

Definitions

Define the following words:

Independent variable

Dependent variable

Control variable

Continuous variable

Discrete variable

Ordered variable

Categoric variable

Accuracy

Precision

Reliability

Calibration

Random error

Systematic error

Zero error

Mean value

Anomalous results

Line of best fit

Gradient

Y-Intercept

How do you improve the precision of a reading?

How do you improve the reliability of your results?

If a weighing scale read 20g when nothing was placed on it how would you describe it?

If you used this to find the masses of different samples of metal what type of error would it produce?

How could you calculate the true value for each of the masses?

How do you calculate a mean value of 4 readings?

If all your readings are to 2 significant figures how many sig fig can your mean value be? Why?

Which type of variable would the following be classed as:

Height in cm?

Gender?

Dress size?

Attractiveness?

Distance in m?

Brightness?

Volume of CO₂ produced in m³?

Temperature in Fahrenheit?

Favourite chocolate bar?

Current in Amps?

Smelliness?

Age in days?

pH?

Pressure in Pa?

Loudness?

T-Shirt size?

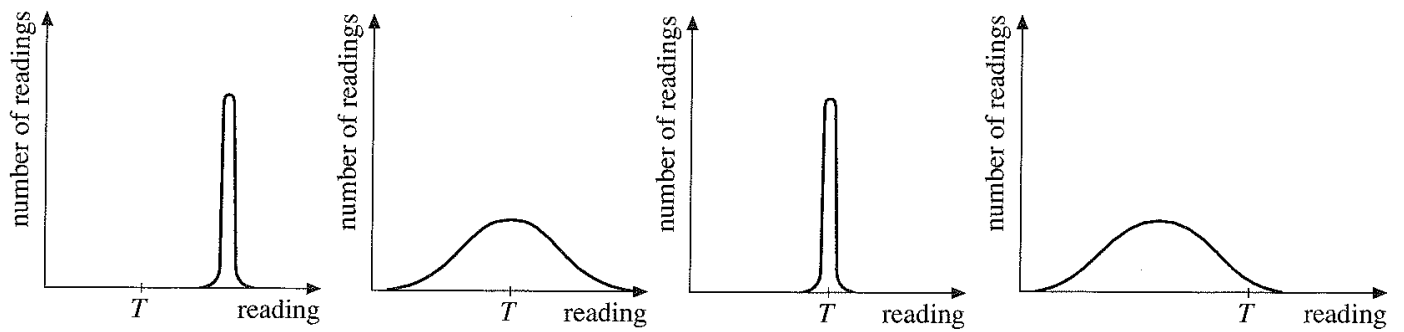
If T represents the true value which of the graphs below represents:

A. Precise and accurate?

B. Precise but not accurate?

C. Accurate but not precise?

D. Neither accurate nor precise?



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	
		10^{power}	Number of zeros	Upward conversion	Downward conversion
P	peta	10^{15}	1000000000000000		↓ x1000
T	tera	10^{12}	1000000000000	↑ ÷ 1000	↓ x1000
G	giga	10^9	1000000000	↑ ÷ 1000	↓ x1000
M	mega	10^6	1000000	↑ ÷ 1000	↓ x1000
k	kilo	10^3	1000	↑ ÷ 1000	↓ x1000
			1	↑ ÷ 1000	↓ x1000
m	milli	10^{-3}	0.001	↑ ÷ 1000	↓ x1000
μ	micro	10^{-6}	0.000001	↑ ÷ 1000	↓ x1000
n	nano	10^{-9}	0.000000001	↑ ÷ 1000	↓ x1000
p	pico	10^{-12}	0.000000000001	↑ ÷ 1000	↓ x1000
f	femto	10^{-15}	0.000000000000001	↑ ÷ 1000	

Convert the figures into the prefixes required.

s	ms	μ s	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				
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A	mA	μ A	nA	kA
0.000000678				
3.56				
0.00092				

Means and Anomalous Results

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		
375.5	511.5	463.4		
1048	888	1655		
0.507	0.415	0.230		
27145	25157	26017		
1450	1014	2238		
9104.32	10529.45	9160.97		

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		
700653	739762	742471	726161		
2670887	2670901	2669942	2670733		
110.4	260.1	1044.2	488.8		

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 1

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		
739762	26017	2.058		
8.15	0.002	106		
132.303	4.123	53800		
152	0.8	0.55		
0.1142	4922388	132000		

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		
0.722	634.23		

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}		
3.142	8.314		

Significant Figures 2

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	
2.8		4.267		94		0.053	
2.9970		0.02		94.0		0.422	

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		
488.8	10529.45	70.98		
0.186	140	1.566		
1.427	53800	402		
34	0.314	739762		
326.19	1.620	2670901		
1.4	39	260.1		

Calculating Errors 1

Complete the table.

Variable	Reading 1	Reading 2	Reading 3	Mean Value	Uncertainty	% Uncertainty
<i>A</i>	121	118	119			
<i>B</i>	599	623	593			
<i>C</i>	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
<i>D</i>	17	17	17			
<i>E</i>	42.5	42.8	42.1			
<i>F</i>	3.60	3.28	3.73			
<i>G</i>	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
<i>H</i>	58205	58309	58193			
<i>I</i>	82.3	81.4	82.8			

<i>J</i>	1985	1988	1980			
<i>K</i>	43	19	27			

What would be the percentage error in the following quantities?

$\frac{H^2 K^4}{AEI}$		$J^3 \frac{HI}{K}$	
<i>KFC</i>		<i>JFK</i>	
$K^4 I$		$I^2 JK$	
$\frac{ABCDEF}{GHIJK}$		$ADH \frac{BEI}{CFJ^2}$	

Calculating Errors 2

Complete the table.

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

What would be the percentage error in the following quantities?

<i>MO</i>		$MO^2 N$	
<i>OMLM</i>		$N^3 O$	
$\frac{L}{M}$		$\frac{NO^2}{L}$	
<i>NML</i>		<i>LMON</i>	
$P^2 R$		<i>QPR</i>	
$SNO^2 P$		<i>PMT</i>	

$\frac{SR}{PM}$		$\frac{R^2S}{N^2}$	
$(QR)^2S$		$TROL^2$	
$QP\frac{VR}{ST}$		$\frac{PO^2}{RUT}$	
$SWOT$		$OWLS$	
$N^4\frac{O^4P^2}{W^2}S^2$		$\frac{TUW^2PN}{MS^2R}$	
$RUST$		WO^2L	

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.

