All you wanted to know about Formulae and Graphs (but were afraid to ask!)

To be able to carry out practical investigations in Physics you must understand the following:

1. What variables are you investigating
2. How the formula relates to the variables you are investigating
3. How the formula relates to a "y = mx + c" graph
4. How to process the variables and draw a linear graph
5. What the linear graph actually tells you

Sometimes you are asked to investigate two variables from a formula that might also be examined in the external exams. Sometimes the formula may be just for the practical assessment you are doing.

Example 1:

Aim: To find the relationship between the **force, F**, applied to a spring and the **extension, x**, of the spring.

Step 1: What variables are you investigating?

Independent variable: ***force*** Dependent variable: ***extension***

Formula: ***F = kx***

Step 2: How the formula relates to the variables you are investigating

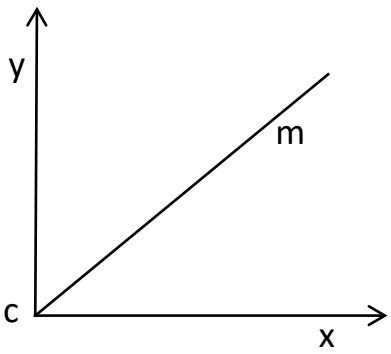
F = ***force***, ***x*** = ***extension***, ***k*** = ***spring constant***

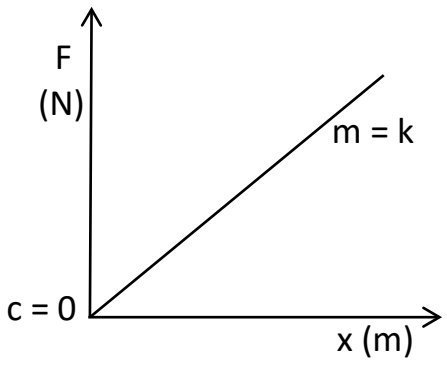
Step 3: How the formula relates to a "y = mx + c" graph

Since **y = mx + c** and ***F = kx***

(You might have to rearrange the equation at this point)

The **y = mx + c** *graph is a straight line graph and so* ***F = kx*** *should be too……*providing you plot F on the y-axis and x on the x-axis





If you plot F on the y – axis and x on the x-axis – this should give you an intercept of 0 (since you could write the equation as F = kx + 0) and the gradient, m, should be equal to the spring constant, k.
In this example there is no step 4 and 5 because this is a linear relationship.

The assessed investigations are non-linear so it may not always be as straightforward as to what you do.

Example 2:

Aim: To find the mathematical relationship between the **distance travelled, d**, and the **time taken, t**, for a basketball to fall from rest towards the ground.

Step 1: What variables are you investigating?

Independent variable: ***distance*** Dependent variable: ***time***

Formula: $d = \frac{1}{2} g t^2$

Step 2: How the formula relates to the variables you are investigating

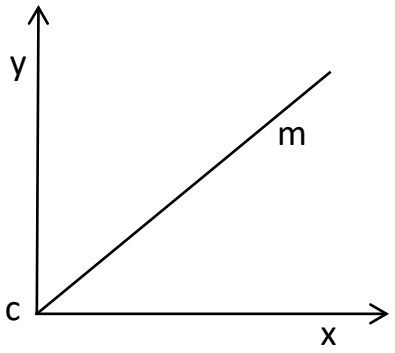
d = ***distance***, ***g*** = ***acceleration due to gravity*** and ***t*** = *time*

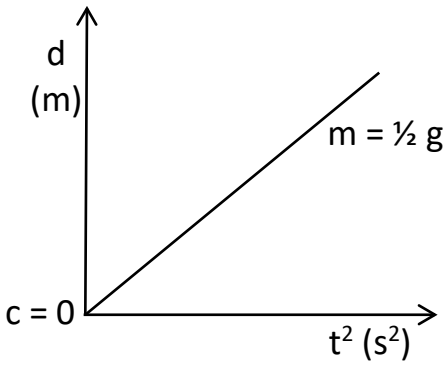
Step 3: How the formula relates to a "y = mx + c" graph

