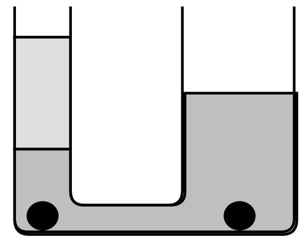
Name ____

PLEASE READ THIS FIRST: Work the problems on separate sheets of paper and staple this sheet to the front. Read each problem carefully. Show your work and/or give brief explanations for *all* answers. (But there is *no* need to be as "wordy" or formal as on the homework.) Make sure that all numerical answers are given with a reasonable number of sig figs and that you have included appropriate units. Check your answers for physical *reasonableness* whenever possible. I do give partial credit, but *only* if I can figure out what you are doing, so be as clear as possible.



1. [20 pts total] The U-tube in the diagram has circular cross sections on both sides. The left side has a cross sectional *area* of 100 cm^2 and the right side has twice the *diameter* of the left. The tube is partially filled with mercury (density = 13.6 g/cm^3) and then 2.00 liters of water (density = 1.00 g/cm^3) are poured into the left side. Two identical 3.0 cm diameter spheres made of solid platinum (density = 21.4 g/cm^3) rest fully submerged in the mercury at the bottom of each side.

   a) [4 pts] What is the cross sectional *area* of the right side?

   b) [4 pts] What is the *height* of the water column?

   c) [8 pts] What is the *level difference* between the tops of the mercury columns on each side?

   d) [4 pts] Which platinum sphere experiences the *larger buoyant force* or are they *equal*? Explain *briefly* and *clearly.*

2. [15 pts] (*This problem is intended to give you a feel for both 1) the amount of energy locked up internally in a gas and 2) the amount of energy required to produce very loud sounds.*) Suppose that *all* of the internal energy in one cubic meter of air was (somehow) extracted and used to produce one hundred decibel sound at a distance of ten meters. For about how long a *time* would the sound be produced? [Hints: Model the air as a diatomic ideal gas at atmospheric pressure and 20°C and determine its internal energy. Model the sound as coming from an isotropically radiating point source and determine the power required to produce the specified sound level at the specified distance.]

3. [25 pts total] A monatomic ideal gas with initial pressure P_i and initial volume V_i undergoes 1) an *isobaric expansion* from state A (the initial state) to state B where it has *five times its initial volume*, 2) an *isovolumetric cooling* from state B back to its *initial temperature* in state C, and 3) an *isothermal compression* from state C back to its *initial volume*.

   a) [4 pts] Indicate what the cycle looks like on a PV diagram. Scale the axes with the volumes and pressures of states A, B, and C (in terms of P_i *and* V_i) and label the "legs" of the cycle "1", "2", and "3" as described above.

   b) [12 pts] Find the values of Q, W, and ΔE_{int} for each of the three legs and present them in a simple table. [Each entry should be given in terms of a numeric factor times the product P_iV_i.]

   c) [3 pts] Which of the three states—A, B, or C—has the lowest entropy? Which has the highest entropy? [Be sure to explain in both cases!]

   d) [3 pts] What would be the efficiency of a reversible heat engine based on this cycle? [Here, and in the next part, I am looking for a numerical answer.]

   e) [3 pts] What would be the efficiency of a Carnot heat engine that runs between the same temperature extremes as this cycle?

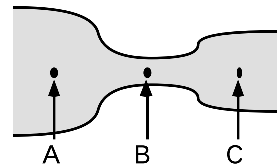
4. a) [8 pts] What maximum altitude would be reached by a projectile that is fired vertically upward at a speed of 5.0 km/s from the surface of Earth? [Hints: Even though it is *clearly* unreasonable to do so, neglect air resistance. Use the more general formula $-\frac{Gm_1m_2}{r}$ for gravitational potential energy. The mass of the earth is 6.0 x 10^{24} kg and its radius is 6.37 x 10^6 m.

   b) [2 pts] Why *can't* you use the formula *mgh* for the gravitational potential energy in this case?

Score ____/100

5. [7 pts] 100 grams of ice at 0°C and 50 grams of water at 64°C are combined in a well insulated calorimeter of negligible heat capacity. How much of the ice melts? [c_{water} = 1.00 cal/g°C, c_{ice} = 0.50 cal/g°C, and L_{fusion} = 80 cal/g]

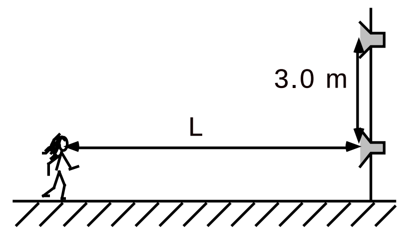
6. [6 pts] Water flows from left to right through a pipe as shown at right. Rank the *pressures* at the indicated positions from *highest to lowest* and *explain* the reasons for your ranking order in terms of physical principles.



7. [7 pts] A sinusoidal ocean wave causes a small boat that is otherwise at rest to move through a total vertical distance of 5.0 meters from its *lowest* point to its *highest* point in 3.0 seconds. Another small boat that is 45 meters away in the direction from which the waves are approaching, is always *half* way *up* the *next* wave whenever the first boat is *at the top* of its own wave. Draw a picture labeled with most of this information and determine the values of the wave's

   a) amplitude, b) frequency, c) angular frequency, d) period, e) wavelength, f) angular wave number, and g) speed

8. Two speakers are driven by the same oscillator with a frequency of 500 Hz on a day when the speed of sound is 340 m/s. The speakers are located 3.0 meters apart on a vertical pole. Starting from very far away, a woman walks straight toward the lower pole as shown in the figure at right.



   a) [5 pts] At how many places will she hear a relative minimum in the sound intensity due to destructive interference between the two sources of sound? (As *always*, explain.)

   b) [5 pts] What is the *smallest* distance L for which this happens?