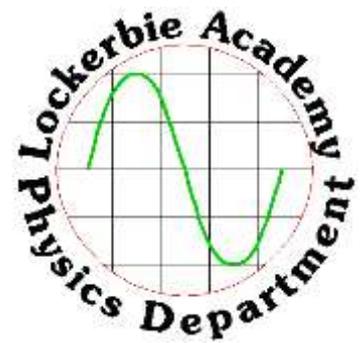


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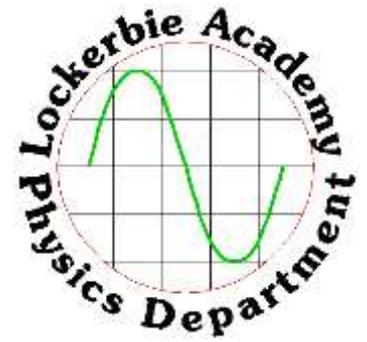
**J A  
HARGREAVES**

**NATIONAL 5  
LEARNING OUTCOMES QUESTIONS**



**2017/18-Don't Panic!**

NAME: Mark Scheme



J A  
HARGREAVES

**NATIONAL 5 DYNAMICS  
LEARNING OUTCOMES ANSWERS**



**2017/18-Don't Panic!**

# DYNAMICS

## QUANTITIES FOR THE DYNAMICS UNIT

For this unit copy and complete the table.

Quantity	Symbol	Unit	Unit Symbol	Scalar / Vector
Time	$t$	seconds	s	scalar
Speed	$v$	metres per second	$\text{ms}^{-1}$	scalar
Velocity	$v$	metres per second	$\text{ms}^{-1}$	vector
Acceleration	$a$	metres per second squared	$\text{ms}^{-2}$	vector
Distance	$d$	metre	m	scalar
Displacement	$s$	metre	m	vector
Force	$F$	Newton	N	vector
Weight	$W$	Newton	N	vector
Friction	$F$	Newton	N	vector
Gravitational Field Strength	$g$	Newtons per kilogram	$\text{Nkg}^{-1}$	vector
Energy	$E$	Joule	J	scalar
Work	$E_w$ or $W$	Joule	J	scalar
Heat Energy	$E_H$	Joule	J	scalar
Gravitational Potential Energy	$E_p$	Joule	J	scalar
Kinetic Energy	$E_k$	Joule	J	scalar
Height	$h$	metre	m	scalar
Initial velocity	$u$	metres per second	$\text{ms}^{-1}$	vector
Final velocity	$v$	metres per second	$\text{ms}^{-1}$	vector
Average velocity	$\bar{v}$	metres per second	$\text{ms}^{-1}$	vector
Mass	$m$	kilogram	kg	scalar

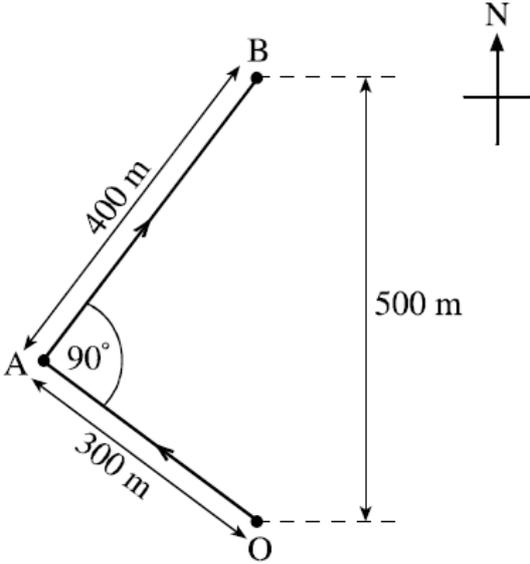
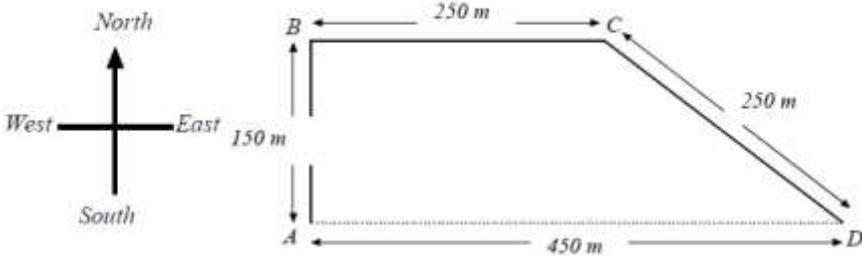
## THE DYNAMICS UNIT IN NUMBERS

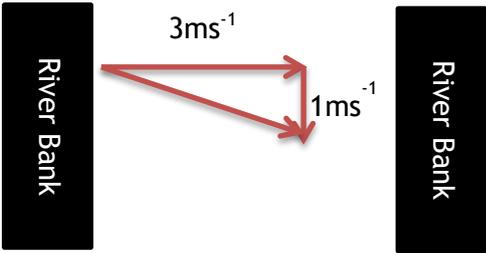
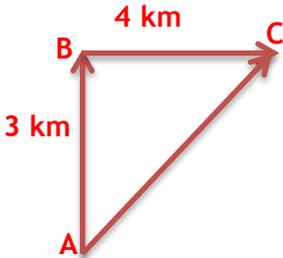
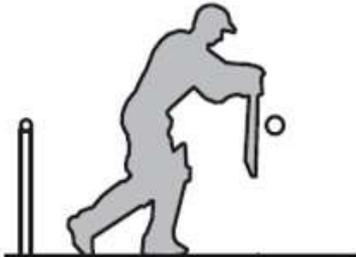
Quantity	Value
How many seconds in a minute?	<b>60 s</b>
How many seconds in an hour?	<b>3600 s</b>
What is the value of the gravitational field strength on Earth?	<b>9.8 Nkg<sup>-1</sup></b>
How many metres are there in a kilometre?	<b>1000 m</b>
How many metres are there in a mile?	<b>1609 m</b>
If 70 mph is equivalent to 31.29 ms <sup>-1</sup> and 30 mph is equivalent to 13.41 ms <sup>-1</sup> , what is the conversion factor to convert mph into ms <sup>-1</sup> ?	<b>÷2.2 or x0.45454545 etc</b>

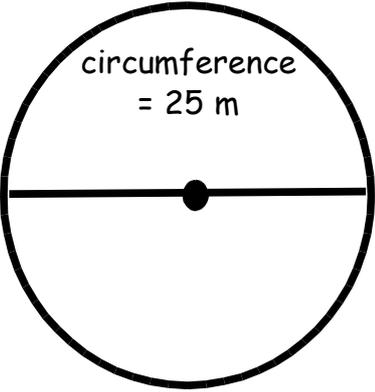
No.	CONTENT
<b>Vectors and scalars</b>	
1.1	I can define scalar quantities and vector quantities.
1.1.1	Define the term scalar quantity.
	<b>A scalar quantity is fully described by a magnitude and unit</b>
1.1.2	Define the term vector quantity.
	<b>A vector quantity is fully described by a magnitude, unit and direction</b>
1.1.3	Describe the difference between vector quantities and scalar quantities.
	<b>A vector quantity requires a direction to fully describe it</b>
1.2	I can identify vector and scalar quantities such as: force, speed, velocity, distance, displacement, acceleration, mass, time and energy.

No.	CONTENT												
1.2.1	<p>Copy and complete the following table placing the quantities in the correct part of the table. <i>force, speed, velocity, distance, displacement, acceleration, mass, time and energy.</i></p> <table border="1" data-bbox="520 331 1204 757" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="background-color: #a52a2a; color: white;">Scalar</th> <th style="background-color: #a52a2a; color: white;">Vector</th> </tr> </thead> <tbody> <tr> <td style="color: red;">Speed</td> <td style="color: red;">Force</td> </tr> <tr> <td style="color: red;">Distance</td> <td style="color: red;">Velocity</td> </tr> <tr> <td style="color: red;">Mass</td> <td style="color: red;">Displacement</td> </tr> <tr> <td style="color: red;">Time</td> <td style="color: red;">Acceleration</td> </tr> <tr> <td style="color: red;">Energy</td> <td></td> </tr> </tbody> </table>	Scalar	Vector	Speed	Force	Distance	Velocity	Mass	Displacement	Time	Acceleration	Energy	
Scalar	Vector												
Speed	Force												
Distance	Velocity												
Mass	Displacement												
Time	Acceleration												
Energy													
1.3	I can calculate the resultant of two vector quantities in one dimension or at right angles.												
1.3.1	What does the term “resultant” mean in terms of two vector quantities?												
	<p><b>The resultant of a number of forces is the single force which has the same effect as the several forces actually acting on the object.</b></p>												
1.3.2	Explain how to find the resultant and direction of a pair of vectors at right angles?												
	<p><b><u>Scale Diagram</u></b>- using the head to tail rule. Draw one vector to scale and on the head of the first vector draw the tail of the second. Join the direct route from tail to the final head. Find the length of this vector and scale up to get the resultant. Measure the angle with a protractor from N or horizontal or vertical. Mark this on your diagram</p> <p><b><u>Pythagoras</u></b>. Redraw the diagram to follow the head to tail rule. Use Pythagoras to find the hypotenuse, which will be the resultant and use <math>\tan\theta</math> to find the angle.</p> <p><b><u>Polar Coordinates</u></b> (remember this method wont get you any intermediate marks so might be a better method of checking). Pol(x value, y value)= first answer is the resultant, second answer is the angle.</p>												
1.3.3	<p>Find the resultant of the following vectors</p> <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div data-bbox="319 1680 782 1814" style="text-align: center;"> <p>(a)</p> </div> <div data-bbox="973 1680 1228 1814" style="text-align: center;"> <p>(b)</p> </div> </div> <div style="margin-top: 20px;"> <p>(c)</p> </div>												

No.	CONTENT
	<p>(a) <math>F_1 + F_2 = F_R</math> <math>2000 + -1200 = 800\text{N}</math> to the left            (b) <math>F_1 + F_2 = F_R</math> <math>700 + -600 = 100\text{N}</math> downwards            (c) <math>F_1 + F_2 = F_R</math> <math>50\,000 + 50\,000 = 100\,000\text{N}</math></p>
1.3.4	<p>Find the resultant of each of the pairs of vectors, remember to quote the direction.</p>
	<p><b>By Pythagoras</b></p> <p>a) <math>R^2 = a^2 + b^2 = 5^2 + 12^2 = 169</math>    <math>R = 13\text{N}</math> @ <math>67^\circ</math> South of East            b) <math>R^2 = a^2 + b^2 = 18^2 + 24^2 = 900</math>    <math>R = 30\text{N}</math> @ <math>53^\circ</math> south of East            c) <math>R^2 = a^2 + b^2 = 5^2 + 15^2 = 250</math>    <math>R = 16\text{N}</math> @ <math>72^\circ</math> South of West            d) <math>R^2 = a^2 + b^2 = 8^2 + 10^2 = 164</math>    <math>R = 13\text{N}</math> @ <math>39^\circ</math></p>
1.4	I can determine displacement and/or distance using scale diagram or calculation.
1.4.1	Explain the term distance.
	<p><b>Distance is the total length of path travelled.</b>  <b>Distance is a measure of how far an object has travelled</b></p>
1.4.2	Explain the term displacement.
	<p><b>Displacement is the length and direction travelled in a straight line from the starting point to the finishing point.</b></p> <p><b>The shortest distance between the start and the finish in a direction towards the finish.</b></p> <p><b>a measure of how far an object has travelled from its starting point in the direction of the object from its start to finish point.</b></p>

No.	CONTENT
1.4.3	<p>The diagram shows the course taken by a boat during a race.</p> <p>The boat starts the race at O and sails to a marker buoy at A. The boat then turns through <math>90^\circ</math> and sails to a marker buoy at B.</p> <p>(i) What is the total distance travelled by the boat in going from O to B?</p> <p>(ii) On reaching the marker buoy at B, what is the displacement of the boat from O?</p> 
	<p><b>(i) The boat has travelled a total distance of 700 m</b></p> <p><b>(ii) The boat has a displacement of 500 m due North</b></p>
1.4.4	<p>An orienteer starts at A, runs to B, then C and finishes at D.</p>  <p>(i) Calculate the total distance travelled by the orienteer.</p> <p>(ii) State the final displacement of the orienteer from point A.</p>
	<p><b>i) distance = <math>150 + 250 + 250 = 650</math> m</b></p> <p><b>ii) The final displacement is <u>450 m due East</u></b></p>
1.5	I can determine velocity and/or speed using scale diagram or calculation.
1.5.1	State the difference between speed and velocity
	<p><b>Speed is the distance travelled every second.</b></p> <p><b>Velocity is the displacement travelled every second in a certain direction.</b></p>
1.5.2	<p>A sculler is rowing his boat at <math>3 \text{ ms}^{-1}</math> <i>through the water</i> straight across a river which is flowing at <math>1 \text{ ms}^{-1}</math>.</p> <p>(a) Draw a vector diagram of these vectors.</p> <p>(b) What is the boat's <b>velocity</b> relative to the bank?</p>

No.	CONTENT
	<div style="text-align: center;">  </div> <p style="text-align: center; color: red;"><math>R^2 = a^2 + b^2 = 3^2 + 1^2 = 10</math>    <math>R=3ms^{-1}</math> @72° to the riverbank</p>
<p>1.5.3</p>	<p>On an orienteering course, a girl runs due north from point A to point B, a distance of 3 km. She then heads in an easterly direction for 4 km to point C.</p> <p>(a) How far has the girl run from A to C?                  (b) What is the girl's displacement from point A when she reaches C?</p>
	<div style="text-align: center;">  </div> <p style="color: red;">(a) The girl has run a distance of 7 km</p> <p style="color: red;">(b) When the girl reaches C she is 5 km from the start at an angle of 53° from North.</p>
<p>1.5.4</p>	<p>The distance between the wickets on a cricket pitch is 20.12 m. On one pitch, the wicket has a north-south orientation. A batsman scores three runs off one ball.</p> <p>(a) What distance does he run?                  (b) What is his final displacement if the wicket at which he batted is at the south end?</p> <div style="display: flex; justify-content: space-around; align-items: center;">   </div>
	<p style="color: red;">(a) The cricketer has run a total distance of <math>3 \times 20.12 \text{ m} = 60.36 \text{ m}</math>                  (b) His final displacement is 20.12 m South.</p>

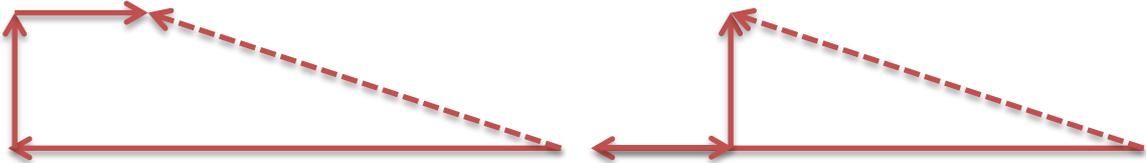
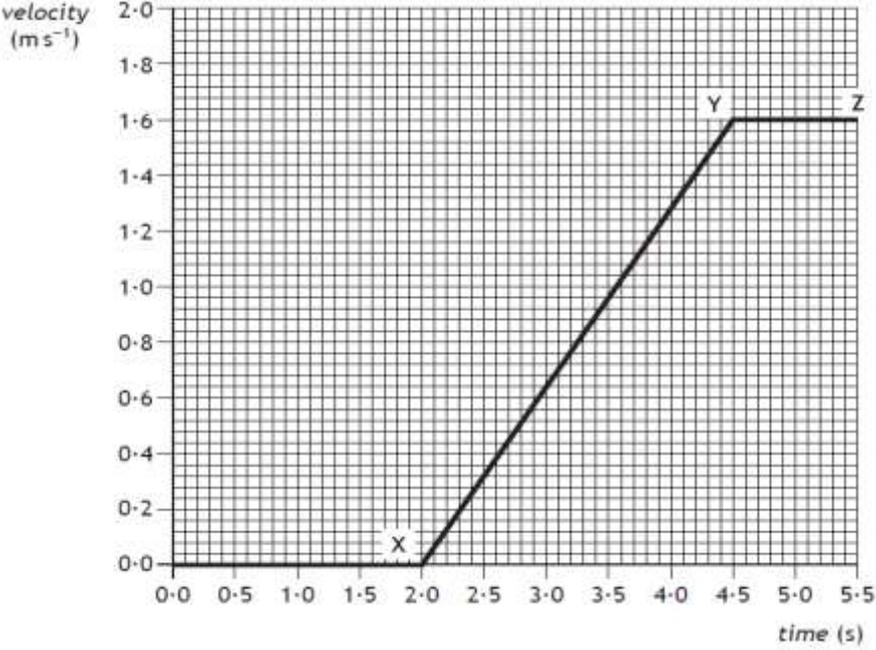
No.	CONTENT
1.5.5	 <p>Ben jogs around the centre circle of a football pitch.</p> <p>(i) What distance has he travelled?  (ii) What is his displacement from the start?</p> <p>Chris walks one and a half times around the circle in the same time</p> <p>(iii) What distance has Chris travelled?  (iv) What is Chris' displacement from the start?</p>
	<p>(i) Ben has jogged the circumference of the circle = 25 m  (ii) Ben arrives back where he started so his displacement is 0 m from the start  (iii) Chris has walked 1.5 circumferences = <math>25 \times 1.5 = 38</math> m  (iv) Chris' displacement is the diameter of the circle  Circumference = <math>\pi d</math></p> $d = \frac{25}{\pi} = 8.0m$
1.6	I can perform calculations/ solve problems involving the relationship between speed, distance and time. ( $d = vt$ , and $d = \bar{v}t$ )
1.6.1	A car travels 100 miles in 2½hours. Calculate its speed in mph?
	$\bar{v} = \frac{d}{t}$ $\bar{v} = \frac{100 \text{ miles}}{2.5 \text{ hours}}$ $\bar{v} = 40 \text{ miles per hour}$
1.6.2	A train travels 100km in 45 minutes. (i) Calculate the speed of the train in $\text{kmh}^{-1}$ ? (ii) Calculate the speed of the train in $\text{ms}^{-1}$ ?

No.	CONTENT
	<p>(i) <math>45 \text{ minutes} = \frac{3}{4} \text{ hours} = 0.75 \text{ hours}</math></p> $\bar{v} = \frac{d}{t} = \frac{100 \text{ km}}{0.75 \text{ h}} = 160 \text{ km/h}$ <p>(ii) <math>45 \text{ minutes} = 40 \times 60 \text{ s} = 2700 \text{ s}</math></p> $100 \text{ km} = 100000 \text{ m}$ $\bar{v} = \frac{d}{t} = \frac{100000 \text{ m}}{2700 \text{ s}} = 37 \text{ m/s}$
1.6.3	<p>A jet plane travels at an average speed of <math>300 \text{ ms}^{-1}</math>.</p> <p>(i) How far could it travel in an hour?</p> <p>(ii) How long would it take to travel the 500km from Edinburgh to London?</p>
	<p>(i) <math>1 \text{ hour} = 60 \times 60 \text{ s} = 3600 \text{ s}</math></p> $d = vt = 300 \times 3600 = 1080000 \text{ m} = 1080 \text{ km}$ <p>(ii) <math>500 \text{ km} = 500000 \text{ m}</math></p> $t = \frac{d}{v}$ $t = \frac{500000 \text{ m}}{300} = 1667 \text{ s} = 27.8 \text{ minutes}$
1.6.4	<p>A runner completes a 200 m race in 25 s. What is his average speed in <math>\text{ms}^{-1}</math>?</p>
	$\bar{v} = \frac{d}{t}$ $\bar{v} = \frac{200}{25}$ $\bar{v} = 8 \text{ ms}^{-1}$
1.6.5	<p>An athlete takes 4 minutes 20 s to complete a 1500 m race. What is the average speed?</p>
	$t = 4 \text{ min } 20 \text{ s} = 4 \times 60 + 20 = 260 \text{ s}$ $\bar{v} = \frac{d}{t}$ $\bar{v} = \frac{1500}{260}$ $\bar{v} = 5.8 \text{ ms}^{-1}$
1.6.6	<p>Concorde can travel at <math>680 \text{ ms}^{-1}</math>, (twice the speed of sound). How far will it travel in 25 s at this speed?</p>

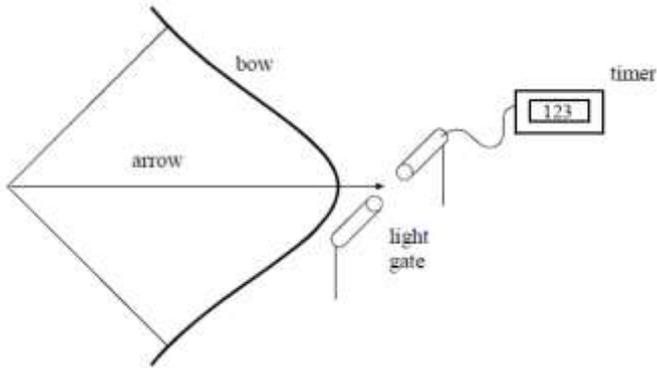
No.	CONTENT
	$\bar{v} = \frac{d}{t}$ $680 = \frac{d}{25}$ $d = 17000 \text{ m} = 17 \text{ km}$
1.6.7	A girl can walk at an average speed of $2 \text{ ms}^{-1}$ . How far will she walk in 20 minutes?
	$t = 20 \text{ min} = 20 \times 60 = 1200 \text{ s}$ $\bar{v} = \frac{d}{t}$ $2 = \frac{d}{1200}$ $d = 2400 \text{ m}$
1.6.8	How long will it take a cyclist to travel 40 km at an average speed of $5 \text{ ms}^{-1}$ ?
	$d = 40 \text{ km} = 40\,000 \text{ m}$ $\bar{v} = \frac{d}{t}$ $5 = \frac{40\,000}{t}$ $t = 8000 \text{ s}$
1.6.9	How long (to the nearest minute) will the Glasgow to London shuttle take if it flies at an average speed of $220 \text{ ms}^{-1}$ for the 750 km flight?
	$v = 220 \text{ ms}^{-1} \quad d = 750 \text{ km} = 750\,000 \text{ m}$ $\bar{v} = \frac{d}{t}$ $220 = \frac{750\,000}{t}$ $t = 3409 \text{ s} = 56 \text{ mins } 49 \text{ s}$
1.6.10	How long, to the nearest minute, will a car take to travel 50 km if its average speed is $20 \text{ ms}^{-1}$ ?

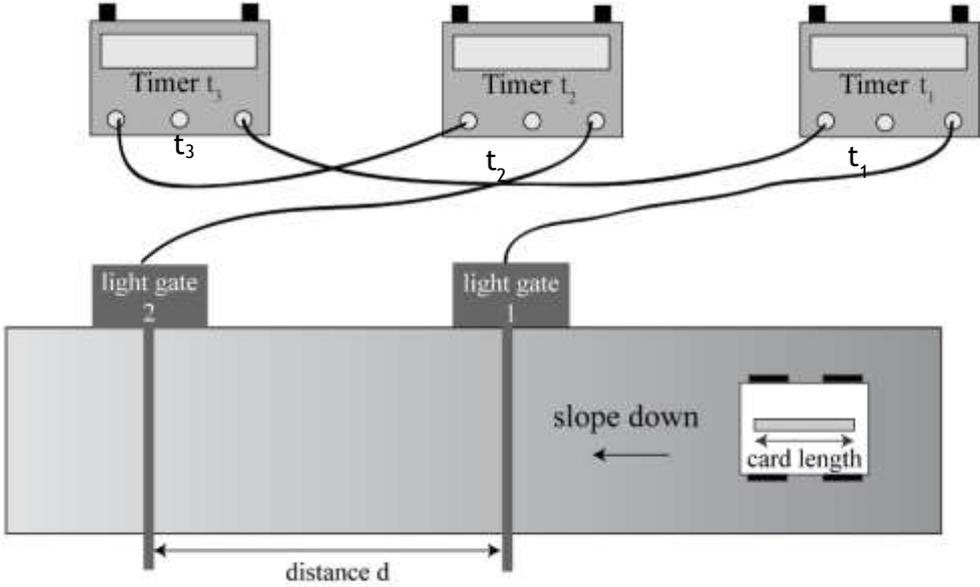
No.	CONTENT
	<p><math>d=50\,000\text{ m}</math>  <math>v=20\text{ ms}^{-1}</math></p> $\bar{v} = \frac{d}{t}$ $20 = \frac{50\,000}{t}$ <p><u><math>t=2500\text{ s} = 2500/60 = 42\text{ mins}</math></u></p>
1.7	I can perform calculations/ solve problems involving the relationship between velocity, displacement and time ( $s = \bar{v}t$ ) in one dimension
1.7.1	<p>A person walks 25 metres west along a street before turning back and walking 15 metres east. The journey takes 50 seconds. What is the:</p> <p>a) Total distance travelled by the person?  b) Displacement of the person?  c) Average speed of the person?  d) Average velocity of the person?</p>
	 <p>a) total distance = <math>25 + 15 = 40\text{ m}</math>  b) displacement = <math>25 - 15 = 10\text{ m to the West}</math>  c)</p> $\bar{v} = \frac{d}{t}$ $\bar{v} = \frac{40}{50} = 0.8\text{ ms}^{-1}$ <p>d)</p> $\bar{v} = \frac{s}{t}$ $\bar{v} = \frac{10}{50} = 0.2\text{ ms}^{-1}\text{ West}$

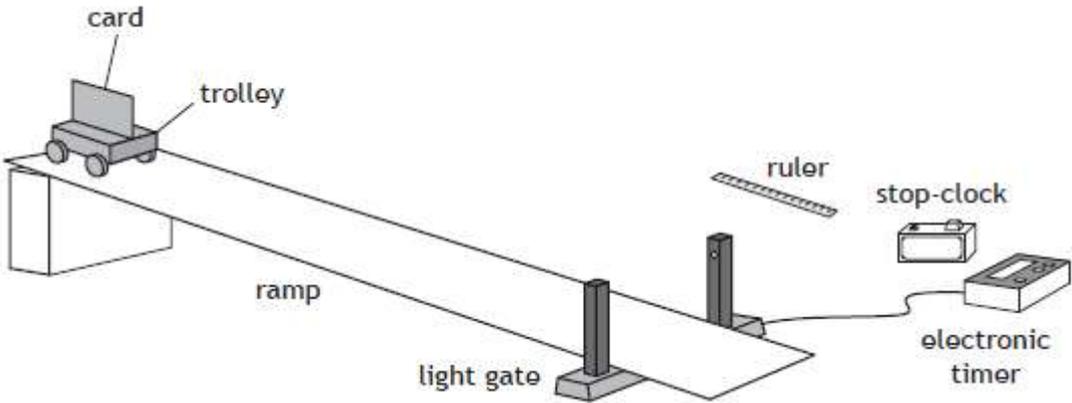
No.	CONTENT
1.7.2	<p>An Olympic runner runs one complete lap around an athletics track in a race. The total length of the track is 400 metres and it takes 45 seconds for the runner to complete the race. Calculate the:</p> <p>a) Displacement of the runner at the end of the race.  b) Average speed of the runner during the race.  c) Average velocity of the runner during the race.</p>
	<p><b>a) Displacement = 0 m as the journey ends at the start</b>  <b>b)</b></p> $\bar{v} = \frac{d}{t}$ $\bar{v} = \frac{400}{45} = 8.9 \text{ ms}^{-1}$ <p><b>c) Average velocity is 0 ms<sup>-1</sup> as the displacement is zero</b></p>
1.7.3	<p>A car drives 15 kilometres east for 12 minutes then changes direction and drives 18 kilometres west for 18 minutes.</p> <p>a) What is the total distance travelled by the car?  b) What is the displacement of the car from the start of the journey?  c) What is the average velocity of the car, in metres per second?</p>
	<p><b>a) Total distance travelled = 15 + 18 = 23 km</b>  <b>b) Total displacement = 15 km + -18km = 3km west</b>  <b>c) Average velocity =</b></p> $\bar{v} = \frac{s}{t}$ <p><b>t = 18 x 60 = 1080s</b></p> $\bar{v} = \frac{3000}{1080}$ $\bar{v} = 2.8 \text{ ms}^{-1}$
1.7.4	<p>On a journey, a lorry is driven 120 kilometres west, 20 kilometres north then 30 kilometres east. This journey takes 2 hours to complete.</p> <p>a) What is the average displacement of the lorry, in km?  b) What is the average velocity of the lorry, in km/h?</p>

No.	CONTENT
	 $R^2 = a^2 + b^2 = (120 - 30)^2 + 20^2 = 92 \text{ km @ } 13^\circ$ $\bar{v} = \frac{s}{t}$ $\bar{v} = \frac{92}{2} = 46 \text{ kmh}^{-1} @ 13^\circ$
1.8	I can determine average and instantaneous speed.
1.8.1	Explain the term average speed
	<p>The average speed of an object is defined as the total distance for the journey divided by the time for the journey, or the rate of covering a distance.</p>
1.8.2	Explain the term <i>instantaneous speed</i>
	<p>Instantaneous speed is the speed of an object at a particular instant of time.</p>
1.8.3	 <p>State the instantaneous speed of the vehicle at</p> <p>a) 0.5 s    b) 3.0 s    c) 4.0 s</p>

No.	CONTENT
	<p><b>Reading from the graph</b></p> <p>a) <math>0 \text{ ms}^{-1}</math>      b) <math>0.6 \text{ ms}^{-1}</math>      c) <math>1.3 \text{ ms}^{-1}</math></p>
1.8.4	<p>Two insulated wires are laid across the road 1.00 metres apart to test the instantaneous speed of cars as they travel between the wires. A Mondeo of length 4.80 m takes 0.06 s to pass between the two wires. Calculate the instantaneous speed of the car.</p>
	$v = \frac{d}{t}$ $v = \frac{1.00}{0.06}$ $\underline{v = 16.7 \text{ ms}^{-1}}$
1.9	I can describe experiments to measure average and instantaneous speed.
1.9.1	<p>Describe how you can measure the average speed of a runner. Include a list of the apparatus you would use, the measurements you would take, how you would carry these out, and the calculation needed to obtain a final value for the speed.</p>
	<p><b>To measure the average speed of the runner, you need to know the distance that they run, and the time this takes. The apparatus needed is therefore a stopwatch and a metre tape.</b></p> <p><b>You would measure the length of the track with the tape.</b></p> <p><b>You would then start the stopwatch when the gun was fired, and stop it when the runner crossed the finish line. You calculate the average speed by dividing the distance by the time.</b></p> $\bar{v} = \frac{d}{t}$
1.9.2	<p>(a) List various methods for measuring the instantaneous speed.</p> <p>(b) Which of these methods is most accurate? Explain your answer.</p>
	<p><b>(a) (i) You can measure instantaneous speed by using light gates connected to an electronic timer. You measure how long it takes the object to move a small distance. You calculate the instantaneous speed by dividing the distance by the time (the time must be very small).</b></p> <p><b>(ii) You can time how long it takes a vehicle to pass a point. Find the instantaneous speed by using the equation</b></p> $\text{instantaneous speed} = \frac{\text{length of vehicle}}{\text{time to pass a point}}$ <p><b>(b) Using an electronic timer is better as it removes any human error caused by reaction time</b></p>

