



PHYSICS

Teacher name: Gary Foster-Adams

Exam board: AQA

Email address: Gary.Foster-Adams@stockton.ac.uk

The content in these task sheets cover some key skills that are integrated throughout the physics course. This will assist you in getting well prepared to study A Level physics at Bede.

Week 1

- Prefixes and units
- Significant Figures
- Converting Length, Area and Volume

Prefixes and units

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 section will give you practice at converting figures between prefixes.

Symbol	Name	What it means	
P	peta	10^{15}	1000000000000000
T	tera	10^{12}	1000000000000
G	giga	10^9	1000000000
M	mega	10^6	1000000
k	kilo	10^3	1000
			1
m	milli	10^{-3}	0.001
μ	micro	10^{-6}	0.000001
n	nano	10^{-9}	0.000000001
p	pico	10^{-12}	0.000000000001
f	femto	10^{-15}	0.000000000000001

Convert the figures into the units required. (First one is done for you).

6km	=	6×10^3	m
54MN	=		N
0.086 μ V	=		V
753 GPa	=		Pa
23.87 mm/s	=		m/s

Convert these figures to suitable prefixed units. (First one is done for you).

640 GV	=	640×10^9 V
	=	0.5×10^{-6} A
	=	93.09×10^9 m
	kN =	32×10^5 N
	nm =	0.024×10^{-7} m

Week 1 continued

Convert the figures into the prefixes required. (First one is done for you).

s	ms	μ s	ns	ps
0.00045	0.45	450	450×10^3	450×10^6
0.000000789				
0.000 000 000 64				
mm	m	km	μ m	Mm
1287360				
295				

The equation for wave speed is:

$$\begin{array}{ccccc} \text{wave speed} & = & \text{frequency} & \times & \text{wavelength} \\ \text{(m/s)} & & \text{(Hz)} & & \text{(m)} \end{array}$$

Whenever this equation is used, the quantities must be in the units stated above. At GCSE we accepted m/s but at AS/A Level we use the index notation. m/s becomes m s^{-1} and m/s^2 becomes m s^{-2} .

By convention we should also leave one space between values and units. 10m should be 10 m.

We also leave a space between different units but no space between a prefix and units.

This is to remove ambiguity when reading values.

*Example: ms^{-1} means 1/millisecond because the ms means millisecond, 10^{-3} s
but m s^{-1} means metre per second the SI unit for speed.
or mms^{-1} could mean mm s^{-1} compared with m ms^{-1}
millimeters per second compared with meters per millisecond - quite a difference!*

Calculate the following quantities using the above equation, giving answers in the required units. First one is done for you.

- Calculate the speed in m s^{-1} of a wave with a frequency of 75 THz and a wavelength 4.0 μm .
 $v = f \lambda = 75 \times 10^{12} \times 4.0 \times 10^{-6} = 3.0 \times 10^8 \text{ m s}^{-1}$ (300 Mm s⁻¹)
- Calculate the speed of a wave in m s^{-1} which has a wavelength of 5.6 mm and frequency of 0.25 MHz.
- Calculate the wavelength in metres of a wave travelling at 0.33 km s^{-1} with a frequency of 3.0 GHz.
- Calculate the frequency in Hz of a wave travelling at $300 \times 10^3 \text{ km s}^{-1}$ with a wavelength of 0.050 mm.
- Calculate the frequency in GHz of a wave travelling at 300 Mm s^{-1} that has a wavelength of 6.0 cm.

Week 1 continued

Significant Figures

1. All non-zero numbers ARE significant. The number 33.2 has THREE significant figures because all of the digits present are non-zero.
2. Zeros between two non-zero digits ARE significant. 2051 has FOUR significant figures. The zero is between 2 and 5
3. Leading zeros are NOT significant. They're nothing more than "place holders." The number 0.54 has only TWO significant figures. 0.0032 also has TWO significant figures. All of the zeros are leading.
4. Trailing zeros when a decimal is shown ARE significant. There are FOUR significant figures in 92.00 and there are FOUR significant figures in 230.0.
5. Trailing zeros in a whole number with no decimal shown are NOT significant. Writing just "540" indicates that the zero is NOT significant, and there are only TWO significant figures in this value. (This can cause problems! We should use point 6 below for clarity, but often don't).
6. For a number in scientific notation: $N \times 10^x$, all digits comprising N ARE significant by the first 5 rules; "10" and "x" are NOT significant. 5.02×10^4 has THREE 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		0.070	
2.0		82.42		2.483×10^4		69324.8	
500		750000		0.0006		0.0063	
0.136		310		5906.4291		9.81×10^4	

When adding or subtracting numbers

Round the final answer to the least precise number of decimal places in the original values.

Eg. $0.88 + 10.2 - 5.776 (= 5.304) = 5.3$ (to 1d.p. , since 10.2 only contains 1 decimal place)

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		

When multiplying or dividing numbers

Round the final answer to the least number of significant figures found in the initial values.

E.g. $4.02 \times 3.1 \div 0.114 = (109.315\dots) = 110$ (to 2s.f. as 3.1 only has 2 significant figures).

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		

Week 1 continued

Divide value 1 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	6.50		
91×10^2	180		

When calculating a mean

1. Remove any obvious anomalies (circle these in the table)
2. Calculate the mean with the remaining values, and record this to the least number of decimal places in the included values

E.g. Average 8.0, 10.00 and 145.60:

- 1) Remove 145.60
- 2) The average of 8.0 and 10.00 is 9.0 (to 1 d.p.)

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	437		
5.00	6.0	29.50		
5.038	4.925	4.900		

(Solutions to all questions can be found at the back of the booklet).