Since **y = mx + c** and $d = \frac{1}{2} g t^2$

(You might have to rearrange the equation at this point)

The **y = mx + c** *graph should a straight line graph and so should* $d = \frac{1}{2} g t^2$ ….. providing you plot ***d*** on the y-axis and t^2 on the x-axis)





Providing you plot ***d*** on the y-axis and t^2 on the x-axis – this should give you an intercept of 0 and the gradient, m, should be equal to $\frac{1}{2} g$, the acceleration due to gravity, g.

Step 4: How to process the variables and draw a linear graph

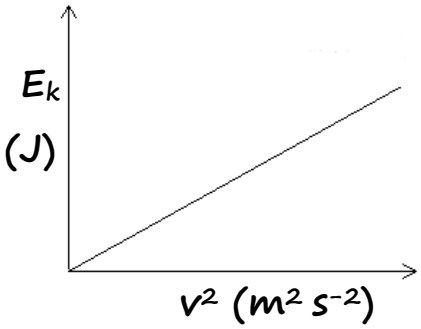
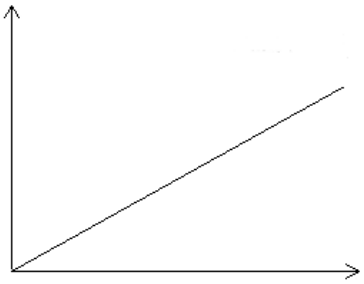
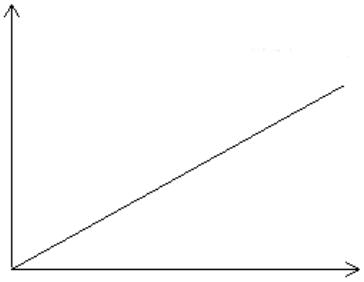
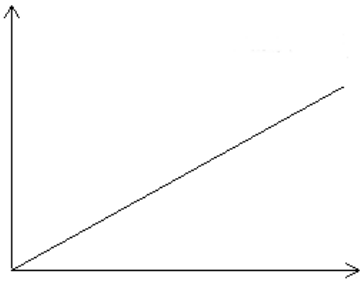
Now you understand that the graph is ***d*** versus t^2, calculate values for t^2 (units of s^2) and plot the graph.

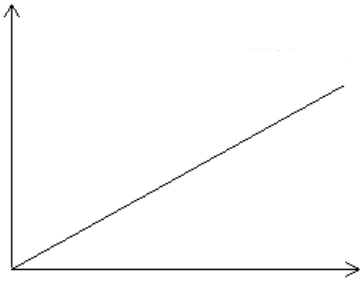
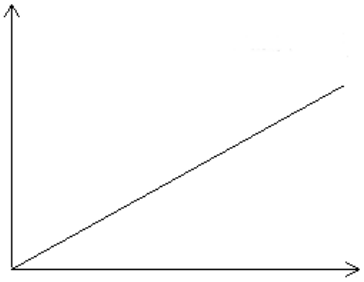
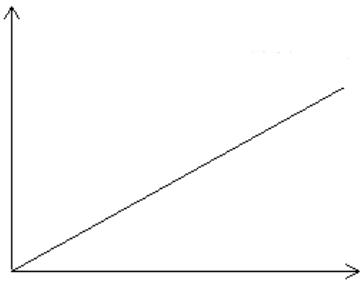
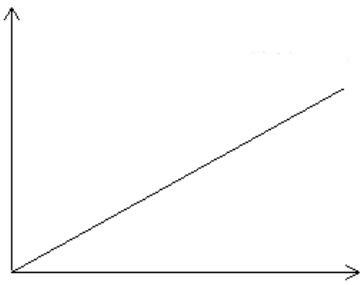
Step 5: What the linear graph actually tells you

You should be able to write a mathematical formula for your graph e.g. $d = 4.8t^2$ (again based upon y = mx + c where c = 0).

