CVEN 311-501 “Fluid Dynamics”

HOMEWORK 2

Due Friday, 9/14/2012 at 8:00 AM
(No late papers accepted without documented university excuse)

PART I – Optional textbook problems. Do not turn these problems in with your assignment.

Pressure Variation in a Fluid at Rest

Standard Atmosphere
3. Textbook problem 2.21, p.83 (6th ed.: 2.16, p. 80)

Measurement of Pressure

Manometry
6. Textbook problem 2.34, p.83 (not in the 6th ed.)
8. Textbook problem 2.49, p. 86 (6th ed.: 2.37, pg. 82)
PART II – Required problems. You must turn these problems in with your assignment. All multiple choice problems should be answered with a complete solution; simply stating a letter answer will receive no credit. Problems 1-3 will be graded on effort alone. Problems 4-6 will be graded for accuracy.

Pressure Variation in a Fluid at Rest

1. In April 2010, the Deepwater Horizon drilling rig experienced a severe explosion and fire and sank off the coast of Louisiana. Eleven persons died, and 17 others were injured. The resulting uncontrolled oil release from the damaged well being drilled persisted for almost 4 months.

The rig was in the process of closing an exploratory oil well in the Gulf of Mexico. The seafloor at the well site was 5,067 ft below the water surface, and the petroleum reservoir was located 18,360 ft below the water surface. One cement plug had been placed at this lower depth, and a second cement plug was being completed at the time of the explosion. A key issue in the investigation of the explosion is the decision to replace drilling fluid (a.k.a. “drilling mud”) with seawater in the well pipe prior to installation of the upper cement plug. Drilling fluid is an engineered mixture of water, polymers, clay, and other material that serves a variety of purposes including acting as a dense counterweight to the high pressure of the petroleum reservoir. Some experts have hypothesized that removal of the drilling fluid in favor of less dense seawater allowed a high pressure methane bubble to move up the well pipe (a “blowout”).

Determine the pressure (psi) at the bottom of the well pipe (depth 18,360 ft) if drilling fluid of specific weight 17 lb/gal were left in place between the seafloor and the petroleum reservoir. Remember that pressure at the seafloor would include hydrostatic pressure due to the seawater ($\gamma = 64.0 \text{ lb/ft}^3$).

Determine the pressure (psi) at the bottom of the well pipe if all drilling fluid were replaced by seawater.
2. {From Fall 2010 Midterm 1} Shown in the graph below are vertical profiles of fluid density for two different scenarios, each of which involves a total fluid depth of 1000 m. For which scenario, A or B, will pressure at the bottom of the fluid column be greater? (You must fully explain your answer; simply writing “A” or “B” will receive no credit.)
Manometry

3. As we discussed in class, when beer is brewed the mixture of ingredients (called “wort”) changes density during the fermentation process as sugars are converted to alcohol (lighter than water) and CO₂ (which is released). Brewers periodically check the density of the wort to determine how far the brewing process has gone.

Diagrammed below is a fermenting vessel with a U-tube, 2-fluid manometer installed to determine wort density. The heavy fluid used here is Fomblin LC08 (SG = 1.83), an industrial chemical that is heavy, non-toxic, and inert. Before the fermenter is filled with wort, the U-tube is filled with LC08 so that it is exactly 9 ft deep in both sides of the U-tube. The fermenter is then filled with wort until the free surface of liquid in the fermenter is 14 ft above the U-tube port. While part of the manometer is filled with wort, you may assume that the manometer tube diameter is small so that the volume of wort in the manometer is negligible (i.e., the 14 ft dimension does not change).

If the specific gravity of the wort is 1.062 at the beginning of fermentation and 1.018 at the end of fermentation, what will be the values of \( h_1 \) and \( h_2 \) at the beginning and end of fermentation, respectively?
4. {From the Fall 2011 Final Exam} The static pressure (Pa) at the bottom of a 7.3 m deep tank of gasoline ($\rho = 720$ kg/m$^3$) is most nearly:

(A) 5 300
(B) 52 000
(C) 72 000
(D) 170 000

5. {From the Fall 2010 Final Exam} A three fluid manometer is shown in the diagram below. The pressure at point A (lb/ft$^2$) is most nearly:

(A) 249
(B) 191
(C) 213
(D) 314

6. {From Fall 2011 Quiz 2} A four-fluid U-tube manometer is diagrammed below. Write an equation that can be used to calculate the pressure at point A $p_A$: