LAB 10 RADIOACTIVE DECAY

EXPERIMENTAL GOAL

In this lab, you will work with a computer simulation of the radioactive decay process. The computer program *RadDecay* models the decay process by assuming that every atom has a fixed probability of decaying during a given time interval (called a “step”): see the code snippet at the bottom of this sheet. You can specify this probability as well as the initial number of atoms.

Use this program to answer these questions:

1. Because of the random nature of the decay process, the number of atoms decaying during the nth step after $t = 0$ will vary from trial to trial, even if the initial number of atoms for each trial is the same. The *standard deviation* in the number of atoms that decay in a given step turns out to be a simple function of the *average* of the number decaying during that step. See if you can figure out what that function is. *Hints:* Large numbers and many trials yield better statistics; going more than a couple steps away from $t = 0$ also helps ensure true randomness. Your standard deviations will themselves be uncertain by about ±30% (you might check this.)
2. *Theoretically*, the decay constant λ that appears in the decay equation $N(t) = N_0 e^{-\lambda t}$ is approximately equal to p/dt, where the probability p that a given atom will decay during the time interval dt, in the limit that $p << 1$). Use *RadDecay* to “experimentally” verify that this is true.
3. Again, in the limit that $p << 1$ and the initial number of atoms $N_0 \to \infty$, an atom’s *average lifetime* becomes a simple function of λ. Verify that *RadDecay* correctly computes the average lifetime, and then see if you can guess what this function is and justify your guess.
4. Finally, your instructor will demonstrate an actual radioactive decay process. Using the data that you will take in class, determine λ and the half-life for this radioactive substance. Use your answer to the first question to estimate the uncertainties.

PROCEDURAL COMMENTS

Your lab instructor will do the experimental run using the actual radioactive substance at the beginning of lab. You will all take data from this run together for the first twenty minutes of lab or so. Simply record the data in your notebooks and analyze it only *after* you have completed your work on at least the first two questions above. You will find *LinReg* helpful in addressing questions 2 and 4 and maybe question 1 as well).

CHECKOUT INTERVIEW

At the end of the lab, you should be able to tell your grader the answer to each of the four questions AND be able to support your answer with convincing argument using your real or simulated experimental data. Be sure that your answers to each of the first three question involve data from more than just one choice of the parameters p and N_0: make your case as strong as possible.

(Crucial Code Snippet from *RadDecay*)

```
Sub DoStep
  // This method goes through the entire array of atoms to see if each atom has already
  // decayed. If a given atom has not yet decayed, then the method checks to see whether it
  // decays during this time step. If the atom gets unlucky, it is marked as having decayed
  // by recording in the atom array the number of steps that atom survived. (The value for a
  // given atom is -1 until it decays.) Note that the Rnd function generates a random
  // number between 0 and 1. If this random number is less than the probability
  // for decay during a step, then we will mark the atom as having decayed.

  dim i as integer              // this index will specify the atom we are checking

  for i = 1 to NAtoms           // do the enclosed for each atom
    if Atom(i) < 0 then         // if the current atom has not yet decayed
      if Rnd <= DecayProb then  // see if it decays this time
        Atom(i) = StepNo        // if so, record number of steps it survived
      end if
    end if
  next                          // go on to the next atom
  StepNo = StepNo + 1           // when we get here, we have finished the step
End Sub
```