{-6} m^2/s and viscosity of air as 0.0184 cP.

6. A ship model of scale 1/50 is towed through sea water at a speed of 1 m/s. A force of 2 N is required to tow the model. Determine the speed of the ship and the propulsive force on the ship, if prototype is subjected to wave resistance only.

7. In an airplane model size 1/10 of its prototype the pressure drop is 7.5 kN/m^2. The model is tested in water. Find the corresponding pressure drop in the prototype. Take density of air is 1.24 kg/m^3, density of water is 1000 kg/m^3, Viscosity of air is 0.00018 poise and viscosity of water is 0.01 poise. **(Nov/Dec 2016)**

8. Using Buckingham's π theorem, show that the drag F_D of a supersonic aircraft is given by: $F_D = \rho L^2 V^2 \phi(Re, M)$. Where, $Re = \rho VL/\mu$ = Reynolds number, $M = V/c$ = Mach number, ρ = fluid density, c = sonic velocity = $\sqrt{K/\rho}$, V = velocity of aircraft, K = bulk modulus of fluid, L = chord length, L^2 = wing area = chord x span, ρ = a functional notation.

9. 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.

10. Check the following equations are dimensionally homogeneous

(i) Drag force = $Cd\ \frac{1}{2}\rho U^2 A$

(ii) F= $\frac{\gamma Q(U_1 - U_2)}{g} - (P_1A_1 - P_2A_2)$

(iii) Total energy per unit mass = $V^2/2 + gz + p/\rho$

11. Consider force F acting on the propeller of an aircraft, which depends upon the variable U, ρ, μ, D and N. Derive the non–dimensional functional form $F/(\rho U^2 D^2) = f((UD\rho/\mu),(ND/U))$.

12. An object of diameter 900 mm is to move in air at 60 m/s. Its drag is to be estimated from tests on a half scale model in water. The drag on the model is 1140 N. Estimate the speed of the model and drag on the full scale object. Given, ρ_{air} = 1.2 kg/m^3, μ_{air} = 1.86 × 10^{-5} Ns/m^2, μ_{water} = 1.01×10^{-3} Ns/m^2, ρ_{water} = 1000 kg/m^3

13. A model of a hydro electric power station tail race is proposed to built by selecting vertical scale 1 in 50 and horizontal scale 1 in 100. If the design pipe has flow rate of 600 m^3/s and the allowable discharge of 800 m^3/s. Calculate the corresponding flow rates for the model testing. **(Nov/Dec 2015)**

14. The power developed by hydraulic machines is found to depend on head H, flow rate Q, density ρ, speed N, runner diameter D, and acceleration due to gravity G. obtain suitable dimensionless parameters to correlate experimental results. **(Apr/May 2015)**

15. Obtain a relation using dimensional analysis for the resistance to uniform motion of a partial submerged body in a viscous compressible fluid. **(Apr/May 2015)**

16. The temperature difference θ at location x at time τ in a slab of thickness L originally at a temperature difference θ_o with outside is found to depend on the thermal diffusivity α, thermal conductivity k and convection coefficient h. using dimensional analysis, determine dimensionless parameter that will correlate the phenomenon. **(May/June 2016)**

17. Convective heat transfer coefficient in free convection over a surface is found to be influenced by the density, viscosity, thermal conductivity, coefficient of cubical expansion, temperature difference, gravitational acceleration, specific heat, the height of surface and flow velocity. Using dimensional analysis, determine the dimensionless parameters that will correlate the phenomenon. **(May/June 2016)**

18. Define similitude and its types. **(Nov/Dec 2016)**

19. Derive the five diffrent types of dimension less number. **(Nov/Dec 2016)**

20. Vortex shedding at the rear of the structure of a given section can create harmfull periodic vibration. To predict the shedding frequency a smaller model is to be tested in a water tunnel. The air speed is expected to be 90kmph. If the geometric scale is 1:6.8 and the water temperature is 28^{o}Cdetermine the speed to be used in the tunnel Consider the air temperature as 40^{o}C If the shedding frequency of model was 60 Hz determine the shedding frequency of proptotype, the dimensions of the structure are dia 0.2m and height 0.4m **(Nov/Dec 2017)**

21. Consider flow over a very small object in a viscous fluid. Analysis of the equation of motion shows that the inertial terms are much smaller than the viscous and pressure terms. It turns out, the the fluid density drops out of the equation of the motion. The only important parameter of the problem are velocity of motion U, Viscosity of the fluid μ and length scale of the body, using the Buckingham pi theorem generate an expression for two dimensional drag $D_{2\text{-}D}$as a function of other parameter of the problem. Use cylinder diameter d as the appropriate length scale. Repeat the dimensional analysis with ρ included as a parameter. Find the non-dimensional relationship between parameters in the problem. **(Nov/Dec 2017)**