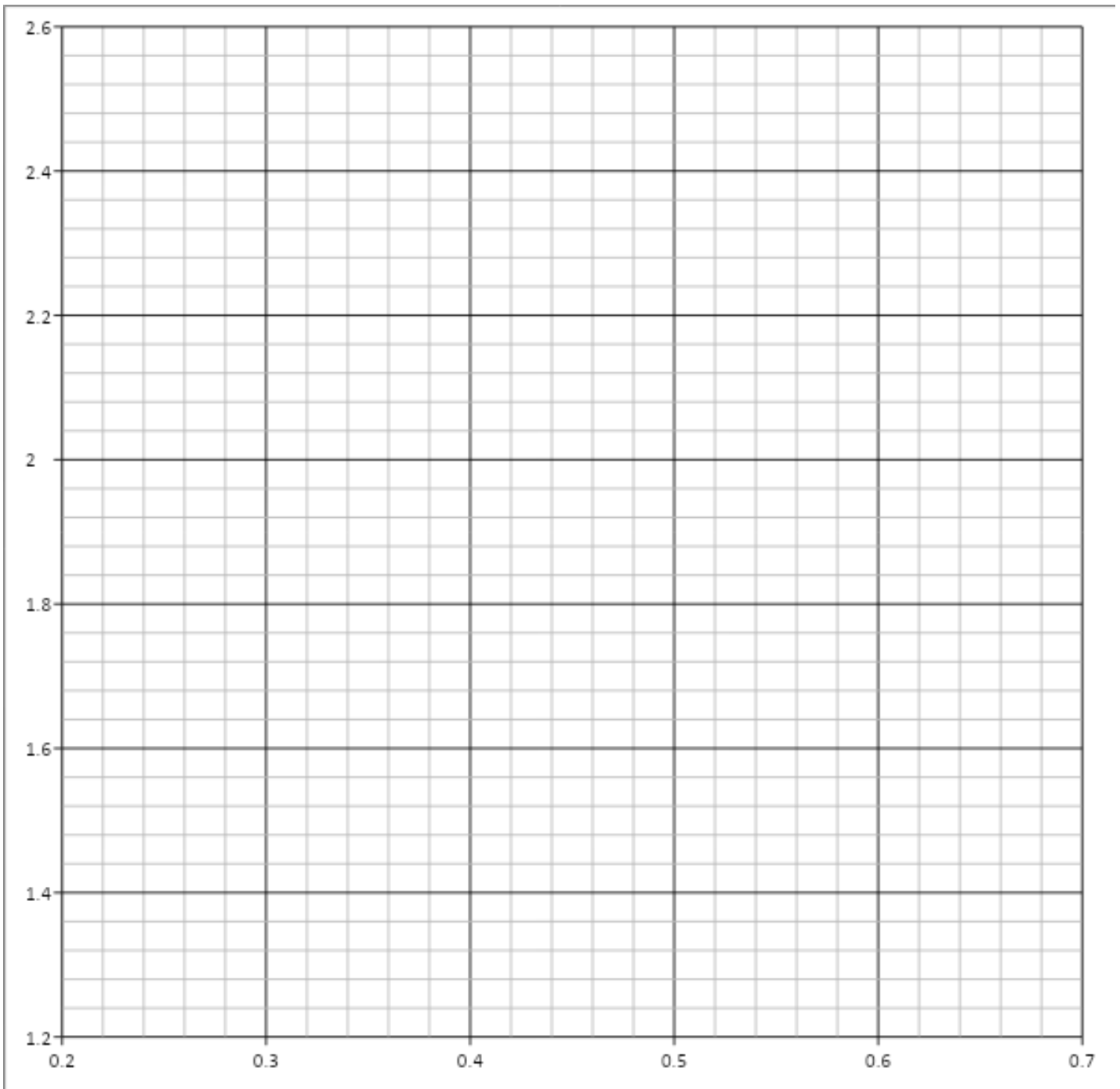
Measurement	Source	Type
A range of values are obtained for the length of a copper wire		
The reading for the current through a wire is 0.74A higher for one group in the class		
A beaker of hot water left on the desk appears to have gained temperature		
A mass of a beaker shows different values on different 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		
