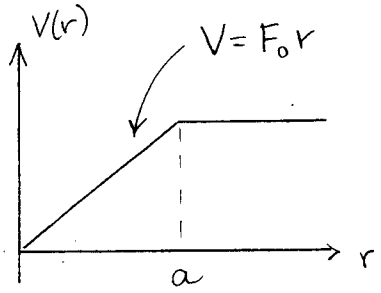
Physics 448 **EXAM 1** **October 17, 2008**

1) In this problem the variable x is the distance traveled between collisions by an atom as it moves through a gas. Assume that the distribution function for travel distances is $F(x) = Ce^{-\alpha x}$. [Helpful information: $\int_0^\infty x^n e^{-x} dx = n!$.]

   (a) Find the average distance traveled between collisions. The average distance is called the mean free path, λ.

   (b) Find the probability that a given atom will travel more than 2λ before its next collision.

2) A particle of mass m moves under the influence of an attractive central force. The force is constant ($F = F_0$) for $x < a$ and zero for $x > a$. The corresponding potential energy function is shown at the right.



   (a) Use the assumptions and methods of the Bohr model to find the radii r_n and energies E_n of the circular orbits.

   (b) Find the number of bound states for an electron in this potential well if $a = 2\,\text{nm}$ and $F_0 = 1.0\,\text{eV/nm}$.

3) Show that the wave function $\psi(x) = Ce^{-ax^2}$ is a solution to the time independent Schrodinger equation for the harmonic oscillator problem ($V = \frac{1}{2}kx^2$) for the appropriate value of a. Find the correct value of a and the energy of the state.

4) In a moderate size cavity there are many electromagnetic standing wave modes with wavelength λ close to 600 nm. Find the probability that the energy of a given mode at this wavelength will be hc/λ (i.e. that exactly one photon will be present) if the temperature of the cavity is 1500 K. [Suggestions: Calculate the photon energy and the value of kT. What do the results tell you?]

$k = 8.617 \times 10^{-5}\,\text{eV/K}$ $\quad m_e c^2 = 5.11 \times 10^5\,\text{eV}$ $\quad \hbar c = 197.33\,\text{eV}\cdot\text{nm}$