Question Set 1.0: Error and Percent Difference

1. *An average chicken egg has a mass of 50 grams. You weigh a bag of eggs and find a mass of 1840 grams.*
   a. *What is the most likely number of eggs in the bag?*

$$\frac{1840\ g}{50\ g/egg} = 36.8 = 37\ \text{eggs}$$

→ This is known exactly... it is <u>not</u> a measurement

   b. *Now you carefully count the eggs and find 39 eggs. What is the percent error of your predicted number of eggs?*

$$\%\ \text{error} = \frac{|\text{"measurement"} - \text{actual}|}{\text{actual}} \times 100 = \frac{|37-39|}{39} = 5.1\ \%$$

2. *Greek philosopher/scientist Eratosthenes measured the circumference of the earth in the year 240 BC (1732 years before Columbus sailed). His equipment was: a hole in the ground, shadow made by sunlight, and very keen reasoning. His results were amazingly accurate. In his calculations, he used a unit of distance called a* ***stadia****. Since no one today is exactly sure how long the stadia is, there is some controversy about how accurate Eratosthenes's results are.*

   a. *If we assume that Eratosthenes used the most common unit for stadia, then his measurement for the earth's circumference (converted to kilometers) is 46,620 km. An accepted value for the average circumference of the earth is 40,041.47 km. What is the percent difference between Eratosthenes's measurement and the accepted value?*

(these numbers are both measurements... we use % difference)

$$\%\ \text{diff} = \frac{|\text{measured value} - \text{accepted value}|}{\text{accepted}} \times 100 = \frac{46{,}620 - 40{,}041.47}{40{,}041.47} = 16.4\%$$

   b. *If we assume that he used a less common "Egyptian Stadium" as his unit for length, his result would be 39,690 km. What, in this case, would be the percent difference between Eratosthenes's measurement and the accepted value?*

$$\frac{39{,}690 - 40{,}041.47}{40{,}041.7} = 0.8\% \quad \text{Wow!}$$

I believe Eratosthenes did his work in Egypt, which means it would be reasonable the he used the Egyptian Stadium.

Question Set 1.2: Systematic and Random Error

1. *Consider an experiment to determine the average acceleration of a ball dropped from a height of 1 meter. Students stand a meter stick on a table top and use a stopwatch to measure the time for the ball to fall from the top of a meter stick to the table. One student drops the ball and another student watches and carefully starts the watch*
   a. *Identify three possible sources of systematic error:*
      i. Reaction time: when to start the watch - time value always shorter than "actual"
      ii. Meter stick not perfectly vertical: If not vertical, time value will be shorter than "actual"
      iii. Using the sound of the ball hitting the table to stop the watch... takes time to generate and transmit sound
   b. *Identify three possible sources of random error:*
      i. Where the ball is released: sometimes too high, sometimes too low
      ii. When the watch is stopped: sometimes to early, sometimes late.
      iii.

2. *Make two suggestions for how the students could change their experiment to improve their results. State whether your suggestion would reduce systematic or random error*
   - use electromagnet to release ball; reduces random error.
   - use photogate to start the timer; reduces systematic error.

3. *In some cases, systematic error can be difficult or impossible to identify. For example, the balance you use in lab might be damaged in such as way that it causes all masses less than 100 grams to seem 50 grams lighter than they are. How, then, can you provide evidence that your measurements do not have systematic error?*

   Use other devices or methods to make the measurement

4. *Random errors are often easy to identify, but impossible to eliminate. How can you determine whether your measurements contain random error?*

   Repeat the measurement, look for differences.