Fundamental Skills for A-level Physics

A-level Physics – basics

Units

Scientists around the world use the same internationally agreed system of units. These are called SI (Système International) units. The system is built upon seven **base units**.

SI Base Units

Quantity	*Name*	*Symbol*
Length		
	Kilogram	
		s
	Ampere	
Temperature		K
Amount of Substance		mol
Luminous Intensity	Candela	cd

Quantities such as speed (ms^{-1}) and density (kgm^{-3}) which are not expressed in a single base unit are expressed in **derived units**.

Derived units

Quantity	*Symbol*	*Name of unit*	*Symbol for unit*	*Base units*
speed or velocity	v		ms^{-1}	ms^{-1}
acceleration	a		ms^{-2}	ms^{-2}
force	F			$kgms^{-2}$
energy	E			kgm^2s^{-2}
power	P		W	kgm^2s^{-3}
pressure	p		Pa	$kgm^{-1}s^{-2}$
frequency	f	hertz	Hz	s^{-1}
charge	Q	coulomb		As
potential difference	V	volt		$A^{-1}kgm^2s^{-3}$
resistance	R		Ω	$A^{-2}kgm^2s^{-3}$
capacitance	C	farad	F	$A^2kg^{-1}m^{-2}s^4$
magnetic flux	B	tesla	T	$A^{-1}kgs^{-2}$

Homogeneity of an equation

If an equation is written correctly it must be homogeneous; that is, the units of the quantities on the left hand side of the equation must be identical to those on the right hand side.

Example

The equation $F = \frac{mv^2}{r}$ describes the relationship between the force applied to an object of mass m so that it travels in a circle of radius r at a speed v. Show that it is homogeneous.

Practice questions

1) Show that $T = 2\pi\sqrt{\frac{l}{g}}$ where T is the period of a pendulum (in seconds), l is the length of the pendulum and g is the acceleration due to gravity, is homogeneous.

2) The equation for the gravitational force of attraction between 2 bodies is given by $F = \frac{GM_1M_2}{r^2}$ where M_1 and M_2 are the masses of the 2 bodies and r is the distance between them. Find the base units for the gravitational constant G.

Prefixes

In Physics we have to deal with quantities from the very large to the very small. A prefix is something that goes in front of a unit and acts as a multiplier. This sheet will give you practice at converting figures between prefixes.

Symbol	Name	What it means		How to convert	
P	peta	10^{15}	1000000000000000		↓ x1000
T		10^{12}	1000000000000	↑ ÷ 1000	↓ x1000
G		10^{9}	1000000000	↑ ÷ 1000	↓ x1000
M		10^{6}	1000000	↑ ÷ 1000	↓ x1000
k	kilo		1000	↑ ÷ 1000	↓ x1000
			1	↑ ÷ 1000	↓ x1000
m		10^{-3}	0.001	↑ ÷ 1000	↓ x1000
µ		10^{-6}	0.000001	↑ ÷ 1000	↓ x1000
n	nano		0.000000001	↑ ÷ 1000	↓ x1000
p	pico		0.000000000001	↑ ÷ 1000	↓ x1000
f	femto		0.000000000000001	↑ ÷ 1000	

Convert the figures into the prefixes required.

s	ms	µs	ns	ps
134.6				
96.21				
0.773				

m	km	mm	Mm	Gm
12873				
0.295				
57.23				

kg	Mg	mg	g	Gg
94.76				
0.000765				
823.46				

Calculating Means

The mean of repeat measurements is the best estimate of the true value, if there is no systematic error.

For each set of values calculate the mean and then calculate the mean ignoring any anomalous results.

