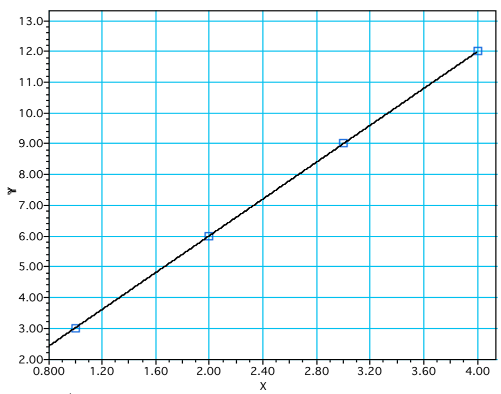
Graphing in Physic

(*Version 2*)

Comments by Carl J. Wenning

Working with graphs -- interpreting, creating, and employing -- is an essential skill in the sciences, and especially in physics where relationships need to be derived. As a physics student you probably have used graphing hundreds of times and are pretty much familiar with both the interpretation and creation of graphs. Nonetheless, my experience in PHY 302 is that most students are unaware of how powerful is the use graphs to determine relationships between variables.

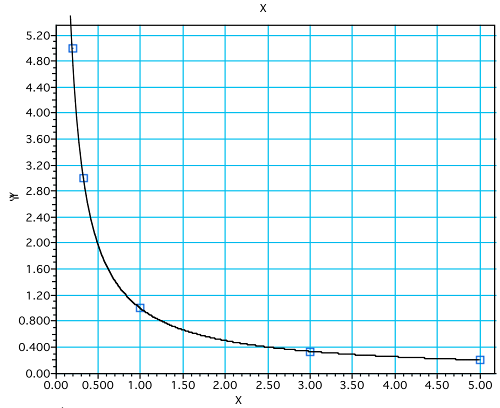
Below are a number of typical physical relationships exhibited graphically. Study the forms of the graphs carefully and be prepared to help your students formulate relationships between variables.



LINEAR RELATIONSHIP: What happens if you get a graph of data that looks like this? How does one relate the X variable to the Y variable? It's simple, Y = A + BX where B is the slope of the line and A is the Y-intercept. Characteristic of Newton's second law and of Charles' law:

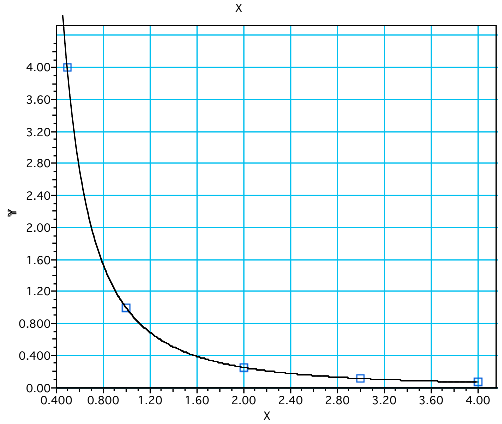
$$F = ma$$

$$\frac{P}{T} = const.$$



INVERSE RELATIONSHIP: This might be a graph of the pressure and temperature for a changing volume isothermal gas. How would you find this relationship short of using a computer package? The answer is to linearize the data. Plot the Y variable versus 1 over the X variable. The graph becomes a straight line. The resulting formula will be Y = A/X or XY = A. This is typical of Boyle's law:

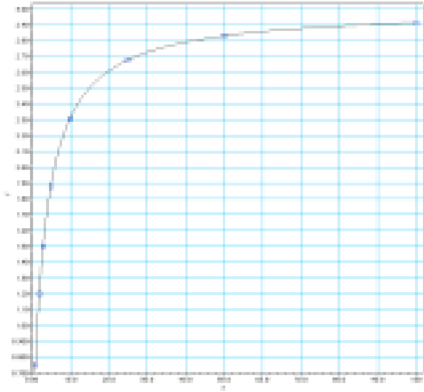
$$PV = const.$$



INVERSE-SQUARE RELATIONSHIP: Of the form Y = A/X^2. Characteristic of Newton's law of universal gravitation of the electrostatic law:

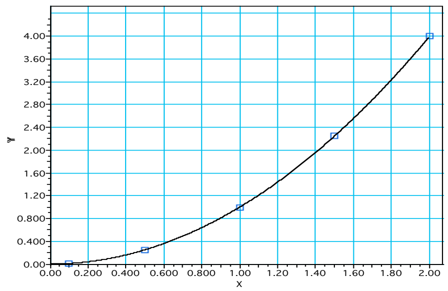
$$F = \frac{Gm_1m_2}{r^2}$$

$$F = \frac{kq_1q_2}{r^2}$$



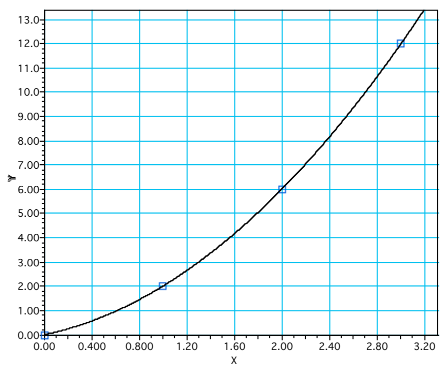
DOUBLE-INVERSE RELATIONSHIP: Of the form 1/Y = 1/X + 1/A. <u>Most readily identified by the presence of an asymptotic boundary (y = A) within the graph.</u> Characteristic of thin lens and parallel resistance formulas.

$$\frac{1}{f} = \frac{1}{i} + \frac{1}{o} \quad \text{and} \quad \frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$$



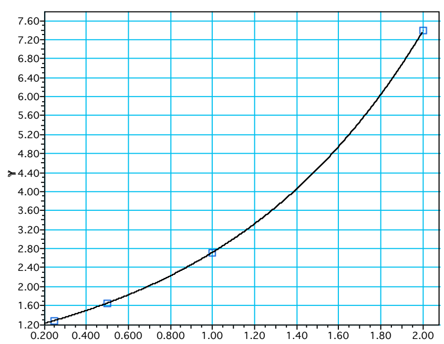
POWER RELATIONSHIP: Of the form Y = AX^B. Typical of the distance-time relationship:

$$d = \frac{1}{2}at^2$$



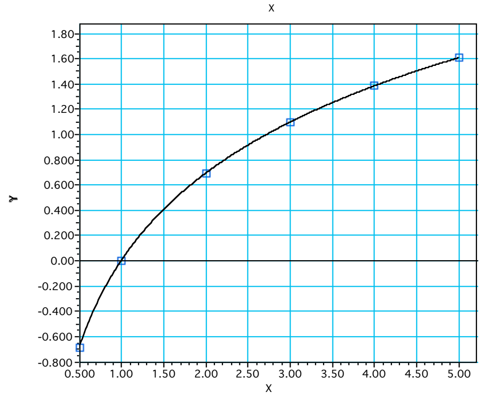
POLYNOMIAL OF THE SECOND DEGREE: Of the form Y = AX + BX^2. Typical of the kinematics equation:

$$d = v_o t + \frac{1}{2}at^2$$



EXPONENTIAL RELATIONSHIP: Of the form Y = A * exp(BX). Characteristic of exponential growth or decay. Graph to left is exponential growth. The graph of exponential decay would look not unlike that of the inverse relationship. Characteristic of radioactive decay.

$$N = N_o e^{\square\square t}$$



NATURAL LOG (LN) RELATIONSHIP: Of the form Y = A ln (BX). Characteristic of entropy change during a free expansion:

$$S_f \square S_i = nR\ln\frac{V_f}{V_i}$$