In this case, the gradient of your ***d*** versus t^2 graph should be about 5 – since it is the same as ½ g.

Complete the following:

1.	Aim: To find the mathematical relationship between the **kinetic energy, E_k**, and the **velocity, v**, for a car involved in a crash. Formula: $E_k = \frac{1}{2} mv^2$	Independent variable: *velocity, v* Dependent variable: *kinetic energy, E_k*	Linear Graph you would draw:  What does the gradient tell you? *(gradient)* **m = ½ m**
2.	Aim: To find the mathematical relationship between the **velocity, v,** of a ball when it hits the ground, and the **height, h**, it is dropped from. Formula: $v = \sqrt{2gh}$	Independent variable: Dependent variable:	Linear Graph you would draw:  What does the gradient tell you?
3.	Aim: To find the mathematical relationship between the **mass, m**, of an object and its **acceleration, a**, for a constant force. Formula: $F = ma$	Independent variable: Dependent variable:	Linear Graph you would draw:  What does the gradient tell you?
4.	Aim: To find the mathematical relationship between the **force exerted on a wire,F**, by a **current, I**, flowing in a constant magnetic field, B. Formula: $F = BIL$ *Why wouldn't you get this as an assessment?*	Independent variable: Dependent variable:	Linear Graph you would draw:  What does the gradient tell you?

5.	Aim: To find the mathematical relationship between the **current**, **I,** flowing in a circuit and the **resistance, R**. Formula: $V = IR$	Independent variable: Dependent variable:	Linear Graph you would draw:  What does the gradient tell you?
6.	Aim: To find the mathematical relationship between the **Time period, T, of a pendulum** and its **length, l**. Formula: $T = 2\pi\sqrt{\frac{l}{g}}$	Independent variable: Dependent variable:	Linear Graph you would draw:  What does the gradient tell you?
7.	Aim: To find the mathematical relationship between the **time period, T,** of a spring-mass system and its **mass, m.** Formula: $T = 2\pi\sqrt{\frac{m}{k}}$	Independent variable: Dependent variable:	Linear Graph you would draw:  What does the gradient tell you?
8.	Aim: To find the relationship between the **distance,** S_i, and the **focal length, f**, of a convex lens Formula: $S_i S_o = f^2$	Independent variable: Dependent variable:	Linear Graph you would draw:  What does the gradient tell you?

Answers

	formula	independent variable	dependent variable	y-axis	x-axis	gradient
1.	$E_k = ½ mv^2$	v	E_k	E_k (J)	v^2 ($m^2 s^{-2}$)	½ m
2.	$v = \sqrt{2gh}$	h	v	v (ms^{-1})	$\sqrt{h}$ ($m^{½}$)	$\sqrt{2g}$
3.	$F = ma$ $(a=F/m)$	m	a	a (ms^{-2})	$1/m$ (kg^{-1})	F
4.	$F = BIL$	I	F	F (N)	I (A)	BL
* You would not get F=BIL in an assessment as this is a linear mathematical relationship.						
5.	$V = IR$ $(I=V/R)$	R	I	I (A)	$1/R$ (Ω^{-1})	V
6.	$T = 2\pi\sqrt{\frac{l}{g}}$	l	T	T (s)	$\sqrt{l}$ ($m^{½}$)	$2\pi / \sqrt{g}$
7.	$T = 2\pi\sqrt{\frac{m}{k}}$	m	T	T (s)	$\sqrt{m}$ ($kg^{½}$)	$2\pi / \sqrt{k}$
8.	$S_i S_o = f^2$ $(f^2 = S_i S_o)$	S_i	f	f^2 (m^2)	S_i (m)	S_o