Take-home Assignment

Due at beginning of lab, September 22

Stolen from Dr. Fletcher

Name ______________________________

In this lab you will be using the computer spreadsheet program Excel to analyze your data. This will involve graphing the data points. The graph on the other side shows the position of a toy train as a function of time. Because this train is moving at a constant velocity, we expect the relationship between the position and the time to be linear — a straight line graph. The data points on this graph are *roughly* linear, but uncertainties and noise in the measurements make them scattered. Remember for a straight line the mathematical relationship is

$$Y = MX + B \quad ,$$

where Y is the dependent variable, X is the independent variable, M is the slope of the line, and B is the intercept of the line (where the line crosses the y-axis). Translated to the specific case of the constant velocity train, this formula becomes

$$y = vt + y_0 \quad ,$$

where the position at any time is y, the independent variable is t, the velocity is v, and the position of the train at $t = 0$ is the intercept, y_0 . By comparing the two equations we can see that the slope of the line must be the velocity of the train. (Note that I could have chosen to denote the train's position with x, but that would have just been more confusing.)

In this assignment, you will use your own common sense to estimate the true equation for the toy train position, including uncertainties. This is of course NOT the way a computer program determines the best fit and the uncertainties for a graph. This method and the computer's method are as different as estimated uncertainty and standard deviation for a single physical quantity. However, just like estimated uncertainty and standard deviation, these methods have the same goals. This exercise should help you to understand the meaning of the concepts.

When the computer does a ***least-squares linear fit***, it finds the single line that minimizes the distance between the line and all the points, according to a particular statistical method. (Note that this method makes some assumptions, which may or may not be true.) Even though there exists a unique line that is "closest" to the data, this does not necessarily mean that line is the "true" position of the train. This is expressed as uncertainties in the slope and intercept. The values that you come up with here will most likely be similar to what the computer would calculate.

In steps 1–3, high accuracy is not required. Even so, estimate your numbers to at least two significant digits.

1. On the graph, use a ruler and draw a straight BLUE line which you believe best matches the data points (assume a linear graph). This is your "best fit" line for these data points.
2. Use your ruler to draw a RED line which has as *small* a slope as you think is likely to have occurred, but which still matches the set of data points reasonably well.
3. Use your ruler to draw a BLACK line which has as *large* a slope as you think is likely to have occurred, but which still matches the set of data points reasonably well.

4. Use the ruler to find the slope (in m/s) and intercept (in the correct units) for each of your lines.
5. The pairs of values you just found match the physical quantities v and y_0 . Use those values to write equations for the motion described by each line.

the BLUE "best fit" line; ______________________________

the RED "small slope" line; ______________________________

the BLACK "large slope" line; ______________________________

6. Using your results from above, estimate the uncertainty on the slope and the uncertainty on the intercept, each of which specify a range around your "best fit" value.
7. Write out the complete "value ± uncertainty" in presentation format for each line parameter.

Slope ± Uncertainty:____________________ Intercept ± Uncertainty:____________________