Université d'Ottawa
Faculté de génie

Département de
Génie Chimique

University of Ottawa
Faculty of Engineering

Department of
Chemical & Biological Engineering

CHG 2312 – Fluid Flow
Sample Problems from Assignment 1

For all questions, provide a free body diagram showing all forces, velocity, etc.

Question 1:
An auto lift consists of a 55.56 cm diameter ram which slides concentrically in a 55.58 cm diameter cylinder (see Figure 1). The cylinder engages a 2.8 m length of the ram at all times. The annular region between the ram and cylinder is filled with viscous oil. The combined mass of the automobile, auto rack and ram is 1750 kg. If the lift drops steadily at the speed of 0.25 m/s after being released, determine:
a) the viscosity of the oil, in Pa.s,
b) the shear stress at the surface of the inner cylinder.

Question 2:
An insulation company is examining a new material for extruding into cavities. The experimental data is given below for the speed U of the upper plate, which is separated from a fixed lower plate by a 1-mm thick sample of the material, when a given shear stress is applied. Determine the type of material. If then a replacement material with a minimum yield stress of 250 Pa is needed, what viscosity will the material need to have the same behavior as the current material at a shear stress of 450 Pa? ***Note:*** *show one sample calculation for one U and submit the plot of the data and results done in Excel with your solution.*

τ (Pa)	50	100	150	163	171	170	202	246	349	444
U (m/s)	0	0	0	0.005	0.01	0.025	0.05	0.1	0.2	0.3

Question 3:
As shown in Figure 2, a cylindrical glass jar 20 cm high by 10 cm in diameter is inverted in air and pushed downwards, very carefully so that no air escapes, to a 4 m depth in a pool of water. The air trapped in the jar is compressed isothermally as the hydrostatic pressure increases. To what height, y, in cm, will the water-air interface in the jar climb during this process? Assume that the water is at 20 ˚C and therefore has a density of 998 kg/m^3.

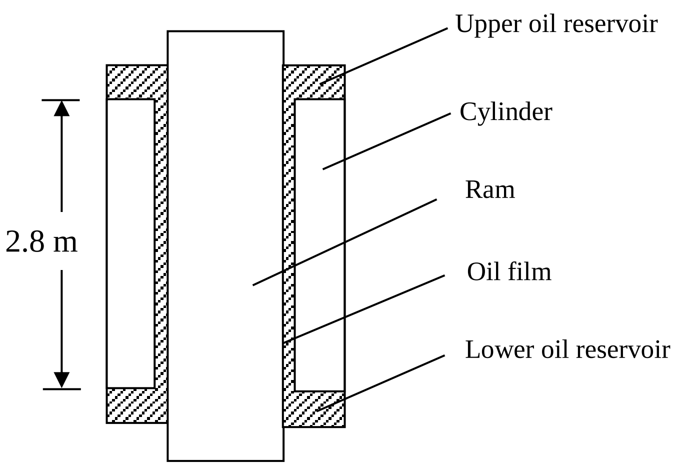

Figure 1

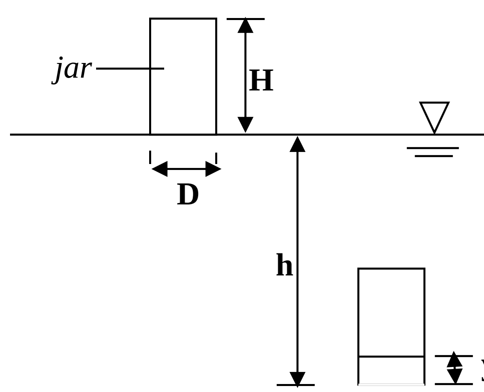

Figure 2

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Question 4:
A reactangular tank, open to the atmosphere, is filled with water to a depth of 2.5 m as shown in Figure 3. A U-tube manometer is connected to the tank at a location 0.7 m above the tank bottom. If the zero level of the Meriam blue manometer fluid is 0.2 m below the connection, determine the deflection l after the manometer is connected and all air has been removed from the connecting leg.

Question 5:
A wedge-shaped block having the dimensions shown in Figure 4 and a mass of 135 kg is lowered blunt end down into a large tank containing a 1.5 m thick layer of water (ρ_w = 1000 kg/m^3) under a 1.5 m thick layer of oil (SG_{oil} = 0.815). Once the block has reached its equilibrium position in the tank, how far, in m, below the air-oil interface will the top edge of the block reside?

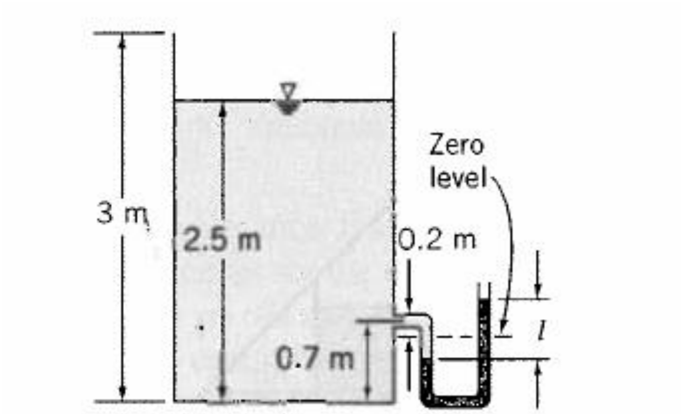

Figure 3

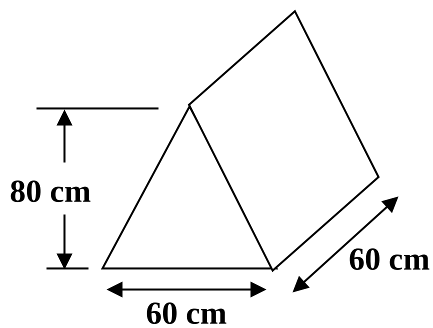

Figure 4

Question 6:
A hot air balloon is designed to lift a basket, two people, three gallons of fuel, a pair of binoculars, a camera, a GPS, a cell phone, a pair of blankets, and the components of the balloon itself (fabric, rope, and torch). The total mass is estimated at 450 kg. The rides are planned in summer morning hours when the air temperature is about 9 ˚C. The torch will warm the air inside the balloon to a temperature of 70 ˚C. Both inside and outside pressures will be "standard" (101 kPa). What volume of hot air should the balloon hold to create neutral buoyancy? What additional volume will ensure a vertical take-off acceleration of 0.8 m/s^2? For this, consider that both balloon and inside air have to be accelerated, as well as some of the surrounding air (to make way for the balloon). The rule of thumb is that the total mass subject to acceleration is the mass of the balloon, all its appurtenances, and twice its volume of air. Given that the volume of hot air is fixed during flight, what can the balloonists do when they want to go down?