Sheet (1)
Properties of Fluids

1-Write the dimensional representation and the SI units of the following:

a) Density b) Specific Weight c) Pressure d) Energy

e) γh f) Discharge g) Power h) $\rho Q v$

l) $V^2/2g$

i) Dynamic Viscosity j) Kinematic Viscosity k) Surface Tension

2-If the specific weight of a gas is 12.40 N/m^3, what is its specific volume in m^3/kg?

3- Define:

a) internal, external, and open-channel flows.
b) incompressible flow and incompressible fluid. Must the flow of a compressible fluid necessarily be treated as compressible?
c) What is the no-slip condition? What causes it?
d) Define stress, normal stress, shear stress, and pressure.
e) Can the coefficient of compressibility of a fluid be negative? How about the coefficient of volume expansion?
f) Consider two identical small glass balls dropped into two identical containers, one filled with water and the other with oil. Which ball will reach the bottom of the container first? Why?

4-Determine the mass and the weight of the air contained in a room whose dimensions are 6 m x 6 m x 8 m. Assume the density of the air is 1.16 kg/m3.

5-Determine the specific weight, density and specific gravity of a fluid that occupies volume of 200 lit, and weighs 178 kg. Will this fluid float on the surface of an oil of specific gravity (0.80)? Provide Results in S.I. units.

6-The specific gravity of ethyl alcohol is 0.79. Calculate its specific weight and its mass density. Also, The kinematic viscosity of an oil, if the density of the oil is 800 kg/m^3 and its dynamic viscosity is 6 x 10-3 kg/m.s

7-Water at 15°C and 1 atm pressure is heated to 100°C at constant pressure. Take the coefficient of volume expansion as 0.484x10-3 K^{-1}, determine the change in the density of water. Consider the density of water at 1 atm is 999 kg/m^3.

8-A water tank is completely filled with liquid water at 20°C. The tank material is such that it can withstand tension caused by a volume expansion of 2 percent.

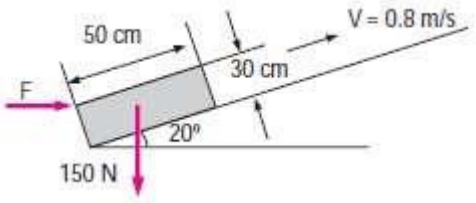
Determine the maximum temperature rise allowed without jeopardizing safety. Take the coefficient of volume expansion as 0.377x10-3 K^{-1}.

9-In a fluid the velocity measured at a distance of 75mm from the boundary is 1.125m/s. The fluid has absolute viscosity 0.048 Pa s and relative density 0.913. What is the velocity gradient and shear stress at the boundary assuming a linear velocity distribution?

10-Calculate the capillary effect in millimeters in a glass tube of 4 mm diameter., when immersed in (i) water and (ii) in mercury. The temperature of liquid is 20^o C and the values of surface tension of water and mercury at this temperature in contact with air are 0.0075 kg/m and 0.052 kg/m. The contact angle for water = 0 and for mercury = 130^o.

11-Determine the force required to pull a 1.0 mm thick plate between two stationary parallel plates separated by a gap 4 mm. the moving plate is $(2*3)m^2$ surface area, and is located 0.5 mm from one of stationary plates. The moving plate has a velocity of 1.2 m/s and the viscosity of the lubricant is 0.07 poise.

12- A 50-cm x 30-cm x 20-cm block weighing 150 N is to be moved at a constant velocity of 0.8 m/s on an inclined surface with a friction coefficient of 0.27. (a) Determine the force F that needs to be applied in the horizontal direction.(b) If a 0.4-mm-thick oil film with a dynamic viscosity of 0.012 Pa.s is applied between the block and inclined surface, determine the percent reduction in the required force.



13-At the ocean surface under normal atmospheric pressure, the density of sea water is 1047 kg/m^3. The absolute pressure is about 35 bar at the deepest point in the Pacific ocean where the depth is about 10860 m. What is the percentage change in the density of the sea water between the surface and the ocean bottom? Bulk modulus of elasticity of sea water = 2338.67 MPa.

