**Practice Problems in Foundational Material**

These problems emphasize some of the foundations of understanding measurement errors, uncertainty, significant figures, etc. Many of these concepts were drawn from the readings in the book, so if you struggle with this material, you may refresh the assigned chapters.

1. You measure the voltage of a battery and get the following digital read out in V. What is the uncertainty in this measurement? State both in terms of absolute and fractional uncertainty.


The uncertainty is due to the resolution of the device. Thus, the absolute uncertainty is 0.0005 V. The fractional uncertainty is 0.0005/1.547 = 0.0003, or also 0.03%

2. You want to measure reaction time for 5 students in class by asking them to press a button when a light comes on.
    a. What are potential sources of error in this measurement? State and label 1 systematic error and 1 random source of error.

There are several options here, some of the most obvious ones include:
Systematic: Latency in the test rig. Inaccurate clock in your timing device.
Random: Natural variation across the test subjects, natural variation within the subject's own ability to repeat the measurement.

    b. What is the average reaction time of this sample? For the time being, use 3 significant figures. The reaction times are as follows:

S1 = 0.57 sec  S2 = 0.139 sec  S3 = 0.2 sec  S4 = 0.2543 sec  S5 = 0.315 sec

$$RT_{best} = \frac{0.57 + 0.139 + 0.2 + 0.2543 + 0.315}{5} = 0.296\ sec$$

    c. To estimate the average reaction time for all students within the class, which source of uncertainty is most appropriate to use? Calculate this uncertainty.

Here we would use standard deviation because we are interested in the reaction times within the class, not our certainty of the average reaction time for the sample. The variability in this sample should be representative of the variability of students within the class.

$$\sigma_{RT} = \sqrt{\frac{(0.57 - 0.296)^2 + (0.139 - 0.296)^2 + (0.2 - 0.296)^2 + (0.2543 - 0.296)^2 + (0.315 - 0.296)^2}{(5 - 1)}}$$

$$\sigma_{RT} = 0.17 \text{ sec}$$

Since this uncertainty leads with a 1, as per the guidelines in the book, we can keep 2 significant figures. An answer of 0.2 would also be acceptable.

d. What is our best estimate of the average reaction time for students within the class?
Reaction time = $0.30 \pm 0.17$ sec or Reaction time = $0.3 \pm 0.2$ sec

3. Solve problems 2.1, 2.5, and 2.27 from the book and check the answers in the back.