Drawing Graphs with Excel

This is a homework exercise rather than an experiment. ***The completed report (with hard-copy of all graphs in the exercise) must be given to your TA at the beginning of the lab in which it is due.*** **Save the Excel file that you used to produce your graphs. Questions to be answered for the report are in bold**. This report is marked and will be included in the calculation of your course grade.

A graph is an important tool for communicating information. But graphs are arguably more important in that they help us to say something about trends in a set of data. This exercise uses Excel to draw graphs and to use trendlines to pick out trends.

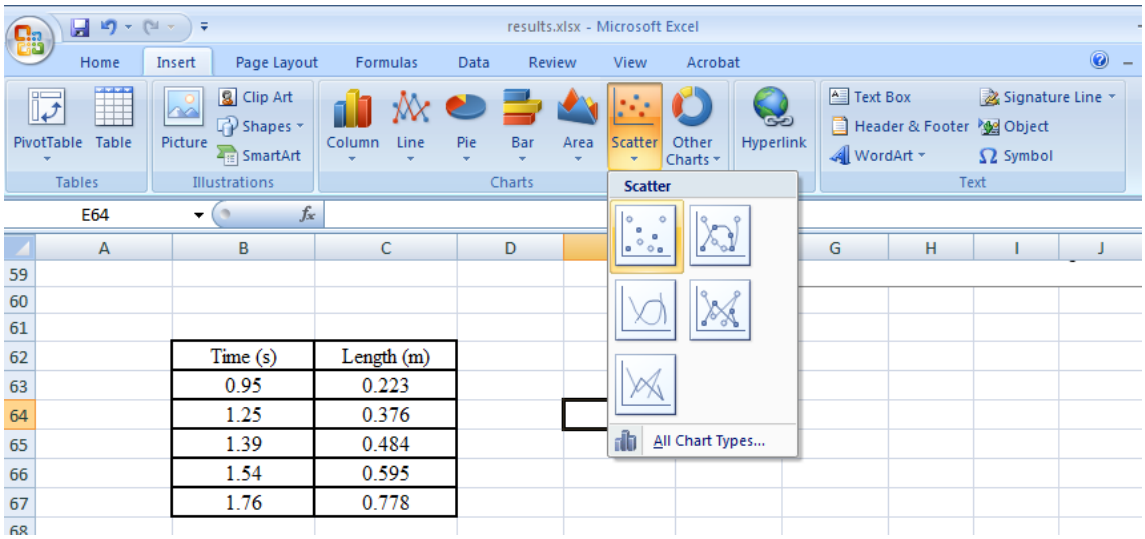
Scatter graphs will be examined because they allow us to compare two sets of numbers that are often part of your experimental data.

We'll begin by doing something familiar: making a graph of the time for one period of a pendulum versus the corresponding length of the pendulum. (Recall that these quantities are [in principle] related by $T = 2\pi\sqrt{\frac{L}{g}}$. Fitting a trendline can be seen as an attempt to show that the quantities of time and length are (approximately) functionally related as claimed by the previous equation.) Type the data into two columns of an Excel file.