1	2	3	Mean	
4152	2996	4018		
935.5	925.8	926.7		
16.2	19.1	17.4		
80.1316	80.1324	80.1466		
2229	2011	1610		
127.664	127.416	127.489		
55.88	11.97	37.59		
3.767	3.763	3.751		

1	2	3	4	Mean	
63.10	62.97	62.53	62.99		
465.98	463.40	466.96	155.56		
3.61	7.39	3.55	3.64		
73.71	70.98	74.19	72.38		
2.058	1.566	2.078	1.787		
416	402	189	986		

1	2	3	4	5	Mean	
140	220	90	180	140		
56300	41200	58600	48300	53800		
0.186	0.341	0.276	0.216	0.314		
1.427	0.235	0.488	1.922	1.620		
34	62	46	12	39		
326.19	360.22	314.20	352.22	400.18		
1.4	5.3	2.7	3.9	2.6		

Significant figures

For each value state how many significant figures it is stated to.

Value	Sig Figs	Value	Sig Figs	Value	Sig Figs	Value	Sig Figs
2		1066		1800.45		0.07	
2.0		82.42		2.483×10^4		69324.8	
2.00		750000		2.483		0.0063	
0.136		310		5906.4291		9.81×10^4	
0.34		3.10×10^2		200000		6717	
54.1		3.1×10^2		12.711		0.91	

Add the values below then write the answer to the appropriate number of significant figures

Value 1	Value 2	Value 3	Total Value	Total to correct sig figs
51.4	1.67	3.23		
7146	–32.54	12.8		
20.8	18.72	0.851		
1.4693	10.18	–1.062		
9.07	0.56	3.14		

Multiply the values below then write the answer to the appropriate number of significant figures

Value 1	Value 2	Total Value	Total to correct sig figs
0.91	1.23		
8.764	7.63		
2.6	31.7		
937	40.01		

Divide value1 by value 2 then write the answer to the appropriate number of significant figures

Value 1	Value 2	Total Value	Total to correct sig figs
5.3	748		
3781	6.434		
91×10^2	180		
5.56	22×10^{-3}		

For each value state how many significant figures it is stated to.

Value	Sig Figs	Value	Sig Figs	Value	Sig Figs	Value	Sig Figs
2.863		689671.49		100000		6.4981×10^{7}	
100		356865		8.5×10^{-3}		7.85	
24.92		13		6400		17.99	
5.18×10^{27}		182.15		875.4		3.189×10^{6}	

Calculate the mean of the values below then write the answer to the appropriate number of significant figures

Value 1	Value 2	Value 3	Mean Value	Mean to correct sig figs
1	1	2		
435	299	4130		
500	600	900		
3.038	4.925	3.6		
720	498	168		
1655	2996	140		
0.230	925.8	56300		
26017	19.1	0.186		
2238	80.1324	1.427		
9160.97	2011	34		
62.99	127.416	326.19		
155.56	11.97	1.4		
3.64	3.763	700653		
72.38	511.5	2670887		
1.787	888	110.4		
986	0.415	62.97		
726161	25157	463.40		
2670733	1014	7.39		

Calculating errors

Complete the table.

Variable	Reading 1	Reading 2	Reading 3	Mean Value	Uncertainty	% Uncertainty
A	121	118	119			
B	599	623	593			
C	3.3	3.6	3.2			

What would be the percentage error in the following quantities?

A^2		CB	
AB		ABC	
$\frac{C}{B}$		$\frac{A^2C}{B}$	

Complete the table.

Variable	Reading 1	Reading 2	Reading 3	Mean Value	Uncertainty	% Uncertainty
D	17	17	17			
E	42.5	42.8	42.1			
F	3.60	3.28	3.73			
G	757	714	739			

What would be the percentage error in the following quantities?

D^3F		EFG^3	
GE^2F		EGD^2	
$\frac{G^2}{DE}$		$\frac{DG}{FE}$	
AFD		F^2B^2G	

Complete the table.

Variable	Reading 1	Reading 2	Reading 3	Mean Value	Uncertainty	% Uncertainty
H	58205	58309	58193			
I	82.3	81.4	82.8			
J	1985	1988	1980			
K	43	19	27			

What would be the percentage error in the following quantities?

$\frac{H^2K^4}{AEI}$		$J^3\frac{HI}{K}$	
KFC		JFK	
K^4I		I^2JK	

Complete the table.

