Year 11: S.I. Units, Numbers, Relations and Graphs.

1. UNITS, SIGNIFICANT FIGURES AND STANDARD (scientific) NOTATION

There are seven basic standard units

Quantity		SI Unit		Fundamental and Derived Dimensions
Name	Symbol(s)	Name	Symbol	
Length	l, x, y, d, etc.	metre	m	L
Mass	m, M	kilogram	kg	M
Time	t, T	second	s	T
Electric current	I	ampere	A	$T^{-1}Q$
Temperature	T	kelvin	K	-
Luminous Intensity	l	candela	cd	-
Amount of Substance	N	mole	mol	mol

e.g. 1 Velocity is equal to the change in displacement divided by the time taken, or $v = \frac{\Delta d}{t}$, so the SI units for the velocity will be the SI unit for displacement (m) divided by the SI unit for time (s) = $\frac{m}{s}$ or ms^{-1}.

e.g. 2 The area of an A4 sheet of paper is 29.8 cm by 21.0 cm. Calculate the area of the page in
i) cm^2 and ii) m^2

i) Area = length x wide
= 29.8 x 21.0
= 625.8 cm^2
= 626 cm(3 sig. fig.)

$1m^2$ = 100 x 100 cm^2
= 10000 cm^2
= 1.0×10^4 cm^2 (scientific notation)
∴ 1 cm^2 = 1.0×10^{-4} m^2 (or standard form)

ii) Area = 626 x 1.0×10^{-4} m^2
= 6.26×10^{-4} m^2(3 sig. fig.)

e.g. 3 Find the dimensions of the following quantities.

a) Area b) velocity c) Kinetic Energy

a) A = L x L
= L^2

b) v = L/ T
= LT^{-1}

c) $E_K = ½ mv^2$ = M x (LT^{-1})
= MLT^{-1}

e.g. 4 How many significant figures present in the following values ?

a) 400 (1 s.f.) b) 0.0987 (3 s.f.) c) 67.00 (4 s.f.) d) 82 (2 s.f.) e) 1.234×10^4 (4 s.f.)

Q1. Using the above table, write down the units for the following combinations of quantities :
a) current x time b) $\frac{\text{length}}{(\text{time})^2}$ c) $\frac{\text{mass x length}}{(\text{time})^2}$

Q2. a) How many cm^3 are there in a L ?
b) How many microseconds are there in 0.1 s
c) How many amperes in one milliampere
d) Express 10^6 m in kilometres
e) Express 3.8×10^{10} g in tonnes (1 t = 1000 kg)
f) Convert the following into the indicated units

mm	cm	m	km
80			
	12		
		1345	

Q3. Write these derived quantities in terms of the three basics of M, L, and T.
a) Volume b) acceleration c) force d) Work
e) Pressure f) Frequency g) Charge h) density

Q4. a) How many significant figures are there in each of the following measurements ;

i) 3.15 mm ii) 0.00324 s iii) 8.023 cm iv) 24 km v) 8.95×10^3 km vi) 300 km

b) Write in the following numbers in scientific notation ;

i) 5003 ii) 0.975 iii) 300000 iv) 0.0000458 v) 130 vi) 49734

c) Use your calculator to evaluate these, to two significant figures ;

i) $(3.4 \times 10^4) \times (2.5 \times 10^6)$ ii) $(4.7 \times 10^{-6}) \times (1.3 \times 10^4)$ iii) $(5.7 \times 10^{-2}) \div (3.7 \times 10^3)$
iv) $(8.23 \times 10^6) \div (10^{-7})$ v) $(48.354 \times 10^{-2})^2$ vi) $9.03 \times (7.8 \times 10^7)^3 \div (10^{15})$

