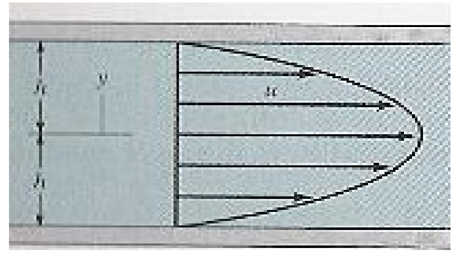
CE 371 HOMEWORK 1

1) The velocity distribution for the flow of a Newtonian fluid between two wide, parallel plates is given by equation

$$u = \frac{3V}{2}\left[1 - \left(\frac{y}{h}\right)^2\right]$$

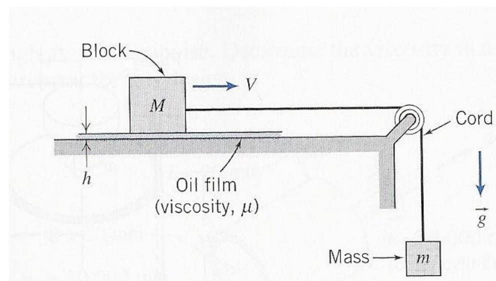


where V is the mean velocity. The fluid has a viscosity of 0.38 Ns/m^2. When V=1m/s and h=0.5 cm determine:

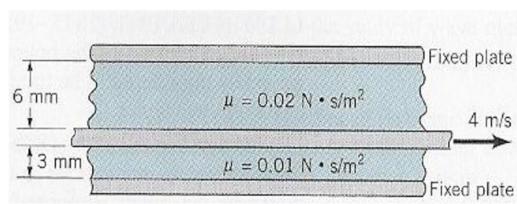
a) the shearing stress acting on the bottom wall

b) the shearing stress acting on a plane parallel to the walls and passing through the centerline

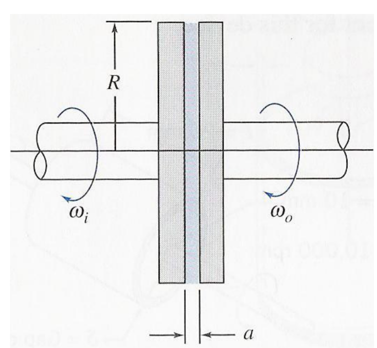
2) A block of mass M slides on a thin film of oil. The film thickness is h and the area of the block A. When released, mass m exerts tension on the cord, causing the block to accelerate. Neglect friction in the pulley and air resistance. Develop an algebraic expression for the viscous force that acts on the block when it moves at speed V. Derive a differential equation for the block speed as a function of time. Obtain an expression for the block speed as function of time. The mass M=5kg, m=1kg, A=25 cm^2, and h=0.5 mm. If it takes 1 second for the speed to reach 1 m/s, find oil viscosity μ.



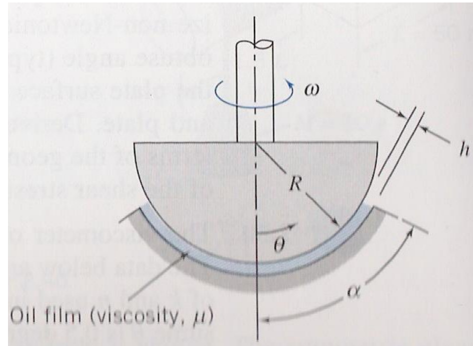
3) A large moveable plate is located between two large plate as shown in the figure. Determine the magnitude and direction of the shearing stresses that act on the fixed walls when the moving plate has a velocity of 4 m/s. Assume that the velocity distribution between the plates is linear



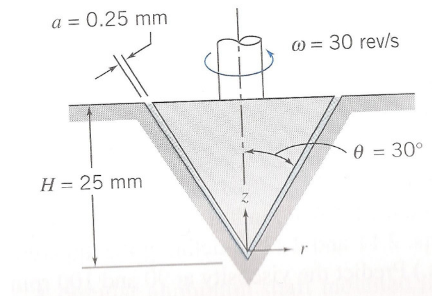
4) A viscous clutch is to be made from a pair of closely spaced parallel disks enclosing a thin layer of viscous liquid. Develop an expression for the torque in terms of liquid viscosity μ, disk radius R, disk spacing a, and the angular speeds; w_i of the input disk and w_o of the output disk.



