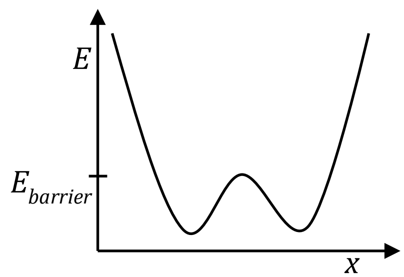
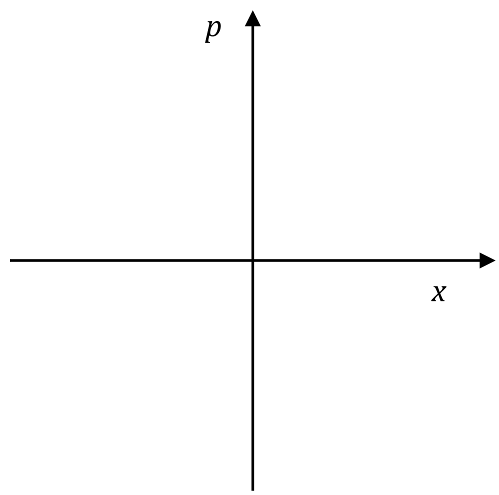
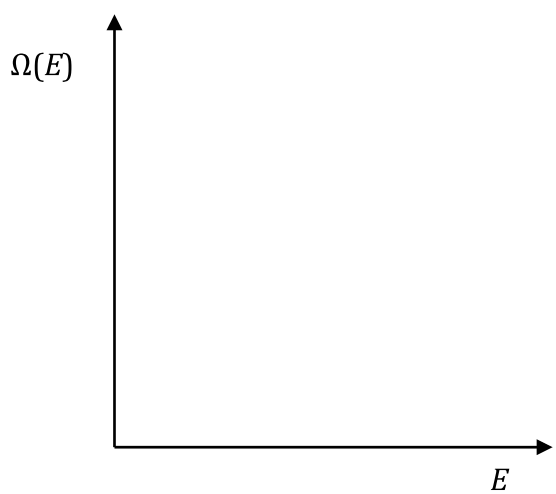
PHYS 4200 Name_____________________________
Midterm exam
Exam is open book, open notes; each problem is worth 10 points.

1. Consider the following double-well potential. At low energies, each of the two lower wells is harmonic with frequency ω. At very high energies, the system behaves like a single harmonic well, again with frequency ω. The barrier has an energy of $E_{barrier}$. Sketch the classical phase space diagram for (a) $E << E_{barrier}$, assuming that $x < 0$, (b) $E >> E_{barrier}$, and (c) E slightly above $E_{barrier}$. (d) Sketch the density of states for this system, $\Omega(E)$.



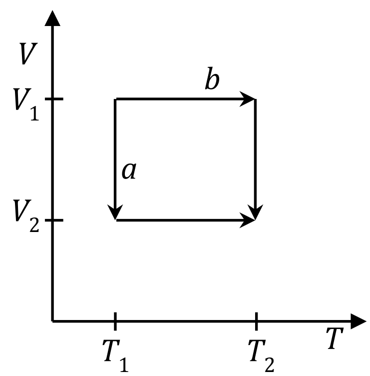




2. The pressure, p, due to the thermal equilibrium radiation field inside a cavity depends only on the temperature T of the cavity and not on its volume V,

$$p = \frac{1}{3}\sigma T^4$$

In this expression σ is a constant. Find the work done *by* the radiation field as the cavity is taken between states (V_1, T_1) and (V_2, T_2) along the two paths shown in the diagram.



3. Is the following equation an exact differential of a function $F(x,y)$? If so, solve for F.

$$\text{đ}F = 2x\left(x^3 + y^3\right)dx + 3y^2\left(x^2 + y^2\right)dy$$

4. If a gas is confined in a container, a fraction of the atoms will inevitably be found on the wall, a process known as physical adsorption. We will study this by neglecting the kinetic energy of the atoms and using a discrete model for the locations of the atoms in the bulk and on the surface.

Define M as the number of spatial cells the atoms may occupy in the bulk and N as the number of spatial cells on the surface. The gas consists of N atoms (just enough to completely fill the surface states). Define n as the number of atoms actually on the surface: $n \le N$. An atom has an energy $-\varepsilon$ while on the surface and 0 while in the bulk; thus $E = -\varepsilon n$. M, N, and ε are constants; n is a variable. M, N and n are all very large.

(a) Find the density of states as a function of n, giving $\Omega(n)$. (Hint: think about the bulk and surface separately.)
(b) Derive an expression relating n to the temperature of the system. You do *not* have to solve the expression to find an explicit relation $n = n(T)$.
(c) Find n when $T = 0$. Use the result from part (b) or physical reasoning.
(d) Find the limit of n/N as $T \to \infty$. Use the result from part (b) or physical reasoning.