Week 2

- Converting Length, Area and Volume
- Drawing Lines of Best Fit

Converting length, area and volume

Whenever substituting quantities into an equation, you must always do this in SI units – such as time in seconds, mass in kilograms, distance in metres...

If the question doesn't give you the quantity in the correct units, you should always convert the units first, rather than at the end. Sometimes the question may give you an area in mm^2 or a volume in cm^3 , and you will need to convert these into m^2 and m^3 respectively before using an equation.

To do this, you first need to know your length conversions:

$$1\text{m} = 100\text{ cm} = 1000\text{ mm} \quad (1\text{ cm} = 10\text{ mm})$$

m to cm	x 100	cm to m	÷ 100
m to mm	x 1000	m to mm	÷ 1000

Week 2 continued

Always think – “Should my number be getting larger or smaller?” This will make it easier to decide whether to multiply or divide.

Converting Areas

A 1m x 1m square is equivalent to a 100 cm x 100 cm square.

Therefore, $1 \text{ m}^2 = 10\,000 \text{ cm}^2$

Similarly, this is equivalent to a 1000 mm x 1000 mm square;

So, $1 \text{ m}^2 = 1\,000\,000 \text{ mm}^2$

m^2 to cm^2	x 10,000	cm^2 to m^2	÷ 10,000
m^2 to mm^2	x 1,000,000	mm^2 to m^2	÷ 1,000,000

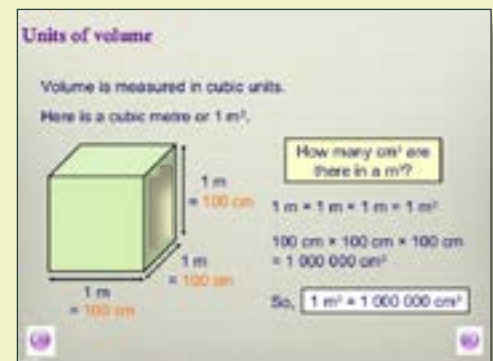
Converting Volumes

A 1m x 1m x 1m cube is equivalent to a 100 cm x 100 cm x 100 cm cube.

Therefore, $1 \text{ m}^3 = 1,000,000 \text{ cm}^3$

Similarly, this is equivalent to a 1000 mm x 1000 mm x 1000 mm cube;

So, $1 \text{ m}^3 = 1\,000\,000 \text{ mm}^3$



m^3 to cm^3	x 1,000,000	cm^3 to m^3	÷ 1,000,000
m^3 to mm^3	x 10^9	mm^3 to m^3	÷ 10^9

6 m^2	=	cm^2
0.002 m^2	=	mm^2
$24,000 \text{ cm}^2$	=	m^2
$46,000,000 \text{ mm}^3$	=	m^3
0.56 m^3	=	cm^3

750 mm^2	=	m^2
$5 \times 10^{-4} \text{ cm}^3$	=	m^3
$8.3 \times 10^{-6} \text{ m}^3$	=	mm^3
$3.5 \times 10^2 \text{ m}^2$	=	cm^2
152000 mm^2	=	m^2

A 2.0m long solid copper cylinder has a cross-sectional area of $3.0 \times 10^2 \text{ mm}^2$. What is its volume in cm^3 ?

Volume = cm^3

For the following, think about whether you should be writing a smaller or a larger number down to help decide whether you multiply or divide. Eg. To convert 5 m ms^{-1} into m s^{-1} – you will travel more metres in 1 second than in 1 millisecond, therefore you should multiply by 1000 to get 5000 m s^{-1} .

Week 2 continued

5 N cm^{-2}	=	N m^{-2}
1150 kg m^{-3}	=	g cm^{-3}
3.0 m s^{-1}	=	km h^{-1}
65 kN cm^{-2}	=	N mm^{-2}
7.86 g cm^{-3}	=	kg m^{-3}

Drawing Lines of Best Fit

When drawing lines of best fit, draw a smooth straight or curved line that passes through the majority of the points. If you can, try to have an even number of points above and below the line if it can't go through all points.

