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Physics 416
Problem Set 3
Due May 3, 2010

1) The probability density function (*pdf*) (often called a Maxwellian Distribution) that describes the speed v of molecules in an ideal gas is given by:

$$p(v) = \frac{4}{\sqrt{\pi}}\left(\frac{m}{2kT}\right)^{3/2} v^2 e^{-\frac{mv^2}{2kT}}$$

Here m is the mass of the molecule, k is the Boltzmann's constant, and T is the temperature.
a) Show this is a properly normalized *pdf*.
b) Find the most probable speed.
c) Find the average speed.
d) Find the variance of the speed.

2) Taylor P3.22, page 83.

3) Taylor P3.24, page 83.

4) Taylor P3.28, page 85.

5) Taylor P3.46, page 90.

6) In the Bohr theory of the structure of the hydrogen atom the energies of the various quantum states are given by:

$$E_n = -\frac{me^4}{2N^2\hbar^2}$$

With: m the mass of the electron
e the electric charge of the electron
$\hbar$ Planck's constant divided by 2π
If: $\sigma_m/m = 0.1\%$ (i.e. the mass is known to 0.1%)
$\sigma_e/e = 0.2\%$ (i.e. the charge is known to 0.2%)
$\sigma_\hbar / \hbar = 0.1\%$
a) Calculate σ_E/E for arbitrary N.
b) If the precision of σ_E/E is to be improved which of the three quantities should be determined more precisely?

7) The decay of an unstable particle is described by the following probability density function in terms of the decay time (t) and the particle's lifetime (λ).

$$p(t,\lambda) = \frac{e^{-\frac{t}{\lambda}}}{\lambda}$$

Three measurements of t ($t_1 = 7$ sec, $t_2 = 3$ sec, $t_3 = 4$ sec) are made.
a) Write down the likelihood function for this problem.
b) Use the Maximum Likelihood Method to calculate the value of λ for this data set.