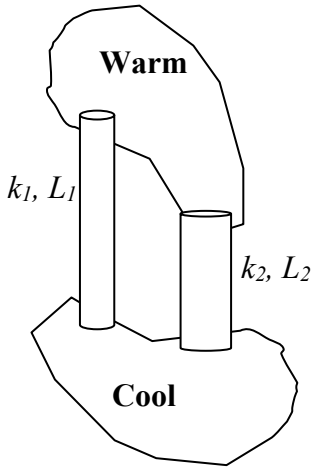


You ditch class and go to the beach. There you find two enormous tide pools. One of them happens to be in the shade and happens to be 5°C cooler than the other one. You decide to get all crazy and connect the two pools using two dissimilar metal rods. Rod 2 has three times the area of rod 1. You set up the system such that each rod transfers the same amount of heat from the warm pool to the cool pool. The conduction coefficient of rod 1 is four times that of rod 2. Assume the only heat transferred is by conduction through the rods.

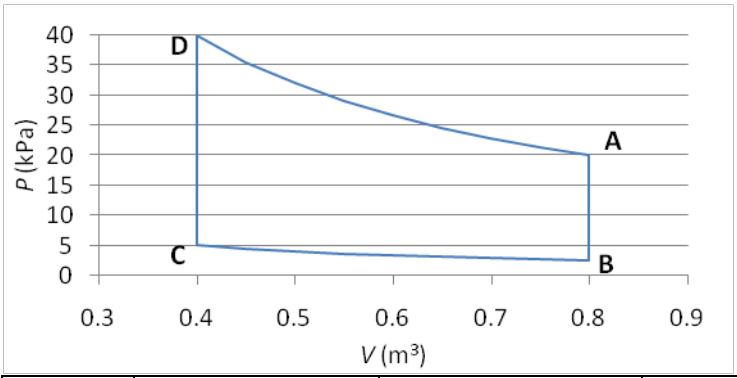
***1a) What ratio of rod lengths (L_2/L_1) causes the rods to transfer heat at the same rate? Assume steady state.

**1b) 20 grams of H_2O at 0°C are frozen into ice by putting it in contact with a very cold piece of metal. Determine the change in entropy of the H_2O (getting the sign correct). Required constants are on the eqt'n sheet.

*1c) Compare the entropy change of the metal to the entropy change of the H_2O. Discuss both the sign of the entropy change and the magnitude of the entropy change of the plate. Also mention the entropy change of the universe for the process of making the ice. **Use the back of this page to write your answer.**

A tire has a gauge pressure of 40 PSI (assume 1 atm = 15 PSI) at 20°C. The tire heats up to 45°C. The volume of the tire is approximately constant. In order to keep the tire at a gauge pressure of 40 PSI, you let some of the air out.

******2) What fraction of the air do you need to let out of the tire?



******3a) A PV diagram is shown for a Stirling engine. The engine uses a diatomic gas between 100K and 1000K. Assume the cycle runs CW. Complete the chart below. **Notice that the units of the pressure are given in kPa and the chart below uses kJ!** You shouldn't need the number of moles or the temperature at each point to do this calculation. If a process is not one of the major four types, list OTHER for the process type. For the degrees of freedom, assume the value is constant given by the value used for almost all of the cycle.

Process	**Process Type**	***Work done on gas* (kJ)**	***Q added to gas* (kJ)**	**ΔE *of gas* (kJ)**
A to B				
B to C	isothermal			
C to D				
D to A				
For entire cycle				

*3b) Calculate the efficiency of the cycle.

efficiency	

*3c) Suppose you want the engine to produce 20.0 Watts of power. How much energy per second must be absorbed by the engine?

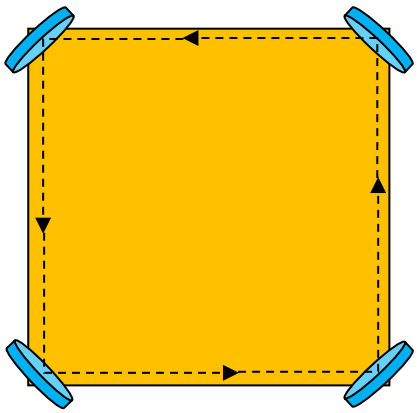
how much erg per sec?	

A spherical balloon with diameter D is filled with helium from a pressurized tank. The balloon is initially empty (r=0). The pressure in the balloon varies according to the equation $P = a(r + b)^2 - c$.

*4a) Determine the units of a, b, and c.

units of a	units of b	units of c

*****4b) Determine the magnitude of work done in filling the balloon. Your answer should be in terms of D, a, b, and c.



A particular ring laser is constructed as shown in the figure. The dotted lines indicate the laser beam with wavelength 600 nm. The cylinders are mirrors. The solid line indicates the boundary of a thin metal plate with area density 25.0 kg/m^2. You may assume the laser beam path forms a square essentially identical to the size of the metal plate. Each side of the plate has length 0.250 m.

As the laser gets hot the plate expands. If it expands too much, the light waves going around the path will be out of phase with each other and the laser will stop working. This problem studies this situation.

As a result of the laser being on, the metal plate absorbs 20 J of heat. The specific heat of the plate is c=400 J/kg·°C. The linear expansion coefficient for the plate is 15×10^{-6} °C^{-1}.

******5a) Determine the change in length of one side of the square. Compare this to the wavelength with a percent difference. If the percent difference is significant (say more than 5%), the laser will operate poorly.

ΔL	
%diff	

****6a) Determine the average speed $\bar{v}$ and standard deviation σ of the Boltzmann distribution for a collection of monatomic gas molecules with average temperature T and mass m. The standard deviation is given by $\sigma = \sqrt{\overline{v^2} - \bar{v}^2}$. Your answers should be in terms of the variables k_B, m, and T. For extra practice, repeat these calculations using the 2D distribution function described in 19.10 on page 85

$\bar{v}$	
σ	

**6b) Describe what happens to the average speed and the width of the speed distribution (measured by σ) at low temperatures. Use this to describe the motion of the particles of gas as the temperature gets lower and lower. Use the back of this page to discuss your answer.

*Extra Credit: First show the efficiency of a Stirling engine is given by $e = \frac{R(T_H - T_C) ln\frac{V_2}{V_1}}{RT_H ln\frac{V_2}{V_1} + C_V(T_H - T_C)}$ where V_2 is larger than V_1. Then assume you have 2.00 moles of a diatomic gas operating using the PV diagram shown earlier. Determine the numerical value of efficiency.