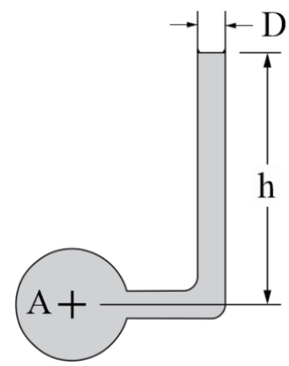
Last Updated: Nov. 2021

MEC516/BME516
Fluid Mechanics I

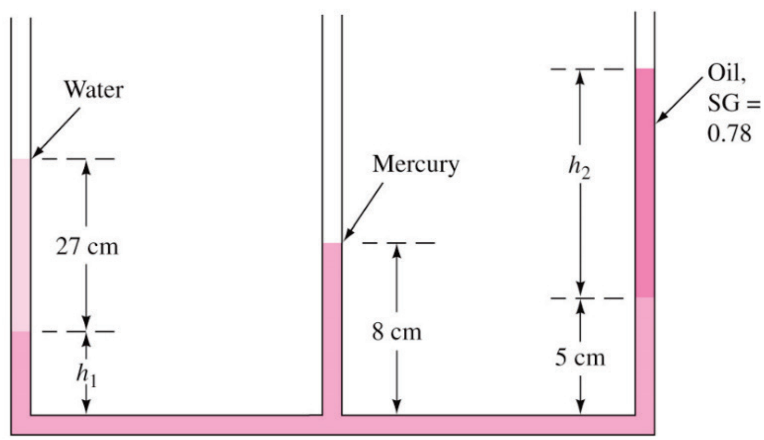
Chapter 2
Recommended Problem Set

I strongly recommended that you work through the details of these problems with pen and paper. ***Be sure that you can solve these problems without looking at the solutions.***

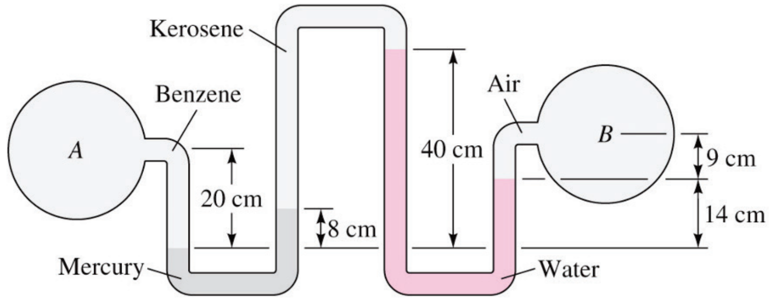
1. A vertical clean glass piezometer tube has an inside diameter of D=1.0 mm. When a pressure is applied at point A, water at 20°C rises into the tube to a height of h=25.0 cm. After correcting for capillary effects (i.e. the extra rise due to surface tension), estimate the gauge pressure at point A (p_A). Assume a contact angle between the water and glass of θ=0º.



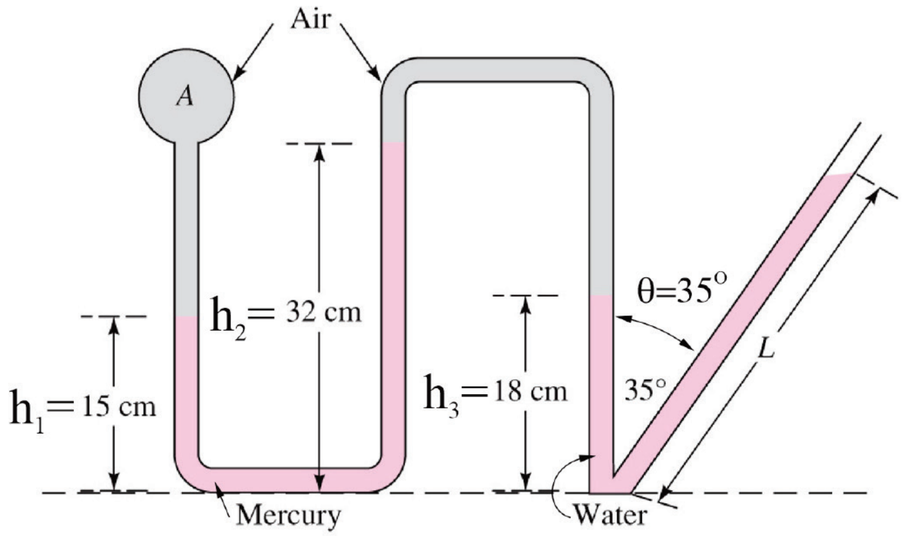
2. Three liquids at 20ºC are contained in open-ended vertical pipes, as shown below. Calculate the heights h_1 and h_2. Neglect the density of air.