A range of values are obtained for the time a parachute takes to reach the ground from 0.5m		

Points Plotting

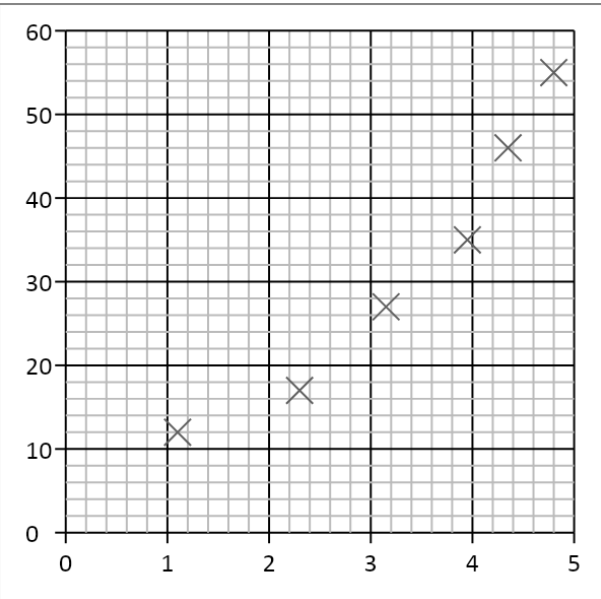
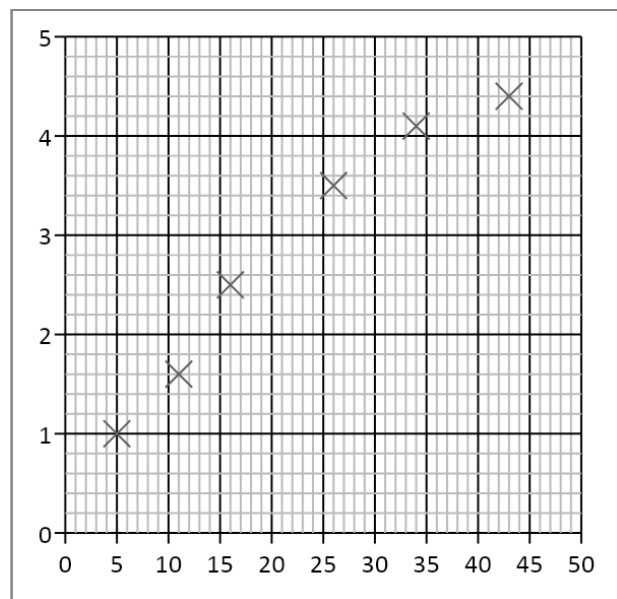
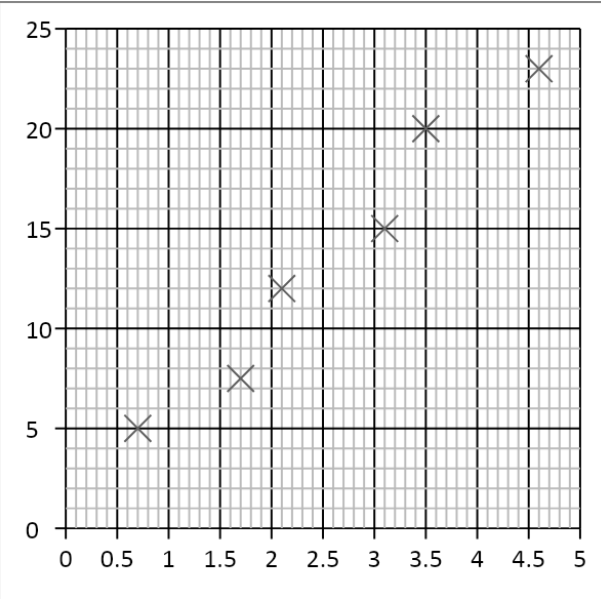
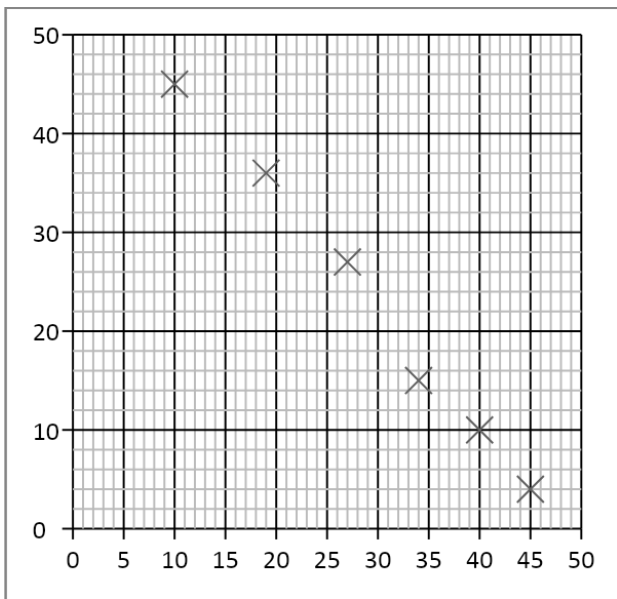
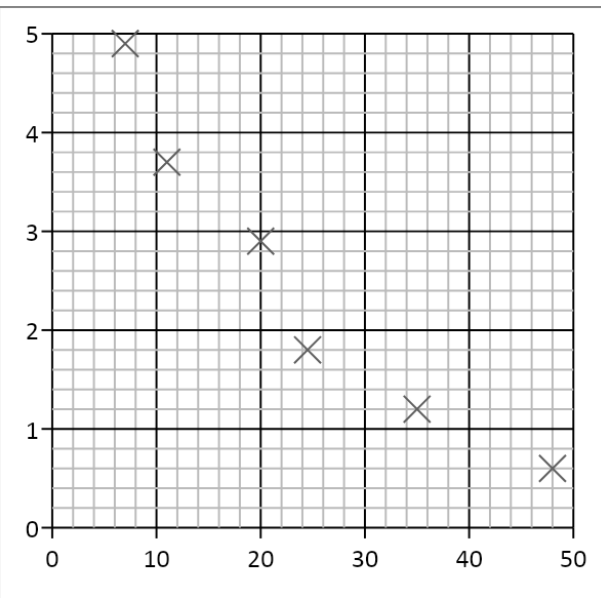
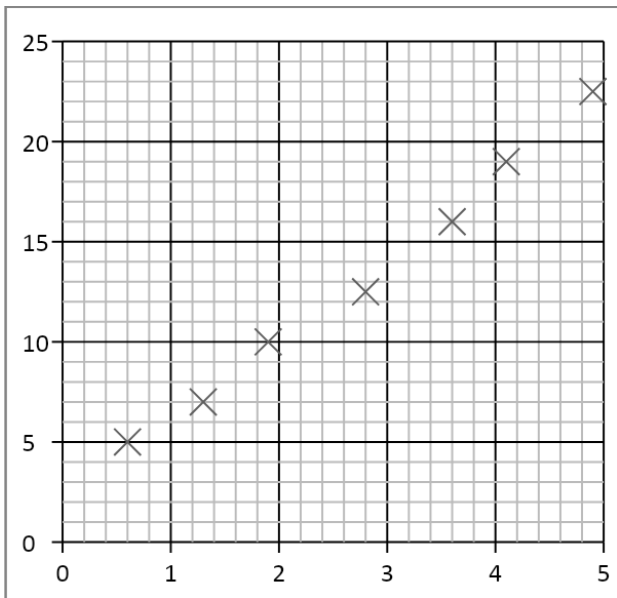
You are going to practice plotting points on a graph. This skill carries up to 3 marks in the ISA.

