QUESTION SET 1

1. Two co-axial cylinder of radii 10 cm and 20 cm and length 30 cm have the space between them is filled with viscous fluid. It is observed that a force of 0.5 N is applied to the outer cylinder is sufficient to give the outer cylinder a rotational velocity of 2 rad/sec with the inner cylinder fixed. Determine the fluid viscosity.
2. A steel ($\rho=7850\ kg/m^3$) shaft 3 cm in diameter and 40 cm long falls of its own weight inside a vertical open tube 3.02 cm in diameter. The clearance assumed uniform is filled with oil of specific gravity 0.9. How fast will the cylinder fall at terminal conditions(Do not neglect buoyancy effect)
3. A pressure cooker has an initial volume of 5 liters. During a hydraulic test, water at 200 MPa is pumped inside the cooker vessel. It is estimated that the change in volume of the container will not exceed by 0.1%. Calculate the mass of the water to be pumped into the vessel. K for water is 2000 MPa.
4. There are two parallel plates at a distance of 0.6 mm and the gap is filled with oil of viscosity 1.5 Ns/m^2 . The upper plate is moving at 3 m/s to the right and the lower plate is moving at 3 m/s to the left. Find the shear stress on both plates if velocity varies linearly from one plate to other.
5. A globe of water of diameter 2 cm suddenly splits into 1000 equal globes under isothermal condition. Determine gain in surface energy. (surface tension for water=0.075 N/m)
6. A shaft 6.0 cm in diameter is being pushed axially through a bearing sleeve 6.02 cm in diameter and 40 cm long. The clearance assumed uniform is filled with oil whose properties are $\upsilon=0.003\ m^2/s$ and specific gravity 0.88. Estimate the force required to pull the shaft at steady velocity of 0.4 m/s.
7. A journal bearing consist of an 8.0 cm shaft in an 8.03 cm sleeve 10 cm long, the clearance space (assumed to be uniform) being filled with lubricating oil of viscosity 1.2 $N\text{-}s/m^2$. Calculate the rate at which heat is generated at the bearing when the shaft turns 120 rpm.
8. There are two parallel plates with a gap of 1 mm and it is filled with oil of viscosity 15 poise. Both the plates are moving at 3 m/s but in opposite direction. Find the

shear stress on both the plates if the velocity varies linearly from one plate to other.

9. A cylinder of 0.12 m radius rotates concentrically inside a fixed cylinder of 0.13 m radius. Both cylinders are 3 m long. Determine the viscosity of the liquid which fills the space between the cylinders if the torque of 0.08 kg-m is required to maintain an angular velocity of 2π rad/sec. Assume a linear velocity profile.
10. A block of base area 20 cm^2 and mass 10 kg moves over a horizontal plane with oil film of 1 mm thickness, μ is 0.05 Ns/m2. If the initial velocity of the block is 2 m/s. find the displacement of the block before coming to rest. How much time it would take for the velocity to reduce to 0.2 m/sec.
11. A vertical gap 25 mm wide of infinite extent contains oil of relative density 0.95 and viscosity 2.4 Pa-s. A metal plate 1.5 m × 1.6 m weighing 45 N is to be lifted through the gap at a constant speed of 0.06 m/s. Estimate the force required.
12. In a 5 cm long Journal bearing arrangement, the clearance between the shaft and the bearing is 0.1 mm. The shaft is 2 cm in diameter and rotates at 3000 rpm. The dynamic viscosity of the liquid used is 0.01 Ns/m^2. Considering the liquid to be Newtonian, estimate the frictional torque the journal has to over come and corresponding power loss. Derive the formula used
13. A small circular jet of mercury 0.1 mm in diameter issues from an opening. What is the pressure difference between inside and outside of the jet? Take surface tension of mercury = 0.15 N/m.
14. The velocity distribution of water in a 10 cm radius pipe is given by the expression $U = 20\left(1 - \frac{r^2}{100}\right)$ cm/s where r is in cm. Draw the velocity profile and obtain the shear stress profile over a cross-section. Calculate also drag per kilometer length of pipe. Take μ= 0.015 poise for water.
15. Calculate the gauge pressure and absolute pressure within

    (i) A droplet of water 0.4 cm in diameter

    (ii) A jet of water 0.4 cm in diameter.