Chart 1

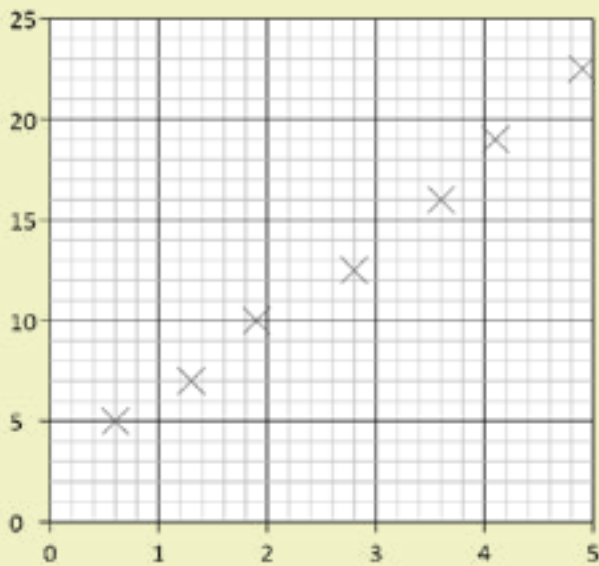


Chart 2

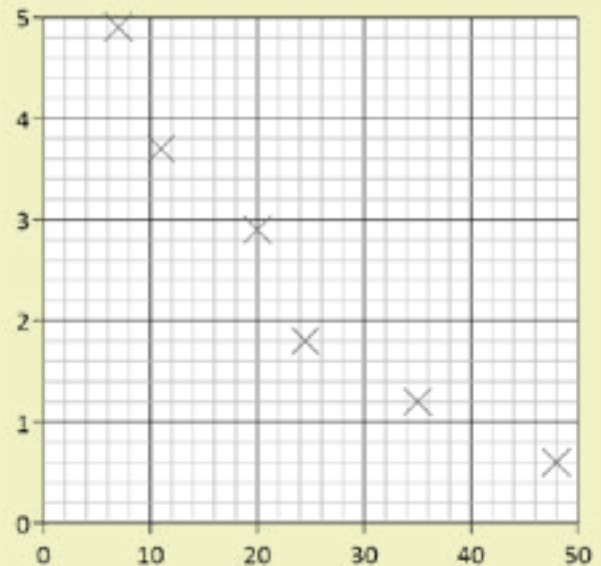


Chart 3

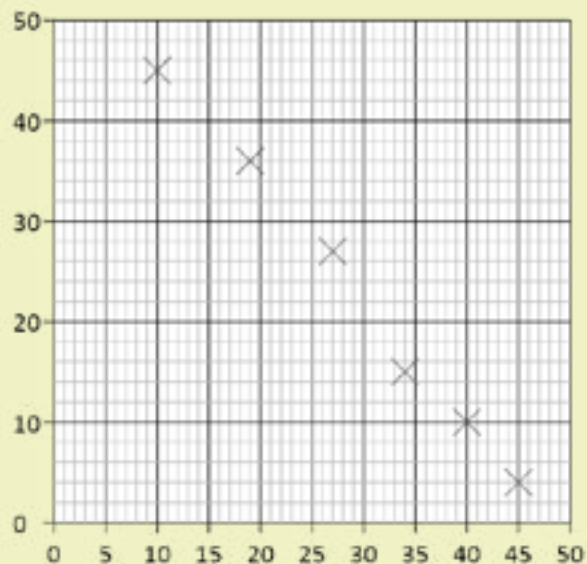


Chart 4

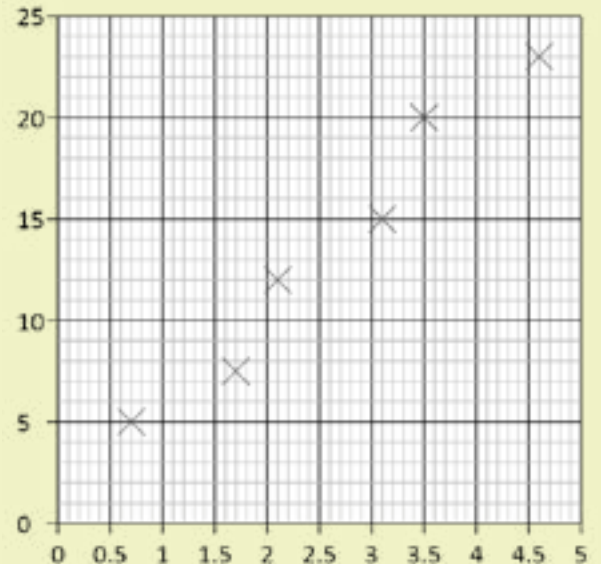


Chart 5

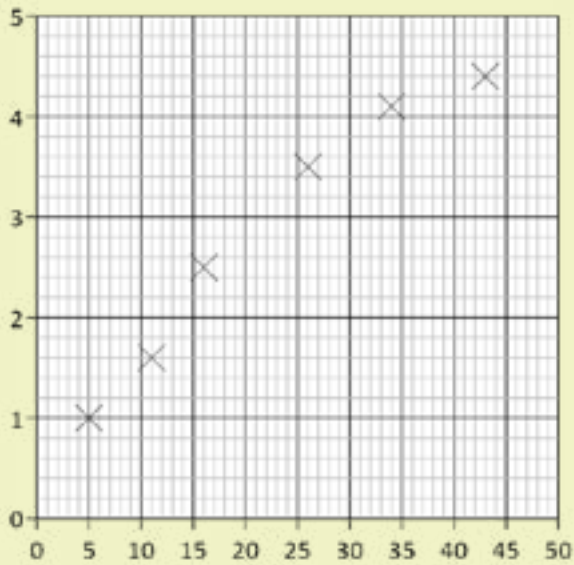
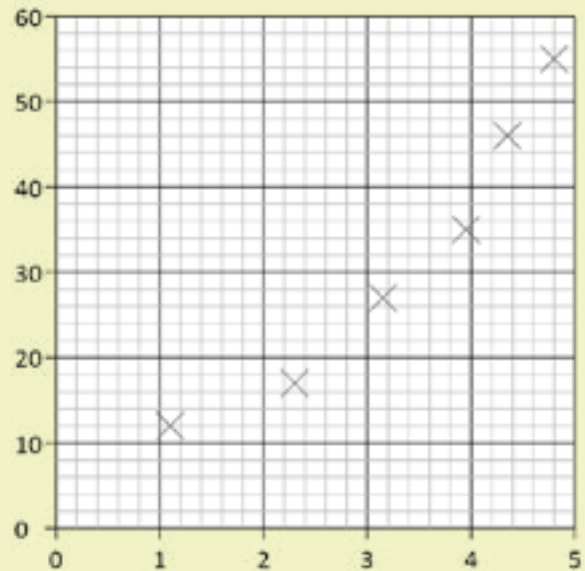


Chart 6



Week 3

- Calculating Gradients – Straight Lines
- Calculating Gradients – Curved Lines

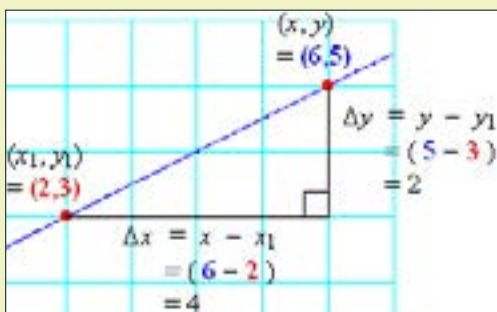
Calculating Gradients – Straight Lines

Gradients are a useful tool that show how fast or slow quantities change – eg speed tells us how fast distance is changing, or how quickly energy is being lost over time.