No.	CONTENT
1.9.3	<p>An arrow of length 0.8 m is shot from a bow.</p> <p>A student designs an experiment to measure the instantaneous speed of the arrow, as it leaves the bow. The student places a light gate connected to a timer, as shown below.</p>  <p>The student states that the speed of the arrow can be found from</p> $\text{speed of the arrow} = \frac{\text{length of arrow}}{\text{time on timer}}$ <p>(i) Explain why the method used by the student does not give the correct value for the speed of the arrow as it leaves the bow.</p> <p>(ii) Suggest how the experiment could be modified to enable the speed of the arrow as it leaves the bow to be found.</p>
	<p>(i) The length of the arrow is too great and during the time the arrow passes through the light gate the instantaneous speed can have changed. The time must be very short to measure instantaneous speed.</p> <p>(ii) Two light gates a few cm apart and measure the gap time. Or add a mask and raise the light gates so that only the mask blocks the light gates. This might have problems with the flight of the arrow.</p>

No.	CONTENT
1.9.4	 <p>From the diagram above, state what measurements are required to find:</p> <ol style="list-style-type: none"> <li>the average speed of the vehicle as it passes down the slope?</li> <li>the instantaneous speed at the bottom of the slope?</li> </ol> <p>State what pieces of equipment give the measurements to find:</p> <ol style="list-style-type: none"> <li>the average speed of the vehicle as it passes down the slope?</li> <li>the instantaneous speed at the bottom of the slope?</li> <li>What additional equipment is required to complete these measurements?</li> </ol>
	<ol style="list-style-type: none"> <li><b>Average speed = distance <math>d</math> / time on timer 3</b></li> <li><b>Instantaneous speed = length of card / time on timer 2</b></li> <li><b>distance <math>d</math> and time on timer 3</b></li> <li><b>length of card / time on timer 2</b></li> <li><b>Ruler</b></li> </ol>

No.	CONTENT
1.9.5	 <p>Copy and complete the diagram and state how the following can be determined:</p> <ol style="list-style-type: none"> <li>the instantaneous speed of the trolley at the bottom of the slope.</li> <li>the average speed of the trolley down the ramp</li> <li>the acceleration of the trolley as it rolls down the ramp.</li> </ol>

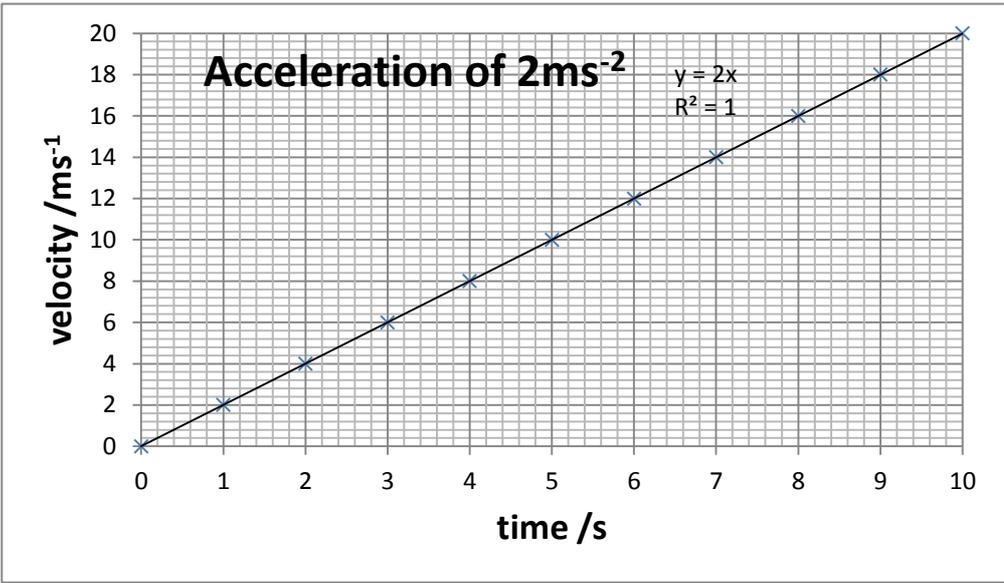
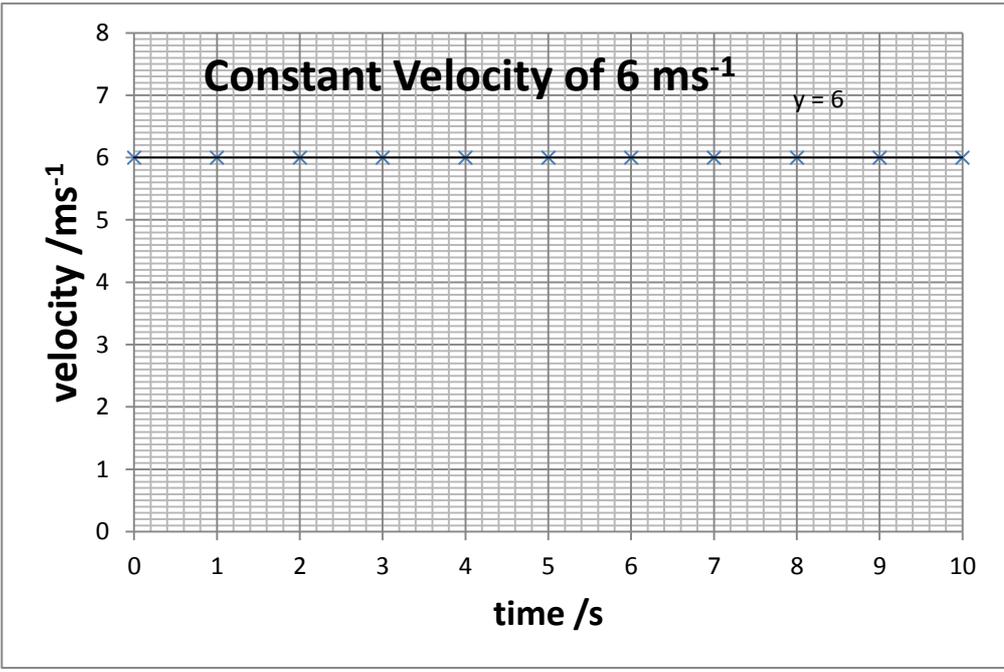
- measure the length of the card with the ruler, time how long it takes the card to pass through the light gate at the bottom of the slope. To find instantaneous speed use the formula  $v = \text{length of the card} / \text{time to pass through the light gate}$ .
- Use the ruler (not great) to measure the length of the slope. Time, with a stop clock how long it takes the trolley to roll down the slope use the formula  $\text{average speed} = \text{length of slope} / \text{time to travel down the slope}$
- The instantaneous initial speed of the vehicle is 0. Measure the instantaneous speed at the bottom of the slope as explained in part a) Time how long the vehicle take to roll down the slope. Find the acceleration using

