Physics 225b Homework 1 Due January 20, 2003

1) Following the derivation that we performed in class for the Poisson distribution, consider the probability that a particle does not decay in a time $(t + \Delta t)$.

a) Form an expression for the time derivative of $P_0(t)$ as the limiting case when $(\Delta t \to 0)$. (Hint: Consider $P_0(t + \Delta t) = P_0(t)P_0(\Delta t)$)

b) Consider the probability that a decay occurs in a short time interval (Δt) after a time interval, t, where no decay has occured. This should be the probability that the particle decays at a certain time $t_1 = t + \Delta t$. Show that this behaves like a probability: take your expression and sum over Δt by replacing Δt by dt and integrating from 0 to infinity. You should get 1.

c) If you take your expression in part b) and divide by Δt, you'll get the probability/unit time that a decay occurs at specific time t, and hence, the distribution of decay times, normalized, for this particular particle. This is useful! What is the most likely value for t in this distribution?

2) Consider the expression for resistance, $R = \rho\ell/A$. For a conductor, you are interested in the change in resistance for a change in temperature. The change in resistivity with temperature can be considered as:

$\Delta\rho = \rho_o \alpha_\rho \Delta T$

And the change in length can be considered as:

$\Delta\ell = \ell_o \alpha_\ell \Delta T$

a) Find an expression for ΔA as a function of temperature using the expression for $\ell + \Delta\ell$ dropping terms of order α_ℓ^2.

b) Using $\alpha_\rho = 3.9 \times 10^{-4}/^oC$ and $\alpha_\ell = 2.9 \times 10^{-5}/^oC$ find the change in resistance due to a change of 100^oC for a piece of stuff that has $R_0 = 100\Omega$.(In practice you would have to worry about where α was measured and how linear it is.)

c) Repeat part b) treating the changes in ρ, ℓ and A as correlated errors.

d) If you can read the temperature difference with an accuracy of 0.1^oC what is the uncertainty in your estimate for the change in resistance?

3) An experiment was performed using a very sophiticated constant volume thermometer. Everything is corrected automatically, except that the machine did not record atomospheric pressure for each data point. The only hope you have of using this data is to use the pressure gauge attached to the wall that monitors and records the pressure every few minutes in the room every day. (Constant volume thermometers use pressure differences. The idea is to use the ideal gas law and plot pressure versus temperature and extrapolate the data to zero pressure to find zero temperature). Unfortunately, this pressure reading is only accurate to 5% of its reading, so all your data points have an error of 5% of the reading attached to them. Find absolute zero using this data. How does this error extrapolate into your estimate for absolute zero? Does your result agree with the standard. You will need to fit the data using a least squares fit with all the errors and correlations taken into account and give me some indication you know what is going on with your fit (i.e. do some checking).

Data Point 1: $P_1 = 1.036\ atm$, $T_1 = 0.01000^oC$ (Triple point of water)
Data Point 2: $P_2 = 0.9104\ atm$, $T_2 = -38.8344^oC$ (Triple point of mercury)
Data Point 3: $P_3 = 0.3010\ atm$, $T_3 = -189.3442^oC$ (Triple point of argon)
Data Point 4: $P_4 = 0.1919\ atm$, $T_4 = -218.7916^oC$ (Triple point of O_2)
Data Point 5: $P_5 = 0.0953\ atm$, $T_5 = -248.5939^oC$ (Triple point of neon)