GRAPHS

Aim: *Making a Good Graph by Hand*

Introduction

Relationships between experimental quantities are often represented in the form of graphs. Straight line graphs are easier to construct and to interpret than curved ones. Data that initially result in a curve when graphed are sometimes mathematically rearranged to result in a straight-line relationship. This can often be accomplished by taking the logarithms of the values for one or both of the quantities that were being plotted and then graphing these new log values. When data that has been graphed forms a straight-line plot, the mathematical relationship between the quantities can be determined from the equation for a line.

Equipment and Supplies

pencil, ruler, calculator, graph paper

Procedure

A. Construction of a graph

A number of rules must be followed when constructing graphs. Your score for this exercise will depend upon how well you follow these rules.

1. Select a good quality graph paper that is easy to use with the metric scale. Graph paper that has divisions marked in blocks with different shades of lines is easier to use (less counting) than paper that has uniform shading. Choose paper that is divided into five by five or ten by ten small squares within a larger grid. Avoid paper in which the large squares are divided into four by four or eight by eight blocks (this type of graph paper is for drafting classes that use English system units).

2. It is customary to plot the quantity that is varied (the independent variable) on the **x** (horizontal) axis and the quantity that is measured (the dependent variable) on the **y** (vertical) axis. In mathematical terms, the quantity on the **y**-axis is a function of the quantity on the **x**-axis.

3. Keep your axes straight: If you need to plot "**A** vs **B**", or "**A** as a function of **B**", then **A** is on the vertical axis and **B** is on the horizontal axis.

vertical axis = y-axis = the "ordinate"

horizontal axis = x-axis = the "abscissa"

3. Use a scale for each axis that will spread the data points to be plotted over the full page (or over the space assigned). **Do not** crowd the data into one corner. However, your scale should result in convenient units (such as **10, 20, 30, etc. or 2, 4, 6, 8**, etc.) for each major division on the graph. A compromise may be necessary.

The crucial part is choosing the range and scale for each axis. Two examples:

a) 0 to 5 sec; 5 graph boxes =1 sec.

b) -300 to +200 degrees; 2 boxes =100 degrees

4. Use a constant scale (the same number of divisions/unit) along each axis. However, because different quantities are plotted on each axis you would not necessarily expect the scale on the **x** and **y** axes to be the same.

*"Choose an appropriate number of boxes between numbers. It is better to have **5** boxes between numbers than **4** since it is easier to interpolate in the first case than in the second. (Similarly, **10** is better than **8**, and **2** is better than **3**.)"*

5. It is only necessary to mark (and label) the intervals at **4** to **6** places along an axis (more than that gets cluttered). For example, if you had mass readings ranging from **7** to **68** g, you might mark and label the axis at **0, 20, 40, 60**, and **80** g. **Do NOT** mark your axes at the data points. The coordinates for the data plotted on the graph should be presented in a table on an unused section of the graph paper (away from the data points) or on a separate piece of paper.

6. The precision in the labels for the axis's intervals should reflect the precision in the data being plotted. For example, if masses were determined to one place after the decimal (such as **9.1** g, **15.4** g, etc.) the intervals on the graph should be labeled **0.0, 20.0, 40.0** and so on.

Note: The precision for measurements plotted on the **y**-axis may differ from those for the **x** axis.

7. If the graph is to be assessed to determine a "straight-line" relationship between data, and you wish to read the **y**-intercept directly from the graph, then you must use intervals and plot the data so that the **y**-intercept is NOT off the graph.

8. Label each axis with the appropriate label.

9. Title each graph. The title should reflect what quantities are being plotted. The title might simply be an equation that has been provided or it might be the description of experimental quantities.

10. Use a small, dark dot for each data point (a pair of $\mathbf{x_i}$ and $\mathbf{y_i}$). Draw a circle around the point to help the reader locate the actual data point.

B. Determination of a Mathematical Relationship from a Straight-Line Graph.

After the data have been plotted, draw either a straight line or a smooth curve that best represents the data points. Do NOT connect the dots with individual straight lines. When data being plotted has been experimentally obtained, you should not expect the line to pass directly through every data point due to experimental errors. Construct a "best-fit" plot in which the points that do not fall on the line are randomly scattered. The sum of the distances between the line and the points above it should be the same as the sum of the distances between the line and the points below it. In addition, the line should be drawn so that these distances are minimized.