Variable	1	2	3	4	Mean Value	Uncertainty	% Uncertainty
L	11.49	11.56	11.63	10.53			
M	385	322	408	328			
N	2736	2729	2743	2643			
O	5101	5108	5003	5098			
P	125	137	167	142			
Q	6124	6118	6510	6123			
R	3.29	3.29	3.29	3.29			
S	4589	4606	4644	4596			
T	417	488	460	456			
U	1.506	3.061	3.085	1.513			
V	274	333	338	277			
W	33.46	33.45	33.96	33.65			

What would be the percentage error in the following quantities?

MO		MO^2N	
$OMLM$		N^3O	
$\frac{L}{M}$		$\frac{NO^2}{L}$	
NML		$LMON$	
P^2R		QPR	
SNO^2P		PMT	
$\frac{SR}{PM}$		$\frac{R^2S}{N^2}$	
$(QR)^2S$		$TROL^2$	

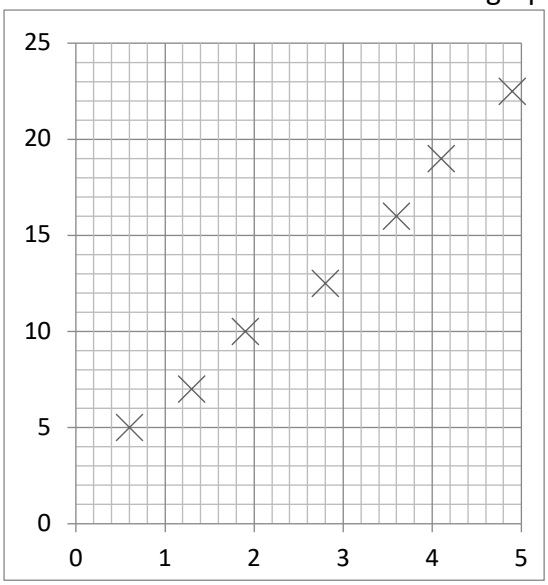
Identifying Errors

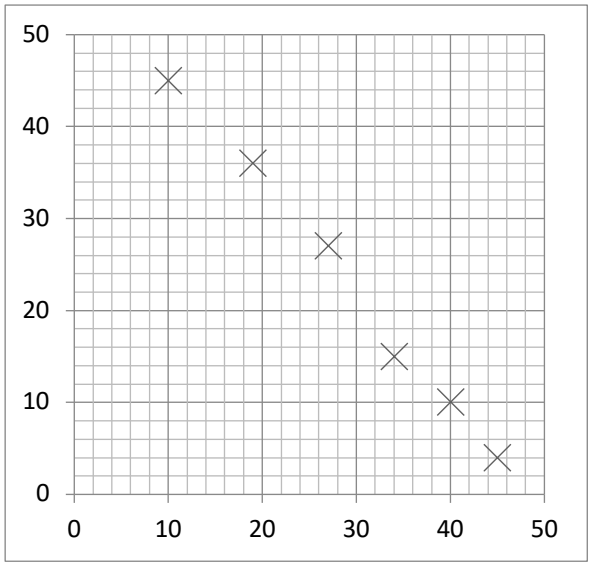
For each of the measurements listed below identify the most likely source of error what type of error this is and one method of reducing it.

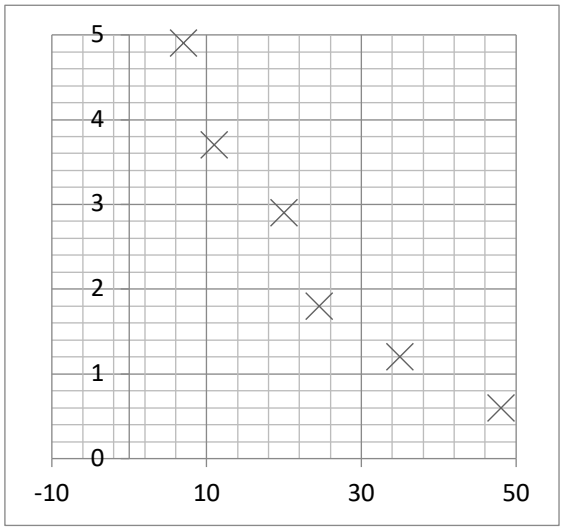
Measurement	Source	Type
A range of values are obtained for the length of a copper wire		
The reading for the current through a wire is 0.74A higher for one group in the class		
A beaker of hot water left on the desk appears to have gained temperature		
A mass of a beaker shows different values on different balances		
A range of values are obtained for the bounce back height of a dropped ball		
A few groups obtain different graphs of resistance vs light intensity for an LDR		
The time period (time of one oscillation) of a pendulum		