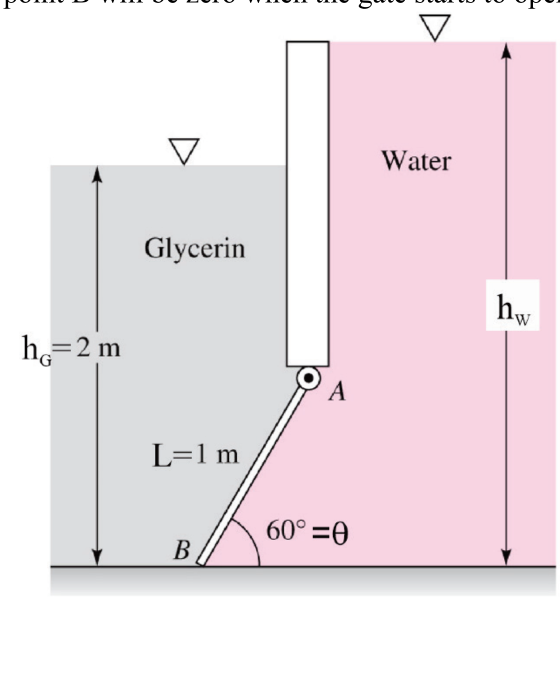
3. Liquid benzene, kerosene, mercury and water at 20ºC are contained in complex U-tube manometer show below. Calculate the pressure difference (in Pa) between point A and point B, $p_A - p_B$. Neglect the density of air.



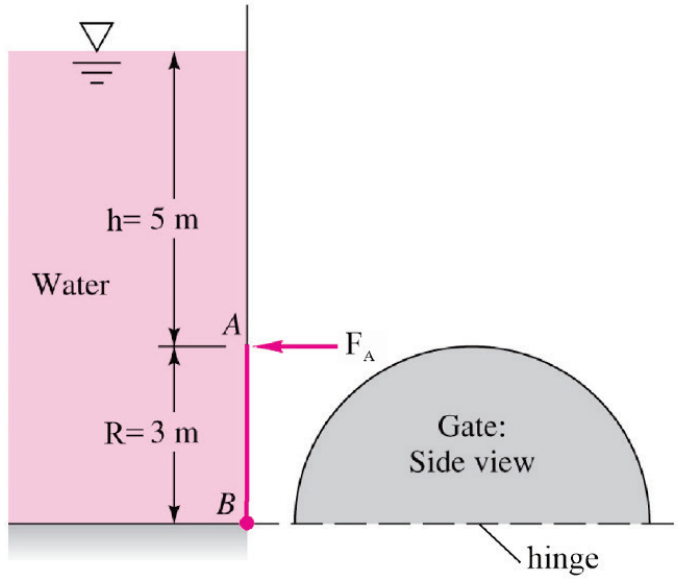
4. The manometer system shown below is open to the atmosphere on the right side. The manometer contains mercury and water at 20ºC. The local atmospheric pressure is 99.5 kPa. The length of the inclined tube is $L = 120\ cm$ (a) What is the gauge pressure at point A? (b) What is the absolute pressure at point A? (c) Calculate the density of the air at point A.