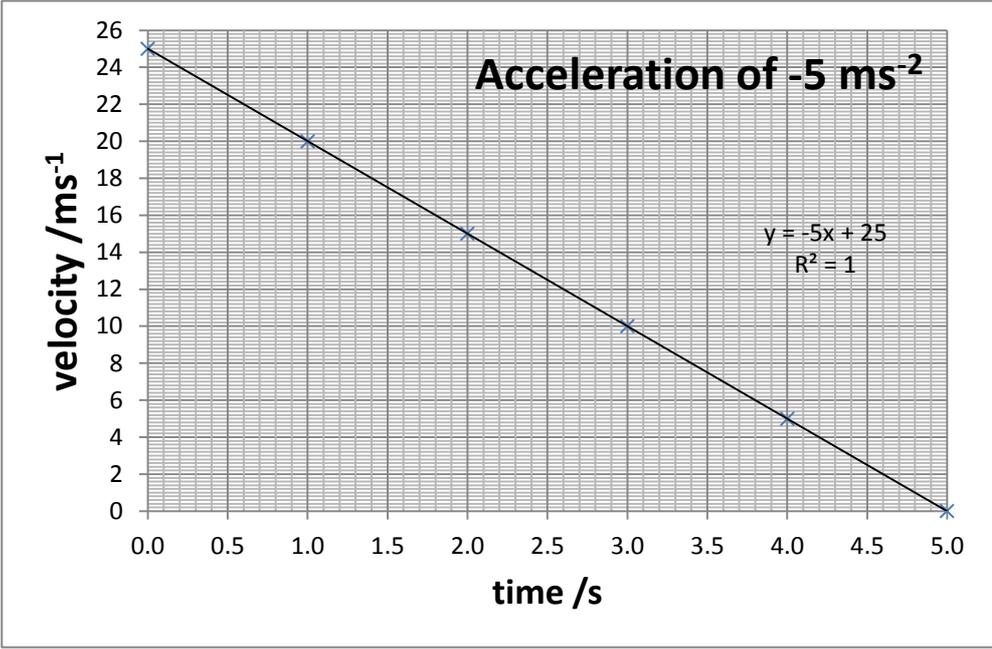
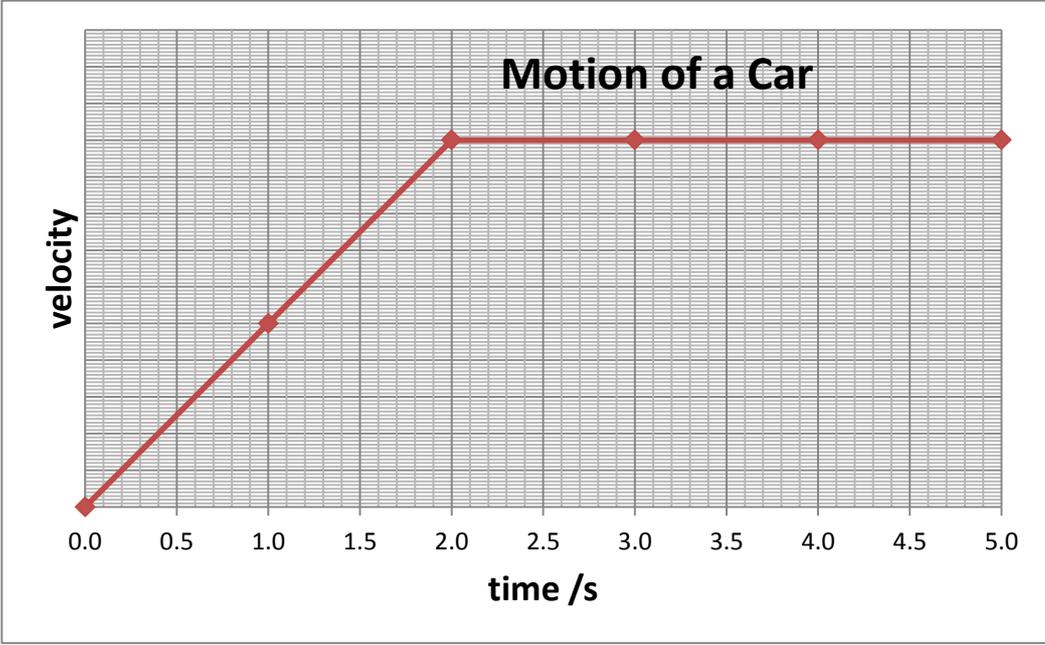
$$a = \frac{v - u}{t} = \frac{v - 0}{t}$$

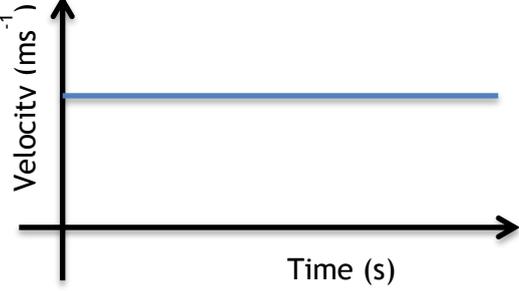
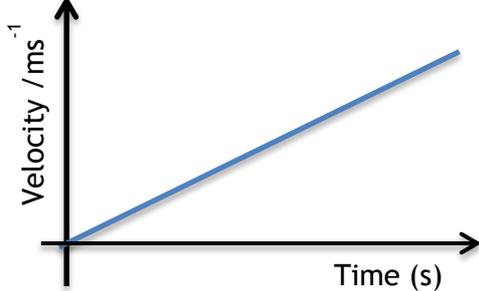
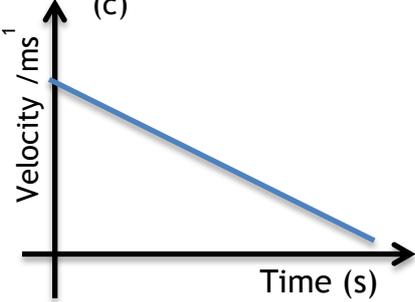
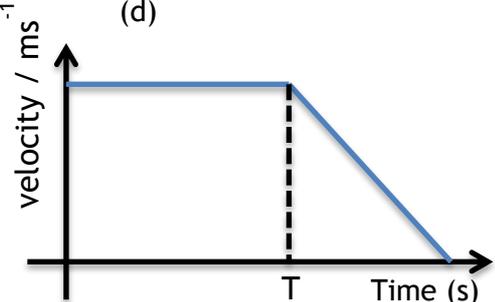
## Velocity- time graphs

2.1	I can draw velocity-time graphs for objects from recorded or experimental data.																				
2.1.1	<p>(a) On graph paper, draw a velocity-time graph of the race car’s journey.                      (b) Using the graph, describe the motion of the race car over the 80 seconds.</p> <table border="1" data-bbox="261 1825 1273 1937"> <tbody> <tr> <td>Time (s)</td> <td>0</td> <td>10</td> <td>20</td> <td>30</td> <td>40</td> <td>50</td> <td>60</td> <td>70</td> <td>80</td> </tr> <tr> <td>Speed (m/s)</td> <td>5</td> <td>5</td> <td>20</td> <td>35</td> <td>50</td> <td>50</td> <td>50</td> <td>25</td> <td>0</td> </tr> </tbody> </table> <p>(c) Using the graph you have drawn, calculate</p> <ol style="list-style-type: none"> <li>The acceleration between 10 and 40 s.</li> <li>The total distance travelled by the race car.</li> <li>The average speed during the 80 seconds.</li> </ol>	Time (s)	0	10	20	30	40	50	60	70	80	Speed (m/s)	5	5	20	35	50	50	50	25	0
Time (s)	0	10	20	30	40	50	60	70	80												
Speed (m/s)	5	5	20	35	50	50	50	25	0												