(Ans: 0.15%)

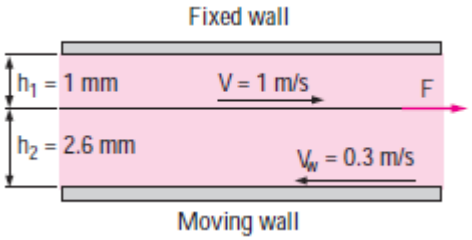
14-A 10-kg block slides down a smooth inclined surface, 20^o with horizontal. Determine the terminal velocity of the block if the 0.1mm gap between the block and the surface contains oil of viscosity 3.8 cP (centipoises). Assume velocity distribution in the gap is linear and the area of block in contact with the oil is 0.1 m^2.

(Ans: 8.83 m/s)

15-A large movable plate is located between two fixed plates at a distance 3.0 mm from one plate and 6.0 mm from the other. The spaces between the movable plate and the fixed plates are filled with oil of viscosity 0.02 and 0.01 Pa.s respectively. Determine the force required to pull the plates at 4 m/s if the surface area of the plate is 0.9 m^2 and its thickness is negligible. If one oil is used to fill the spaces between the plates (μ = 0.01 Pa.s), what is the minimum force required to pull the plate at the same velocity? Determine the location of the movable plate with respect to the fixed plates in this case.

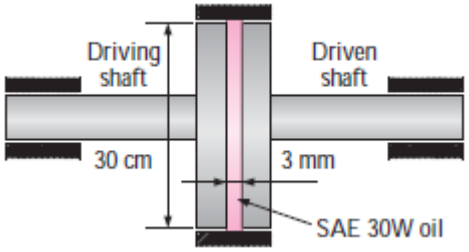
(Ans: 29.99 N, 16 N, the plate will be in the middle)

16- A thin 20-cm x 20-cm flat plate is pulled at 1 m/s horizontally through a 3.6-mm-thick oil layer sandwiched between two plates, one stationary and the other moving at a constant velocity of 0.3 m/s. The dynamic viscosity of oil is 0.027 Pa.s. Assuming the velocity in each oil layer to vary linearly, (a) plot the velocity profile and find the location where the oil velocity is zero and (b) determine the force that needs to be applied on the plate to maintain this motion.

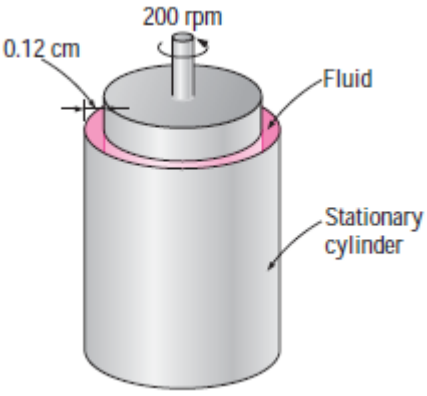


17-A lubricated shaft rotates inside a concentric sleeve bearing at 1200 rpm. The clearance δ is small compared with the radius R, so a linear velocity distribution in the lubricant may be assumed. What is the power required to rotate the shaft? R = 2 cm, L = 6 cm, δ = 0.1 mm and μ = 0.2 N.s/m^2, where L is the bearing length. (Ans: 95.3 W)

18- The clutch system shown is used to transmit torque through a 3-mm-thick oil film with μ = 0.38 N. s/m^2 between two identical 30-cm-diameter disks. When the driving shaft rotates at a speed of 1450 rpm, the driven shaft is observed to rotate at 1398 rpm. Assuming a linear velocity profile for the oil film, determine the transmitted torque.



19- The viscosity of a fluid is to be measured by a viscometer constructed of two 75-cm-long concentric cylinders. The outer diameter of the inner cylinder is 15 cm, and the gap between the two cylinders is 0.12 cm. The inner cylinder is rotated at 200 rpm, and the torque is measured to be 0.8 N.m. Determine the viscosity of the fluid.



20- Determine the gage pressure inside a soap bubble of diameter (a) 0.2 cm and (b) 5 cm at 20°C. Take the surface tension coefficient of the soap bubble $\Upsilon = 0.025$ N/m.
