Assignment 2

1. Energy produced in the center of the sun getting to the surface. On average in the sun, a photon travels 1 cm between collisions with hydrogen atoms, and on average it is held about 10^{-8} sec by the hydrogen atom before being reemitted in a completely random direction. Hence, the photon takes about 10^{8} "steps" per second.
   a) The average displacement in the any direction per step is zero. What is the standard deviation about this value?
   b) The radius of the sun is about 7×10^{10} cm. About how many "steps" must be a photon take before having a 32% chance of being outside the sun?
   c) How many years does the answer in part b correspond to?

2. Poisson Distribution
   a) Take the limit of the binomial distribution as $N \to \infty$ and $p \to 0$ such that $Np = \mu$ remains finite. Show that $P(k) = \frac{\mu^k}{k!} e^{-\mu}$
   b) Show $\sum_{k=0}^{\infty} P(k) = 1$
   c) Show the mean value of k is μ. It can also be shown that $\sigma^2 = \mu$.

3. Plot the binomial and Poisson distributions on the same graph for
   a) $N = 160$ and $p = 0.0625$
   b) $N = 160$ and $P = 0.25$

4. Consider the radioactive decay of 1 microgram of ^{137}Cs which has a half-life of 27 years.
   a) What is the number of atoms N in the sample?
   b) What is the probability p in 1 second that a Cs atom decays?
   c) Explain why the Poisson distribution applies.
   d) Evaluate the average number of decays per second λ.
   e) The probability of observing k decays in time t seconds is given by

$$P(k) = \frac{(\lambda t)^k}{k!} e^{-\lambda t}$$

   Plot this probability versus k for the values of $\lambda t = 0.5, 1, 4, 10$.