x axis	y axis	x axis	y axis	x axis	y axis
0.44	2.44	0.34	1.75	0.67	2.12
0.27	1.39	0.49	1.99	0.58	1.64
0.39	2.13	0.26	2.22	0.65	2.52
0.62	1.23	0.31	2.49	0.29	1.92
0.37	1.52	0.52	2.36	0.45	1.47
0.22	2.56	0.61	2.23	0.53	1.27
0.42	1.84	0.64	1.83	0.24	1.71
0.48	1.70	0.55	2.15	0.67	1.45



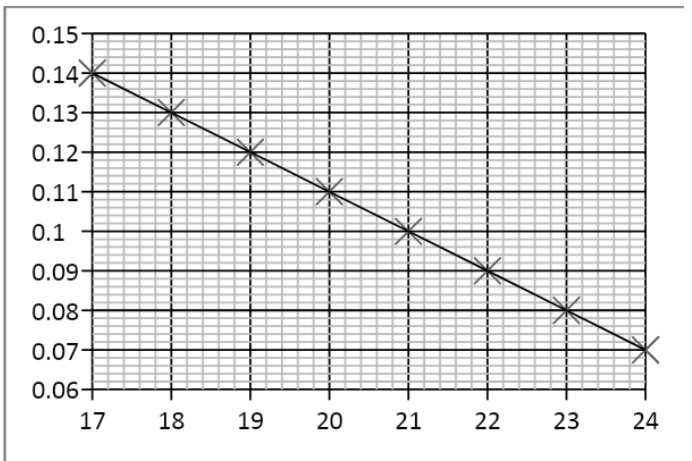
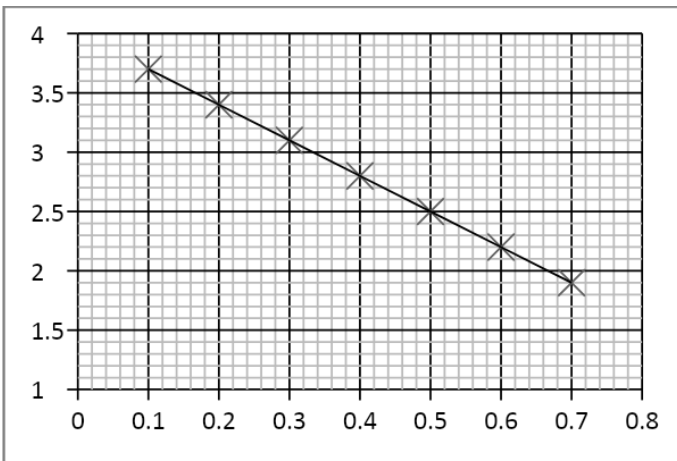
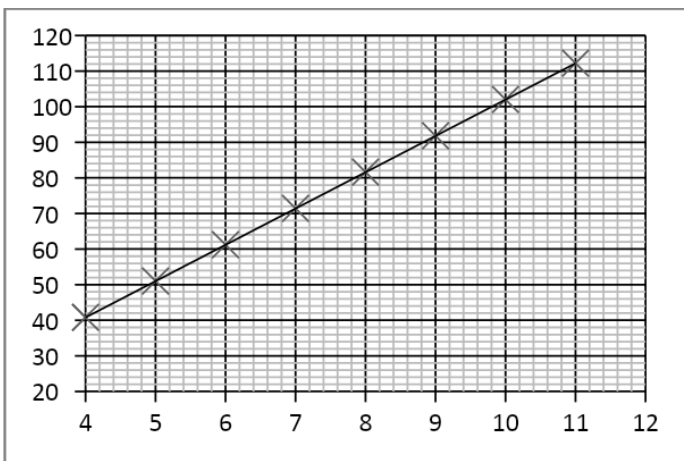
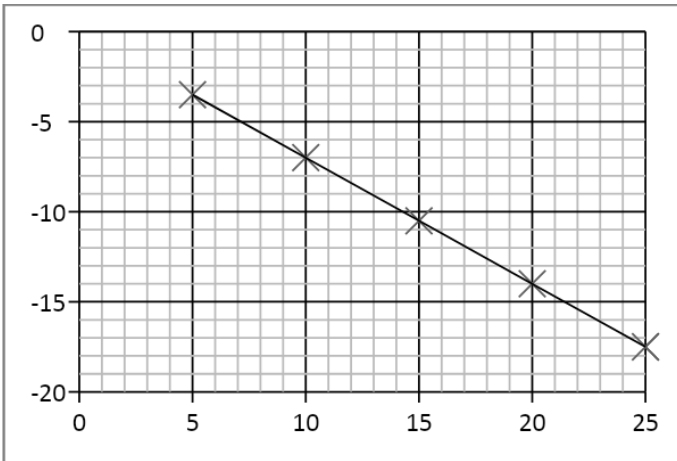
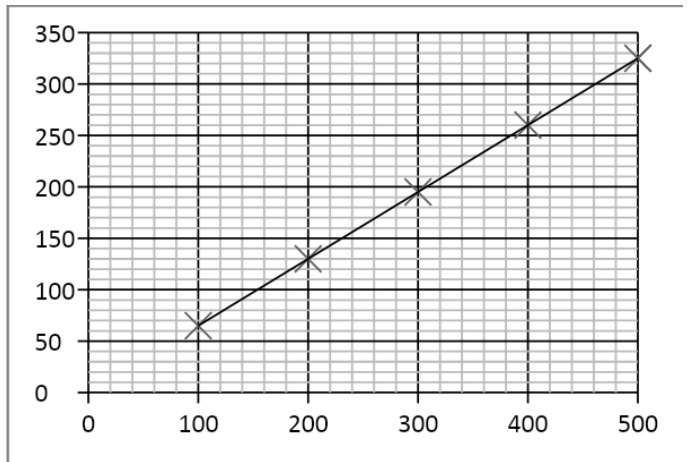
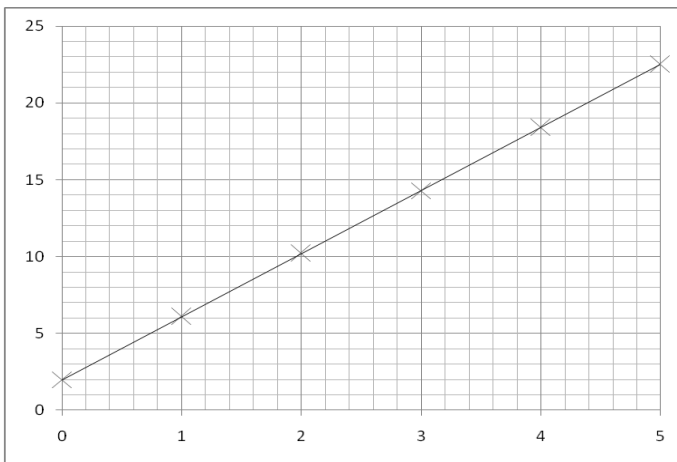
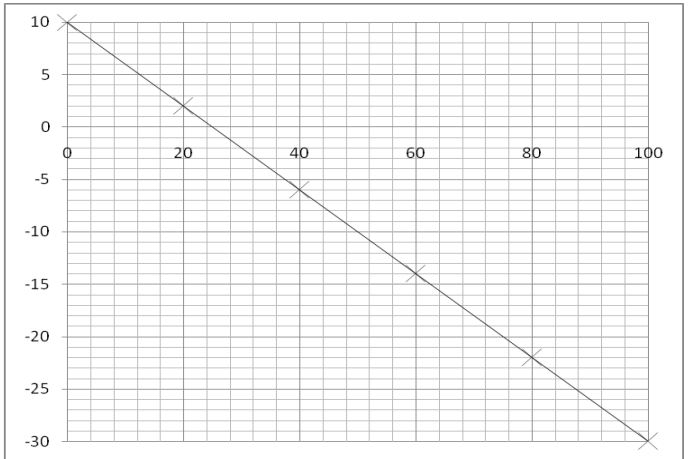
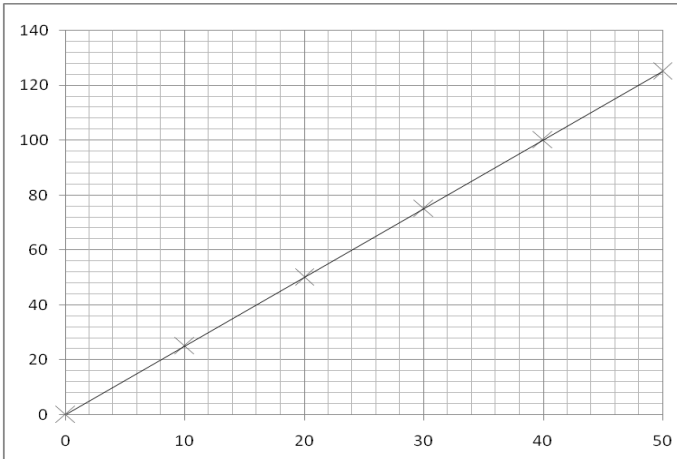
Lines of Best Fit

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



Gradients

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



Gradient Equations 1

Complete the table below about graphs and gradients

Equation	Graph	Rearrange Equation	Gradient	Intercept
$y = mx + c$	y plotted on the y axis	$y = mx + c$	m	c
	x plotted on the x axis			
$V = IR$	y axis = V	$V = RI$	R	0
	x axis = I			
$I = \frac{Q}{t}$	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			
$s = \frac{(u + v)}{2}t$	y axis = v			
	x axis = s			
$w = \frac{\lambda D}{s}$	y axis = λ			
	x axis = w			