To calculate the gradient, pick any two points on the line as far away as possible and draw a large triangle between them.

The gradient is given by:
$$\text{gradient} = \frac{(\text{difference in } y \text{ values})}{(\text{difference in } x \text{ values})}$$

But make sure you subtract the values in the same order! Remember – if the line slopes up, the gradient should be positive; if the line slopes down, then the gradient should be negative.

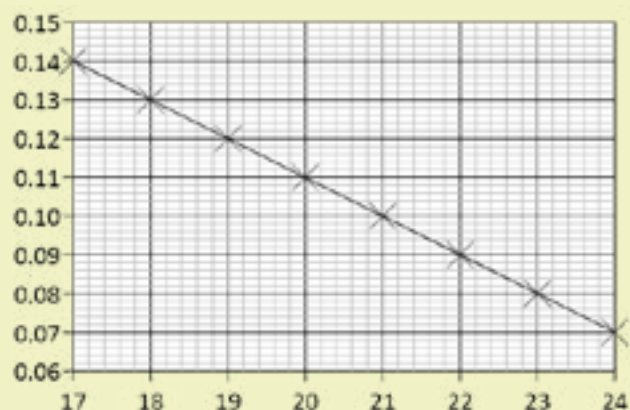
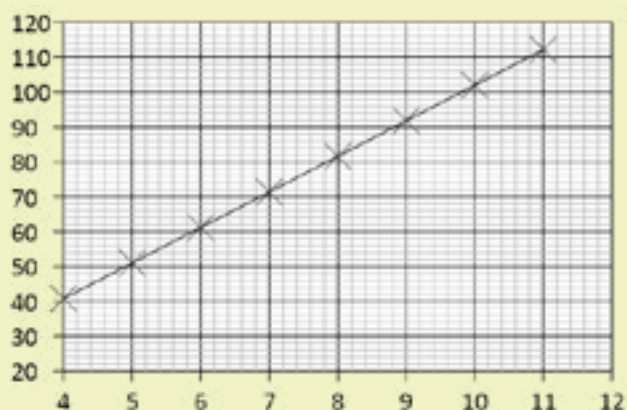
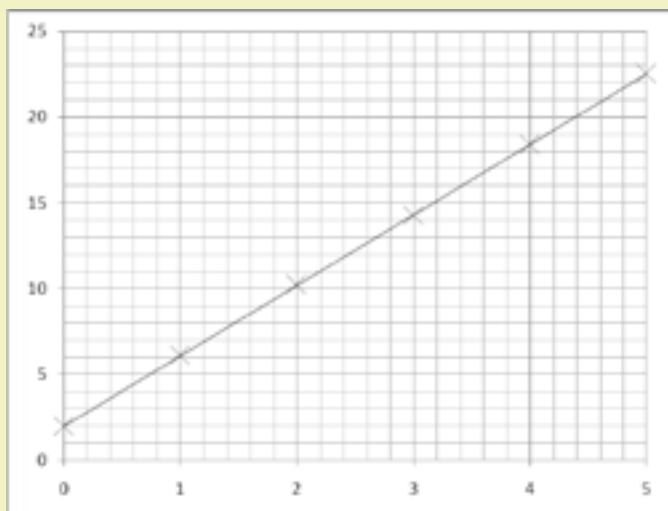
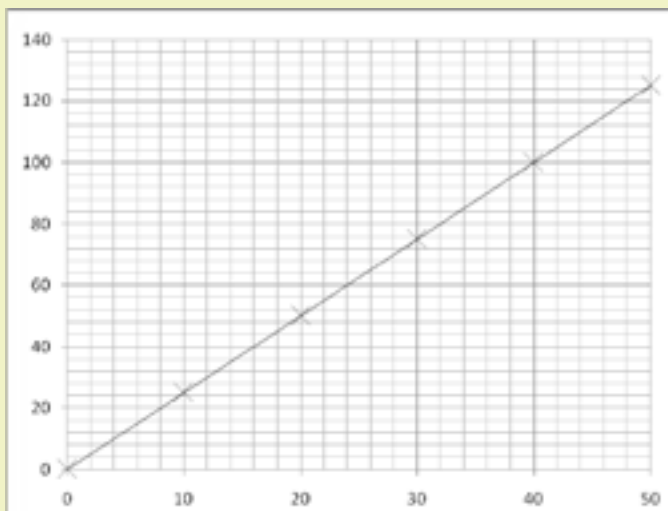


$$\begin{aligned} \text{Gradient} &= \frac{2}{4} \\ &= 0.5 \end{aligned}$$



Week 3 continued

Calculate the gradients of the graphs below.



