Some Graphing Techniques

The purpose of this appendix is to remind you of some common relationships between variables. There are many many ways that two variables can be related. We review here only 3 common ones that occur in radiation detection: linear, exponential, and power law relationships.

Graphing is used to obtain a visual representation of the relationship between two (or more) variables. Usually one plots the variables such that **if** the graph results in a straight line, **then** the data are consistent with the theoretical (or postulated) relationship.

Linear Relationship

In a linear relationship, the variables y and x are related as:

$$y = mx + b \tag{1}$$

By graphing the variables using linear scales on the axes, one can test if the relation ship is linear, and if so determine the parameters m and b. Let's check if the following data are linearly related:

x(sec)	y(meters)
12	87
14	100
26	170
34	220
51	320

You should use a spreadsheet (e.g. Excel) for your graph and fit. You should find that the data are consistent with a linear relationship. You should find that the parameters are $m \approx 6$m/s and $b \approx 15$ m.
Some points to remember:

a) m is called the slope of the line
b) The value of b is the intercept of the vertical axis.
c) The "best fit" line (from the data) does not necessarily go through any data points.
d) The axis have units.
e) The slope m and intercept b have units.

Exponential Relationship

In an exponential relationship, the variables x and y are related as:

$$y = cb^{ax} \tag{2}$$

Usually (in this class) the base b will be the natural logarithm e:

$$y = ce^{ax} \tag{3}$$

A spreadsheet program (Excel) can help us check if two variables are related exponentially. Let's practice by checking if the following data have an exponential relationship:

x (sec)	y (counts)
0	100
20	37
40	13.5
60	5.0
80	1.8

You should find that the data are consistent with an exponential relationship, and that $a \approx -0.2$ sec^{-1} and $c \approx 100$. It is often useful to change the axis such that data related exponentially plot in a straight line. This can be done by changing the scale on the vertical axis to "logarithmic". To see that this works, just take the log of both sides of the equation:

$$log(y) = log(c) + a\ log(e)\ x \tag{4}$$

Thus, if $log(y)$ is ploted versus x a straight line will result.

Some points to remember:

a) The parameter a will have units of x^{-1}.
b) In our applications, a will be either the decay constant or the attenuation constant.

Power Law Relationship

In a power law relationship, x and y are related as:

$$y = cx^n \tag{5}$$

A spreadsheet program (Excel) can help us check if two variables are related via a power law. Let's practice by checking if the following data have this relationship:

x	y
2	8.5
5	34
12	125
19	248

You should find that the data are consistent with a power law relationship, and that $n \approx 1.5$ and $c \approx 3$. It is often useful to change the axis such that data related this way plot in a straight line. This can be done by changing the scale on both the vertical and horizontal axes to "logarithmic". To see that this works, just take the log of both sides of the equation:

$$log(y) = log(c) + n\ log(x) \tag{6}$$

Plotting $log(y)$ on the vertical axis and $log(x)$ on the horizontal axis will yield a straight line in "power-law" relations.

A point to remember:

a) The parameter n is *unitless.*

Some examples of these relationships in this class are as follows: The number of radioactive nuclei and activity decrease *exponentially* in time. The intensity decreases *exponentially* with shielding thickness. *Power law* relationships are found with the decrease of intensity with distance (inverse-square law), and the efficiency of detectors with energy. An approximate *linear* relationship exists between the energy of the radiation and channel number in detectors.