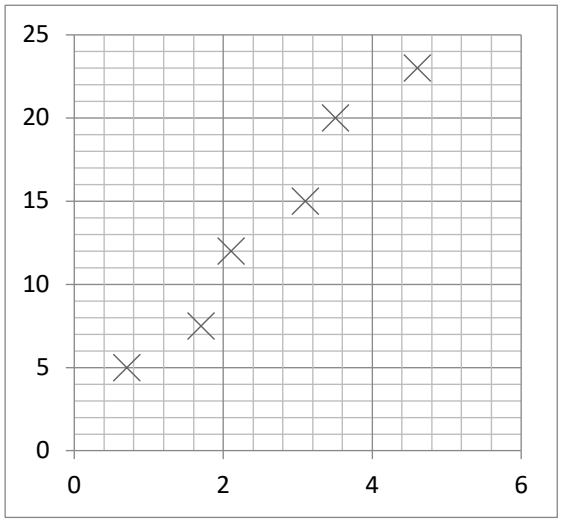
Lines of best fit

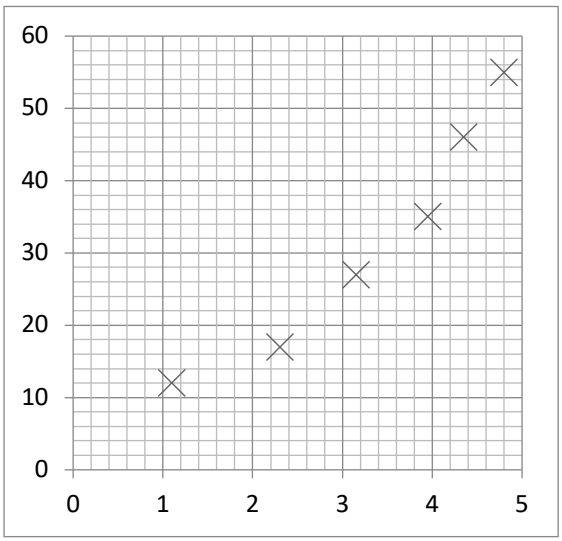
Draw a line of best fit for each of the graphs.