5) A spherical thrust bearing is shown. The gap between the spherical member and the housing is of constant width h. Obtain an expression for the torque on the spherical member, as a function of angle α.



6) A conical pointed shaft turns in a conical bearing. The gap between shaft and bearing is filled with oil having viscosity of 0.2 Ns/m^2. Calculate the viscous torque that acts on the shaft.



7) If the inside diameter of capillary tube is 3 mm, θ angle is equal to 30° and the σ for the water in the presence of air is 0.0730N/m determine the height h, of water rise in the capillary tube and draw the figure of the capillary tube. Specific weight of water in the capillary tube is 9806 N/m^3

ANSWERS

1) a) 228 N/m^2 b)0

2) $F_v = \mu VA/h$ **;** $V = (mgh/\mu A)(1 - \exp[-\mu At/(M+m)h])$ **;** $\mu = 1.29\ Ns/m^2$

3) 13.3 N/m^2 in direction of moving plate

4) $T = \pi\mu \cdot \Delta\omega \cdot R^4 / 2a$

5) $T = \dfrac{2\pi\mu\omega R^4}{h}\left(\dfrac{\cos^3\alpha}{3} - \cos\alpha + \dfrac{2}{3}\right)$

6) T= 0.0205 N.m

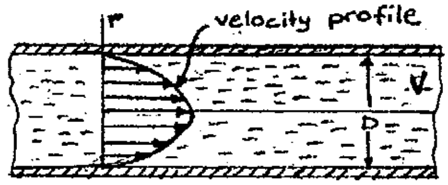
7) 8.6 mm

CE 371 HOMEWORK I.2

Q1) Water is moving through a pipe. The velocity profile at some section is given mathematically as

$$V = \frac{\beta}{4\mu}\left(\frac{D^2}{4} - r^2\right)$$

where β= a constant, r = radial distance from centreline, V= velocity at any position r, as shown in the figure below.

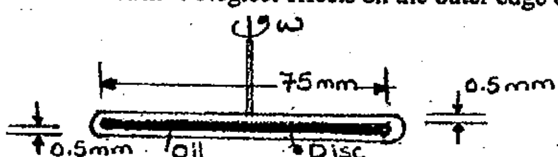


a) What is the shear stress at the wall of the pipe from the water ? $\left(\tau = \frac{\beta D}{4}\right)$

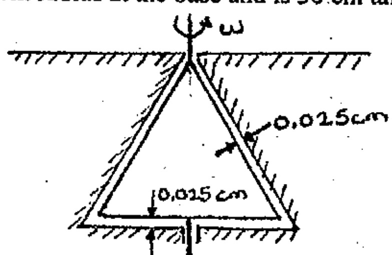
b) What is the shear stress at a position r = D/4? $\left(\tau = -\frac{\beta D}{8}\right)$

c) If the profile above persists a distance L along the pipe, what friction drag is induced on the pipe by the water in the direction of flow over this distance ? $\left(F = \frac{\beta D^2 \pi L}{4}\right)$

Q2) The motion of pointer mechanism is dampened by having a circular disc turn (with the pointer) in a container of oil. In this way, extraneous rotations are damped out. What is the damping torque for ω=0.2 rad/s if the oil has a viscosity of 8×10^{-3} N.s/m^2 ? Neglect effects on the outer edge of the rotating plate. $(T = 1.988\times10^{-5}\ \mathrm{Nm})$

