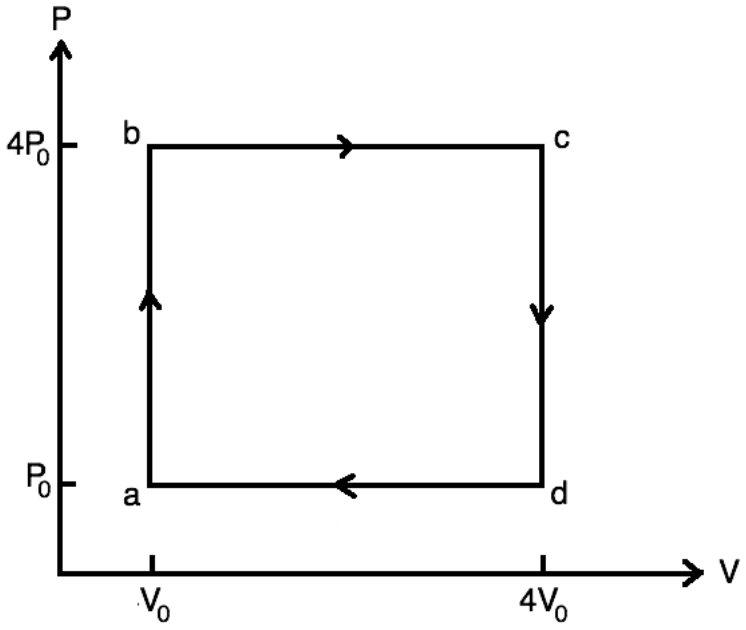
Studio PHY-2048C
Thermodynamics, Week 15

Cycles in a heat engine

The basic idea of a heat engine is to add heat to a gas, and have the gas perform work on its environment via an expansion, which in turn is used to power motion. The gas is then restored to its original temperature and the cycle begins again. You can assume that the same amount of gas remains in the engine during the cycle. A convenient way to think about these cycles is a pressure vs. volume plot.

(a) Suppose a gas is follows the rectangular path shown in the P-V plot.



For each of the parts of the cycle, use the first law of thermodynamics conservation of energy), $Q = W + \Delta U$, where Q is the heat added **to** the gas, W is the work done **by** the gas, and ΔU is the change in the internal energy $\Delta U=(5/2)nR\Delta T$ of the gas. Assume we are using a diatomic gas like N_2, and treat it as an ideal gas so $PV = nRT$. Fill in the table with the sign (+, 0, or -) of each of these quantities:

	Q	W	ΔU
a to b			
b to c			
c to d			
d to a			

(turn over)

(b) If the temperature of the gas at point a is T_0, what is the temperature at points b, c, and d?

For the following, express your answers in terms of only P_0 and V_0.

(c) What is the internal energy of the gas at points a, b, c, and d?

(d) How much heat is added to the gas during the heating phase (from a to b)?

(e) How much work is done **by** the gas during the expansion phase (from b to c)?

(f) How much heat is added **to** the gas during the expansion phase (from b to c)?

(g) How much work is done **by** the gas during the compression phase (from d to a)? What is the net work done **by** the gas during the entire cycle?

(h) What is the ratio of the **total** heat added **to** the gas (during the heating and expansion phases) to the net work done **by** the gas?