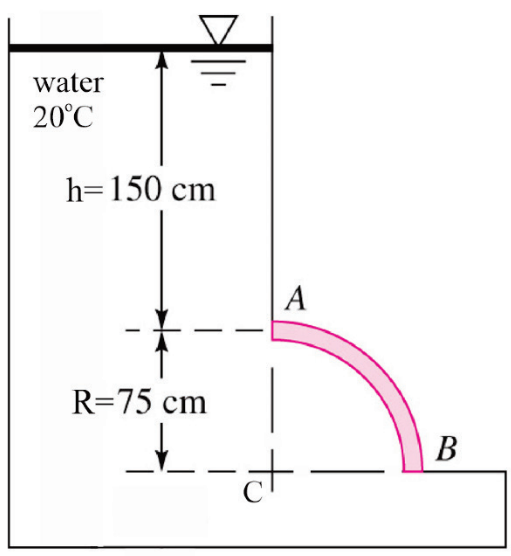
5. Gate AB is a uniform thickness plate with m=180 kg. The gate is L=1.0m long and w=1.2 m wide (into the page), resting on smooth bottom B. All fluids are at 20°C. The glycerin on the left side of the gate has a depth of h_G=2.0 m. As the water level on the right side rises, at what water depth h will the gate open? (Hint: The force at point B will be zero when the gate starts to open.)



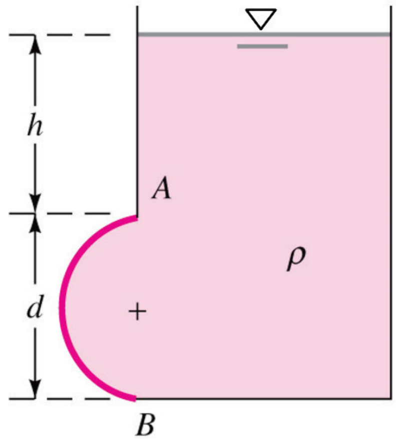
6. Consider water at 20ºC in a reservoir with a semi-circular gate AB is hinged along the edge at B. The radius of the gate is R=3 m. The gate is held closed by a horizontal force F_A at point A. Calculate the force F_A.



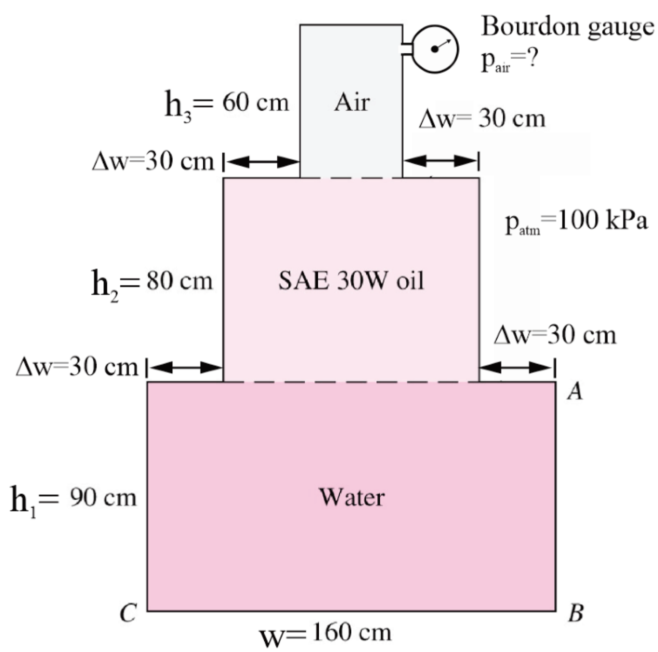
7. As shown in the sketch, consider water at 20ºC in a reservoir with a quarter-circular gate AB. The radius of the gate is R=0.75 m. The depth of the gate is w=1.2 m into the page. (a) Sketch the hydrostatic pressure distribution on the curved surface of the gate A-B. (b) Calculate the vertical and horizontal hydrostatic forces on the curved gate AB. Clearly indicate the directions of these two forces.



