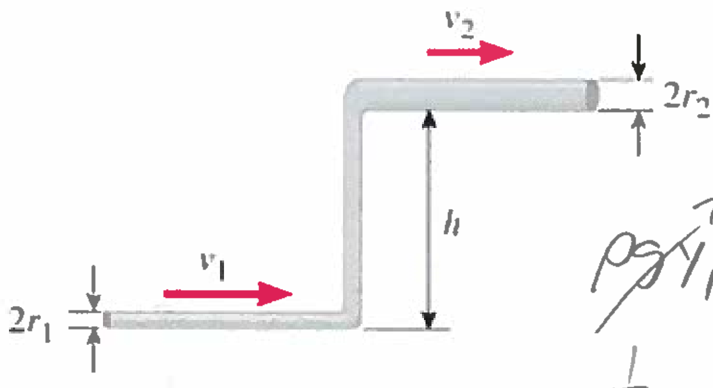
Physics 10154 - Exam #4C

Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (25 pts) Water is flowing through an S-shaped pipe as shown. The radius of the lower pipe is 3.2 cm. The radius of the upper pipe is 5.5 cm. The height difference (h) between the two pipes is 8.5 meters. What must the volume flow rate be in the pipe in order for the pressure in the two pipe sections the same?



$P_1 = P_2$

$\rho g y_1 + \frac{1}{2}\rho v_1^2 = \rho g y_2 + \frac{1}{2}\rho v_2^2$ ($y_1 \to 0$)

$\frac{1}{2}v_1^2 = gh + \frac{1}{2}v_2^2$

$v_1^2 = 2gh + v_2^2$

$A_1 v_1 = A_2 v_2$

$v_1 = \frac{A_2}{A_1} v_2 = \frac{\pi(.055)^2}{\pi(.032)^2} v_2 = 2.954 v_2$

$v_1^2 = 8.73 v_2^2$

$8.73 v_2^2 = 2gh + v_2^2$

$7.73 v_2^2 = 2gh$ $\quad v_2 = \sqrt{\frac{2gh}{7.73}} = 4.64 \text{ m/s}$

$A_2 v_2 = \pi(.055)^2(4.64) = \boxed{.044 \text{ m}^3/\text{s}}$

2. (25 pts) 185 grams of ice with an initial temperature of -15.0 °C is added to 850 mL of lemonade at an initial temperature of 25.0 °C. Assume the density of lemonade is the same as water (1000 kg/m3) and the specific heat is also the same as water (4186 J/kg °C). What is the final temperature of the system? If the final temperature is zero, how much ice melts?

Warm ice to 0°C = 5800 J
Melt ice = 61605 J } 67405

$M_L = \rho_L V_L = (1000 \frac{kg}{m^3})(850 \times 10^{-6} m^3) = 0.850 kg$

Cool lemonade to 0°C = -88953 J

Takes more energy to cool lemonade (88953 > 67405), so all ice melts. $T_F > 0$

$\Delta Q_{ice} + \Delta Q_L = 0$

$67405 + (.185)(4186)(T_F - 0) + (.850)(4186)(T_F - 25) = 0$

$67405 + 774.4 T_F - 88952.5 + 3558.1 T_F = 0$

$+21547.5 + 4332.5\, T_F = 0$

$T_F = \frac{21547.5}{433.25} = \boxed{5.0°C}$

3. (25 pts) An ideal gas has an initial density of 0.185 kg/m³. Keeping the number of moles and volume of gas constant in a fixed container, the pressure is increased by a factor of 1.50 while the temperature changes from 25.0 °C to 87.0 °C. What is the new density of the gas?

$$\frac{\rho_2}{\rho_1} = \frac{m_2/\bar{V}_2}{m_1/\bar{V}_1} = \frac{\bar{V}_1}{\bar{V}_2}$$

$$\frac{\bar{V}_1}{\bar{V}_2} = \frac{\left(\frac{n_1}{n_2}\right)\left(\frac{R}{R}\right)\left(\frac{T_1}{T_2}\right)}{\left(P_1/P_2\right)} = \frac{(1)(1)\left(\frac{298}{360}\right)}{\left(1/1.50\right)}$$

$$= 1.24$$

$$\rho_2 = 1.24\,\rho_1 = \boxed{0.230\ \text{kg/m}^3}$$

4. (25 pts) A person stands at the midpoint between two speakers that are broadcasting uniformly in all directions with no reflections. The speakers are 28.0 meters apart and the power of the sound coming from each speaker is 0.0130 Watts.

a) What is the loudness (dB) at the person's initial position halfway between the speakers?

b) If the person walks 7.00 meters in the direction of one of the two speakers, what is the loudness (dB) at the new location?

a) $I = 2 * \frac{.0130}{4\pi(14)^2} = 1.0556 \times 10^{-5}$

$\beta = 10 \log\left(\frac{1.0556 \times 10^{-5}}{10^{-12}}\right) = \boxed{70.2 \text{ dB}}$

b) $I = \frac{.0130}{4\pi(7)^2} + \frac{.0130}{4\pi(21)^2} =$

$= 2.11 \times 10^{-5} + 2.35 \times 10^{-6} = 2.35 \times 10^{-5}$

$\beta = 10 \log\left(\frac{2.35 \times 10^{-5}}{10^{-12}}\right) = \boxed{73.7 \text{ dB}}$