Random Uncertainties– Prelab Quiz

Answer these questions after reading the “Random Uncertainties” assignment. Submit your answers via Blackboard as either a MS Word (.docx) or MS Excel spreadsheet file (.xlsx). Be sure to show all of your work so that partial credit can be given.

1. **[2 points]** An experiment counts events at an average rate of 1000 events per second (or 1000 Hz).

   If a student wants to count an average of 50 events per sample, how long should the sample time be?

2. **[5 points]** Work Problem 11.9 (page 257) from John R. Taylor’s “An Introduction to Error Analysis” (2nd Edition)

   You may find the following guide helpful:
   Part A:

   (a) Differentiate both sides of the identity (11.15) twice with respect to μ.

   $$\sum_{\nu=0}^{\infty} e^{-\mu}\frac{\mu^{\nu}}{\nu!} = 1 \tag{11.15}$$

   You will have 3 terms.

   (b) Rewrite each term such that you get back the Poisson distribution form $\left(e^{-\mu}\frac{\mu^{\nu}}{\nu!}\right)$ with powers of μ and ν multiplying it. Eg. use $\mu^{k-1} = \mu^k/\mu$.

   (c) Use the identities $\sum P_\mu(\nu) = 1$ (11.15) and $\sum \nu P_\mu(\nu) = \mu$ (11.6) to simplify. Remember μ is a constant.

   (d) Find an expression for $<\nu^2>=\sum \nu^2 P_\mu(\nu)$

   Part B:

   (a) Use $\sigma =<\nu^2> - <\nu>^2$ (11.7) to prove that the standard deviation of ν is $\sigma_\nu = \sqrt{\mu}$.

3. **[3 points]**

   In Problem 2 you showed that Poisson statistics predict that

   $$\sigma_\nu = \sqrt{\mu}.$$

   Describe and justify a linear plot that could be used to experimentally verify the relationship between the mean observed count rate and the standard deviation.