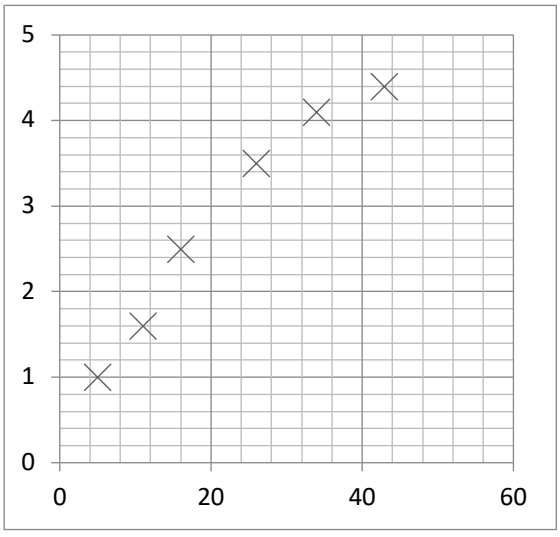






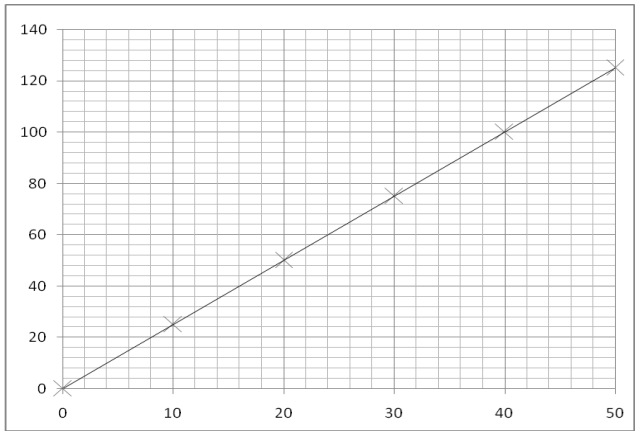


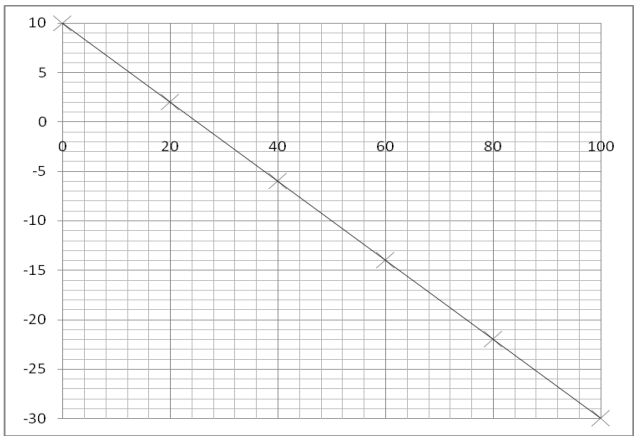


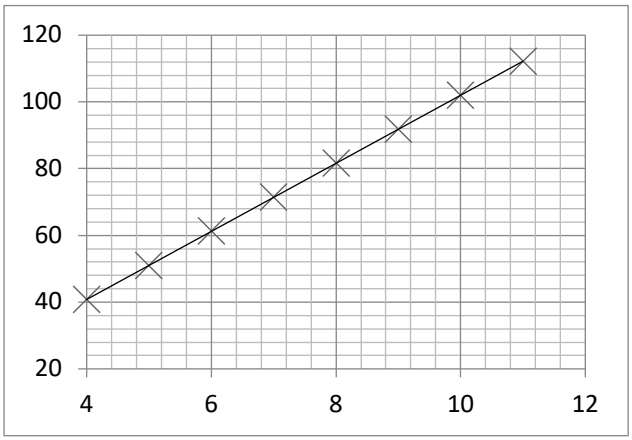


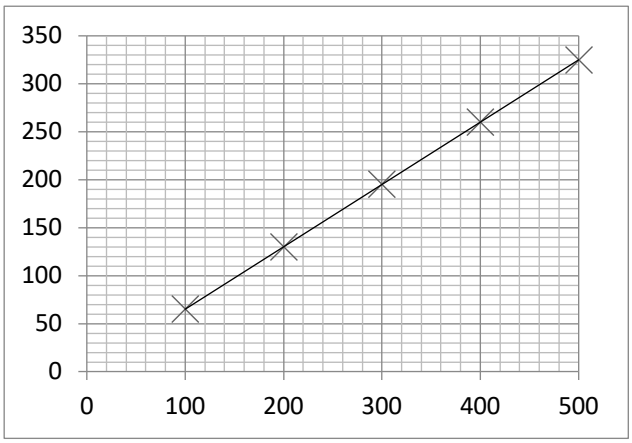
Calculating Gradients

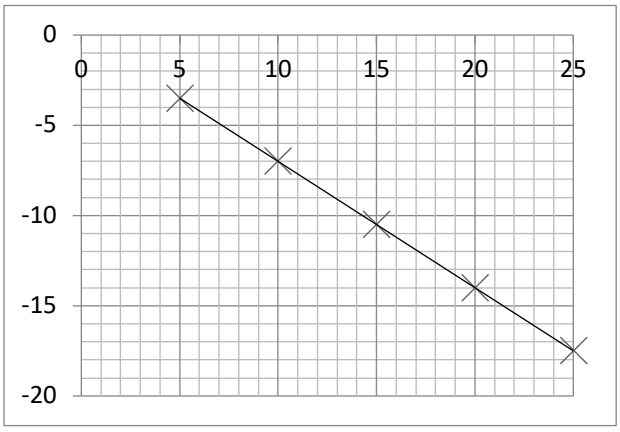
Calculate the gradients of the graphs below. Work out the equation for the line.