Time (s)	Length (m)
0.95	0.223
1.25	0.376
1.39	0.484
1.54	0.595
1.76	0.778

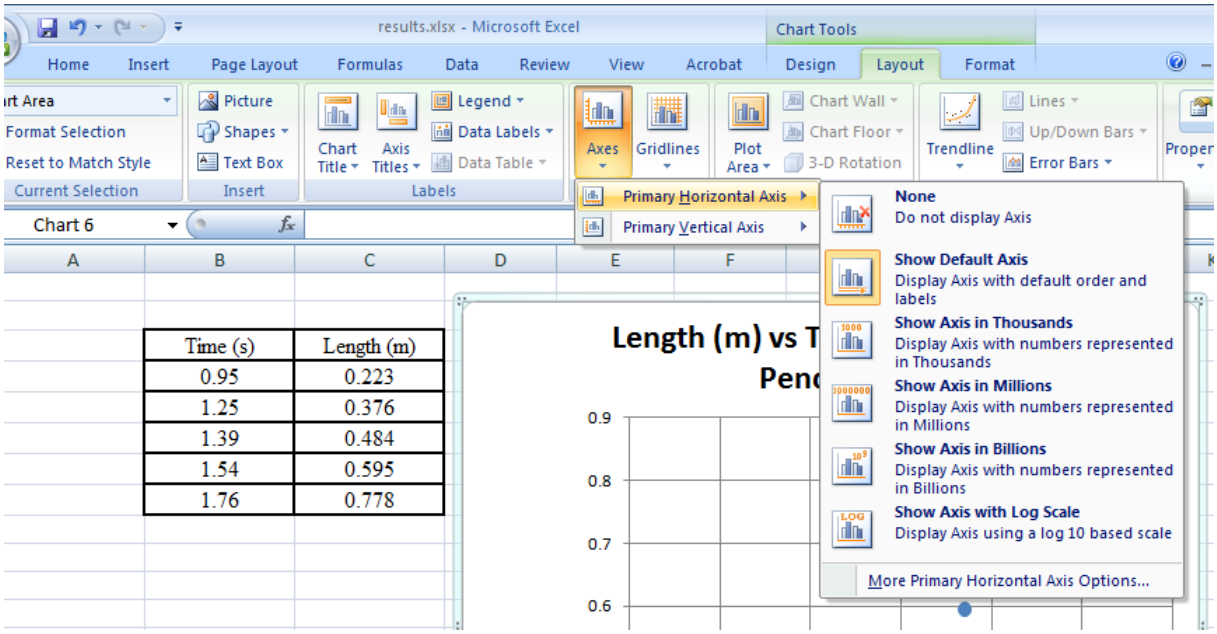
The first column of data will appear on the x-axis and the second on the y-axis.

Select *all* data. (If you select the titles too, then you'll have a little less typing to do in a future step!). From the ribbon, select the 'insert' tab. A drop-down window shows five graphs. Choose the first one:



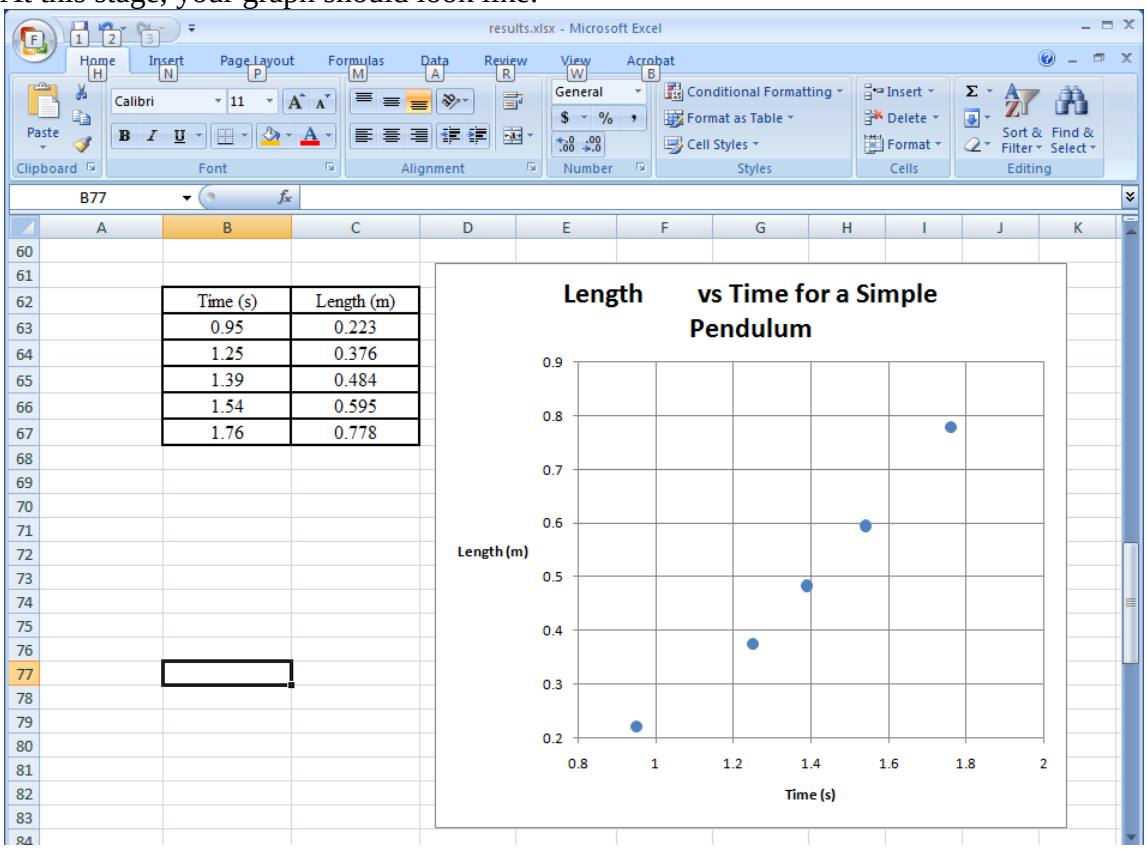
This inserts a scatter graph into your spreadsheet. When the graph is selected, A highlight called 'chart tools' appears above the Design, Layout and Format tabs. Select the layout tab. The Labels group now lets you put a title on the chart and both axes. (You will need to do these for all graphs in this exercise.) You can get rid of the Legend pressing the Legend button and selecting 'none' from the dropdown menu (but I just select the legend in the graph and press delete.

