

Assignment #1 – Due May 22nd

Due: *Wednesday, May 22nd not later than 8:30 a.m. in class.*

Alternately, you may drop off this assignment May 22nd not later than 8:15 a.m. in Professor Houtman's PHY1122 drop box on the 3rd Floor of the STEM building.

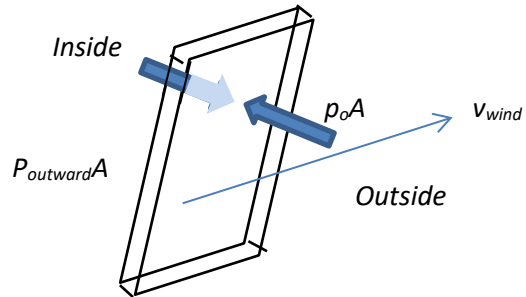
1. A young boy at summer camp stands on a wooden raft ($\rho_w = 700 \text{ kg/m}^3$) floating in a freshwater lake ($\rho = 1000 \text{ kg/m}^3$) and finds that his weight just cancels the buoyancy of the raft; the water touches the soles of his feet but the raft doesn't sink. He then jumps onto rectangular block of Styrofoam ($\rho_s = 50 \text{ kg/m}^3$). The Styrofoam has 1/3 the volume of the wooden raft, but now the top of the Styrofoam block sits 3 cm above the waterline with the boy standing on top. (a) How many centimetres of the Styrofoam block sit below the water?, and (b) How thin can the Styrofoam block be until it just supports the weight of the boy?

2. A constant volume gas thermometer contains an ideal gas which is known to have a *linear response** between temperature and pressure over a wide range. The thermometer was calibrated using two substances with known values. First, the bulb was immersed in Liquid nitrogen, which has a temperature of $-195.8\text{ }^{\circ}\text{C}$. This gave a reading of 0.3642 atm . Second, the bulb was immersed in boiling ethyl alcohol with a known temperature of $78.37\text{ }^{\circ}\text{C}$. This gave a reading of 1.6352 atm . (a) Based on this information, what would be the estimated value of absolute zero, in $^{\circ}\text{C}$, i.e. the temperature of the thermometer when the pressure was zero? (b) What temperature would be inferred if the pressure was at 611.2 Pa , the pressure used for the triple point of water?

*Hint: a linear response guarantees that the equation will have the general form $T = aP + b$, where T and P are the temperature and pressure, respectively, a is the slope of the curve, and b the temperature in $^{\circ}\text{C}$ at which the pressure is zero. Given two equations with two unknowns (a and b) you should be able to determine b without needing to plot the result on a graph.

3. In the year 2021 an eccentric billionaire (and former U.S. president) decides to build a steel band ($\alpha_{\text{steel}} = 1.25 \times 10^{-5} \text{ K}^{-1}$) around the world at the equator. As initially constructed, this band sits on the surface of the planet and forms a perfect ring of radius $R = 6371 \text{ km}$. Since the billionaire doesn't believe in global warming, he orders his engineers *not* to build any expansion joints into the structure. If the mean temperature of the planet rises $0.50 \text{ }^\circ\text{C}$ by 2061, then (a) how high off the ground will this ring sit then, in meters? (b) what is the annual increase in the height of the steel band each year?

4. The Bernoulli effect plays an important role in the construction of skyscrapers. For example, when it was first constructed, the John Hancock Tower in Boston faced problems with windows panes that burst out of their frame and shattered on the ground below whenever there was a strong wind blowing. The building's ~10,000 windows were replaced at a cost of ~\$7 million to the structure. Why did this happen? Consider the following question: (a) If a horizontal wind blows



across the face of a skyscraper window with an area of 3.6 m X 1.1 m and a speed of 12.0 m/s, what is the total force exerted on the window pane due to the flow of air outside the window? Assume the density of air is 1.2 kg/m³ (b) Assume a hurricane rolls up the Atlantic coast, and the wind speed outside the skyscraper window increases to 60.0 m/s. How does this effect the force exerted on the window pane?

5. A kitchen tap has a radius of 0.90 cm. When it is turned on, a steady stream from the tap fills a 150-cm³ container in 18.3 seconds. Find the diameter of the stream at a point 10.0 cm below the tap. (Hint: $dV/dt = Av = \text{const}$ at all points along the stream)

6. A taxi driver fills up his cab early in the morning when the temperature is $-20\text{ }^{\circ}\text{C}$ and the density of gasoline is 730 kg/m^3 . Assuming he purchases 40 litres of gas at this temperature, how many extra kilograms of gasoline will he get by filling up at this time, rather than if he waited later in the day when the temperature of the gas is $0\text{ }^{\circ}\text{C}$. Assume that (1) the pump is not temperature compensated, and (2) $\beta = 9.60 \times 10^{-4}\text{ K}^{-1}$ for gas (3) The temperature of the car, and the gas tank, remain constant.