    Assume surface tension of water as 0.073 N/m and atmospheric pressure as 101300 N/m3.

16. A flywheel weighing 600 N has a radius of gyration of 30 cm. When it is rotating at 600 rpm, its speed reduces by 1 rpm/sec., due to viscous friction. If the length of sleeve bearing is 5 cm, the shaft diameter 20 mm and the radial clearance between the shaft and the sleeve 0.05 mm, determine the fluid viscosity.
17. A block of base area 20 cm^2, weight 120 N slides down plane over an oil film thickness 1 mm. Coefficient of viscosity of oil 500 poise. Estimate the steady state velocity of the block.
18. What is the pressure with which you will need to blow to get soap bubbles of 3 cm diameter if the ambient pressure is 1.03 kg/cm^2 and the surface tension coefficient for the soap is 0.25 N/m. derive the expression used.
19. A circular plate of radius 50 mm and an angular ring of ID 20 mm and OD 70 mm, both of negligible thickness are dipped in oil and are rotated at the same angular speed. Which of the two will consume more power and by how much percentage.
20. A uniform film of oil 0.13 mm thick separates two discs, each of 200 mm diameters, mounted coaxially. Ignoring edge effects calculate the torque necessary to rotate one disc relative to the other at a speed of 7 rev/sec. If oil has viscosity 0.4 Ns/m^2.
21. A skater weighing 800 N, skates on ice at a speed of 36 km/hr. The average skating area supporting the skater is 8 cm^2, and the average thickness of water film separating the skater from the ice surface is 10^{-3} mm. assuming the viscosity of water at 00c to be 1.8×10^{-3} kgs/m^2, determine the dynamic coefficient of friction, resisting the motion of the skater.
22. A flywheel 60 kg mass and radius of gyration of 25 cm is mounted in the middle of the shaft 3 cm in diameter. The shaft is supporting by two bearings each 5 cm long. The clearance between shaft and bearing is 0.06 mm and is filled with oil of viscosity 0.02 Ns/m2. Estimate the angular retardation of the flywheel due to friction effects at a speed of ω rad/sec. what would be the time required to bring it to rest from a speed of 1000 rpm.
23. What force is needed to lift a thin wire ring 3 cm in diameter from a water surface assume surface tension for water as 0.07 N/m and angle of contact zero.

24. Calculate the maximum rise of water to be expected between two vertical clean glass plates spaced 1 mm apart. Take surface tension of water as 0.0735 N/m. derive the formula used.

25. A cubical box of mass 20 kg and having 20 cm edge is allowed to slide down on an inclined plane surface making an angle of 200 with the horizontal on which there is a thin film of oil having viscosity of 2.2×10^{-3} Ns/m^2. What will be the terminal velocity attained by the block if film thickness is estimated to be 0.025 mm.

26. A shaft of 8 cm diameter is being pushed through a bearing sleeve 8.02 cm in diameter and 30 cm long. The clearance, assumed uniform, is filled with oil of kinematic viscosity 0.005 m^2/s and specific gravity 0.9. If the shaft moves axially at 0.5 m/s, estimate the resistance force exerted by oil on shaft.

27. A gate of quarter circular cross-section of radius 3 m and length (perpendicular to the plane of paper) 5 m is held in position by horizontal force P as shown in figure. Estimate the value of P.

28. A spherical vessel is filled completely with water of weight W. Show that the resultant fluid force on each of the halves into which it is divided by a vertical diametrical plane is $\frac{W\sqrt{13}}{4}$. If the diametrical plane is horizontal show that the resultant fluid force on one half is 5 times on the other.

29. A horizontal cylindrical tank 2.5 m in diameter has hemispherical endsfastened to it by six bolts on each side. The tank is half filled with oil of specific gravity 0.8 and half with water. A pressure gauge at the top of the tank reads 1 kg/cm^2(g). Assuming that the bolts share the hydrostatic force uniformly calculate the stress in each bolt if they are 8 mm diameter.

30. A spherical vessel of radius R is filled completely with a liquid. Show that the total downward force on the bottom half is five times the total upward force on the top half.