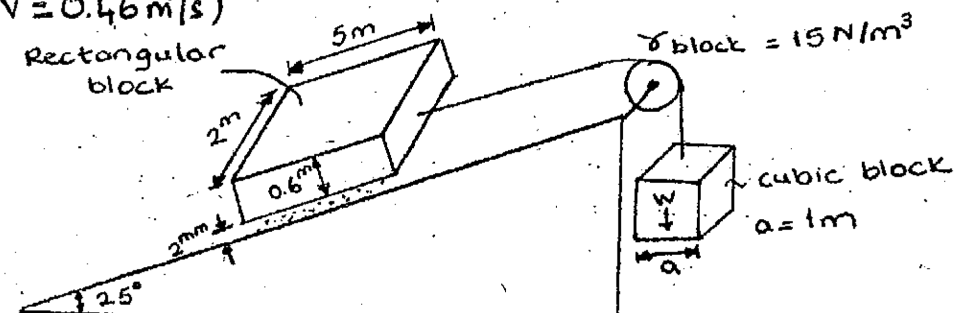


Q3) A conical body is made to rotate at a constant speed of 42 rad/sec. A film of oil having a viscosity of 0.5 poise seperates the cone from the container. The film thickness is 0.025 cm. What torque is required to maintain this motion ? The cone has a 10 cm radius at the base and is 30 cm tall. $(T = 5.49\ \mathrm{Nm})$



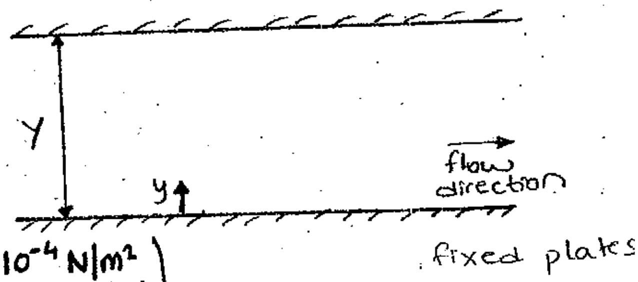
Q4) If the inside diameter of the capillary tube is 2 mm, θ angle is equal to 130° and σ for the mercury in the presence of air is 0.48 N/m, determine the height of mercury rise in the capillary tube and draw the figure of the capillary tube. Density of the mercury in the capillary tube is 13600 kg/m^3. $(h = -0.46\ \mathrm{cm})$

Q5) Rectangular block is sliding over the oil film on the inclined plane which has the angle of 25°. If the specific weight of the blocks is 15 N/m^3 and the viscosity of oil is 10^{-2} N.s/m^2, find the velocity of the system, system has a constant velocity. Dimensions of the rectangular block are $2^m\times0.6^m\times5^m$, thickness of the oil film is 2 mm. $(V = 0.46\ \mathrm{m/s})$



CE 371 HOMEWORK I.3

Q1) Water is flowing between two parallel fixed plates. The velocity profile at some section is given mathematically as $V = 10(0{,}01y - y^2)$ where y = distance from the bottom plate, V= velocity at any position y, as shown in the figure.



$\mu = 1{,}005 \times 10^{-3}\ N.s/m^2$

a) What is the distance Y between the plates ? (1 cm)

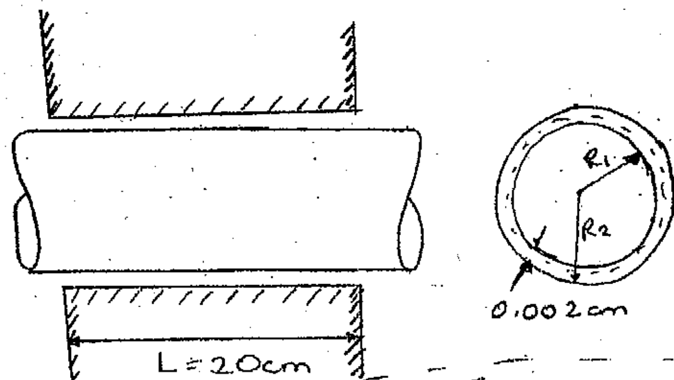
b) What is the shear stress at both plates? Draw the distribution of shear stress between the plates. ($\tau_b = 1.005\times10^{-4}\ N/m^2$, $\tau_u = -1.005\times10^{-4}\ N/m^2$)

c) What is the shear stress at a distance 20μm from the plate? ($\tau = 0.1\times10^{-3}\ N/m^2$)

