Warm-up problems

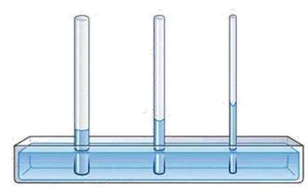
1. **Heat, energy and work.** The 1.20-kg head of a hammer has a speed of 7.5 m/s just before it strikes a nail and is brought to rest. Assume the nail does not melt or deform. What happens to the kinetic energy of the hammer if this energy is completely absorbed by the nail? What is the energy change of the nail? Do you have enough information to calculate the total thermal energy of the nail?

2. **Calculating work**. You may remember from another course that an ideal gas is a simplified version of a gas in which we imagine gas particles as particles that move and collide with one another. We can relate the temperature, pressure, and volume of the gas using the ideal gas law: PV = nRT. In this relationship, P is the pressure of the gas, V is the volume of the gas, n is the number of moles of gas[1], R is a constant, and T is the temperature of the gas. Constant volume, changing pressure and temperature:
    a. What is the work done by the gas if its volume remains constant at 5.0 m^3 while its pressure changes from 5.0 kPa to 3.0 kPa?
    b. Sketch a plot of pressure vs. volume of the ideal gas in this situation. To do this, you can plot points. What is the pressure of the gas when the volume is 5.0 m^3?
    c. A gas is enclosed in a cylinder fitted with a light piston that moves without friction. This piston always exerts a constant, atmospheric pressure on the gas so that the pressure within the gas is constant, atmospheric pressure. 1250 kJ of heat is added to the gas at the same time the volume of the gas decreases from 18.2 m^3 to 12.0 m^3. What is the work done by the gas on the environment in this process? What is the work done by the environment on the gas in this process? What is the energy change of the gas? What is the energy change of the environment?

Turn-in problems

1. What is the pressure difference between two ends of a pipe that are separated by 1.9 kilometers? In this situation, the pipe has a diameter of 29cm. It transports oil at a rate of 650 cm^3/s. The oil has density 950 kg/m^3 and viscosity coefficient 0.20 Pa s.

2. For the liquid and tubes shown in the image, which forces are stronger in the fluid: adhesion or cohesion? How can you tell? How can you explain this picture in light of the hydrostatic pressure equation?



3. **Heat, energy and work.** At a crime scene, the forensic investigator notes that a 7.2-g lead bullet was stopped in a door frame and melted completely on impact. Describe the energy in this problem just before the bullet hits the frame and after it melts: what kinds of energy and how much are present at each time? Assume no energy is used deforming the door frame. Note: although you do not know the thermal energy of the bullet before it hits the door frame, how does it compare to the thermal energy in the bullet after it hits the door frame?

[1] A mole is just a unit of number of particles. 1 mole = 6.02214129(27)×10^{23} particles.

4. **Calculating work.** A gas is enclosed in a cylinder fitted with a light piston that moves without friction. This piston always exerts a constant, atmospheric pressure on the gas so that the pressure within the gas is constant, atmospheric pressure.
    a. Sketch a plot of pressure vs. volume in this situation. To do this, you can plot points. What is the pressure of the gas when the volume is 12.0 m^3? 18.2 m^3?
    b. When 1250 kJ of heat is added to the gas, the volume of the gas increases from 12.0 m^3 to 18.2 m^3. What is the work done on the environment by the gas in this process? What is the work done on the gas by the environment in this process? What is the energy change of the gas? What is the energy change of the environment?

5. **Calculating work**: **changing volume and pressure, constant temperature.**
    a. Set up an expression (integral) to calculate the work done by external forces if an ideal gas expands in volume from 1.0 m^3 to 6.0 m^3 while its temperature remains constant (pressure is not constant). If you want to solve this integral, recall that $\int \frac{dx}{x} = ln(x)$. $\int \frac{dx}{x} = ln(x)$ and $ln(a) - ln(b) = ln(\frac{a}{b})$.
    b. Sketch a plot of pressure vs. volume of the ideal gas in this situation. To do this, you can plot points. What is the pressure of the gas when the volume is 1.0 m^3? 6.0 m^3? Use the ideal gas law to determine the shape of the plot.