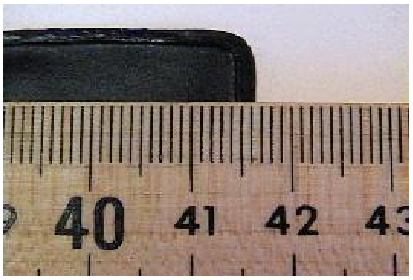
Math & Measurement Reference Sheet for Physics

I. Accuracy, Precision, and Uncertainty

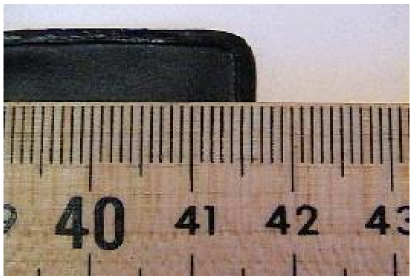
A. Distinguishing between accuracy and precision

1. Accuracy: How close to the true value is the measurement? In other words, is it the *actual, accurate* number?
2. Precision: The precision of a measuring instrument is determined by the smallest unit to which it can measure. For a typical meter stick or ruler this value is 1 mm (which is 0.1 cm and 0.001m). We can handle precision *either* by measuring with an estimated digit *or* by identifying the uncertainty of our measurement.
    a) An estimated digit is a guess about how far a measurement is between the smallest marks on the device. In the picture below, we can say that the object is 41.6 cm, but it's a little more than 41.6 cm. We can guess that the object is about 4/10 of the way between 41.6 and 41.7 cm. Therefore we can say it's 41.64 cm.



Watch this video from the beginning through 10:20. [Precision, Accuracy, Measurement, and Significant Figures]

    b) Uncertainty: In physics, sometimes we use uncertainty of measurement instead of making estimated digits. In this method, the scientist measures to the smallest unit on the measuring device and determines which of these smallest units is closest to the true value *without* an estimated digit. In our example, the object is closest to 41.6 cm. The next step is to report the uncertainty. To determine the uncertainty of a measurement, add and subtract ("+/-") one half of the smallest unit of the measuring instrument. On a typical ruler, the smallest unit is 1 mm. Therefore the uncertainty is +/- 0.5 mm. Example:



Measuring with an estimated digit: 41.64cm (4 is an estimated digit.)
Measuring with uncertainty: 41.6 cm +/- 0.5 mm

II. Significant Figures: When measuring, there are limits to how precise our measurements are. Significant figures represent the precision of a measurement. When an estimated digit is used, the significant figures include the estimated digit. When uncertainty is used, the significant figures only include the digits before the +/-.

A. Please watch this video and then do the practice problems at the end of the video. Instead of clicking his link, the right answers are below.
   1. Video: Significant Figures Shortcut 1 of 3: Identifying Significant Figures
   2. Answers: (1.) 1 (2.) 2 (3.) 3 (4.) 4 (5.) 1 (6.) 4 (7.) 6 (8.) 1 (9.) 4 (10.) 5

III. Scientific Notation: This is a shorthand mathematical “language” that you must be able to read and write in order to function in physics.

A. Some websites that will help you master scientific notation are:
   1. Scientific Notation - Explained!
   2. Scientific Notation: Introduction
   3. Practice: Scientific Notation

B. It is VERY IMPORTANT that you type these numbers into your calculator correctly. Typing 4 x 10ˆ3 is INCORRECT, even if it sometimes seems to work. You must type numbers into your calculators using the following steps, or your results will often be wrong. This video will show you how to do it: TI Calculator Tutorial: Scientific Notation
   1. Punch the coefficient into your calculator.
   2. Push the EE or the EXP button. (On Texas Instruments calculators, this will be a 2nd function of the button above the number 7 key.)
   3. Enter the exponent number and use the +/- button to change the exponent’s sign if necessary.

C. Calculating with scientific notation and significant figures:
   1. Multiplication & Division: The input (factor, dividend, and/or divisor) with the fewest digits determines how many digits should be in your answer. Then use rounding rules.

      4.1 X 2 = 8

      (3.0 E 8) x (2.00 E 2) = 6.0 E 10

   2. Addition & Subtraction: The input (term) with the fewest digits after a decimal determines how many digits after the decimal there will be in the answer. If none of the inputs have digits after a decimal, then keep all digits when adding and subtracting. Then use rounding rules.