There is a button called Axes in the Axes group. Press it to get the drop-down menus in the next screen-shot.



Navigate to the last option: "More Primary Horizontal Axis options". Among other things, this will allow you to change the minimum value on the horizontal axis to 0.8 s. ("More Primary Vertical Axis options" allows you to change the minimum value on the vertical axis to 0.2 m

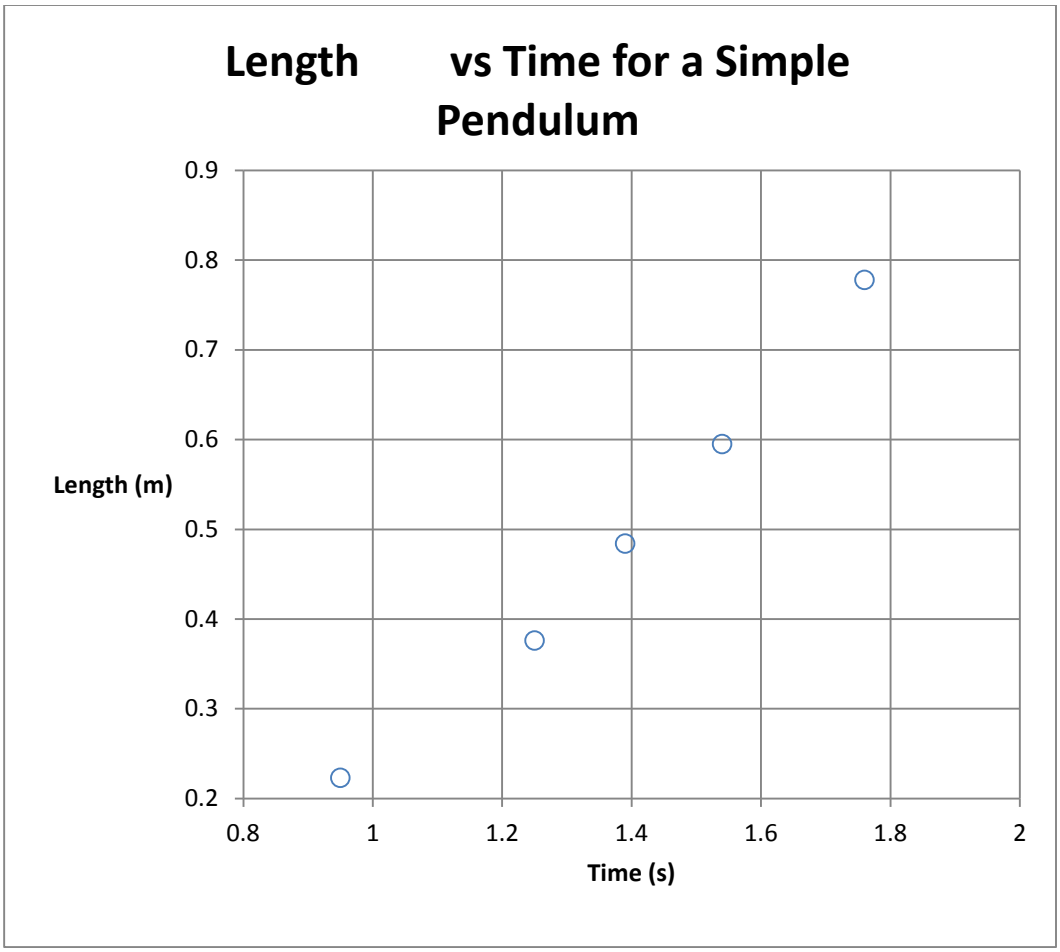
At this stage, your graph should look like:



Time (s)	Length (m)
0.95	0.223
1.25	0.376
1.39	0.484
1.54	0.595
1.76	0.778

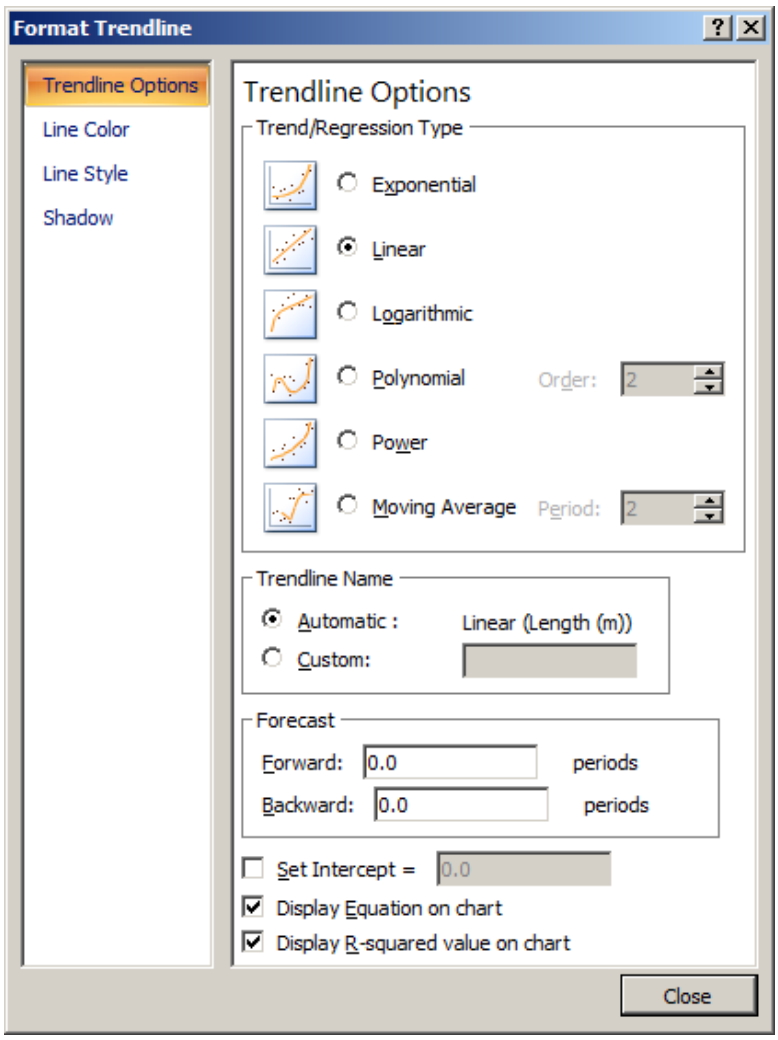
The chart area is the white area around the graph. (Charts are Excel's name for graphs). The chart area is still too small so select it and re-size it.