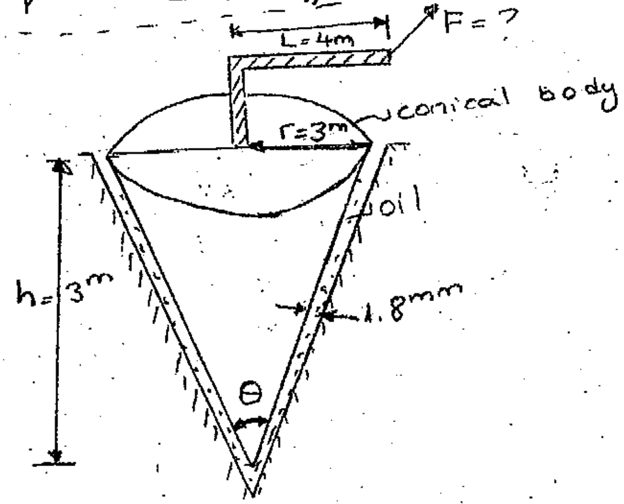
d) Determine the distance from the bottom plate where the shear stress is zero. ($y = 0.005\ m$)

e) Determine the distance from the bottom plate where the maximum velocity occurs. ($y = 0.005\ m$)

Q2) A 10 cm-diameter shaft rotates in a cylindrical bearing at a constant speed of 30 rpm as shown in the figure. The lubricant that fills the 0.002 cm gap between the shaft and bearing is an oil having a viscosity of 0.44 N.s/m². What torque is required to maintain this motion assuming (a) a linear velocity distribution (b) a non-linear velocity distribution in the oil. (a) 10.85 N.m (b) 10.85 N.m



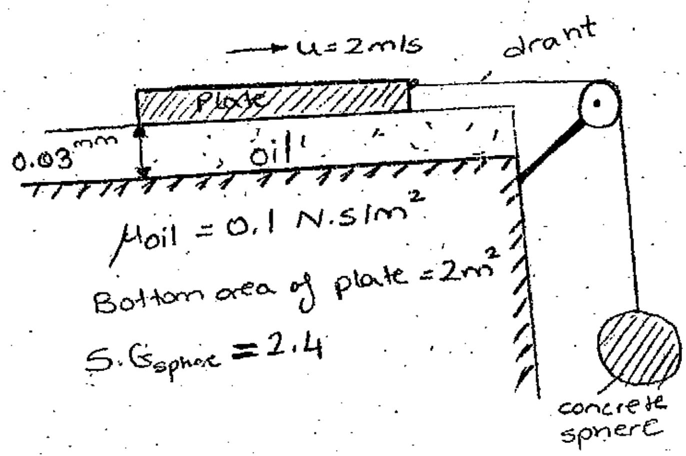
Q3) Find the force F required to rotate the conical body with the angular velocity of 8 rad/s if the clearance is 1.8 mm and viscosity of the oil is 10^{-5} N.s/m². Height and radius of the conical body is 3m and θ=90°. (F=1.99 N)



Q4) If the inside diameter of the capillary tube is 2 mm, θ angle is equal to 20° and σ for the water in the presence of air is 0.0730 N/m, determine the height h of water rise in the capillary tube and draw the figure of the capillary tube. Specific weight of water in the capillary tube is 9806 N/m³.