Gradient Equations 2

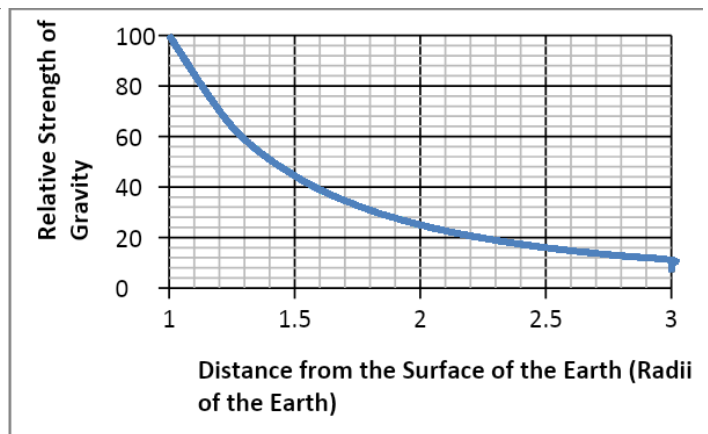
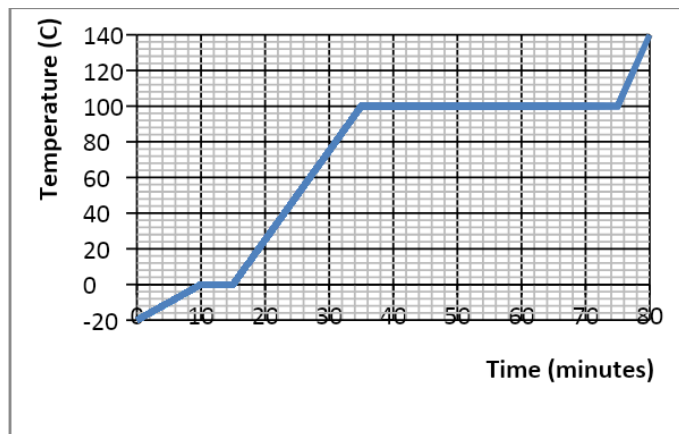
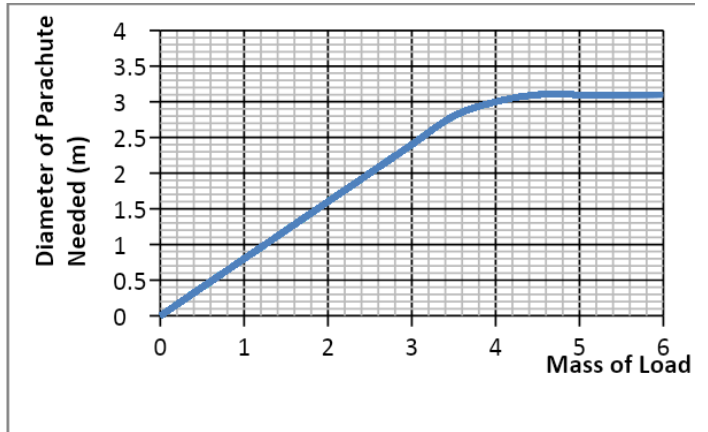
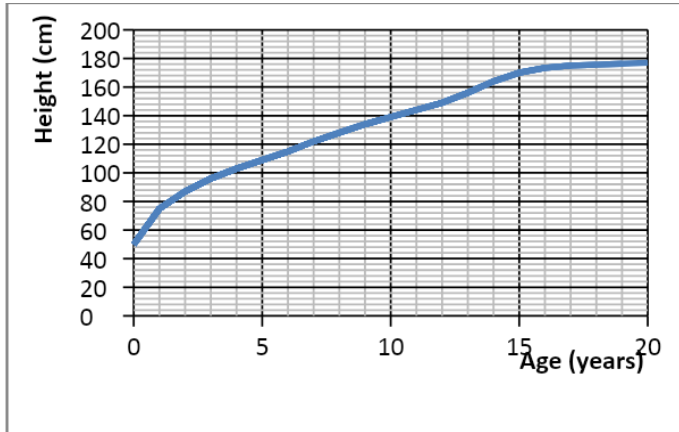
Complete the table below about graphs and gradients

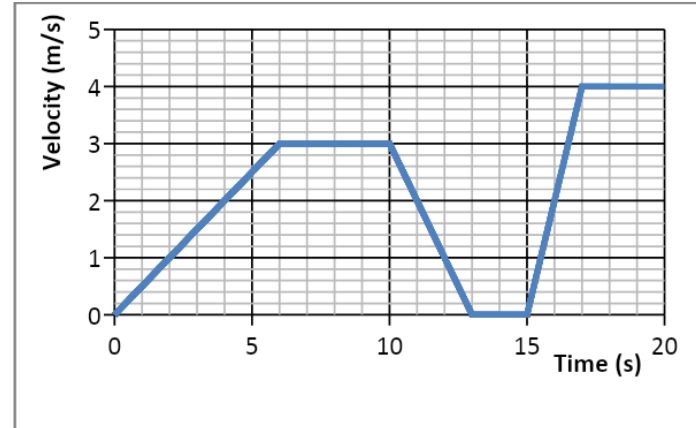
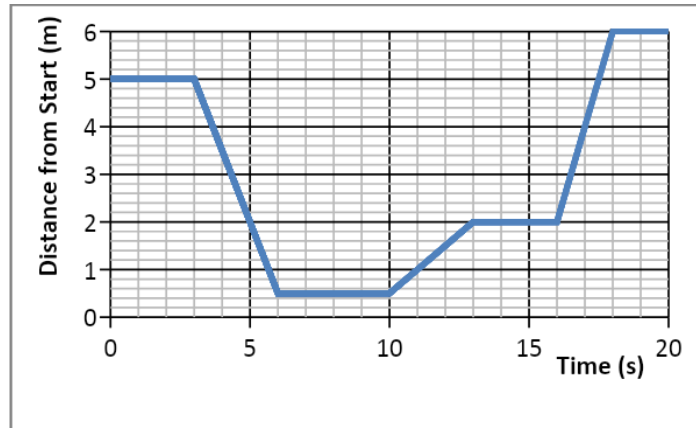
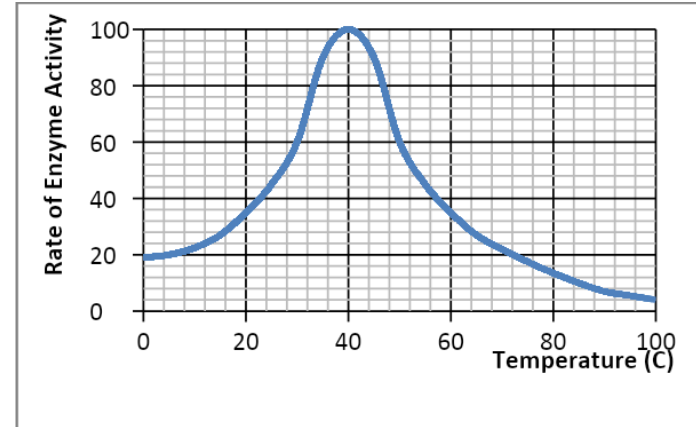
Equation	Graph	Rearrange Equation	Gradient	Intercept
$y = mx + c$	y plotted on the y axis	$y = mx + c$	m	c
	x plotted on the x axis			
$V = IR$	y axis = V	$V = RI$	R	0
	x axis = I			
$F = \frac{\Delta(mv)}{\Delta t}$	y axis = v			
	x axis = F/m			
$F = m\omega^2 r$	y axis = r			
	x axis = F/m			
$T = 2\pi\sqrt{\frac{l}{g}}$	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			
$F = \frac{Qq}{4\pi\epsilon_0 r^2}$	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			
$\epsilon = N \frac{\Delta\phi}{\Delta t}$	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			
$Q = mc\Delta T$	y axis = T			
	x axis = Q			