22. Model of an air duct operating with water produces a pressure drop of 10 kN/m^2 over 10 m length. If the scale ratio is 1/50. Density of water is 1000 kg/m^3 and density of air is 1.2 kg/m^3. Viscosity of water is 0.001 Ns/m^2 and viscosity of air is 0.00002 Ns/m^2. Estimate corresponding drop in a 20 m long air duct. **(Nov/Dec 2015)**

23. It is desired to obtain the dynamic similarity between a 30 cm diameter pipe carrying linseed oil at 0.5 m^3/s and a 5 m diameter pipe carrying water. What should be the rate of flow of water in lps? If the pressure loss in the model is 196 N/m^2, what is the pressure loss in the prototype pipe? Kinematic viscosities of linseed oil and water are 0.457 and 0.0113 stokes respectively. Specific gravity of linseed oil = 0.82.

24. A 1:100 model is used for model testing of ship. The model is tested in wind tunnel the length of the ship is 400m the velocity of the wind tunnel around the model is 25 m/s and the resistence is 55 N Determine the length of the model. Also find the velocity of the ship as well as resistance developed. Take density of air and sea water as 1.24 kg/m^3 and 1030 kg/m^3. The kinematic viscosity of air and sea water are 0.018 stokes and 0.012 stokes respectively **(Apr/May 2017)**

25. The pressure difference ΔP in a pipe of diameter D and length l due to turbulent flow depends on the velocity V, viscosity μ, density ρ and roughness K. By using dimensional analysis, obtain an expression for the pressure difference ΔP .**(Nov/Dec 2016)**

UNIT- IV PUMPS

PART – A

1. What is meant by Pump?
2. What is Euler equation of motion? How will you obtain Bernoulli's equation from it?
3. Mention main components of Centrifugal pump.(Nov/Dec 2012)
4. What is the slip in reciprocating pump?
5. What is meant by Priming? (Nov/Dec 2016)
6. What are the main parts of reciprocating pump?(Nov/Dec 2012)
7. How will you classify the reciprocating pump?
8. Define Mechanical efficiency.
9. Define overall efficiency.
10. Define speed ratio, flow ratio.
11. Mention main components of Reciprocating pump.
12. Define Slip of reciprocating pump. When the negative slip does occur?
13. Why negative slip occurs in reciprocating pump? (May/June 2016)
14. What is indicator diagram?
15. What is meant by Cavitation? What will be its effects?(Apr/May 2017)
16. What are rotary pumps?
17. What is an air vessel? (Nov/Dec 2016)
18. What is the purpose of an air vessel fitted in the pump?(Apr/May 2017)
19. What is the relation between Work done of a Pump and Area of Indicator Diagram?
20. What is the work saved by fitting a air vessel in a single acting, double acting pump?
21. Define coefficient of discharge of reciprocating pump?
22. List the losses in centrifugal pump. (Nov/Dec 2015)
23. What is meant by NPSH? (Nov/Dec 2015&Nov/Dec 2017)
24. Definemanometric efficiency and Mechanical efficiency (Apr/May 2015)
25. What are the operating characteristic curves of centrifugal pump. (Apr/May 2015)
26. Why is forward curved blading rarely used in pumps ? (May/June 2016)
27. Draw the outlet velocity triangle for a forward curved centrifugal pump.(Nov/Dec 2017)

PART – B

1. Explain about working principle of centrifugal pump.

2. A centrifugal pump is to discharge $0.118m^3/s$ at a speed of 1450 rpm against a head of 25m. The impeller diameter is 250mm. Its width at outlet is 50mm and the manometric efficiency is 75%. Find the vane angle at outer periphery of the impeller.

3. A centrifugal pump is to discharge 0.12 m^3/sec at a speed of 1450 rpm against a head of 25m. The impeller diameter is 250mm, its width at outlet is 50mm and manometric efficiency is 75 percent. Find the vane angle at the outer periphery of the impeller.

4. Two geometrically similar pumps are running at the same speed of 1000rpm. One pump has an impeller diameter of 0.30m and lifts water at the rate of 20 litres per second against a head of 15m. Determine the head and impeller diameter of the other pump to deliver half the discharge.