Calculating Gradients – Curved Lines

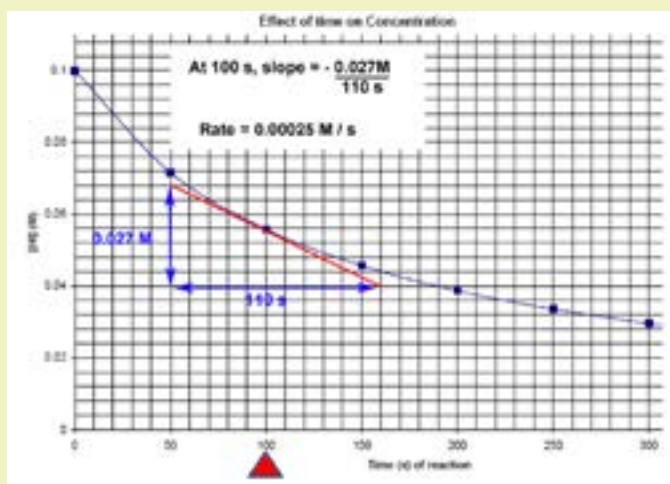
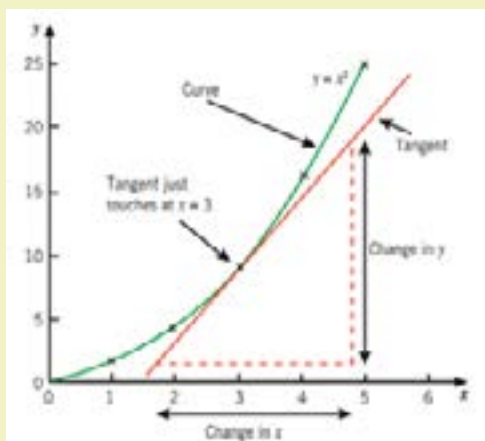
Most graphs in real life are not straight lines, but curves; however it is still useful to know how the quantity changes over time, hence we still need to calculate gradients.

If we want to know the gradient at a particular point, firstly we need to draw a *tangent* to the curve at that point.

A tangent is a straight line that follows the gradient at the required point. Once we have drawn the straight line tangent, its gradient can be calculated in exactly the same way as the previous page showed.

Tip – make sure your tangents and gradient triangles are as big as possible to be as accurate as you can!

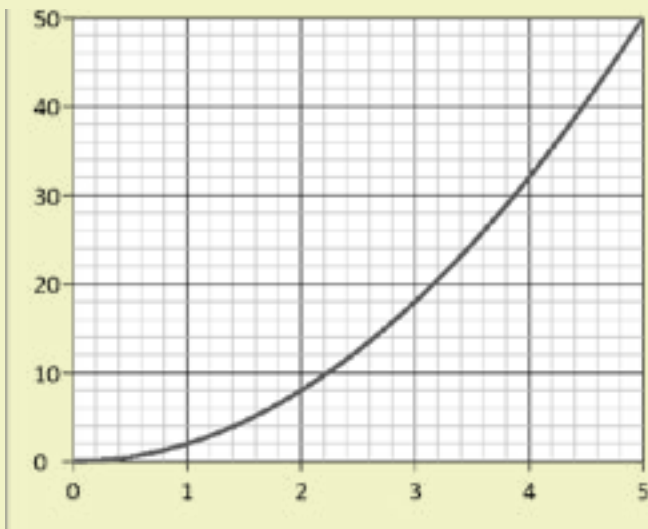
Examples of drawing tangents and calculating the gradient of a tangent:



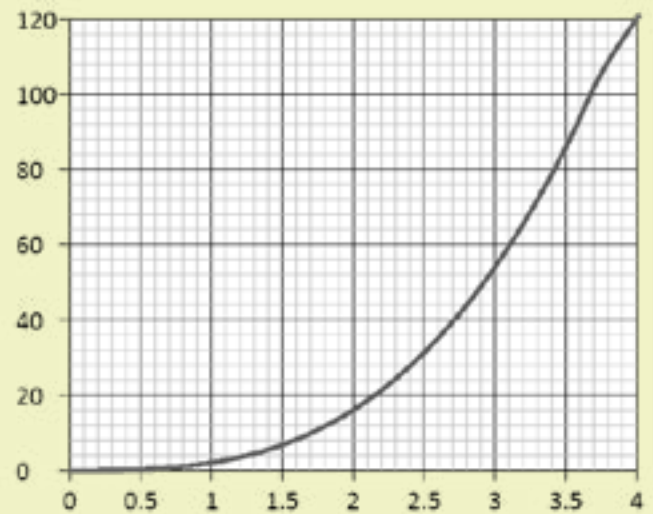
Week 3 continued

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

(Note - gradients in Physics often have units, this is something we will consider as we progress in the course)



Calculate the gradient at the following x-axis values: 2.0 and 4.0



Calculate the gradient at the following x-axis values: 1.5 and 3.5

Week 4

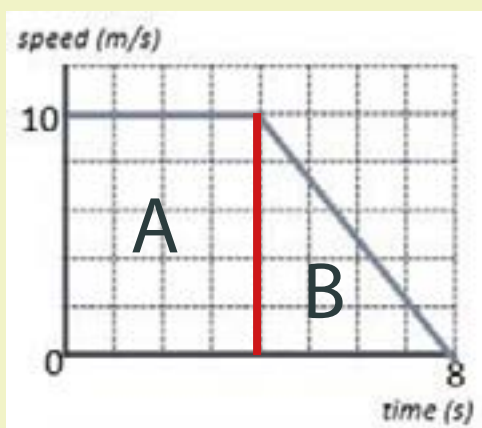
- Calculating Areas – Straight Line Graphs
- Calculating Areas – Curved Line Graphs
- Interpreting Graphs

Calculating Areas – Straight Line Graphs

Often other quantities can be found by multiplying the two quantities represented on a graph together (for example, multiplying velocity and time gives distance travelled). The exact quantity can be found by calculating the area under the graph.

If the graph is made of straight lines, the total area can be found by splitting the graph into segments of rectangles and triangles (or into a trapezium) and adding those areas together.

Important – the heights that you use should always be the perpendicular height from the base.



