

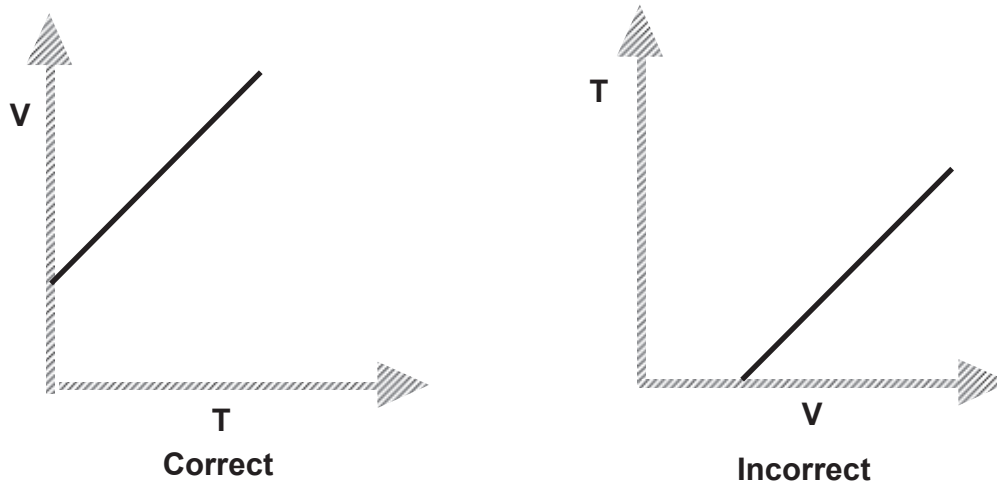
Unit I Reading – Graphical Methods

One of the most effective tools for the visual evaluation of data is a graph. The investigator is usually interested in a quantitative graph that shows the relationship between two variables in the form of a curve.

For the relationship $y = f(x)$, x is the *independent variable* and y is the *dependent variable*. The rectangular coordinate system is convenient for graphing data, with the values of the dependent variable y being plotted along the *vertical axis* and the values of the independent variable x plotted along the *horizontal axis*.

Positive values of the dependent variable are traditionally plotted above the origin and positive values of the independent variables to the right of the origin. This convention is not always adhered to in physics, and thus the positive direction along the axes will be *indicated by the direction the arrow heads point*.

The choice of dependent and independent variables is determined by the experimental approach or the character of the data. Generally, the **independent variable** is the one over which the *experimenter has complete control*; the **dependent variable** is the one that *responds to changes* in the independent variable. An example of this choice might be as follows. In an experiment where a given amount of gas expands when heated at a constant pressure, the relationship between these variables, V and T , may be graphically represented as follows:



By established convention it is proper to plot $V = f(T)$ rather than $T = f(V)$, since the experimenter can directly control the temperature of the gas, but the volume can only be changed by changing the temperature.

A. Curve Fitting

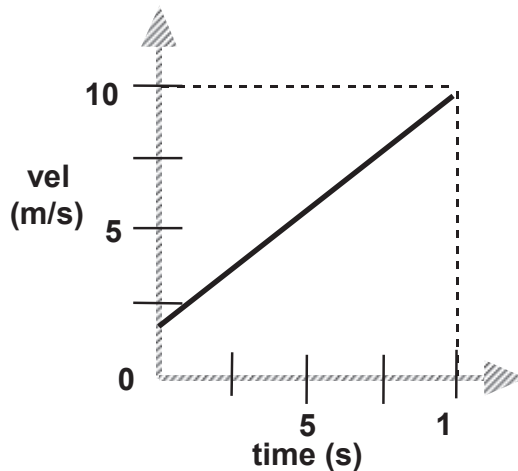
When checking a law or determining a functional relationship, there is good reason to believe that a uniform curve or straight line will result. The process of matching an equation to a curve is called **curve fitting**. The desired empirical formula, assuming good data, can usually be determined by inspection. There are other mathematical methods of curve fitting, however they are very complex and will not be considered here. Curve fitting by inspection requires an assumption that the curve represents a linear or simple power function.

If data plotted on rectangular coordinates yields a straight line, the function $y = f(x)$ is said to be *linear* and the line on the graph could be represented algebraically by the slope-intercept form:

$$y = mx + b,$$

where **m** is the slope and **b** is y-intercept.

Consider the following graph of velocity vs. time:



The curve is a straight line, indicating that $v = f(t)$ is a linear relationship. Therefore,

$$v = mt + b,$$

$$\text{where slope} = m = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

From the graph,

$$m = \frac{8.0 \text{ m/s}}{10.0 \text{ s}} = 0.80 \text{ m/s}^2 .$$

The curve intercepts the v-axis at $v = 2.0 \text{ m/s}$. This indicates that the velocity was 2.0 m/s when the first measurement was taken; that is, when $t = 0$. Thus, $b = v_0 = 2.0 \text{ m/s}$.

The general equation, $v = mt + b$, can then be rewritten as

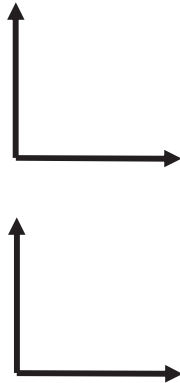
$$v = (0.80 \text{ m/s}^2)t + 2.0 \text{ m/s}.$$

Worksheet 1: GRAPHING PRACTICE

For each data set below, determine the mathematical expression. To do this, first graph the original data. Assume the 1st column in each set of values to be the **independent** variable and the 2nd column the **dependent** variable. Write an appropriate mathematical expression for the relationship between the variables. Be sure to include units!