The straight-line relationship between quantities x and y can be represented by:

$$y = mx + b$$

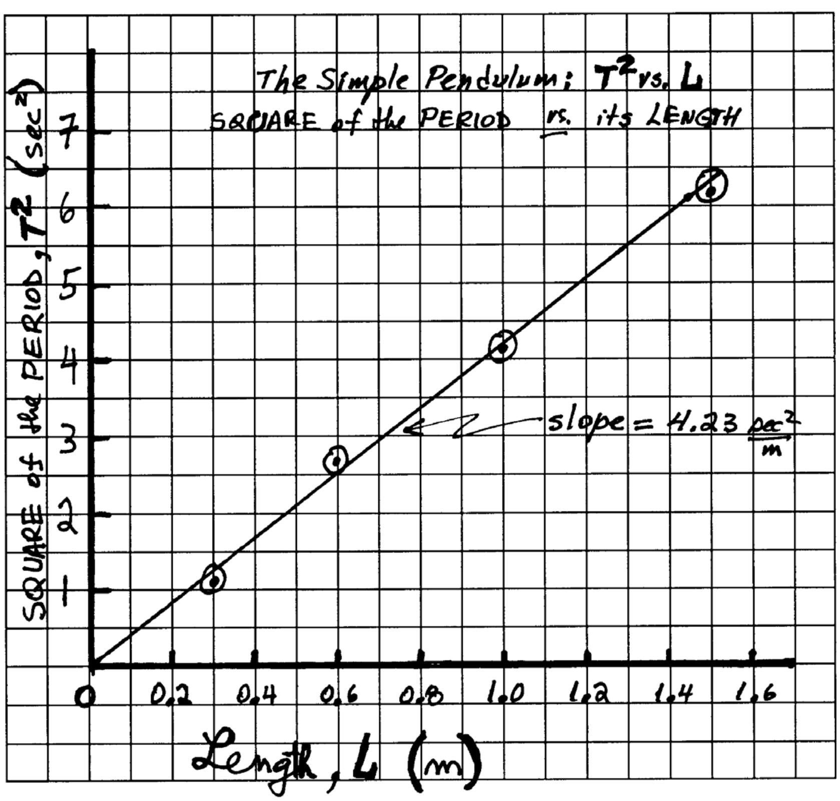
where **y** (the quantity plotted on the vertical axis) is a function of x (the quantity plotted on the horizontal axis). The "**m**" is the slope of the line and "**b**" is called the **y**-intercept. Linear regression analysis and substitution can be used to obtain the exact value for the slope and **y**-intercept, but in this exercise these values will be estimated by reading them directly from the graph.

1. Graph the data and draw a "best-fit" straight line (see Part A of the Procedure).

2. Determine the slope of the line. Choose two points on the line (not necessarily data points) that can be read accurately. To maximize precision, these two points should be fairly far apart. Read the coordinate values for each point. Point number one is the data point having an **x** value closest to the origin and the values for point one will be **(x_1, y_1).** The other point will have values of **(x_2, y_2).** The slope of the line is:

3. The sign of the slope can be negative (indicating an inverse relationship between the quantities **x** and **y**). Note that the number of significant figures for the slope will be artificially reduced if the points on the line selected for slope determination are too close together. Be sure to include units (unit for **y**/unit for **x**) with the value for the slope.

4. To determine the **y**-intercept value from the graph, extrapolate (extend) the line until it reaches the **y**-axis (**x = 0**) and read the value for **y** at that point (include units).

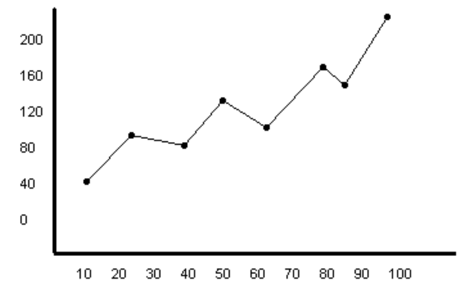


Exercises

Draw a GRAPH for each of the three given tables (*It will be presented to you in the laboratory*)

Questions

1- This is a **bad graph**! Why?
Answer;



2- This is a **good graph**! Why?
Answer;