Homework Assignment #7 - Due Wed. 4/03/13

1) Estimate the depth in the ocean that the static pressure is 50% due to the water depth and 50% due to the air pressure above the water. Use 1G = 9.8 m/s^2 and 1 g/cm^3 for the density of sea water, and 1atm for the air pressure.

   $P_t = P_w + P_{air}$: $P_w = P_{air}$

   $P_{air} = 1atm = 101.325kPa$: $P_w = \rho gh$

   $\rho gh = 1atm \rightarrow h = \frac{1atm}{\rho g}$

   $h = \frac{101.325kPa}{1000kg/m^3 9.8m/s^2} = 10.3m$

   depth in the ocean = $10.3m$

2) A MEMS submarine is being used to monitor the cooling fluid in an industrial transformer. The transformer fluid (liquid) has a density of 2 g/cm^3. The sub is in motion and measures the total pressure (1960.1 Pa) and the static pressure (1960 Pa) that it experiences, using gage pressure sensors. For 1G = 9.8 m/s^2, estimate the velocity of the sub in mm/s?

   $\rho = 2g/cm^3 = 2000kg/m^3$

   $P_t = 1960.1Pa$: $P_s = 1960Pa$

   $P_t = P_s + \frac{\rho v^2}{2} \rightarrow v = \sqrt{\frac{2(P_t - P_s)}{\rho}}$

   $v = \sqrt{\frac{2(1960.1-1960)}{2000}} = 100\mu m/s$

   $v = 0.100mm/s$

3) For the sub in (2), what is the depth of the sub in mm, ignoring atmospheric pressure?

   $P_s = 1960Pa$: $P_s = \rho gh$

   $1960 = (2000)(9.8)(h) \rightarrow h = 0.1m = 100mm$

   depth of the sub = $100mm$

4) For the pressure sensor diaphragm shown below, the four identical P-type piezoresistors have a gauge factor of +180:

   (a) Under pressure, is each resistor in compression or tension?

   (b) Under pressure, has each resistor increased or decreased in resistance?

Resistor	(a)	(b)
R_1	Tension	Increased
R_2	Compression	Decreased
R_3	Compression	Decreased
R_4	Tension	Increased

5) Estimate the acceleration level of a shock event of a $1Kg$ object falling $10m$ onto a hard surface where it completely stops moving $10ms$ after initial impact. (1G = 9.8 m/s^2)

   $V_0 = 0m/s$: $V_1 = gt_1$

   $d = 0.5g{t_1}^2 \rightarrow t_1 = 1.428s$

   $V_1 = 9.8m/s^2 \times 1.428s = 14m/s$

   $V_2 = 0m/s$: $t_2 = 10ms = 0.01s$

   $V_2 = at_2 + V_1 \rightarrow a = \frac{V_2 - V_1}{t_2}$

   $a = \frac{-14m/s}{0.01s} = -1400m/s^2$

   shock acceleration = $1400m/s^2 \approx 142.8$G's

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