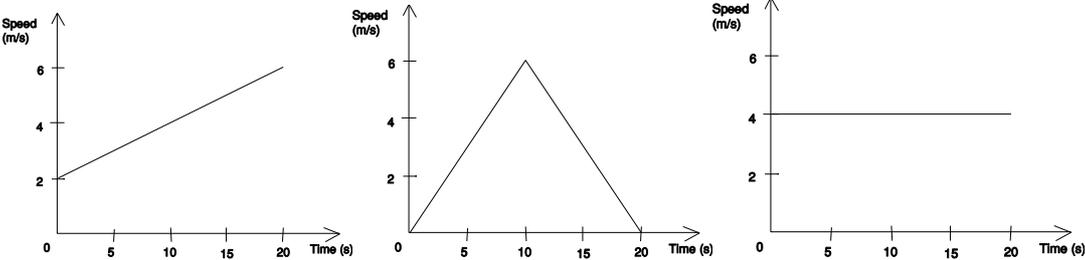
No.	CONTENT
	<div data-bbox="260 197 1225 775" style="text-align: center;"> </div> <p data-bbox="403 792 1449 936">b) The car takes 10 s to start moving. It accelerates from 10 s to 40s and then from 40 s to 60 s moves at constant velocity. From 60 s to 80s the car has a constant uniform deceleration or negative acceleration until it reaches rest.</p> <p data-bbox="403 945 435 981">c)</p> $a = \frac{v - u}{t} = \text{gradient}$ $a = \frac{50 - 5}{30} = 1.5 \text{ ms}^{-2}$ <p data-bbox="403 1120 1043 1155">d) Total distance = area under a v-t graph</p> <p data-bbox="451 1155 943 1191">Area 1 + area 2 + area 3+ area 4</p> $(40 \times 5) + (\frac{1}{2} \times 30 \times 45) + (20 \times 50) + (\frac{1}{2} \times 20 \times 50) = 2375 \text{ m}$ <p data-bbox="403 1232 435 1267">e)</p> $\bar{v} = \frac{d}{t}$ $\bar{v} = \frac{2375}{80} = 30 \text{ ms}^{-1}$
2.1.2	<p data-bbox="260 1469 1023 1505">Draw a labelled speed-time graph showing an object</p> <p data-bbox="355 1518 730 1554">(a) accelerating at <math>2 \text{ ms}^{-2}</math>,</p> <p data-bbox="355 1568 983 1603">(b) travelling at a steady velocity of <math>6 \text{ ms}^{-1}</math>,</p> <p data-bbox="355 1617 730 1653">(c) accelerating at <math>-5 \text{ ms}^{-2}</math>.</p>

No.	CONTENT
	<p>a)</p>  <p>Acceleration of <math>2\text{ms}^{-2}</math></p> <p><math>y = 2x</math> <math>R^2 = 1</math></p> <p>velocity /<math>\text{ms}^{-1}</math></p> <p>time /s</p> <p>b)</p>  <p>Constant Velocity of <math>6\text{ms}^{-1}</math></p> <p><math>y = 6</math></p> <p>velocity /<math>\text{ms}^{-1}</math></p> <p>time /s</p>

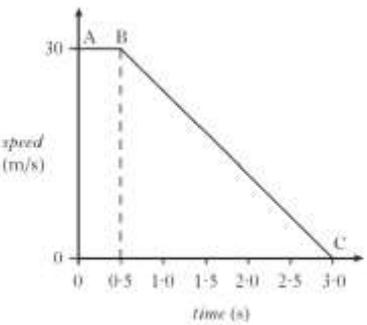
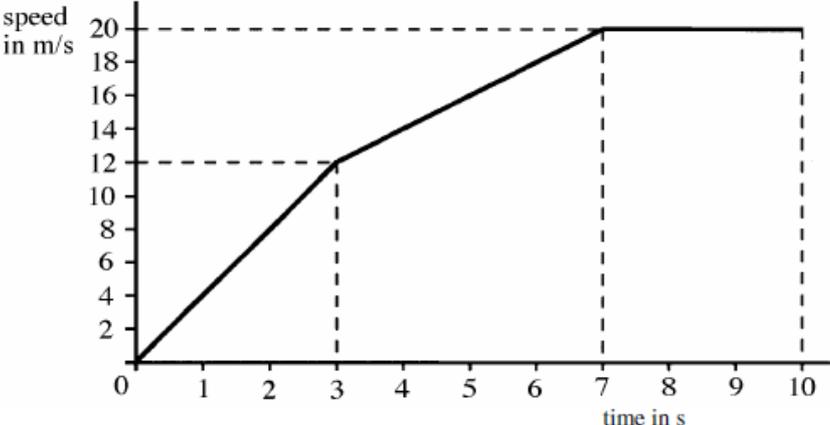
No.	CONTENT
	<p>c)</p>  <p><b>Acceleration of <math>-5 \text{ ms}^{-2}</math></b></p> <p><math>y = -5x + 25</math> <math>R^2 = 1</math></p>
<p>2.1.4</p>	<p>During a test run, a car starts from rest on a straight, flat track. For the first 2 s it has a constant acceleration. It then maintains a constant velocity for a further 3 s. Sketch a velocity-time graph to show how the velocity of the car varies during the test run. Numerical values are only required on the time axis.</p>
	 <p><b>Motion of a Car</b></p>
<p>2.2</p>	<p>I can interpret velocity-time graphs to describe the motion of an object.</p>

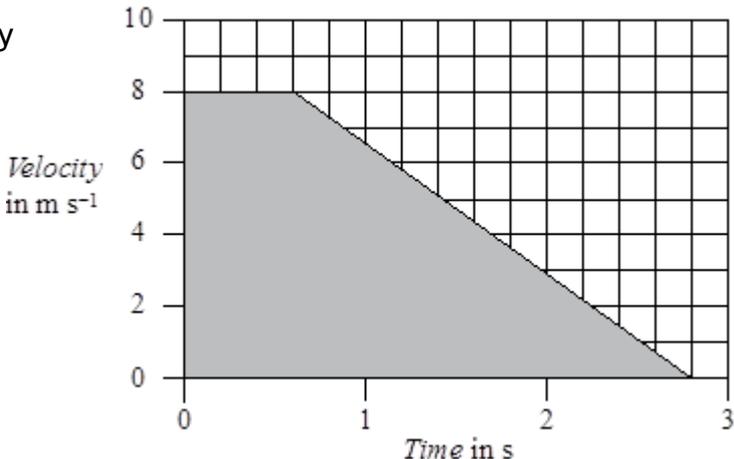
No.	CONTENT
2.2.1	<p>Fully describe the motion of the vehicles.</p> <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;"> <p>(a)</p>  <p>Velocity (<math>\text{ms}^{-1}</math>)</p> <p>Time (s)</p> </div> <div style="text-align: center;"> <p>(b)</p>  <p>Velocity / <math>\text{ms}^{-1}</math></p> <p>Time (s)</p> </div> </div> <div style="display: flex; justify-content: space-around; align-items: flex-start; margin-top: 20px;"> <div style="text-align: center;"> <p>(c)</p>  <p>Velocity / <math>\text{ms}^{-1}</math></p> <p>Time (s)</p> </div> <div style="text-align: center;"> <p>(d)</p>  <p>velocity / <math>\text{ms}^{-1}</math></p> <p>Time (s)</p> </div> </div> <p>a) A vehicle travels at constant speed  b) a vehicle has a constant acceleration starting from <math>0 \text{ ms}^{-1}</math>  c) A vehicle has a constant deceleration (or negative acceleration)  d) the vehicle has a constant velocity until time T when it uniformly accelerated to rest.</p>

