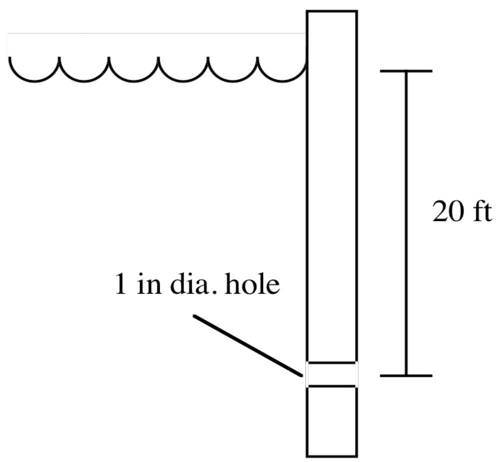
PROBLEM SET 2 CBE30355 DUE 9/4/12

1). According to an old story, a brave Dutchman saved his (or perhaps her) country by plugging a hole in the dike with a finger. In this problem we examine just how difficult this feat was.

a. Consider the dike depicted below. Assuming that the hole is 20ft below sea level and the density of sea water is 1.04 g/cm^3, calculate the force required to plug a hole 1 inch in diameter.

b. repeat the calculation for a hole 1 foot in diameter. This is why it is a good idea to catch leaks early!



2). Compute the viscosity of oxygen, nitrogen, CO_2, and air at room temperature (20ºC) and 1 atm pressure, and compare it to values you find in a reference of your choice (the web is helpful here). The Chapman-Enskog equation described in chapter 1 of BS&L is useful here!

3). The viscosity of many liquids is approximately exponential in the inverse of the temperature in ºK (e.g., the equation in chapter 1 of BS&L).

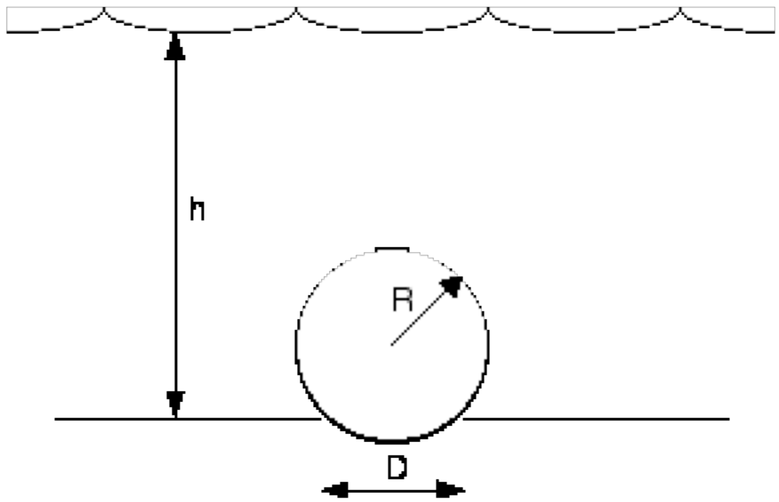
a. Using this, and data from the Dow Chemical website:

http://www.dow.com/glycerine/resources/physicalprop.htm

determine constants for such a model near room temperature (plot the correlation and the data up). Use the data from 10°C to 40°C.

b. By what factor does the viscosity change if the temperature increases from 20ºC to 21ºC?

c. The viscosity over the entire range of temperature from 0°C to 100°C is well fit by a quadratic function of 1/T. If we include this extra term, what is the new answer to part b?



4). Pool drains can be dangerous things - there was a tragic case a few years ago in this area where a child was stuck in a drain on the bottom, plugging it, and drowning as a result. Here we look at a somewhat simpler problem. Suppose a ball of radius R is plugging a drain of diameter D at the bottom of a pool of depth h as depicted above. Obviously, $R > D/2$ or the ball goes down the drain! Estimate the conditions under which the net force on the ball is zero for very small ratios of D/R (you can do the precise calculation for arbitrary D/R, but the math gets a little messy!). Assume that the pressure distribution in the drain is just atmospheric pressure, and that in the water is governed by the hydrostatic pressure distribution. If R is 1 ft and D is 6 inches, what is the corresponding depth?

5). Calculate the pressure at the center of the earth, assuming (for simplicity) a constant density of $5.67 g/cm^3$ and radius of 3957miles. Give your final result in atmospheres. Hint: don't forget that gravity is a function of position!