Data points have diamond shaped markers by default. Right click on any one of them and choose to "Format Data Series" on the context menu that appears. Select Marker Options and then the radio button beside 'Built-in'. The Type (of marker) should be available and choose circles from the drop-down menu beside it. This will turn the blue diamond markers into blue circles. In marker Fill, select No Fill to get open circles.

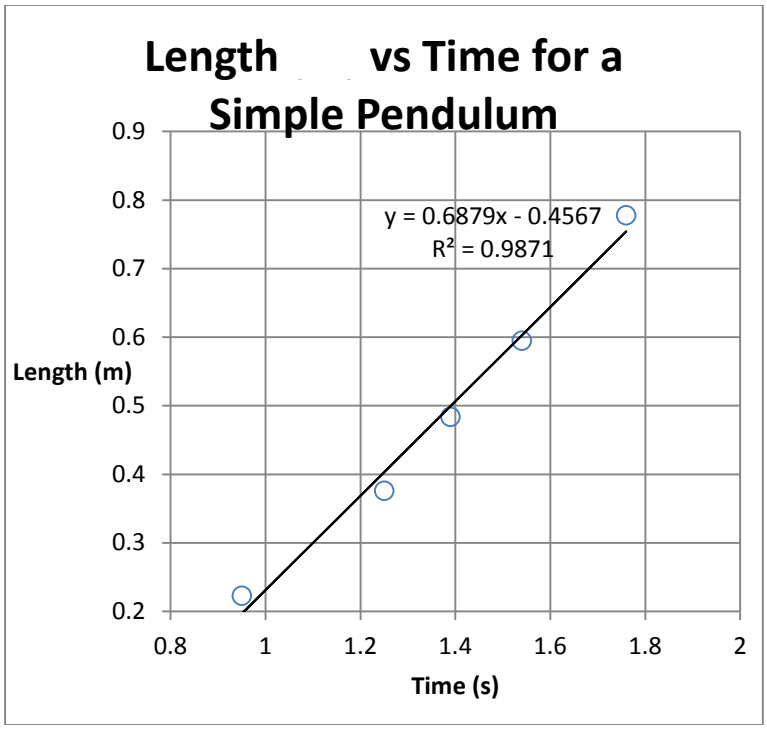


What does the graph tell us that isn't readily apparent from the raw data? As it is, the graph might just be a straight line. Excel can tell us what equation best fits the data. We want to add a trend-line that fits the data best[1]. Right-click on a data-marker. Choose "Add Trendline" in the context menu that appears. (Another way: From the Layout tab on the ribbon, press the button called Trendline. Select More Trendline options from the menu that appears.) Either way, you should be at,

[1] Such a curve is called a "best-fit" curve.



