Week 12- Problems

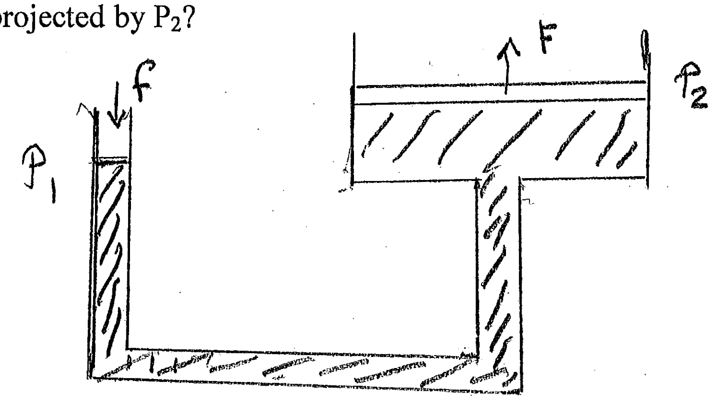
12-1. a) Show that in a gas or liquid, near Earth, the pressure change in going from height y to $(y+\Delta y)$ where $\Delta y \ll 1\text{m}$ is given by

$$\Delta P = -d\, g \Delta y \qquad \text{-- (1)}$$

Where d is the density.

b) Explain why Eq(1) can be used to calculate the pressure change for any Δy in a liquid but not in a gas.

12-2. In a hydraulic press the diameters of the pistons P_1 and P_2 are 1cm and 30cm, respectively. If you push down with a force f=50 N on P_1, what force F will be projected by P_2?



12-3. What is temperature? Develop the definition by taking two thermodynamic systems which are isolated from the surroundings but separated from one another by a conducting wall. Each system contains a certain amount of gas.

12-4. At what temperature do the Celsius and Fahrenheit scales have the same numerical value?

12-5. What is heat? What is the difference between specific heat and latent heat?

12-6. A copper sphere of radius 2.000cm is placed over a hole of radius 1.999cm in an aluminum plate at 20°C. The expansion coefficients are $\alpha_{cu} = 17 \times 10^{-6}\,C^{-1}$ and $\alpha_{Al} = 24 \times 10^{-6}\,C^{-1}$. At what common temperature will the sphere pass through the hole? Why?

12-7. A Pyrex glass beaker $\lfloor \alpha = 3.2 x 10^{-6} C^{-1} \rfloor$ of volume $100cm^3$ is filled to the brim with water $\lfloor \beta = 2.1 x 10^{-4} C^{-1} \rfloor$ at 20°C. If you put it in a microwave oven and let the temperature rise to 90°C, how much water will spill out?

12-8. A 250-g lead ball at 210°C is placed in a 90g aluminum calorimeter that contains 200g of liquid at 20°C. If the find temperature is 25°C, what is the specific heat of the liquid $[C_{Pb} = 130 J/kg - C, C_{Al} = 900 J/kg - C]$?

12-9. 20g of ice at -5°C are dropped into a calorimeter containing 100g of water at 20°C. Assuming that the mass of the calorimeter is negligible, calculate the final temperature $C_{ice} = 2000 J/kg-°C$, $L_{ice} = 334 x 10^3 J/kg$, $C_{water} = 4186 J/kg-°C$.

12-10. What is the difference between conduction and convection?

12-11. For flow of heat by conduction in the steady state, the heat current is written as:

$$\frac{DQ}{\Delta t} = -KA\frac{\Delta T}{\Delta X}$$

Why is there a <u>negative</u> sign on the right side of this equation?

12-12. A 1m long copper bar of cross-section 1cm x 2cm has one end in a steam chamber at 100°C and the other dipping in an ice bath at 0°C. If the thermal conductivity of copper is 39 J/m-sec-°C, how much ice will melt in 10 secs? $[L_{Ice} = 334x10^3 J/kg]$ (assume zero heat loss to surroundings)

12-13. Two spheres are made of the same material (Identical emissivities). Their diameters are 1m and 4m, respectively. (i) If they are at the same temperature, which one emits more heat radiation per sec and by what factor?
(ii) By what factor would you increase the temperature of the smaller one so it emits the same amount of heat per sec as the larger one?

12-14. When an object of surface area A and temperature T_1 is sitting inside an enclosure at temperature T_2 the heat exchange per sec is:

$$\frac{DQ}{\Delta t} = Ae\sigma(T_1^4 - T_2^4)$$

Where e is emissivity and σ is the Stefan-Boltzmann constant. Show that if (T_1-T_2) is much less than T_1 or T_2 this leads to Newton's law of cooling: rate of cooling is proportional to (T_1-T_2).