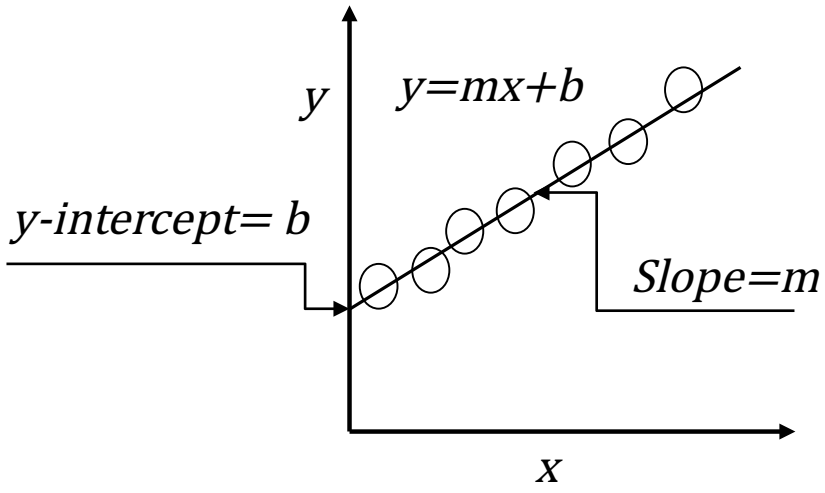
Plotting and Interpreting Graphs

Working with graphs is an essential skill in the sciences, and especially in physics where relationships need to be derived. A graph is a visual representation of a relationship between two variables, x (the independent variable) and y (the dependent variable). Graphs make it easy to identify trends in data that you have collected and can be analyzed to perform a calculation, related to addressing the aims of an experiment. A line (straight line or curve line) drawn that best expresses the apparent relationship is called a line of best fit. The best fit lines can be described by mathematical equations. The physical meanings of the fitted data can be drawn after comparing the physical equations with mathematical equations.

Plotting your results

A software called "***Graphical Analysis 3.0***" will be used in the lab to plot and analyze the data set.

Plotting y vs. x produces the graph below and a linear fit was done by software. The fitted data of slope $\boldsymbol{m}$ and $\boldsymbol{y-intercept\ b}$ will be used for interpreting the graph.



Interpreting Graphs

In physics your dependent and independent variables have a physical meaning, i.e. they are physical quantities like mass (M), volume (V), position (x) or time (t) to name a few. These quantities are related to each other via physical laws, generally expressed as equations. When interpreting your graph, you need to

know the related equation.

Example: Given a set of data of velocity and time for a falling object with constant acceleration, find the acceleration and initial velocity of this object.

The kinematics equation which includes all the variables (velocity, time, acceleration and initial velocity) is:

$$v = v_0 + at = at + v_0$$

This shows that the velocity v of the object is linearly dependent on its time t. A plot of v (on y-axis) versus t (on x-axis) should be a straight line which can be described by a linear mathematical equation $y = mx + b$. A best linear fit (or linear regression) of the data set by software will result in numerical values of the parameters m and b. The physical meanings of $the\ slope\ m\ and\ the\ y-intercept\ b$ can be found by comparing the mathematical equation with the physical equation.

Mathematical equation $y = mx + b$

Physical Equation $v = at + v_0$

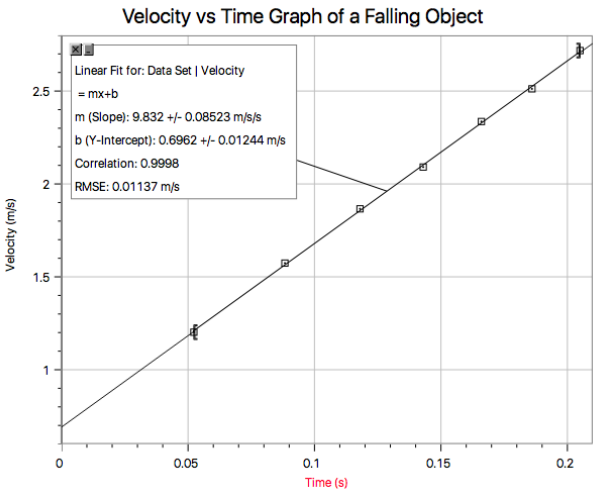
$\boldsymbol{slope\ m = acceleration\ a}$

$\boldsymbol{y-intercept\ b = initial\ velocity\ v_0}$

Data set

Velocity (m/s)	Time (s)
1.202	0.0523
1.574	0.0883
1.866	0.1180
2.091	0.1430
2.336	0.1660
2.512	0.1860
2.718	0.2050

Velocity vs Time graph



From the comparison results, you can get the results for acceleration and initial velocity.

$$\boldsymbol{acceleration\ a} = slope\ m = (9.832 \pm 0.08523)\ m/s^2 \cong \mathbf{(9.83 \pm 0.09)\ m/s^2}$$

$$\boldsymbol{initial\ velocity\ v_0} = y - intercept\ b = (0.6962 \pm 0.01244)\ m/s \cong \mathbf{(0.70 \pm 0.01)\ m/s}$$

A graph submitted with your workbook should have the following format:

1. A title.
2. Labelled axes including the units.
3. A well chosen scale and range.
4. The correct data plotted.
5. Remove connecting lines.
6. A best fit line including the fit box.

Summary

For plotting and interpreting graphs follow the steps below and refer to the previous example as needed:

1. Identify which physical variable is the $x\ (x - axis)$ and which is the $y\ (y - axis)$. [e.g., $v\ (y - axis),\ t(x - axis)$]
2. Identify which physical variables you need to find. [e.g., a, v_0]
3. Identify a physics equation that relates the known and need to find variables. [e.g., $v = v_0 + at$]
4. Note the relationship of your data, i.e. linear, quadratic etc. [e.g. linear]
5. Write down the general form of the mathematical equation i.e. $y=mx+b$, $y=ax^2+bx+c$, etc. [e.g. $y=mx+b$]
6. Compare the physical equation to the mathematical equation of the fit. [e.g., Comparing $v = v_0 + at$ to $y=mx+b$, gives $m=a$, $b=v_0$]