Interpreting Graphs

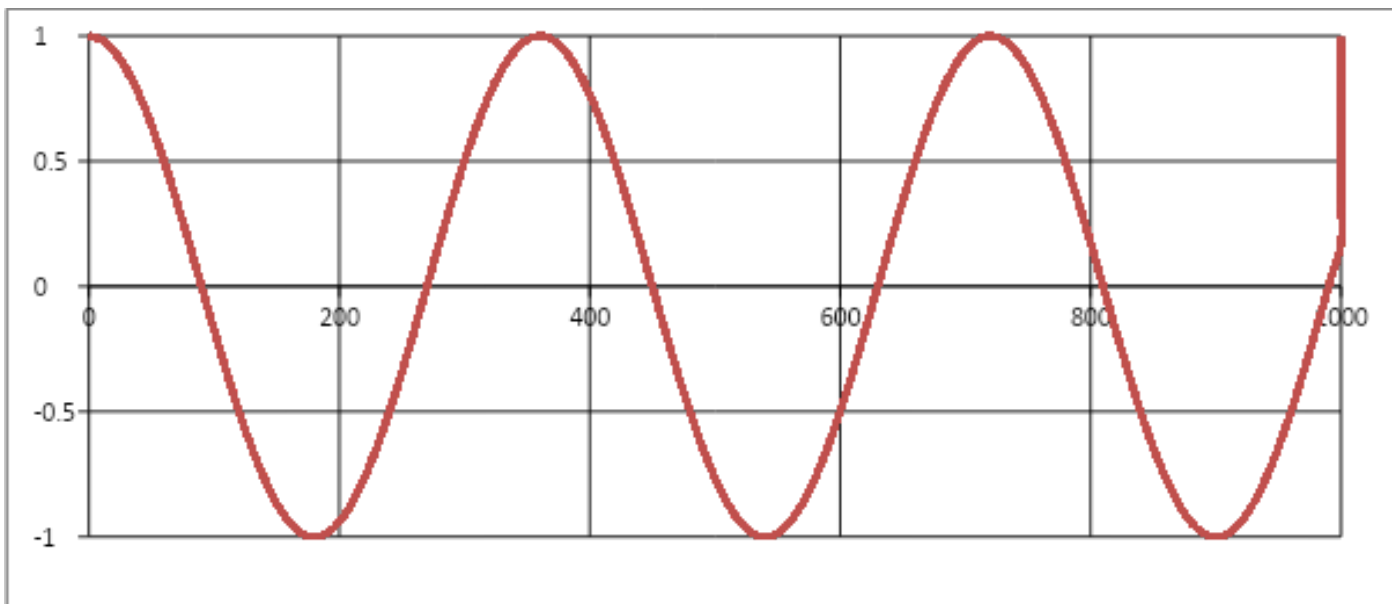
Explain the relationship between the two variables shown in the graphs below.
Describe the general trend/relationship/identify sections of highest/lowest gradient
Quote any significant numerical values/Calculate any gradients you can



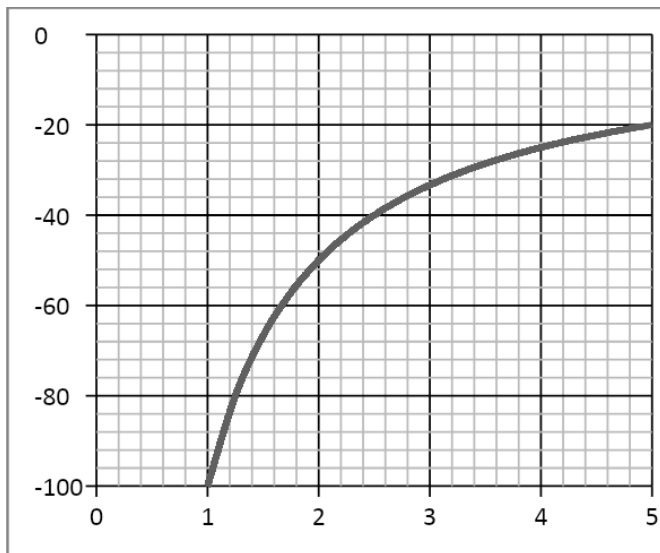


Tangents

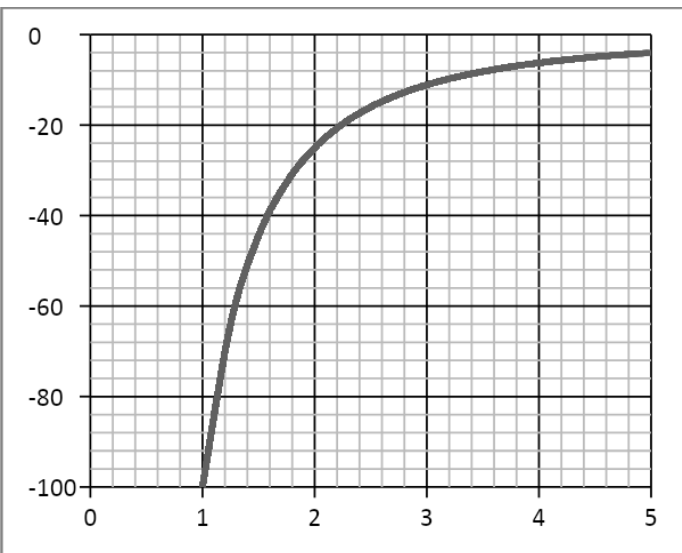
Draw tangents to the line at the following values along the x-axis: 225, 360, 630 and 1035



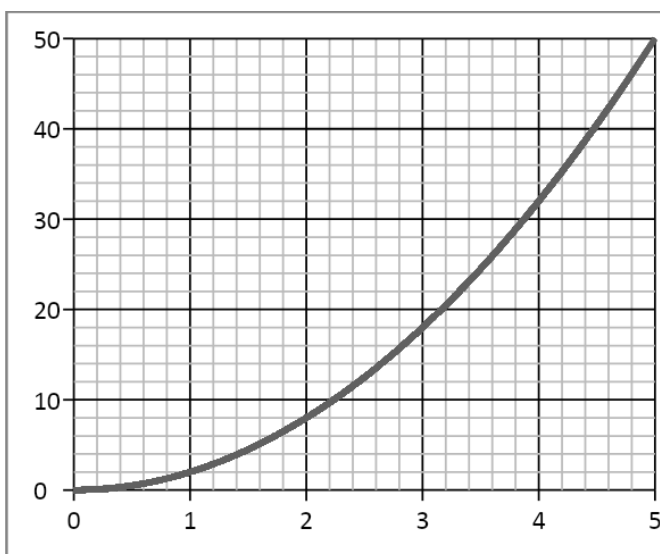
Draw a tangent to the line and calculate its gradient at the following x-axis values:



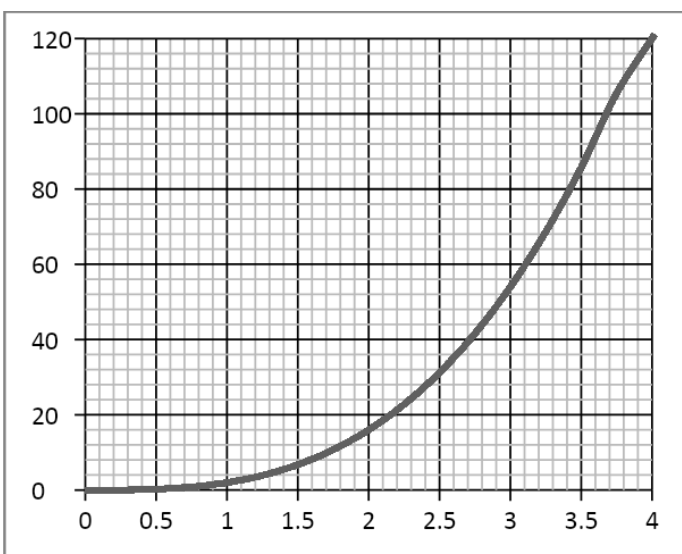
2.0 and 3.9



1.5 and 3.0



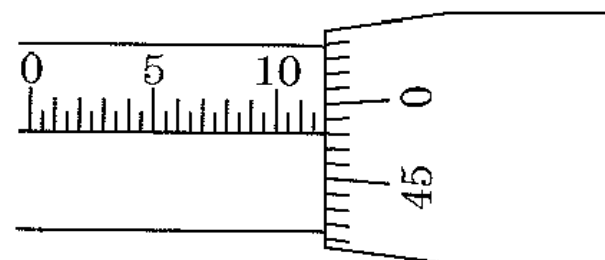
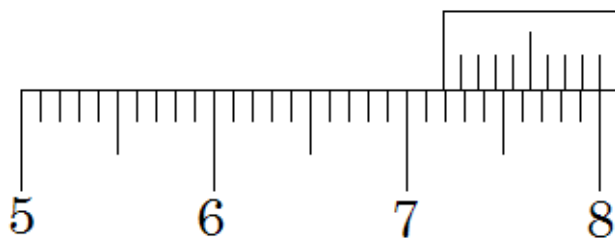
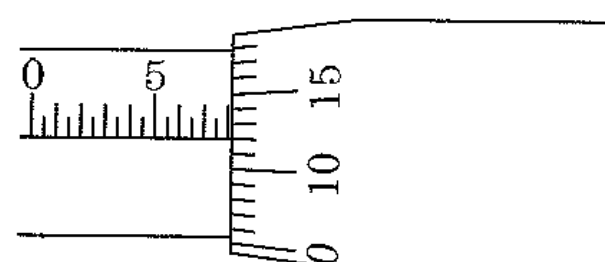
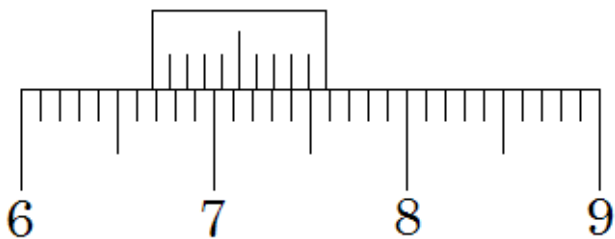
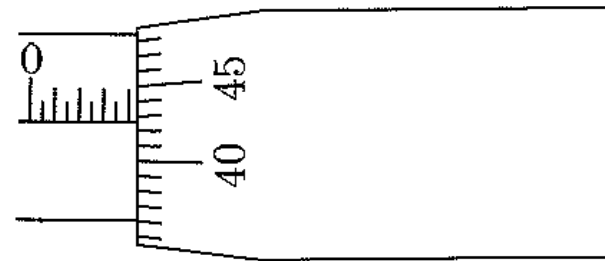
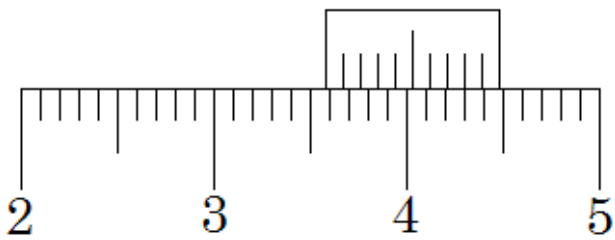
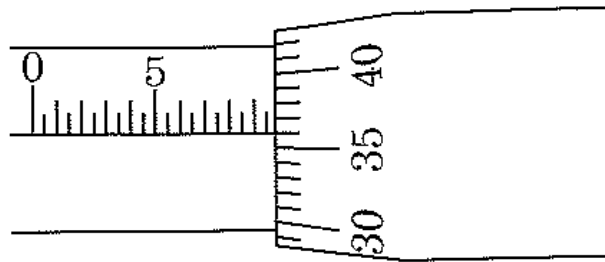
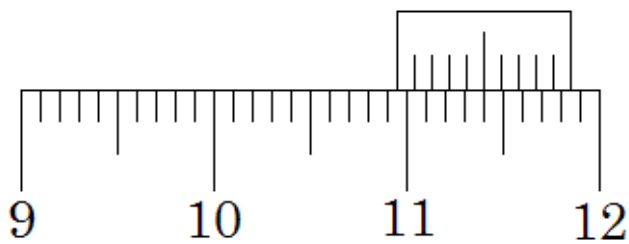
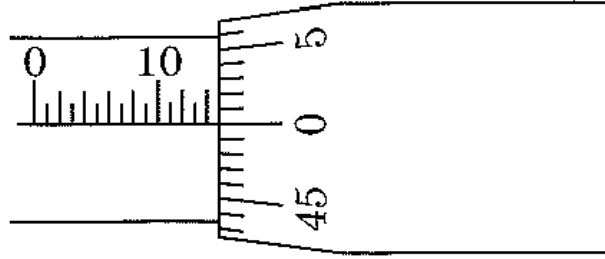
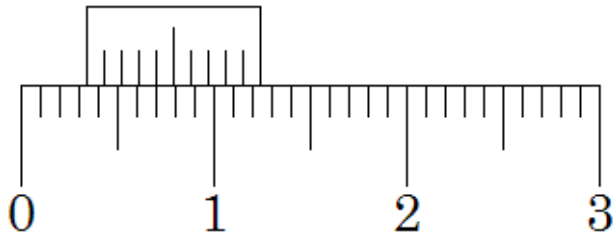
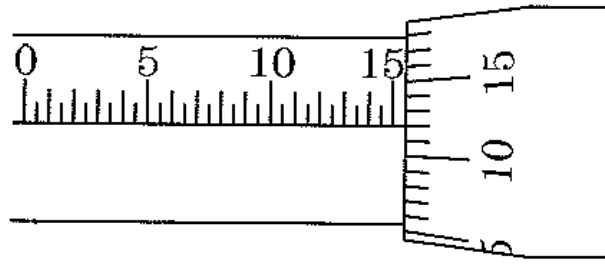
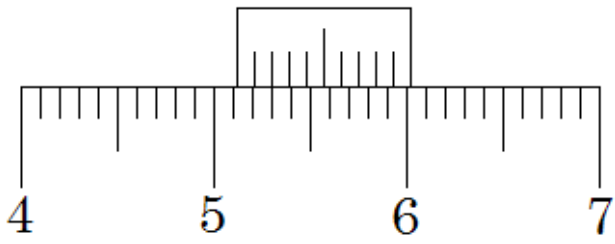
2.2 and 4.0



1.6 and 3.4

Vernier Callipers and Micrometres

State the reading on the Vernier Callipers to the left and the micrometres to the right.



Describing Experiments 1

The last question of the ISA often requires the description of an experiment to support a theory.

Change – Which variables will you keep the same and which will you change?

Range – Give specific values for the variables you will use.

Calculate – What will you calculate or plot?

Conclude – What result will help you either prove or disprove the theory?

GCSE. A student suggests that if an egg was dropped from different heights the area of splatter would increase as the height increases but only until a certain point. How could you investigate this?

GCSE. Is the flight time of a paper plane directly proportional to the angle of the nose (θ), the sine of the angle ($\sin\theta$) or neither?

GCSE. What is the relationship between the time that a fizzy pop bottle is shook up for and the volume of liquid that is lost when the bottle is opened?

U1. How could you investigate the theory that the surface temperature of a resistor is directly proportional to the current flowing through it?

U1. A battery with internal resistance r is connected in series with a resistor of resistance R . A student suggests that the power of the resistor will be a maximum when it has a value equal to the internal resistance of the battery.

U1. How could you investigate the connection between the temperature at which a resistor stops obeying Ohm's law and the value of the resistor?

U1. The photoelectric effect experiment is set up so that photoelectrons are released. How could you prove that the intensity does affect the rate of electron emission but only when above the threshold frequency?

U1. A potato can be used as a battery if electrodes of copper and zinc are inserted into it. Explain how you could find the internal resistance and the emf of the potato using resistors of 5 different values.

U1. How could you find the relationship between the resistivity of a metal and the temperature?

U2. Water is placed in a plastic tray, one end it raised, dropped and the speed of the water wave is measured. A student suggests that the speed of the wave depends on the height of the water in the tray. How could you prove this?