Calculate the distance travelled by determining the area under the graph:

$$\text{Area A} = 10 \times 4 = 40 \text{ m}$$

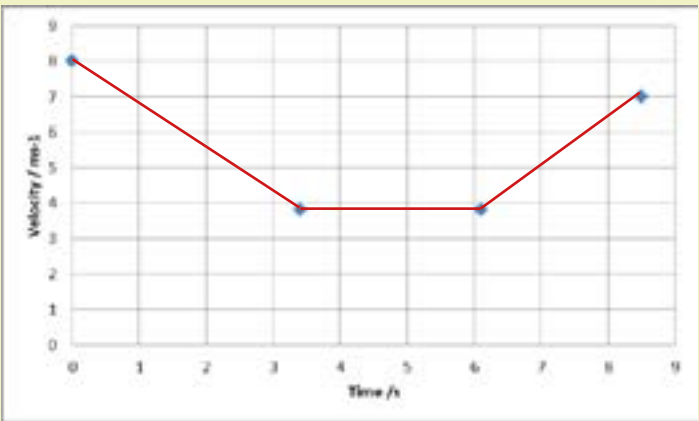
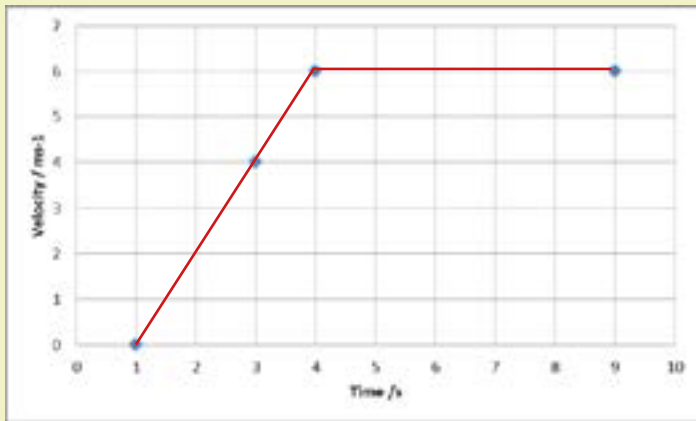
$$\text{Area B} = \frac{1}{2} \times 4 \times 10 = 20 \text{ m}$$

$$\text{Total Area} = \text{A} + \text{B} = 40 + 20 = 60 \text{ m}$$

Or

$$\text{Area of trapezium} = \frac{1}{2} (4 + 8) \times 10 = 60 \text{ m}$$

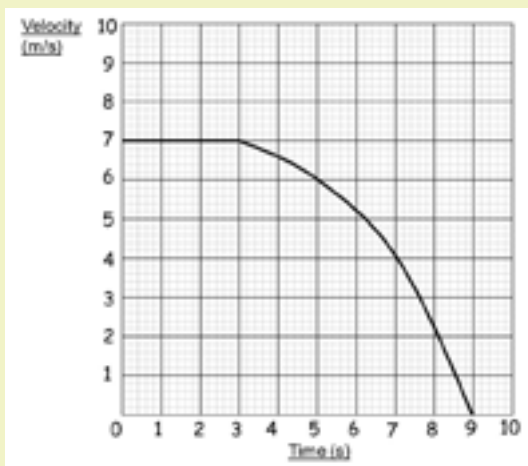
Calculate the area of the below graphs and the correct unit for that area.



Calculating Areas – Curved Line Graphs

When graphs have curved lines we use a simple process of counting squares and estimating.

1. Calculate the area of 1 small (but the not smallest!) square on the graph
2. Count the number of whole squares under the line
3. Estimate the whole number of squares that have been segmented by the line.
4. Multiply the total number of squares by the area of one square to estimate the area.

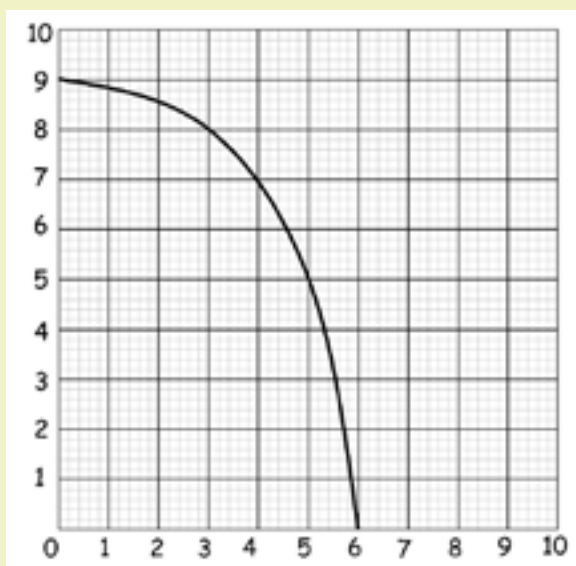


Eg. Work out the distance travelled by calculating the area under the graph.

1. 1 square = 1 m s⁻¹ x 1 s = 1 m
2. Whole Squares = 44
3. Segmented squares = 4
4. 48 squares x 1 m = 48 m

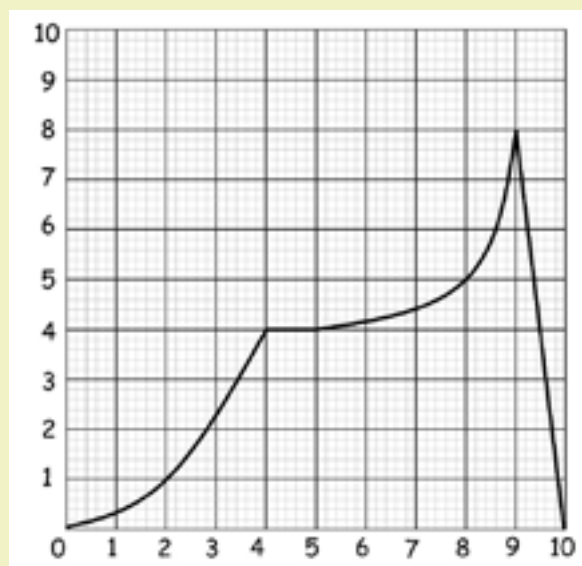
Calculate the area under the following graphs. (Watch out for units).