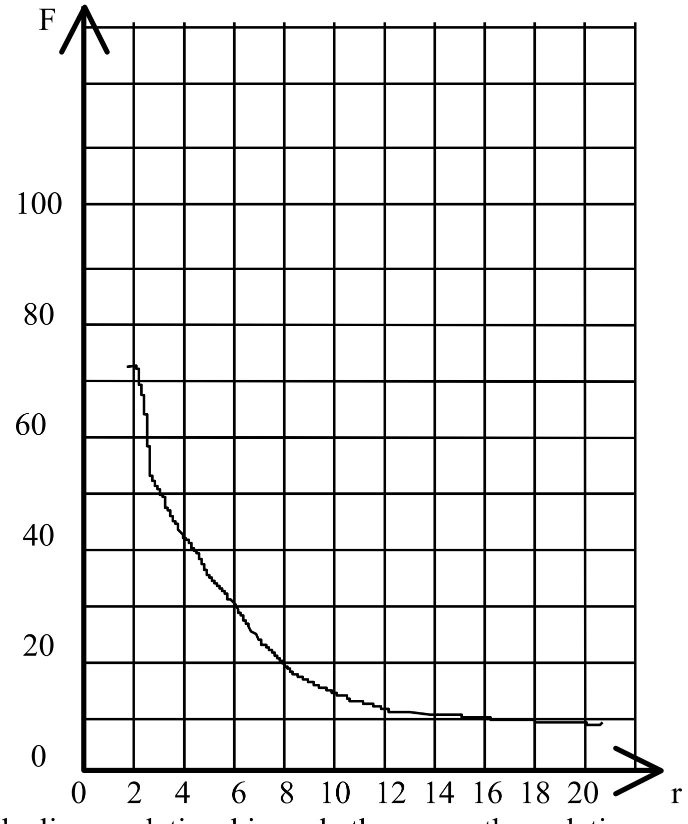
2. GRAPHS AND RELATIONSHIPS

1. Experimentally data is produced in such a way that two corresponding sets of results are produced, (F, r).

F	72.0	48.0	24.0	18.0	12.0	9.0
r	2.0	3.0	6.0	8.0	12.0	16.0

2. These results can then be graphed, r on the horizontal axis and F on the vertical axis **Generally time (t) is always along the horizontal axis unless it is the Period (T), this goes along the vertical axis.**

Graph A.

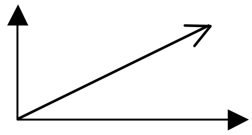


3. It is easiest to find a linear relationships rule than any other relation as ; given the co-ordinates of the data (F, r) $F = m r + c$ (mathematically $y = m x + c$) , where m = the gradient of the slope of a straight line, and c = the intercept of the vertical axis, gradient = rise / run (if it goes through the origin (0,0), c = 0)

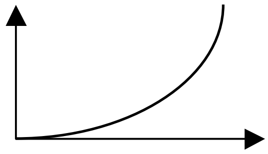
4. If the graph is not a linear (straight) one, then based on your knowledge of mathematical relations you need to re-calculate the data, and plot the new data to see if it now is linear.

Possible relations in form six are likely to be

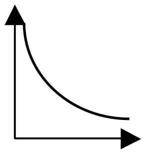
(i) $y \alpha x$ **LINEAR**



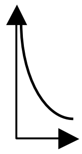
(ii) $y \alpha x^2$ **PARABOLA**



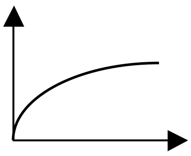
(iii) $y \alpha \frac{1}{x}$ **INVERSE**



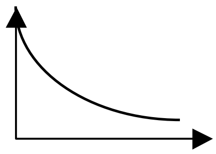
(iv) $y \alpha \frac{1}{x^2}$ **INVERSE SQUARE**



(v) $y \alpha \sqrt{x}$ **SQUARE ROOT**



(vi) $y = y_0e^{-kx}$ **EXPONENTIAL** (decay)