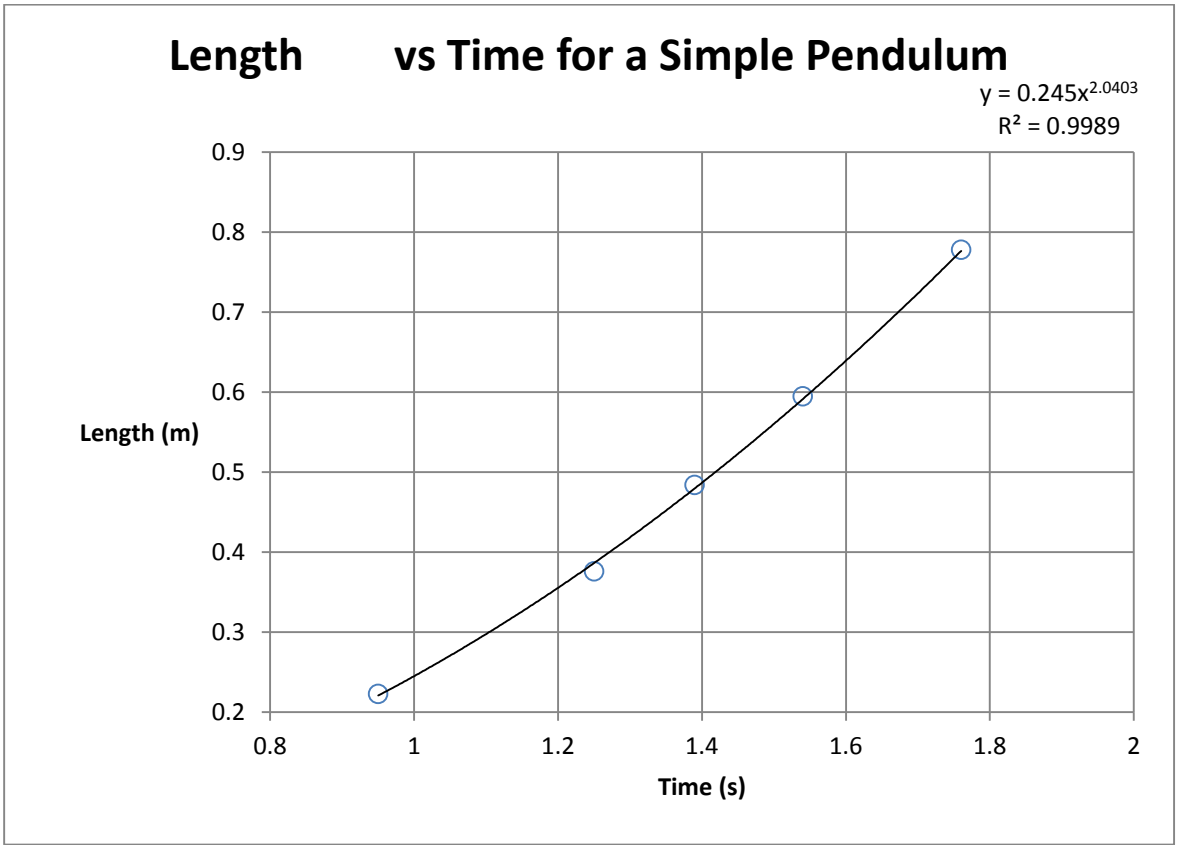
Press the radio button beside linear (to get a linear fit). **You won't use 'Polynomial fit' for any graph in this homework assignment**. No matter what fit you choose, always check the last two boxes to get the curve-fit equation and regression coefficient on your graph.



The value of the regression coefficient (R^2) is a number between zero and one that says how closely the trend line approximates the data (with one being a perfect fit). Excel's fit-equation uses the data to relate the quantity on the Y-axis (Length) to the quantity on the X-axis. From the stand-point of blindly fitting a curve to data, the small regression coefficient $R^2 = 0.9871$ isn't bad but might be even closer to one.

But recall that a linear trend line was only a guess. In Physics I, a theoretical treatment of a simple pendulum gave either $T = 2\pi\sqrt{\frac{L}{g}} = \left(\frac{2\pi}{\sqrt{g}}\right)\sqrt{L}$ or $L = \left(\frac{g}{4\pi^2}\right)T^2$. Notice that the terms in parentheses are constants. Since the data is the periodic time and corresponding length of a simple pendulum, this relation suggests that the length and time are related by a power law (where the power is a two). First remove the linear trendline (that is on the Layout tab) and selecting the radio-button for *None* and closing the dialog. Now try a curve fit that is a power law. (Excel uses $y = Ax^p$ where *A* and *p* are constants that will be found using the data.)

The graph should now look like,



Compare your fit with $L = \left(\frac{g}{4\pi^2}\right)T^2$. Are time and length functionally related as you expect?" Explain why. [4]

Other questions for report:

Four graphs are described below. Label both axes and include a title on each. After fitting a trend line to each (and displaying both R^2 and the equation of the curve that is fit to the data), print the graph and attach them to your report.

<u>Use Excel to make a graph</u> of the periodic time of a simple pendulum versus its length using the data;

Length (cm)	Times (s)
15.29	0.782
21.65	0.917
29.2	1.101
36.85	1.219
42.4	1.295

Fit an appropriate trend line to your graph. Does the data agree with $T = \left(\frac{2\pi}{\sqrt{g}}\right)\sqrt{L}$ **? Explain**.