31. A rectangular tank is divided into two compartments by a frictionless vertical plate of height 30 cm hinged at its top edge keeping close clearance with the bottom and two opposite sides of the tank.One compartment is filled with oil of specific

gravity 0.8. To what height the water must be filled in the other compartment to keep the plate in equilibrium? Use trial and error or Newton-Rapson Method to get the answer within 0.01 cm accuracy.

32. The gate shown in figure is hinged at its top edge A. On one side it is subjected to oil pressure upto the top edge. On the other side water. What must be the height of water accurate upto 0.01mm so that the gate is just in equilibrium? The gate is rectangular. The specific gravity of oil is 0.8.
33. A vertical dock gate is 5 m wide. There is water to the depth of 10m on one side and 4 m to the other side. Find the resultant horizontal force on the gate and position of its action.
34. The tank shown in figure is divided into two independent chambers. The oil chamber is exposed to the atmosphere. The mercury manometer is connected to the water chamber shows 15 cm deflection. A sphere of wood of sphefic gravity 0.8 is fastened to the wall compute-
    - (i) Buoyant force on the sphere
    - (ii) The force excerted by the separating wall on the sphere(magnitude and direction)
35. A tank completely full of water is 5 m square at the top, 3 m square at the bottom and 2 m deep. The four sides are planes, each having same trapezoidal shape.Find-
    - (i) The magnitude of resultant force on one side of the tank.
    - (ii) The location of centre of pressure
36. The outlet end of horizontal rectangular sewer is 1.3 m wide and 1 m deep. It is covered by a plain flap inclined at 400 to the horizontal and hinged at the horizontal upper edge of the sewer. The flap weights 2700 N. The line of action of the weight is 34 cm horizontally from the hinge. To what height must the water level in the sewer rise so as to just cause the flap to open.
37. The cylinder shown in figure is 2.5 m long and is hinged at O. what is the torque necessary to hold the gate in position.
38. Calculate the horizontal and vertical components of the hydrostatic force acting on the conical plug shown in the figure.

39. Find the magnitude and point of application of the force on the circular gate shown in the figure.
40. A gate in the side of a dam which opens automatically when the water level Z exceeds a certain value. The gate is pivoted at a distance above its base and extends a distance 5d above the pivot. Determine the ratio Z/d for the force P on the sluice is a maximum and the ratio Z/d for which the gate just opens.
41. A sluice gate consist of a quadrant of a circle of ardius 1.5 m pivoted at the centre O. Its C.G. is at G. as shown. Calculate the magnitude of the resultant force on the gate due to water and the turning moment required to open the gate. The width of the gate is 3 m and has a mass of 6000 kg.
42. A tank has a circular gate of diameter 3 m in one of its vertical side at the bottom. The gate is hinged at its top edge. If oil of specific gravity 0.8 is stored in the tank upto a height of 8m, calculate the torque needed at the hinge to keep the gate closed.
43. A 1 m diameter sphere of mass 1500 kg closes a 40 cm diameter hole in the bottom of the tank as shown in figure.Calculate the force needed to dislodge the sphere from the hole.[Note:- The volume of part of sphere cut by a plane is given by $\pi h^2\left(R - h/3\right)$ where, h is height of cut portion and R is the radius.
44. The face of dam is curved according to relation $y = \frac{x^2}{2.4}$ where, x and y are in meters. A is at the base of the tank.and free surface is 15.25 m above A. Calculate the resultant force F due to fresh water acting on unit breath of the dam and determine the position of the point at which the line of action of the resultant force cuts the horizontal plane through A.
45. The gate shown in the figure is in equilibrium. Compute W, the gravity force of counterbalance per meter of width, neglecting mass of the gate.
46. The gauge reading in the figure is 2 kN/m2. Determine (i) The height of levels of liquids in piezometer tubesE,F,G.(ii) The difference of level of mercury in U tube Manometer