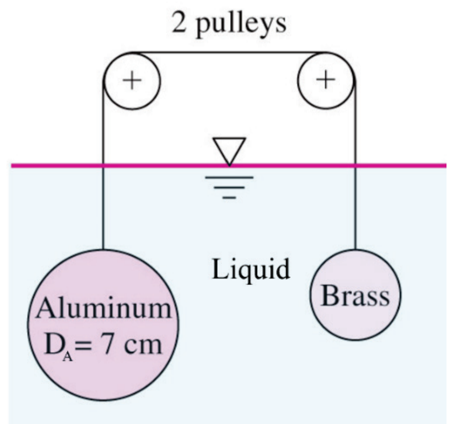
8. A tank contains a fluid with density ρ. Using the dimensions (*d, h*) shown in the sketch, derive an expression for horizontal and vertical forces on the semicircular gate AB. The gate has depth *w* into the page. Clearly indicate the direction of the hydrostatic forces on the gate.



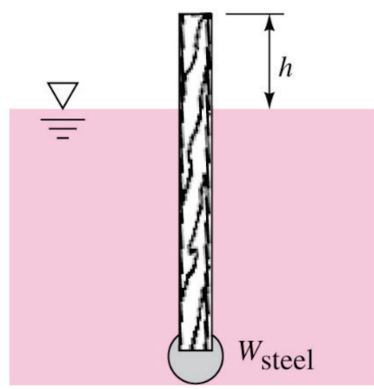
9. This problem considers three layered fluids: air, SAE 30W oil and water at 20ºC. The closed layered box shown in the figure has square horizontal cross sections everywhere. Calculate the reading on the Bourdon gauge attached to the air layer of the box, if the hydrostatic force on panel AB is 48.0 kN.



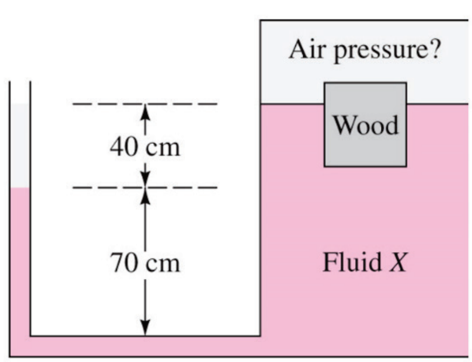
10. A solid aluminum sphere (SG = 2.70) with diameter D_A =7.0 cm and a solid brass sphere (SG = 8.50) balance when fully submerged in a liquid, as in the figure below. Assume that the pulleys are frictionless, so the tension in the massless suspension wire is constant. If the liquid is water at 20°C, what is the diameter of the brass ball?



11. A spar buoy is a rod weighted to float vertically, as shown in the sketch below. The buoy is maple wood (SG_M = 0.60), 2 inches by 2 inches by 12 feet long, floating in seawater (SG_f =1.025). How many pounds of steel (SG_S=7.85) should be added at the bottom so that h=18 inches?



12. As shown in the sketch, a block of wood (SG = 0.60) floats in an unknown fluid such that 75% of its volume is submerged in the fluid. Calculate the gauge pressure of the air in the tank.



13. As shown below, a large empty "Ziplock" back is placed on a kitchen scale. The scale is "tared", such that it reads zero grams when the empty plastic bag is on the scale. The plastic bag is then filled with 1 litre of room air (at 20ºC, 1 atm), sealed, and placed back on the scale:

(a) What is the **weight** of the air in the bag? (Hint: It is not zero!)

(b) Draw a free body diagram of the air-filled bag (excluding the weight of the plastic).

(c) Will the scale still read zero when the bag is filled with 1 litre of room air? Explain your answer.