

ASSIGNMENT 2 (SOLUTION)**(DUE Tuesday, February 1st 2011)****PROBLEM 1 (10 points)**Determine the pressure in bar at a depth of 10 m in oil of relative density, $S = 0.750$.**Solution:**

$$\text{gage pressure } p' = \frac{\rho g h}{10^5} = \frac{(0.750 \times 9810)10}{10^5} = 0.736 \text{ bar}$$

PROBLEM 2 (15 points)Determine the pressure (in Pa) at a depth of 6m below the free surface of a body of water, and find the absolute pressure (in Pa) when the barometer reads 760mm of mercury ($S_{Hg} = 13.57$).**Solution:**Using an average value of 9810 N/m³ for ρg

$$p = \rho g h = 9810 \times 6 = 58\,860 \text{ Pa}$$

Note: The ratio 62.4/144 will occur often and the reader may save time by using 0.433 as the quotient. The reciprocal is 144/62.4 = 2.31.

$$\begin{aligned} \text{Absolute pressure} &= \text{atmospheric pressure} + \text{pressure due to 6 m water} \\ &= (13.57 \times 9810)(0.76) + 9810 \times 6 = 160\,000 \text{ Pa} \end{aligned}$$

PROBLEM 3 (10 points)What depth of oil with relative density, $S = 0.750$, will produce a pressure of 2.75 bar? What depth of water?**Solution:**

$$h_{\text{oil}} = \frac{p}{\rho_{\text{oil}} g} = \frac{2.75 \times 10^5}{0.750 \times 9810} = 37.4 \text{ m}, \quad h_{\text{water}} = \frac{p}{\rho_{\text{water}} g} = \frac{2.75 \times 10^5}{9810} = 28 \text{ m}$$

PROBLEM 4 (15 points)In the figure below the area of the plunger **A** and cylinder **B** are 0.004 m² and 0.4 m² respectively and the weight of **B** is 40kN. The vessel and the connecting passages are filled with oil of relative density 0.750. What force **P** is required for equilibrium, neglecting the weight of A?**Solution:**

First determine the unit pressure acting on the plunger **A**. Since X_L and X_R are at the same level in the same liquid, then

$$\text{pressure at } X_L \text{ in Pa} = \text{pressure at } X_R \text{ in Pa}$$

$$\text{or} \quad \text{pressure under } A + \text{pressure due to 5 m oil} = \frac{\text{weight of } B}{\text{area of } B}$$

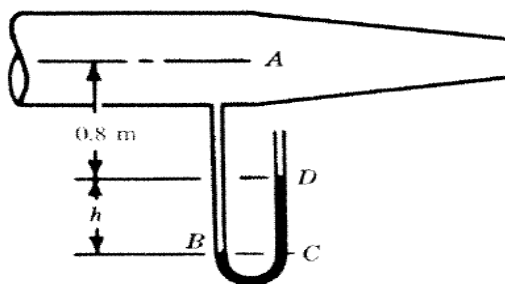
$$\text{Substituting,} \quad p_A + \rho gh = \frac{40 \times 10^3 \text{ N}}{0.4 \text{ m}^2}$$

$$p_A + (0.750 \times 9810)5 = 10^5 \text{ Pa} \quad \text{and} \quad p_A = 63\,200 \text{ Pa}$$

$$\text{Force } P = \text{uniform pressure} \times \text{area} = 63\,200 \text{ Pa} \times 0.004 \text{ m}^2 = 253 \text{ N}$$

PROBLEM 5 (15 points)

Oil of relative density 0.750 flows through the nozzle shown in the figure below and deflects the mercury in the U -tube gage. Determine the value of h if the pressure at A is 1.38 bar.



Hint: Although there is flow in the nozzle (*i.e.* the flow is not static), the fluid in the U -tube gage is static!

Solution:

$$\text{Pressure at } B = \text{pressure at } C$$

$$\text{or, using bar units,} \quad p'_A + \frac{\rho gh}{10^5} (\text{oil}) = p'_D + \frac{\rho gh}{10^5} (\text{mercury})$$

$$1.38 + (0.75 \times 9810)(0.8 + h) \times 10^{-5} = (13.57 \times 9810)h \times 10^{-5} \quad \text{and} \quad h = 1.14 \text{ m}$$

Another method:

Using convenient metres of water units,

$$\text{Pressure head at } B = \text{pressure head at } C$$

$$\frac{1.38 \times 10^5}{9810} + (0.8 + h)0.75 = 13.57h \quad \text{and} \quad h = 1.14 \text{ m, as before.}$$

PROBLEM 6 (20 points)

For a gage pressure at **A** of -11 000 Pa, find the relative density of the gage liquid **B** in the figure below.

Note: 1) The numbers on the side of the manometers represent elevation in metres; 2) the relative density of the fluid between marks **C** and **D** is 1.60.

Solution:

$$\text{Pressure at } C = \text{pressure at } D$$

or, using Pa units.

$$p_A + \rho g h = p_D$$

$$-11\,000 + (1.6 \times 9810)0.5 = p_D = -3150 \text{ Pa}$$

Now $p_G = p_D = -3150$ Pa, since the weight of 0.7 m of air can be neglected without introducing significant error. Also $p_E = p_F = 0$ in Pa gage.

Thus, pressure at **G** = pressure at **E** – pressure of (3.4 – 3.0)m of gage liquid

or

$$p_G = p_E - (\text{rl dn} \times 9810)(3.4 - 3.0)$$

$$-3150 = 0 - (\text{rl dn} \times 9810)0.4 \quad \text{and} \quad \text{rl dn} = 0.8$$

PROBLEM 7 (15 points)

The loss through a device **X** is to be measured by a differential gage using oil of relative density **S** = 0.750 as the gage fluid. The liquid flowing has relative density, **S** = 1.50. Find the change in pressure head between **A** and **B** for the deflection of the oil shown in the figure below.

Note: The numbers on the side of the manometers represent elevation in metres

Solution:

$$\text{Pressure at } C \text{ in Pa} = \text{pressure at } D \text{ in Pa}$$

$$p_B - (1.5 \times 9810)0.7 - (0.75 \times 9810)0.9 = p_A - (1.5 \times 9810)3.4$$

$$\text{Then } p_A - p_B = 33\,100 \text{ Pa, and difference in pressure heads} = \frac{33\,100}{\rho g} = \frac{33\,100}{1.50 \times 9810} = 2.25 \text{ m of liquid.}$$

Another method:

Using metres of liquid (rl dn 1.50) units.

$$\text{pressure head at } C = \text{pressure head at } D$$

$$\frac{p_B}{\rho g} - 0.7 - \frac{0.750 \times 0.9}{1.50} = \frac{p_A}{\rho g} - 3.4$$

$$\text{Then } p_A / \rho g - p_B / \rho g = \text{difference in pressure heads} = 2.25 \text{ m of the liquid, as before.}$$