      4.2 + 3.22 = 7.4

      1,900,201 + 302 = 1,900,503

D. Complete the scientific notation practice problems in the practice document.

IV. SI Units and Metric Conversions

A. You must use SI units in all of your calculations in physics class. Please check out the links below to learn about the SI units.
   1. Why the metric system matters - Matt Anticole
   2. SUPER EASY way to remember SI Prefixes | Must Watch! - Dr K

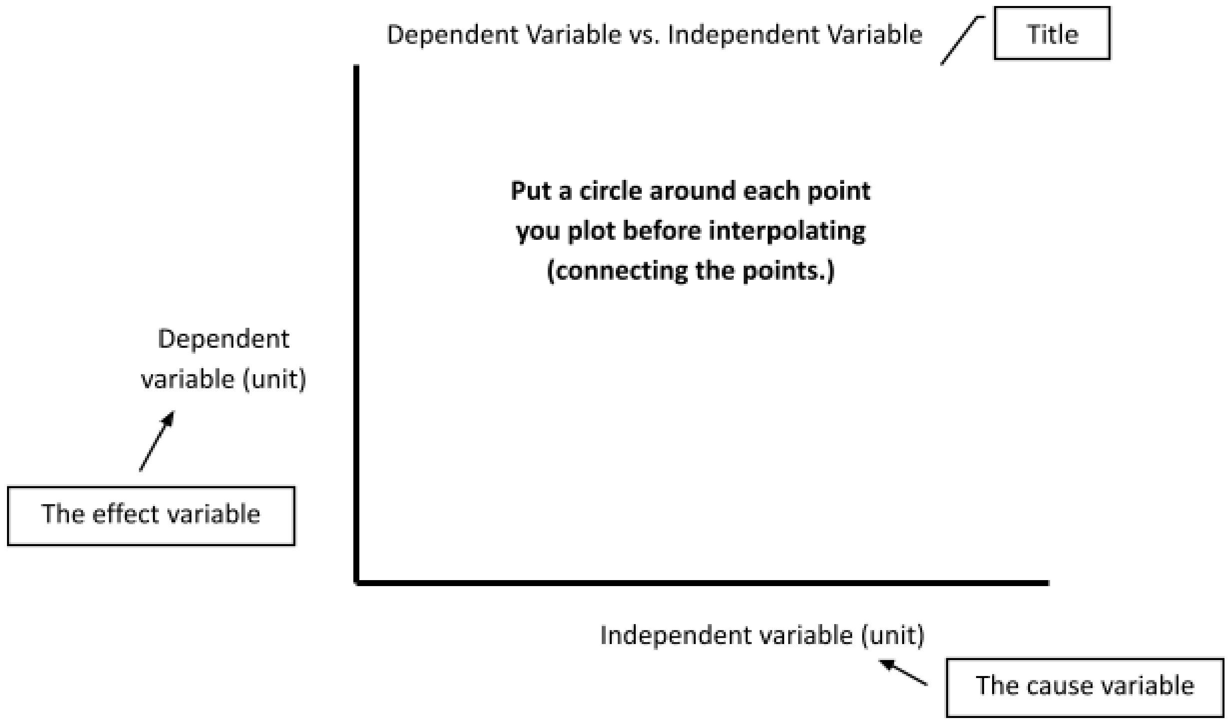
B. Watch this video to learn how to do unit conversions in physics using dimensional analysis. Please be sure to read the note below the video.

https://sgbscience.com/helpful-how-to-podcasts/how-to-do-conversions-in-physics/

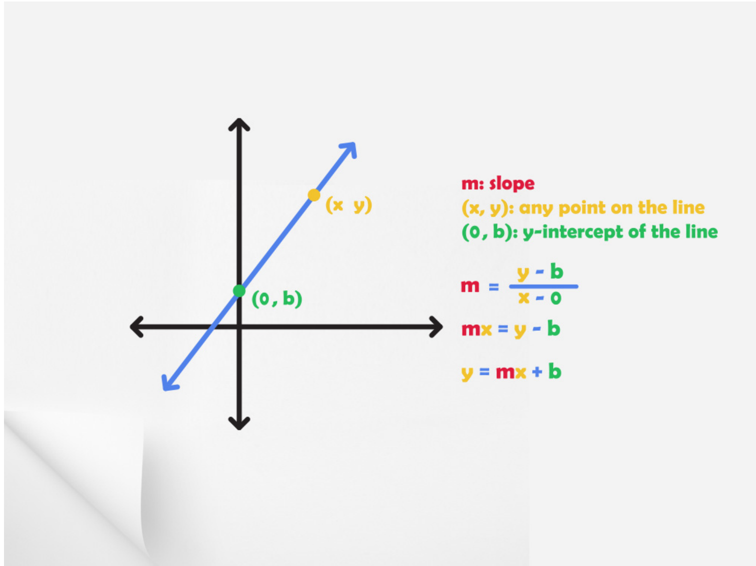
C. Complete the unit conversion practice problems in the practice document.

V. Graphing:

A. Proper graphing format:



B. Linearization: When graphing a scatter plot, if the plotted points seem to take the shape of a straight line, scientists might draw a line of best fit through the average position of the points. The straight line then has an equation, $y = mx + b$, in which m represents the slope of the line, and b represents the y-intercept, or the point on the y-axis where the line falls when $x = 0$. The slope of the line of best fit, in particular, will be very important in physics.



VI. **Algebraic Order of Operations:** You will use algebra frequently to solve for an unknown value. Please watch this video to review the order of operations when solving algebraic equations. Be sure to do the practice problems at the end of the video to make sure you can get the right answers. Order of Arithmetic Operations: PEMDAS