Velocity / m s⁻¹



time / s

Velocity / km s⁻¹



time / mins

Interpreting Graphs

When interpreting graphs that are worth more than 2 marks, you need to go into more detail describing how the gradient changes over time and pick specific values to help support your answer.

Tips:

Use the quantities on the axes to support your answer.

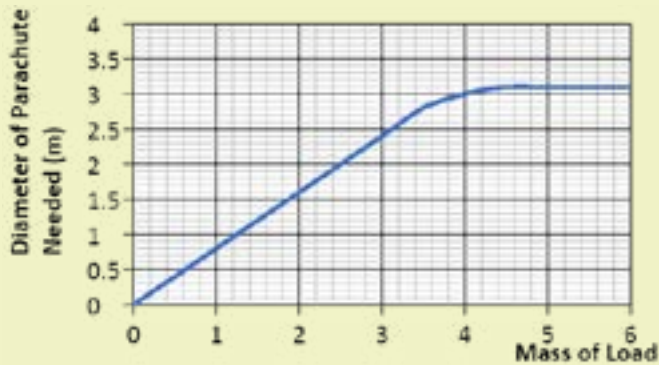
Are there any points where the y value doesn't change? What is this value? When does this happen on the x axis?

Are there any maximum or minimum values? What are they? When do they occur?

The gradient increases/decreases at a constant/increasing/decreasing rate?

Does the gradient represent anything (eg. velocity or acceleration)?

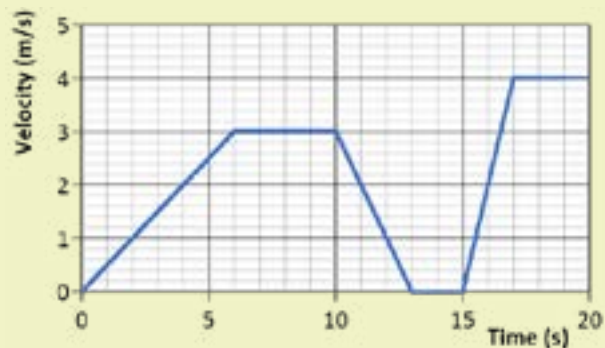
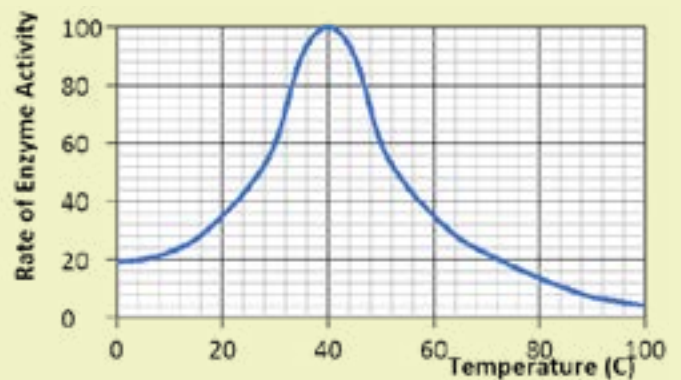
Are there multiple gradients? Are some steeper than others?



Example

As the mass of the load increases, the diameter of the parachute needed also increases at a constant rate. This occurs to a mass of 3.4kg (which gives a diameter of 2.8m), where the gradient increases at a decreasing rate until the diameter remains constant at 3.1m for any load beyond 4.4kg.

Interpret the graphs below using the tips.



Solutions

Week 1: Prefixes and units

54×10^6
0.5 μm

0.086×10^{-6}
93.09 Gm

753×10^9
3 200 kN

23.87×10^{-3}
2.4 nm

s	ms	μs	ns	ps
0.00045	0.45	450	450 000 or 450×10^3	450×10^6
0.000000789	0.000789	0.789	789	789×10^3
0.000 000 000 64	0.000 000 64	0.000 64	0.64	640

mm	m	km	μm	Mm
1287360	1 287.360	1.28 7360	1 287 360 000	0.001 287 360
295	0.295	0.000 295	295 000	0.000 000 295

2. $v = f \lambda = 0.25 \times 10^6 \times 5.6 \times 10^{-6} = 1400 \text{ m s}^{-1}$

3. $\lambda = v/f = 330 / 3.0 \times 10^9 = 1.1 \times 10^{-7} \text{ m}$

4. $f = v/\lambda = 300 \times 10^6 / 0.050 \times 10^{-3} = 6.0 \times 10^{12} \text{ Hz} = 6.0 \text{ THz}$

5. $f = v/\lambda = 300 \times 10^6 / 6.0 \times 10^{-2} = 5.0 \times 10^9 \text{ Hz} = 5.0 \text{ GHz}$

Week 1: Significant Figures

Value	Sig Figs	Value	Sig Figs	Value	Sig Figs	Value	Sig Figs
2	1	1066	4	1800.45	7	0.070	2
2.0	2	82.42	4	2.483×10^4	4	69324.8	6
500	1	750000	2	0.0006	1	0.0063	2
0.136	3	310	2	5906.4291	8	9.81×10^4	3

Value 1	Value 2	Value 3	Total Value	Total to correct sig figs
51.4	1.67	3.23	56.3	56.3
7146	-32.54	12.8	7126.26	7126
20.8	18.72	0.851	40.371	40.4
1.4693	10.18	-1.062	10.5873	10.59
9.07	0.56	3.14	12.77	12.77

Value 1	Value 2	Total Value	Total to correct sig figs
0.91	1.23	1.1193	1.1
8.764	7.63	66.86932	66.9
2.6	31.7	82.42	82