47. Figure shows water column with air trapped in the manometer bend. Compute the pressure head at A in meters of water.
48. A vertical manometer made 6 mm ID glass tube has one end enlarged to 15 mm as shown in the figure.The enlarged end contains oil of specific gravity 0.75. There is mercury on the lower side of the manometer. The smaller end is opened to atmosphere. When the enlarged end is subjected to unknown air pressure, the oil level is depressed by 6 mm. Estimate the gauge value of applied pressure. Density of mercury is 13600 kg/m^3.
49. A glass tube of 1 mm diameter is used as a piezometer as shown in figure. Find the pressure P_1. Take surface tension of water as 0.07 Ns/m^2. Neglect air density .
50. A pipe of 100 mm diameter contains water flowing at 30^0c. The pressure in the pipe at a given point fluctuates between 1.2 kg/cm^2 absolute and 0.95 kg/cm^2 absolute. What kind of a pressure measuring device would you use to record the pressure, give atleast two alternatives. Take atmospheric pressure as 1.03 kg/cm^2. Draw a sketch of arrangement.
51. Liqud A weights 8.4 kN/m^3. Liquid B weights 12.3 kN/m^3. Manometer liquid is mercury. If the pressure at B is 200 kN/m^2, find the pressure at A.
52. A rectangular pantoon floating in sea water is 21 m long, 7 m wide, 2.4 m deep and has a mass of 150 tones. It carries on its upper deck a normal vertical load of 100 tones. The centre of gravity of the load is 2.4 m above the deck and that of the pantoon is 1.2 m below the deck. Find the metacentric height.
[1 tone = 1000 kg and deck is the top surface of the pantoon]
53. A hollow cylinder with closed ends is 300 mm in diameter and 450 mm high. It has a mass of 27 kg and a small hole in the base. It is lowered into the water so that its axis remains vertical. Calculate the depth to which it will sink, the height to which the water will rise inside it and the pressure inside it. Disregard the effect of wall thickness and assume that compression of air is isothermal.
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which the water will rise inside it and the pressure inside it. Disregard the effect of wall thickness and assume that compression of air is isothermal.(Atmospheric pressure is 0.1013 MPa) If cylinder is pushed downwards so that its upper edge flushes with the water surface. Estimate the downward force required to hold the cylinder in position.

55. A cube 1 m on edge , has its lower half is of specific gravity 1.4 and upper half is of specific gravity 0.6. It is submerged into a two layered fluid, the lower sp.gr. 1.2 and the upper sp. gr. 0.9. Determine the height of the top of the cube above the interface.

56. A rectangular water tank has a vertical door in one side. The door is square with dimensions 0.4 m × 0.4 m. It is hinged at the top edge and the top edge is at a depth of 4 m from the free surface of water. The tank is completely closed and the air above water is at a pressure of 50 kN/m2(gauge). Calculate the force F required to keep the hinged door closed . the force F is applied at the bottom edge of the door.

57. A spherical ball of 5 cm diameter is made of wood of sp.gr.0.85. It is reinforced with small pieces of metal so that only $1/10^{th}$ of the ball by volume is visible when dipped in water. Calculate the total weight of the metal bits and the volume occupied by it.Take sp.gr. of metal as 5.0

58. A thick walled cylinder 1 m external radius and 0.5 m internal radius and of height 2.2 m is floating in water with its axis vertical and the length of 0.7 m below water surface. The cylinder is open ended, find out whether it is stable or not.

59. A cylinder has a dimension of 30 cm and sp.gr. 0.8 what is the maximum permissible length so that it may float in water with its axis vertical in a stable condition.

60. A sphere of radius 10 cm and made of material of sp.gr.0.7 is floating in water . Find the depth of immersion.

61. A buoy floating in sea water of density 1025 kg/m3 is conical in shape with diameter at top of 1.2 m and vertex angle of 600. Its mass is 300 kg.and its C.G. is 750 mm from the vertex. A flashing beacon is to be fitted at the top of the buoy.

If this unit has a mass of 55 kg, what is the maximum height of the C.G. above the top of the buoy if the whole assembly is not to be unstable.

NOTE: The centroid of volume of cone is (3/4th h) from vertex .

62. A hollow cylinder of 1 m diameter and 10 cm wall thickness has one end closed and the other end open. It is made of material of specific gravity 0.6. Neglecting the weight f the cylinder base, determine the length of the cylinder so that it floats with its axis vertical and is stable in water.
63. A ship weights 2000 tones and has a crosssection at water line as shown in figure. The centre of buoyancy is 1.7 m.below the free surface. Compute metacentric heightfor rotation about longitudinal axis.
64. A conical wooden box of 20 cm diameter base and height 30 cm is floating in an interface of oil and water with apex down.The depth of apex below interface is 20 cm.Determine the specific gravity of wood.