5. The diameter and width of a centrifugal pump impeller are 300 mm and 60 mm respectively. The pump is delivering 144 litres of liquid per second with a manometric efficiency of 85 per cent. The effective outlet vane angle is 30°. If the speed of rotation is 950 rpm. Calculate the specific speed of the pump.

6. The centrifugal pump has the following characteristics. Outer diameter of impeller = 800 mm; width of the impeller vane at outlet = 100 mm. angle of the impeller vanes at outlet = 40º.The impeller runs at 550 rpm and delivers 0.98 m^3/s under an effective head of 35 m. A 500 kW motor is used to drive the pump. Find the manometric, mechanical and overall efficiencies of the pump. Assume water enters the impeller vanes radially at inlet.

7. The impeller of a centrifugal pump having external and internal diameters 500 mm and 250 mm respectively, width at outlet 50 mm and running at 1200 r.p.m. works against a head of 48 m. The velocity of flow through the impeller is constant and equal to 3.0 m/s. The vanes are set back at an angle of 40° at outlet. Find: (i) Inlet vane angle (i) Work done by the impeller on water per second (iii) Manometric efficiency. **(Apr/May 2017)**

8. Explain about working principle of Reciprocating pump. **(Nov/Dec 2013)**

9. Explain about rotary positive displacement pumps. **(Nov/Dec 2013)**

10. The diameter and stroke length of a single acting reciprocating pump are 150mm and 300mm respectively, the pump runs at 50rpm and lifts 4.2 lps of water through a height of 25m. The delivery pipe is 22m long and 100mm in diameter. Find (i) Theoretical power required to run the pump (ii) % of slip and (iii) Acceleration head at the beginning and middle of the delivery stroke **(Apr/May 2017)**

11. The diameter and length of a suction pipe of a single acting reciprocating pump are 10Cm and 5m respectively. The pump has a plunger diameter of 15cm and a stroke length of 35cm. The center of the pump is 3m above the water surface in the sump. The atm. Pressure head is 10.3m of water and the pump runs at 50rpm. Find (i) pressure head due to Acceleration at the beginning of the suction stroke. (ii) maximum pressure head due to Acceleration and (iii) pressure head in the cylinder at the beginning and end of the suction stroke.

12. Show from first principles that work saved in a single acting reciprocating pump, by fitting an air vessel is 84.8 percent.

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

14. What is Air vessel and write the expression for workdone by the reciprocating pump fitted with Air vessel.

Closed chamber containing compressed air in the top portion

15. A single acting reciprocating pump has a bore of 200 mm and a stroke of 350 mm and runs at 45 rpm. The suction head is 8 m and the delivery head is 20 m. Determine the theoretical discharge of water and power required. If slip is 10%, what is the actual flow rate?

16. A double acting reciprocating pump has a bore of 150 mm and stroke of 250 mm and runs at 35 rpm. The piston rod diameter is 20 mm. The suction head is 6.5 m and the delivery head is 14.5 m. The discharge of water was 4.7 l/s. Determine the slip and the power required.

17. In a single acting reciprocating pump with plunger diameter of 120 mm and stroke of 180 mm running at 60 rpm, an air vessel is fixed at the same level as the pump at a distance of 3 m. The diameter of the delivery pipe is 90 mm and the length is 25 m. Friction factor is 0.02. Determine the reduction in accelerating head and the friction head due to the fitting of air vessel.

18. In a reciprocating pump delivering water the bore is 14 cm and the stroke is 21 cm. The suction lift is 4 m and delivery head is 12 m. The suction and delivery pipe are both 10 cm diameter, length of pipes are 9 m suction and 24 m delivery. Friction factor is 0.015. Determine the theoretical power required. Slip is 8 percent. The pump speed is 36 rpm

19. Explain about performance characteristics of centrifugal pumps.**(Nov/Dec 2015)**

20. Discuss the working of lobe and vane pumps. **(Apr/May 2015)**

21. Discuss about air vessel used with reciprocating pump .Asingle acting reciprocating pump handles water. The bore and the stroke of the unit are 22 cm and 32 cm. The suction pipe diameter is 12 cm and the length is 10 m. The delivery pipe is 12 cm and the length is 30 m. Take frictional factor 0.02. The speed of operation is 32 rpm. Determine the frictional power with and without air vessel. **(May/June 2016)**

22. Derive the expression for pressure head due to acceleration in the suction and delivery pipes of reciprocating pumps. **(Nov/Dec 2016)**

23. Discuss the working of gear pump using its schematic. **(Apr/May 2017)**

24. A centrifugal pump running at 920 rpm and delivering 0.32 m^3/s of water against a head of 28 m , the flow velocity being 3m/s . If the manometric efficiency is 80% . Determine the diameter and width of impeller. The blade angle at outlet is 25º. **(Apr/May 2015)**

