Theory Questions - Experiment 1

1 Theory Questions

The theory questions are written to help you prepare for the lab. Your answers are due at the beginning of the experiment to ensure that you are ready to work with your partner. **You must show all of your work to receive full credit.**

1. (1 pt) Which equation(s) should be used to quantify the accuracy of a measurement? *Hint:* the notion of accuracy depends on the knowledge of a reference value.

Absolute errror or relative relative equations

2. (1 pt) Which equation should be used to quantify the precision of a measurement?

The uncertainty propagation equation should be used to quantify overall precision

3. The accepted value for the electron charge is $q_{ref} = -1.60217 \cdot 10^{-19}$ C. Use this value for the following two questions:

   (a) (2 pt) A careful experimenter measures $q_m = -1.61819 \cdot 10^{-19}$ C for the electron charge. Use Equations 1 and 2 to quantify the error.

   (b) (1 pt) Student A has an absolute error of $4.80651 \cdot 10^{-21}$ C. Student B has a relative error of 2%. Which student made a more accurate measurement? *Hint:* use q_{ref} to find Student A's relative error.

In [2]:
```
print(-1.60217 - (-1.61819))

abs(-1.60217 - (-1.61819))/abs(-1.60217)
```

```
0.016019999999999923
```

Out[2]:
```
0.009998938939063846
```

Absolue error is $0.016020 * 10^{-19}$ while relative error is somewhat larger, 0.009999

4. (2 pt) Two quantities $x \pm \delta x$ and $y \pm \delta y$ are measured and used to calculate $q = x \cdot y$. Use Equation 4 to write the uncertainty δq in terms of x, δx, y, and δy.

$$\delta q = \sqrt{\left(\frac{\partial q}{\partial x} \cdot \delta x\right)^2 + \left(\frac{\partial q}{\partial y} \cdot \delta y\right)^2}$$

5. (1 pt) What is the difference between an exponential function and a polynomial?

ab^x vs ax^b. Growth-wise, exponential functions grow/decay faster than polynomial

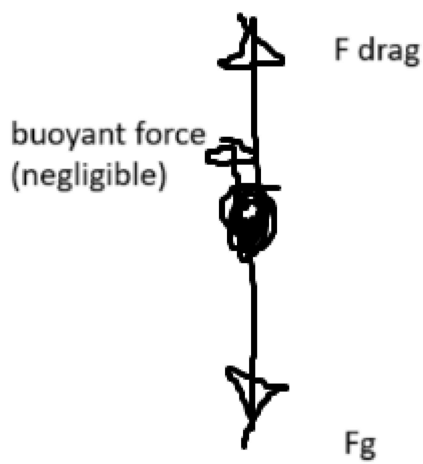
6. (1 pt) A steel ball is dropped into the ocean. It falls under the influence of gravity until it reaches the bottom. Along the journey, is the acceleration of the ball always equal to the gravitational acceleration, g? Is it ever equal to g? Explain your reasoning.

The acceleration varies since there is a drag force and a bouyant force as it moves through the water

7. (1 pt) A doctor accidentally writes a prescription for a 0.1 g dose of a medication instead of the desired therapeutic dose of 10 mg. The drug causes serious side effects for any dose 20 times larger than the therapeutic dose. Will the doctor's unit conversion error lead to complications?

0.1g = 100mg, so it should be fine

3.1



1.

2. Acceleration is zero

3. Terminal velocity occurs when $F_D = F_g$.

$$-mg = -\frac{1}{2} C_D \rho A_{cs} v^2 \hat{v}$$
$$v = \sqrt{\frac{2mg}{C_D \rho A_{cs}}}$$

Thanks to $\hat{v}$, we know the solution must be negative.

Using the constants provided and $C_D = 0.47$ this is

$$v = -\sqrt{\frac{2 * 981}{0.47 * 1.25 * 28} m} = -\sqrt{119.27 m} = -10.92 \sqrt{m} \text{ m/s}$$

4. $y = (-10.92) x^{0.5}$

Note: a later section asks us to find C_D using curve.fit instead of assuming it. Maybe the answer we want here is $|v_T| = A m^B$?

5. $A = -\sqrt{\frac{2g}{C_D \rho A_{cs}}}$ and $B = 0.5$

3.2

1. Plot attached

2. The result is $B = 0.47 \pm .014$, which has an upper bound below 0.5. The relative error is $\frac{0.5-0.47}{0.5} = 6\%$. A six percent error is not terribly bad, but the upper limit on B is less than 0.5, which indicates that the difference isn't entirely due to measurement techniques. It is likely the model is slightly off from the real situation. Some assumptions may be the source of the difference

3. Using $A = 11.67 = \sqrt{\frac{2g}{C_D \rho A_{cs}}}$ we obtain

$$C_D \rho A_{cs} = \frac{2g}{A^2}$$
$$C_D = \frac{2g}{A^2 \rho A_{cs}} = \frac{2 * 981}{11.67^2 * 1.25 * 28} = 0.412$$

Which is pretty close to my earlier assumption of 0.47

4. Uncertainty comes from A and A_{cs}, all others are $\delta n = 0$

$$\frac{\partial C_D}{\partial A_{cs}} = \frac{2g}{A^2 \rho}\left(-\frac{1}{A_{cs}^2}\right)$$
$$\frac{\partial C_D}{\partial A} = \frac{2g}{A_{cs} \rho}\left(-\frac{2}{A^3}\right)$$