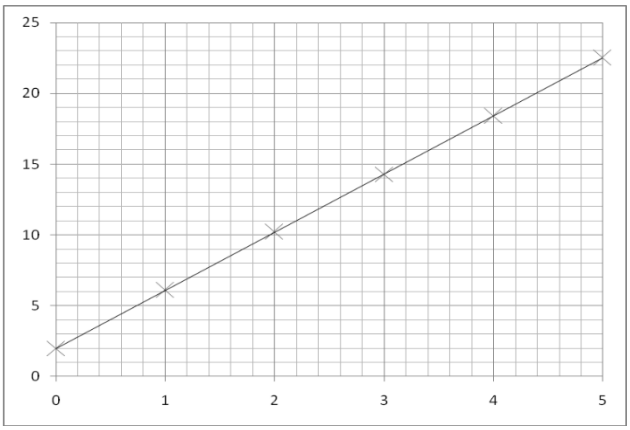












Gradient Equations

Complete the table below about graphs and gradients

Equation	Graph	Rearrange Equation	Gradient	Intercept
$y = mx + c$	y plotted on the y axis x plotted on the x axis	$y = mx + c$	m	c
$V = IR$	y axis = V x axis = I	$V = RI$	R	0
$I = \frac{Q}{t}$	y axis = t x axis = Q			
$\rho = \frac{RA}{l}$	y axis = l x axis = R			
$\varepsilon = V + Ir$	y axis = V x axis = I			
$E = VIt$	y axis = E/t x axis = V			
$hf = \phi + E_K$	y axis = E_K x axis = f			
$\lambda = \frac{h}{mv}$	y axis = $1/v$ x axis = m			
$E_P = mgh$	y axis = mg x axis = E_P			
$E = \frac{1}{2}Fe$	y axis = e x axis = $1/F$			
$c = f\lambda$	y axis = $1/\lambda$ x axis = f			
$v = u + at$	y axis = a x axis = $1/t$			
$v^2 = u^2 + 2as$	y axis = v^2 x axis = s			

Complete the table below about graphs and gradients

Equation	Graph	Rearrange Equation	Gradient	Intercept
$y = mx + c$	y plotted on the y axis x plotted on the x axis	$y = mx + c$	m	c
$V = IR$	y axis = V x axis = I	$V = RI$	R	0
$F = \frac{\Delta(mv)}{\Delta t}$	y axis = v x axis = F/m			
$F = m\omega^2 r$	y axis = r x axis = F/m			
$T = 2\pi\sqrt{\frac{l}{g}}$	y axis = l x axis = g			
$T = 2\pi\sqrt{\frac{m}{k}}$	y axis = T^2 x axis = m			
$g = -\frac{GM}{r^2}$	y axis = M x axis = g			
$F = \frac{Qq}{4\pi\varepsilon_0 r^2}$	y axis = F x axis = q/r^2			
$C = \frac{Q}{V}$	y axis = V x axis = Q			
$Q = Q_0 e^{-t/RC}$	y axis = $\ln(Q/Q_0)$ x axis = t			
$\varepsilon = N\frac{\Delta\phi}{\Delta t}$	y axis = ε x axis = $N\phi$			
$\frac{N_S}{N_P} = \frac{V_S}{V_P}$	y axis = N_P x axis = N_S			
$R = r_0 A^{1/3}$	y axis = R^3 x axis = A			
$pV = nRT$	y axis = T x axis = V			