Value 1	Value 2	Total Value	Total to correct sig figs
5.3	748	7.085561×10^{-3}	7.1×10^{-3}
3781	6.50	581.6923077	582
91×10^2	180	50.55555555556	51

Value 1	Value 2	Value 3	Mean Value	Mean to correct sig figs
1	1	2	1.3333	1
435	299	437	436	436
5.00	6.0	29.50	5.50	5.5
5.038	4.925	4.900	4.9543333333	4.954

Week 2: Converting Length, Area and Volume

6m^2	=	$60\,000\text{ cm}^2$
0.002 m^2	=	2000 mm^2
$24,000\text{ cm}^2$	=	2.4 m^2
$46,000,000\text{ mm}^3$	=	0.046 m^3
0.56 m^3	=	$560\,000\text{ cm}^3$

750 mm^2	=	0.00075 m^2
$5 \times 10^{-4}\text{ cm}^3$	=	$5.0 \times 10^{-10}\text{ m}^3$
$8.3 \times 10^{-6}\text{ m}^3$	=	8300 mm^3
$3.5 \times 10^2\text{ m}^2$	=	$3.5 \times 10^6\text{ cm}^2$
152000 mm^2	=	0.152 m^2

A 2.0m long solid copper cylinder has a cross-sectional area of $3.0 \times 10^2\text{ mm}^2$. What is its volume in cm^3 ?

$$h = 2.0\text{ m} = 2.0 \times 10^2\text{ cm}$$

$$\text{csa} = 3.0\text{ cm}^2$$

$$V = \text{cross-section area} \times \text{height} = 2.0 \times 10^2 \times 3.0 = 600$$

$$\text{Volume} = 600\text{ cm}^3$$

5 N cm^{-2}	=	$50\,000\text{ N m}^{-2}$
1150 kg m^{-3}	=	$(1150 \times 1000 / 100 \times 100 \times 100) = 1.15\text{ g cm}^{-3}$
3.0 m s^{-1}	=	$(3.0 / 1000) \times (60 \times 60) = 10.8\text{ km h}^{-1}$
65 kN cm^{-2}	=	650 N mm^{-2}
7.86 g cm^{-3}	=	7860 kg m^{-3}

Drawing Lines of Best Fit

1. Straight line positive gradient, constant
2. Curve, negative gradient, steep then getting shallower
3. Straight line, negative gradient, constant
4. Straight line positive gradient, constant
5. Curve, positive gradient, decreasing
6. Curve, positive gradient, increasing

Week 3: Calculating Gradients – Straight Lines

Show construction lines on your graphs.

1. $m = 124 - 0 / 50 - 0 = 2.5$
2. $m = 22.5 - 2.0 / 5.0 - 0 = 4.1$
3. $m = 112 - 42 / 11 - 4 = 10$
4. $m = 0.07 - 0.14 / 24 - 17 = -0.01$

Week 3: Calculating Gradients – Straight Lines

Construction lines need to be drawn on graphs for the full method.

1. Gradient at point 2.0 $m = 22 - 0 / 4 - 0 = 5.5$ gradient at point 4.0 $m = 46 - 0 / 5.0 - 1.8 = 14.4$
2. Gradient at point 1.5 $m = 424 - 0 / 4 - 1 = 14.7$ gradient at point 3.5 $m = 116 - 0 / 4 - 2 = 58$

Week 4: Calculating Areas – Straight Line Graphs

- always show a full method with your solutions.

Top graph area = 39 m Bottom graph area = 33 +/- 1 m (to 2 sig fig)

Week 4: Calculating Areas – Curved Line Graphs

All values approximate, your estimate should be within quoted error.

Left hand graph- 41 squares each square 1 m s⁻¹ x 1 s = 1 m area = 41 m +/- 1 m
Right hand graph 31 squares each square 1 km s⁻¹ x 60 s = 60 km area = 1860 km +/- 60 km

Week 4: Interpreting Graphs

Graph 1

0-10 minutes temperature rises at a constant rate from -20 °C to 0 °C of 2 °C min⁻¹.

This is a graph of ice gaining thermal energy.

10-15 minutes temp is constant at 0 °C as a change of state occurs; *solid to liquid.*

15- 35 minutes temp rises at 5 °C min⁻¹, constant rate because gradient is constant.

35-75 minutes temp constant at 100 °C, change of state ; *liquid to gas.*

75-80 minutes rapid increase in temp, gradient steepest 8 °C min⁻¹, *gas phase.*

(The comments in italics are expected as is relevant theory which you will cover in the course).

Graph 2

Section 1 At 0 °C activity low at 20 units (no units given so we use units as a term) rising to a max activity of 100 units at 40 °C.

Section 2 From peak at 40 °C activity rapidly drops to a low of 4 units at 100 °C.

Optimum activity is at 40 +/- 4 °C

Graph 3

6- sections (only 2 described you need to write a description for all sections)

Section 1 - Constant acceleration of $3/6 = 0.5 \text{ m s}^{-2}$ for 6 seconds, covering a displacement from the start point of

$$(3 \times 6) / 2 = 9\text{m}$$

Section 2 - constant velocity of 3 m s⁻¹ for 4 seconds covering a displacement of $3 \times 4 = 12\text{m}$





Reading list

The internet has hundreds of resources to help you with the work above. However take care when looking for the sites. For example searching for 'Physics Significant Figures' will generate loads of useful results; just searching for 'significant figures' may not.

The course will start with mechanics so looking through the sections of any GCSE book on velocity and acceleration will help. Also the Institute of Physics have a resources on vectors in physics. It is designed for teachers but does have some useful worksheets with answers. Use this URL <https://spark.iop.org/episode-201-scalars-and-vectors> .