Data set 1

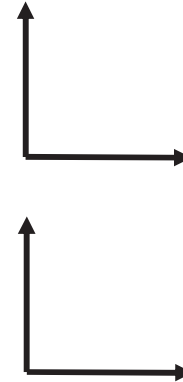
V (m ³)	P (pa)
.1	40
.5	8
1	4
2	2
4	1
5	.8
8	.5
10	.4



Mathematical expression #1

Data set 2

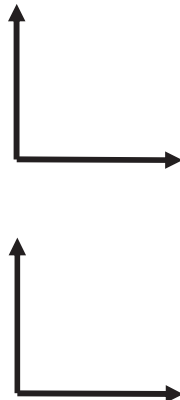
t (s)	x (m)
.1	.03
.2	.12
.5	.75
1	3
2	12
3	27
4	48
5	75



Mathematical expression #2

Data set 3

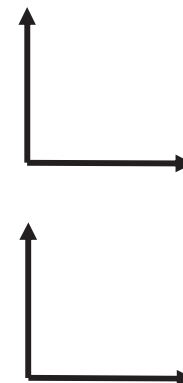
A (mont hs)	W (lbs)
1	7.3
2	9.4
3	10.5
4	12.0
5	13.0
6	14.3
7	15.2
8	16.7



Mathematical expression #3

Data set 4

t (s)	v (m/s)
.3	10
1.2	20
2.7	30
4.8	40
7.5	50
10.8	60
14.7	70
19.2	80

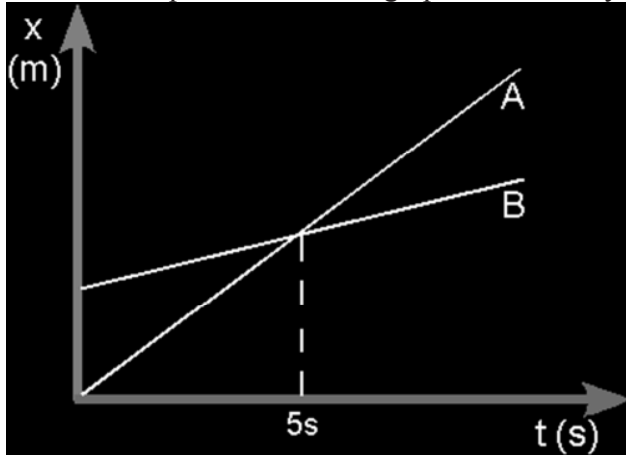


Mathematical expression #4

****Additional required reading for this unit is chapter 2 in Conceptual Physics. It is the expectation that you****
****read this before you come to class.****

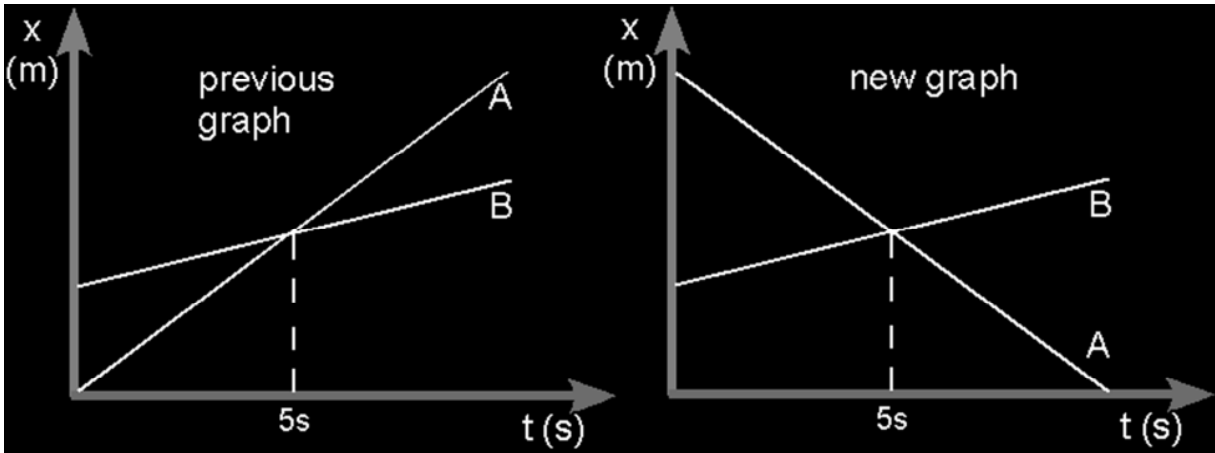
Worksheet 2

1. Consider the position vs. time graph below for cyclists A and B.



- Do the cyclists start at the same point? How do you know? If not, which is ahead?
- At $t = 7\text{s}$, which cyclist is ahead? How do you know?
- Which cyclist is travelling faster at $t = 3\text{s}$? How do you know?
- Are their velocities equal at any time? How do you know?
- What is happening at the intersection of lines A and B?

2. Consider the new position vs. time graph below for cyclists A and B.



- How does the motion of the cyclist A in the new graph compare to that of A in the previous graph from page one?
- How does the motion of cyclist B in the new graph compare to that of B in the previous graph?
- Which cyclist has the greater speed? How do you know?
- Describe what is happening at the intersection of lines A and B.
- Which cyclist traveled a greater distance during the first 5 seconds? How do you know?