(h= 13.99 mm)

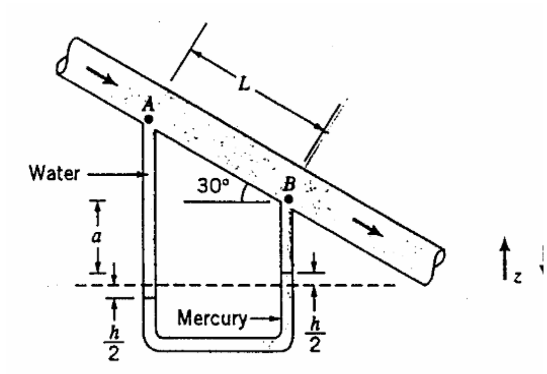
Q5) The plate, shown in the figure, moves with a constant velocity of 2 m/s. Determine the radius of the concrete sphere. Neglect the friction of the hinge and the weight of the draht. (r = 0.513 m)



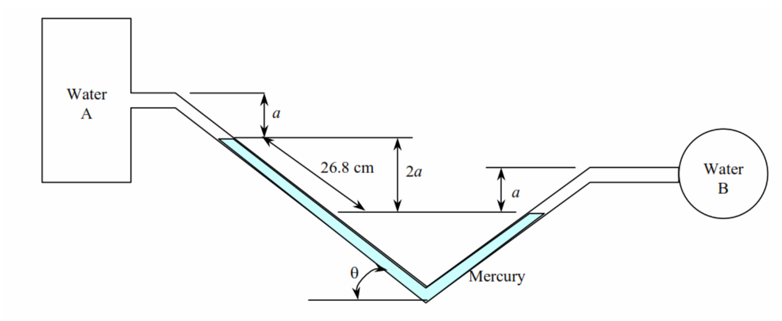
CE 371 HOMEWORK 2

If information related to properties of a fluid or an object (such as density, viscosity, etc.) is not given in the problem you should find these values in the related fluid mechanics, physics books or from internet search. Please indicate the source that you used in the solution of the problem. (For example: Kundu, P.K., Cohen, I.M. (2004) "Fluid Mechanics", Elsevier Academic Press, page 250.)

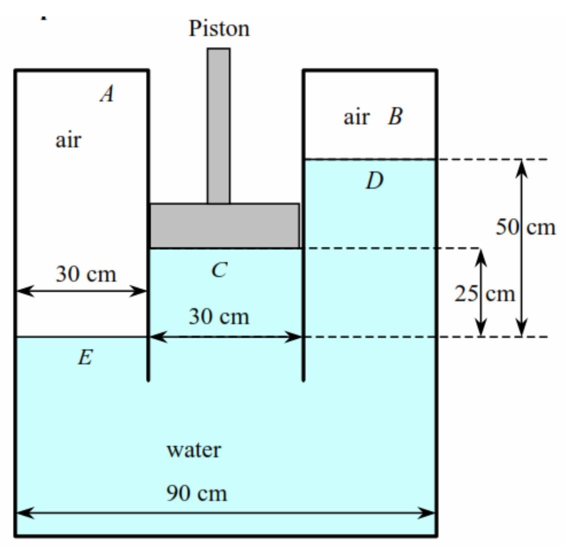
1) Water flows down along a pipe that is inclined at 30° below the horizontal, as shown. Pressure difference $p_A - p_B$ is due partly to gravity and partly to friction. Determine an algebraic expression for the pressure difference.



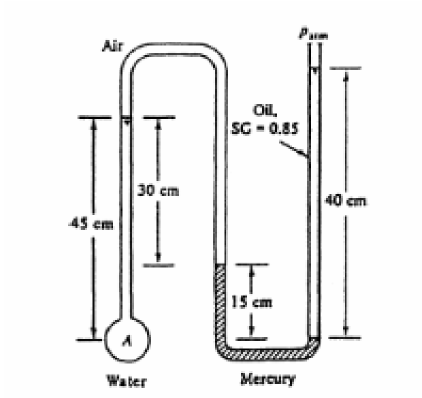
2) Two water tanks are connected to each other through a mercury manometer with inclined tubes. If the pressure difference is 20 kPa, determine *a* and θ.



3) Determine the gage pressures in A and B if the piston's diameter and weight are 30 cm and 25 N, respectively.



4) Determine the gage pressure at point A. Is it higher or lower than the atmospheric pressure?



5) From a manometer reading R and depth L, compute the depth of water h that has risen in the diving bell shown in the figure.