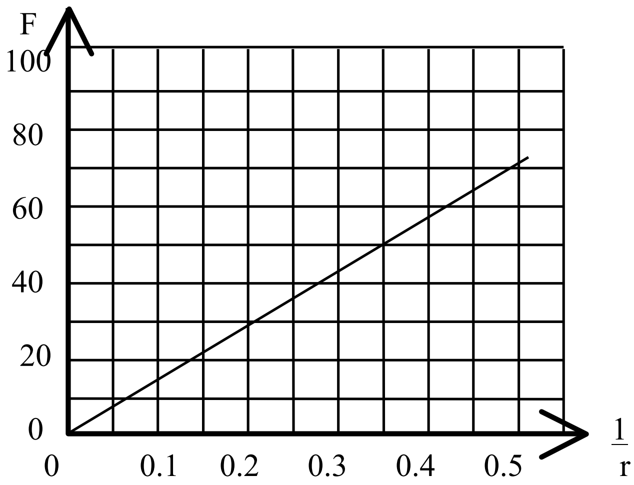


5. Looking at graph A. above it can be seen it is obviously not a straight line. It is hyperbolic in shape so what is required is to calculate r^{-1} , or $\frac{1}{r}$.

F	72.0	48.0	24.0	18.0	12.0	9.0
r	2.0	3.0	6.0	8.0	12.0	16.0
r^{-1}	0.50	0333	0.167	0.125	0.083	0.063

Plotting these points onto another graph (graph B.) it can be seen that the relation is linear.

Graph B.



hence,

$F \alpha \frac{1}{r}$ or $F = k.\frac{1}{r}$, where k is the constant of proportionality and can be found from the gradient.

$$k = \frac{\Delta y}{\Delta x} = \frac{rise}{run} = \frac{72 - 18}{0.50 - 0.125} = \frac{54}{0.375} = 144$$

$\therefore$ $F = \frac{144}{r}$ is the mathematical relationship for this set of data.

Q5. A student hangs several masses on a spring and records the gravitational force on each mass and the corresponding extension.

Grav. Force on the mass, F (N)	1.0	1.5	2.0	3.0	3.5	5.0	6.0
Extension, x (m)	0.019	0.031	0.040	0.061	0.069	0.100	0.122

a) Plot a graph of gravitational force along the vertical (y) axis against extension along the horizontal (x) axis.
b) Find the gradient and hence determine the force constant of the spring.
c) What is the mathematical relationship between the gravitational force F and extension x for the spring?

Q6. A tank is filled with water to various depths, h. The pressure, P, at the base of the tank is measured for each of the depths and recorded in the table below.

Depth of water, h (m)	0.0	0.5	1.0	1.5	2.0	2.5	3.0
Pressure at base, P (kPa)	0.0	0.40	0.85	1.3	1.7	2.0	2.5

a) Does the water pressure depend upon the depth, or, does the water depth depend upon the pressure ? Hence state which of the two is the dependent variable.
b) Plot a full size, accurate graph of the data.
c) Use your graph to estimate the water pressure at a depth of 2.2 m.
d) Extend your graph so as to estimate the depth of the tank when the base pressure is 2.7 kPa.
e) Write a full sentence to describe the relationship between water pressure (P) and depth (h).
f) Calculate the gradient from your graph.
g) Hence write down an equation for the relationship between P and h.

Q7. A light glider is resting on a frictionless air track. The track is inclined slightly to the horizontal so that the glider slowly gains speed down hill when released from rest. The glider was released to travel various distances down the track, and the time taken to travel each distance was measured. The results are recorded below:

Distance , d (m)	2.00	1.80	1.40	1.00	0.80	0.60
Time, t (s)	2.4	2.3	2.0	1.7	1.5	1.3
t^2 (s^2)						

(a) Plot a graph of d vs. t
(b) Complete the t^2 row
(c) Plot the graph of d vs. t^2
(d) What is the slope of the line of best fit for your graph?
(e) Use the kinematics equation $d = 1/2\ at^2$ and your answer to (d) above. to find the acceleration of the glider.

Q8. The light intensity at different distances from a light source is measured and the following results obtained:

Distance, d (m)	0.10	0.15	0.20	0.25	0.30
Light intensity, l (lux)	9600	4600	2200	1500	1100

a) Plot a graph of l vs. d. Then do graphs of:
b) l vs. 1/d , and c) l vs. $1/d^2$

Draw your conclusions from the graphs.