U2. A cylinder of solid metal is rolled down a ramp and the speed is calculated from the distance rolled and the time taken to roll. There is a suggestion that if the cylinder was hollow it would be affected more by the air resistance. How could you investigate this?

U2. How could you investigate whether or not the critical angle of a Perspex block is affected by the colour of light that is incident on the block?

U2. A fellow scientist suggests that the Young modulus of a material depends on the temperature of the material. How could you find any possible relationship between the variables?

U2. A speaker is attached to the top of an open glass tube and set to give out a sound of fixed frequency. The bottom of the tube is placed in water and the height is adjusted until the first harmonic is heard. There is a claim that the height will vary depending on the diameter of the glass tube. How could you investigate this?

Describing Experiments 2

The last question of the ISA often requires the description of an experiment to support a theory.

Change – Which variables will you keep the same and which will you change?

Range – Give specific values for the variables you will use.

Calculate – What will you calculate or plot?

Conclude – What result will help you either prove or disprove the theory?

AS. Explain how it is possible to find the resistivity of a conducting material at room temperature. The material is a cylinder of radius r and length l .

AS. Describe the experiment and accompanying calculations/graphs to find the Young modulus of a material of original length l and cross sectional area A .

AS. Explain how to find the spring constant of a metal spring with five 100g masses and a 30 cm ruler.

AS. Describe the experimental set up and the graph you would draw to find the refractive index of a transparent material. How would your graph give you an answer?

U4. A mass and spring system is set up with a piece of card placed between two of the masses. The time period of this damped system is measured. It is suggested that the area of the card does not affect the time period but the shape of the card does, how could you investigate this?

U4. A pendulum and a mass/spring system are set up to have the same time period of oscillation. You are to investigate which SHM system will suffer the greatest degree of damping and conclude which will stop first.

U4. A capacitor has the capacitance and maximum voltage printed on the casing. How could you investigate that this was the largest voltage allowed before the capacitor breaks?

U4. Car A is crashed into stationary car B. How could you investigate the theory that the collisions will be elastic when car B has less mass than car A but inelastic when car B has an equal or greater mass than car A?

U4. How could you investigate whether the angle a pendulum is displaced from affects the time period?

U4. A student suggests that the efficiency of a transformer is directly proportional to the diameter of the wire which is wrapped around the primary coil. How could you prove this theory, what would you plot on a graph and what result would support the theory?

U5. A student uses a GM tube to investigate the inverse square law. How could she investigate if the inverse square law holds true in all direction from an alpha source?

U5. Explain how it is possible to find the absolute zero temperature using air trapped in a glass tube in a science lab which is well above the value itself.

U5. How could you find the constant of proportionality between the volume of a gas and the temperature when investigating Charles' gas law?

U5. With the use of a block of ice, a temperature probe and Bunsen burner that provides a constant energy supply, explain how you could find out how many times bigger the specific latent heat of vaporisation is than the specific latent heat of fusion.

Rearranging & Deriving Equations 1

Rearrange $v^2 = u^2 + 2as$ to make a the subject

Substitute this into $F = ma$	
Substitute this into the equation $P = Fv$	
Substitute this into the equation $E = Pt$	
Use $v = \frac{s}{t}$ to simplify the equation	

Substitute $v = u + at$ into the equation $\lambda = \frac{h}{mv}$	
Multiply out the brackets	
Substitute this into the equation $d \sin \theta = n\lambda$	
Rearrange the equation to find the angle to the 3 rd maxima	

Substitute $R = \frac{V}{I}$ into the equation $\rho = \frac{RA}{l}$	
Substitute $V = \frac{E}{Q}$ into the equation	
Substitute $E = Pt$ into the equation	
Use $I = \frac{Q}{t}$ to remove t from the equation	
Simplify this	

Elastic energy is converted into kinetic	
Make v^2 the subject	
Replace this with $v^2 = u^2 + 2as$	
If $u=0$ rearrange the equation to make a the subject	
Use $F = ma$ to make F the subject	
Calculate the Energy stored using $E = Fs$ if the distance moved is e	

Rearranging & Deriving Equations 2

The centripetal force of a satellite is due to the gravitational force between it and the planet	$\frac{mv^2}{r} = \frac{GMm}{r^2}$
Simplify the equation and much as you can and rearrange to make r the subject	
Use $\omega = \frac{v}{r}$ to remove v from the equation	
Simplify the equation and use $\omega = 2\pi f$ to replace ω	
Use $f = \frac{1}{T}$ to remove f from the equation	

Rearrange $Q = Q_0 e^{-t/RC}$ to make $e^{-t/RC}$ the subject	
Make $-\frac{t}{RC}$ the subject	
Rearrange the equation to make t the subject	

The centripetal force of a charged particle is due to the magnetic force acting on it	$\frac{mv^2}{r} = BQv$
Rearrange the equation to make Q the subject	
Substitute $\frac{Q}{t} = I$ into the equation	
Use $\phi = BA$ to remove B from the equation	

Rearrange $N = N_0 e^{-\lambda t}$ to make $e^{-\lambda t}$ the subject	
Make $-\lambda t$ the subject	
Substitute $T_{1/2} = \frac{\ln 2}{\lambda}$ into the equation	

Rearrange $E = mcT$ to make T the subject	
Substitute this into the equation $pV = nRT$	
Substitute $p = \frac{F}{A}$ into the equation	

If the V is volume of a cube of side l , rearrange the equation to make F the subject

Units

Write down the standard units for the following quantities.

Energy	Work Done	Time Constant
Wavelength	Density	Energy Stored
Frequency	Tensile Strength	Force on a Moving Charge
Current	Tensile Stress	Magnetic Flux
Potential Difference	Refractive Index	Magnetic Flux Density
Resistance	Momentum	Magnetic Flux Linkage
EMF	Impulse	Induced EMF
Resistivity	Angular Displacement	Intensity
Power	Angular Speed	Activity
Moment	Time Period	Half Life
Velocity	Gravitational Field Strength	Pressure
Acceleration	Gravitational Potential	Volume
Mass	Electric Field Strength	Temperature
Weight	Electric Potential	Specific Heat Capacity
Force	Capacitance	Specific Latent

There are 7 base units (SI units) which all other units can be derived from.

Length in metre, m
 Mass in kilogram, kg
 Time in second, s
 Electric Current in ampere, A
 Thermodynamic Temperature in kelvin, K
 Amount of Substance in mole, mol
 Luminous Intensity in candela, cd

Write down the units for the following quantities in SI units.

Area	Frequency
Volume	Wavelength
Current	Refractive Index
Voltage	Momentum
Resistance	Force
Resistivity	Impulse
Power	Planck's Constant
Energy	De Broglie Wavelength
Distance	Angular Displacement
Speed	Angular Velocity
Acceleration	Centripetal Acceleration
Force	Centripetal Force
Work Done	Gravitational Field Constant
Energy	Gravitational Potential
Moment	Electric Field Strength
Weight	Electric Potential
Power	Permittivity of Free Space
Gravitational Field Strength	Capacitance
Pressure	Time Constant
Density	Energy Stored in a Capacitor
Spring Constant	Magnetic Flux Density
Tensile Stress	Force on a Moving Charge
Tensile Strain	Magnetic Flux
Young Modulus	Induced EMF
Elastic Energy Stored	Activity

Binding Energy
Molar Gas Constant

Specific Heat Capacity
Specific Latent He