25. The internal and external dia of an impeller of a centrifugal pump which is running at 1200 rpm are 300 mm and 600 mm. The discharge through the pump is 0.05m^3/s and the velocity of flow is constant and equal to 2.5 m/s. the diameter of the suction and delivery pipes are 150 mm and 100 mm respectively and suction and delivery heads are 6 m and 30 m of water. If the outlet vane angle is 45° and power required to drive the pump is 17 kW. Determine 1. Vane angle of the impeller at inlet. 2. Overall efficiency of the pump. 3. Manometric efficiency of the pump. **(Nov/Dec 2016 & Nov/Dec 2017)**

26. The dimensionless specific speed of a centrifugal pump is .006. Static head is 32 m. Flow rate is 50l/s. The suction and delivery pipes are each of diameter 15cm. The friction factor is 0.002. Total length is 60 m. other losses equal 4 times the velocity head in the pipe. The vanes are forward curved at120º. The width is one tenth of diameter . There is a 7 % reduction in flow areadue to blade thickness . The manometric efficiency is 80%. Determine the impeller diameter if inlet is radial **(Nov/Dec 2015 & Nov/Dec 2017)**

27. An axial flow pump running at 620 rpm deliver 1.5m^3/s against a head of 5.2 m. The speed ratio is 2.5. The flow ratio is 0.5. The overall efficiency is 0.8. Determine the power required and the blade angles at the root and tip and the diffuser blade inlet angle. Inlet whirl is zero. **(May/June 2016)**

UNIT -V TURBINES

PART – A

1. Define hydraulic machines.
2. Give example for a low head, medium head and high head turbine.
3. What is impulse turbine? Give example. (Apr/May 2015)
4. What is reaction turbine? Give example. (Apr/May 2015)
5. What is axial flow turbine?
6. What is mixed flow turbine?
7. What is the function of spear and nozzle?
8. Define gross head and net or effective head.
9. Define hydraulic efficiency. (Nov/Dec 2012)
10. Define mechanical efficiency.
11. Define volumetric efficiency.(Nov/Dec 2015)
12. Define overall efficiency.
13. How will you classify the turbines?
14. Differentiate between the turbines and pumps.
15. Define specific speed of the turbine. (Apr/May 2015)
16. What are the functions of draft tube? List the most commonly used draft tubes.(Nov/Dec 2017)
17. State and concise on Euler turbine equation(Nov/Dec 2015)
18. Define plant efficiency of turbines.
19. Why does a Pelton wheel not possess any draft tube?
20. What are the different types of draft tubes?
21. List down the main components of pelton wheel. (May/June 2016)
22. Diffrentiate between Kaplan and propeller turbine. (May/June 2016)
23. Explain the type of flow in francis turbine. (Nov/Dec 2016)
24. What is draft tube? (Nov/Dec 2016)
25. How do you classify turbine based on flow direction and working medium. (Apr/May 2017)
26. What is meant by Governing of turbines? (Apr/May 2017)
27. Discuss the importance of Muschel curves. (Nov/Dec 2017)

PART -B

1. Derive an expression for maximum hydraulic efficiency in an impulse turbine. **(Nov/Dec 2013)**

2. Compare radial flow and axial flow turbo machines.

3. A Pelton wheel, working under a head of 500 m develops 13 MW when running at a speed of 430 rpm. If the efficiency of the wheel is 85%, determine the rate of flow through the turbine, the diameter of the wheel and the diameter of the nozzle. Take speed ratio as 0.46 and coefficient of velocity for the nozzle as 0.98.

4. A Pelton wheel works under a gross head of 510 m. One third of gross head is lost in friction in the penstock. The rate of flow through the nozzle is 2.2 m^3/sec. The angel of deflection of jet is 165°. Find the (i) power given by water to the runner (ii) hydraulic efficiency of Pelton wheel. Take CV = 1.0 and speed ratio = 0.45

5. A 137 mm diameter jet of water issuing from a nozzle impinges on the buckets of a Pelton wheel and the jet is deflected through an angle of 165° by the buckets. The head available at the nozzle is 400m. Find: (a) Force exerted on the buckets and (b) Power developed. Assume C_v as 0.97, speed ratio as 0.46 and reduction in velocity while passing through the buckets as 15%.