[4]

<u>Use Excel to make a graph and fit an exponential trend line</u> to the data;

Time (s)	Voltage (V)
0	14
3	7.5
6	3.8
9	2.3

Write down the equation that Excel has fit to the data. (The equation will be of the form $y = Ae^{-Bx}$ where numerical values for *A* and *B* are given by Excel. The *x* stands for the times that you gave Excel and *y* stands for the voltages that you specified so that the equation fit by Excel really means $V = Ae^{-Bt}$.) **[1]**

The equation $V = Ae^{-Bt}$ can't depend on the units that you used. (After all, Excel didn't use information about units in the curve-fit.) **What are the units of *A*? What are the units of *B*?** (Hint: begin by thinking about the units that *B* must have if time is measured in seconds.) **[3]**

(Note: Excel will fit to the exponential shape of this data but you might find it interesting to see what happens in you make the Voltage axis a log axis while leaving the Time axis as a linear axis.)

<u>Use Excel to make a graph and fit a trend line</u> to the data;

Current (A)	Weight (relative units)
7.6	1
8.9	2
9.8	3

(Hint; Use the regression coefficient to guide your choice of a suitable trend line. *Remember not to use 'Polynomial fit'*.) **[4]**

<u>Use Excel to make a graph and fit a trend line</u> to the data;

r = Distance (mm)	Force (relative units)
3.3	0.1
2.2	0.3
1.7	0.5
1.2	1.1
1.0	1.5

Is the data consistent with $F = \left(\frac{q^2}{4\pi\varepsilon_0}\right)\frac{1}{r^2}$ [where q is a known (unspecified) constant]? **Explain why. [3]**

REPORT (attach graphs)

NAME:_____ Course & Section: _____

Feel free to draft your answers in pencil but remember that the report to be given to your TA must be in pen.

The completed report (with hard-copy of all graphs in the exercise) must be given to your TA at the beginning of the lab in which it is due.

Compare your fit with $L = \left(\frac{g}{4\pi^2}\right) T^2$. Are time and length functionally related as you expect?" Explain why.

_____

_____

_____**[4]**

Draw a graph of the periodic time of a simple pendulum versus its length using the data;

Length (cm)	Times (s)
15.29	0.782
21.65	0.917
29.2	1.101
36.85	1.219
42.4	1.295

Fit an appropriate trend line to your graph. (Does the data agree with $T = \left(\frac{2\pi}{\sqrt{g}}\right)\sqrt{L}$? Explain.

_____

_____**[4]**

Draw a graph and fit an exponential trend line to the data;

Time (s)	Voltage (V)
0	14
3	7.5
6	3.8
9	2.3

Write down the equation that Excel has fit to the data that you gave it. The equation will be of the form $y = Ae^{-Bx}$ where numerical values for *A* and *B* are given by Excel. The *x* stands for the times that you gave Excel and *y* stands for the voltages that you specified so that the equation fit by Excel really means $V = Ae^{-Bt}$.)

_____**[1]**

The equation $V = Ae^{-Bt}$ can't depend on the units that you used. (After all, Excel didn't use information about units in the curve-fit.) What are the units of *A*? What are the units of *B*? (Hint: begin by thinking about the units that *B* must have if time is measured in seconds.)

_____

_____**[3]**

(Note: Excel will fit to the exponential shape of this data but you might find it interesting to see what happens in you make the Voltage axis a log axis while leaving the Time axis as a linear axis.)

Draw a graph and fit a trend line to the data;

Current (A)	Weight (relative units)
7.6	1
8.9	2
9.8	3

(Hint; Use the regression coefficient to guide your choice of a suitable trend line. **Remember not to use 'Polynomial fit'**.) **[4]**

The last part of the exercise is to graph and fit the data;

r = Distance (mm)	Force (relative units)
3.3	0.1
2.2	0.3
1.7	0.5
1.2	1.1
1.0	1.5

Is the data consistent with $F = \left(\frac{q^2}{4\pi\varepsilon_0}\right)\frac{1}{r^2}$ [where q is a known (unspecified) constant]? Explain why.

_____

_____ **[3]**