6. 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 (i) Quantity of water required, (ii) Diameter of the wheel, (iii) No of jets, (iv) No and size of the bucket vanes on the runner

7. A pelton wheel turbine develops 3000kW power under a head of 300m. The overall efficiency of the turbine is 83%. If the speed ratio = 0.46, Cv = 0.98 and specific speed is 16.5, then find diameter of the turbine and diameter of the jet.

8. A pelton wheel has a mean bucket speed of 10m/s with a jet of water flowing at the rate of 700 lps under a head of 30m. The buckets deflect the jet through an angle of 160deg. Calculate power given by the water to the runner and the hydraulic efficiency of the turbine. Assume coefficient of velocity as 0.98.

9. A reaction turbine works at 450 r.p.m. under a head of 120 m. Its diameter at inlet is 1.2 m and the flow area is 0.4 m^2. The angles made by absolute and relative velocities at inlet are 20° and 60° respectively with the tangential velocity. Determine: (i)the volume rate of flow, (ii) the power developed, and (iii) the hydraulic efficiency.

10. The velocity of whirl at inlet to the runner of an inward flow reaction turbine is 3.15 $\sqrt{H}$ m/s and the velocity of flow at inlet is 1.05 $\sqrt{H}$ m/s. The velocity of whirl at exit is 0.22 $\sqrt{H}$ m/s in the same direction as at inlet and the velocity of flow at exit is 0.83 $\sqrt{H}$ m/s, where H is head of water 30 m. The inner diameter of the runner is 0.6 times the outer diameter. Assuming hydraulic efficiency of 80%, compute angles of the runner vanes at inlet and exit.

11. A Kaplan turbine develops 24647.6kW power at an average head of 39m. Assuming the speed ratio of 2, flow ratio of 0.6, diameter of the boss equal to 0.35 times the diameter of the runner and an overall efficiency of 90%, calculate the diameter, speed and specific speed of the turbine.**(Nov/Dec 2015& Apr/May 2017)**

12. Discuss about draft tube and its types. Discuss about Kaplan turbine with a neat sketch.**(Apr/May 2015)**

13. Describe the efficiencies of the turbine. **(Nov/Dec 2016)**

14. Explain the working of Kaplan turbine. Construct its velocity triangle. **(Nov/Dec 2016)**

15. Explain the performance Characteristics curves of turbine. **(Apr/May 2017)**

16. Thefollowing data is given for francisturbine :Net head = 60 m, speed = 700 rpm, shaft power = 294.3 kW, η_o= 84%. η_h = 93 %, flow ratio = 0.2, breadth ratio = 0.1, outer diameter of the runner = 2 inner diameter of the runner. The thickness of vanes occupies 5% of the circumferential area of the runner. Velocity of flow is constant at inlet and outlet and discharge is radial outlet. Determine : 1. The guide blade angle, 2. Runner vane angle the inlet and outlet. 3. Diameter of the runner at inlet and outlet. 4. Width of the wheel at the inlet.

(Nov/Dec 2016&Apr/May 2017)

17. A Kaplan turbine delivering 40 MW work under a head of 40 m. And runs at a speed of 150 rpm,the hub diameter is 6m. The overall efficiency is 90%. Determine the blade angles of the hub and tip also at a dia of 4m. also find the speed ratio and flow ratio based on tip velocity. Assume hydraulic efficieny as 95% . **(May/June 2016)**

18. A Francis turbine developing 16120 kW under a head of 260m runs at 600rpm. The runner outside diameter is 1500mm, width 135mm, flow rate 7m^3/s. The exit velocity of draft tube outlet, whirl velocity is 0 at exit. Neglect blade thickness. Determine overall and hydraulic efficiency and rotor blade angle at inlet. Also find guide vane outlet angle. **(Apr/May 2015 & Nov/Dec 2017)**

19. At a location selected to install a hydro electric power plant, the head estimated as 540 ms.The flow rate was determined as 22 m^3/s. The plant is located at a distance of 2 km from the entry to the penstock pipes along the pipes. Two pipes of 2 m diameter are proposed with a frictional factor of 0.03. Additional loses amount to about 1/4th of frictional loss. Assuming an overall efficiency of 85%, determine how many single jet unit running at 330 rpm will be required. **(May/June 2016)**

20. A hub diameter of a Kaplan turbine, working under a head of 12m, is 0.35 times the diameter of the runner. The turbine is running at 100rpm. If the vane angle of the runner at outlet is 15deg. And flow ratio 0.6, find (i) diameter of the runner, (ii) diameter of the boss, and (iii) Discharge through the runner. Take the velocity of whirl at outlet as zero. **(Nov/Dec 2015 & Nov/Dec 2017)**