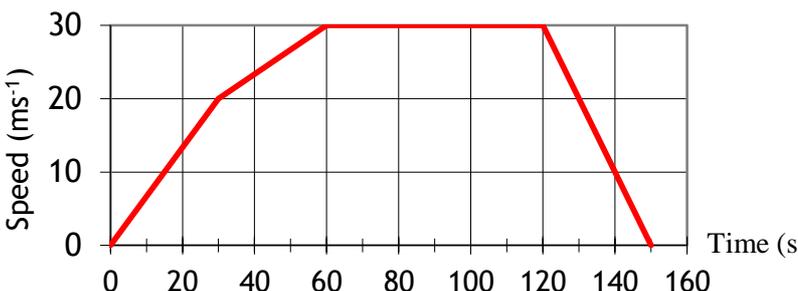
No.	CONTENT
2.1.2	<p>The velocity-time graph shown below describes the motion of a ball which has been thrown straight up into the air then allowed to fall to the ground.</p> <p>From the graph below</p> <ol style="list-style-type: none"> <li>Determine the time the ball reaches its maximum height?</li> <li>Calculate the maximum height that the ball reaches.</li> <li>Calculate the height from maximum to the ground.</li> <li>Use your answers to ii. and iii. to calculate the height above the ground that the ball was thrown from.</li> </ol> <div data-bbox="260 544 1225 1120" style="border: 1px solid black; padding: 10px; margin: 10px 0;"> </div> <ol style="list-style-type: none"> <li>The ball reaches its maximum height at 1.0 s</li> <li>The maximum height reached is the area under the first part of the velocity time graph = <math>\frac{1}{2}bh = \frac{1}{2} \times 1 \times 10 = 5</math> m</li> <li>The maximum height to the ground is the area under the lower part of the velocity time graph = <math>\frac{1}{2}bh = \frac{1}{2} \times 1.2 \times 12 = 7.2</math> m</li> <li>The ball was thrown from a height of <math>7.2-5=2.2</math> m</li> </ol>
2.2.3	<div data-bbox="260 1462 948 1859" style="border: 1px solid black; padding: 10px; margin: 10px 0;"> </div> <ol style="list-style-type: none"> <li>Describe the motion of the car during the 35 seconds</li> <li>Calculate the acceleration between 0 and 10 seconds</li> <li>Calculate the acceleration between 30 and 35 seconds</li> <li>Calculate the final displacement of the car from the starting position</li> <li>Calculate the average velocity during the 35 seconds.</li> </ol>

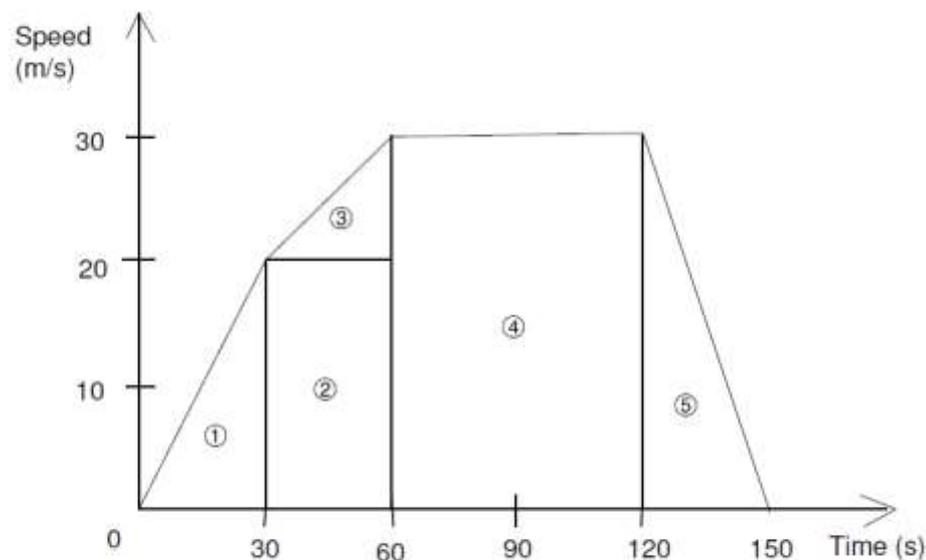
No.	CONTENT
	<p>a) The car has a constant uniform acceleration of <math>1.6 \text{ ms}^{-2}</math> between 0 and 10s. the car then travels at constant velocity of <math>16 \text{ ms}^{-1}</math> for 20s and finally decelerates at <math>-3.2 \text{ ms}^{-2}</math> for 5s (always give the values of a and v if this is possible!)</p> <p>b) as above (gradient of the graph) <math>u=0 \text{ ms}^{-1}</math>, <math>v=16 \text{ ms}^{-1}</math>, <math>t=10\text{s}</math> so <math>a=1.6 \text{ ms}^{-2}</math></p> <p>c) as above (gradient of the graph) <math>v=0 \text{ ms}^{-1}</math>, <math>u=16 \text{ ms}^{-1}</math>, <math>t=10\text{s}</math> so <math>a=1.6 \text{ ms}^{-2}</math></p> <p>d) Displacement = area under the v-t graph  <math>\frac{1}{2} bh + bh + \frac{1}{2} bh</math>  <math>(\frac{1}{2} \times 10 \times 16) + (20 \times 16) + (\frac{1}{2} \times 5 \times 16)</math>  <math>s=1320 \text{ m}</math></p> <p>e)</p> $\bar{v} = \frac{s}{t}$ $\bar{v} = \frac{1320}{35} = 38 \text{ ms}^{-1}$
2.2.4	<p>(i) For each of the graphs shown below, find</p> <p>(a) the instantaneous speed at 10s</p> <p>(b) the distance travelled over the 20 second period</p> <p>(c) the average speed over the 20 second journey.</p> <div style="display: flex; justify-content: space-around; align-items: flex-start;">  </div> <p><b>(NB time axis scale has each major unit = 5s, velocity axis major unit is <math>2 \text{ ms}^{-1}</math>)</b></p> <p>(ii) Compare the average speed with the instantaneous speed at ten seconds and comment on the difference (if any).</p> <p>(iii) In what situation will the instantaneous speed always be the same as the average speed?</p>

No.	CONTENT
	<p> <i>distance = area under graph</i>  <i>= area of <math>\Delta</math> + area of <math>\square</math></i>  <i>= <math>(\frac{1}{2} \times 4 \times 20) + (2 \times 20)</math></i>  <i>= <math>80m</math></i> </p> <p> <math>\bar{v} = \frac{d}{t} = \frac{80m}{20s} = 4m/s</math> </p> <p> <i>from the graph, speed at 10s = 4m/s</i>  <i>so the average speed does equal the instantaneous speed at 10 seconds.</i> </p> <p> <i>distance = area under graph</i>  <i>= area of <math>\Delta</math> + area of <math>\Delta</math></i>  <i>= <math>(\frac{1}{2} \times 6 \times 10) + (\frac{1}{2} \times 6 \times 10)</math></i>  <i>= <math>60m</math></i> </p> <p> <math>\bar{v} = \frac{d}{t} = \frac{60m}{20s} = 3m/s</math> </p> <p> <i>from the graph, speed at 10s = 6m/s</i>  <i>so the average speed does not equal the instantaneous speed at 10 s.</i> </p> <p> <i>distance = area under graph</i>  <i>= area of <math>\square</math></i>  <i>= <math>4 \times 20</math></i>  <i>= <math>80m</math></i> </p> <p> <math>\bar{v} = \frac{d}{t} = \frac{80m}{20s} = 4m/s</math> </p> <p> <i>from the graph, speed at 10s = 4m/s</i>  <i>so the average speed does equal the instantaneous speed at 10 s.</i> </p>

No.	CONTENT
2.2.5	<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <p>A car travels along a motorway. A graph of the car's motion is shown. Describe the motion of the car:</p> <p>(a) Between A and B (a) Between B and C</p> </div> </div>
	<p>a) the car travels at a constant speed of <math>30 \text{ ms}^{-1}</math> for the first <math>0.5 \text{ s}</math>  b) the car travels at constant acceleration of <math>-10 \text{ ms}^{-2}</math> between B and C until reaching a speed of <math>0 \text{ ms}^{-1}</math></p>
2.2.6	<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <p>The graph below shows how the speed of a skier varies with time during the first 10 seconds of a downhill run.</p> </div> </div> <p>(a) Calculate the acceleration of the skier during the first 3 seconds of the run.  (b) Suggest a possible reason for the change in the skier's acceleration after the first 3 seconds.  (c) Describe the motion of the skier between 7 seconds and 10 seconds.  (d) Show that the average speed of the skier during the first 7 seconds of the run is <math>11.7 \text{ ms}^{-1}</math>.</p>

No.	CONTENT
	<p>a)</p> $a = \frac{v - u}{t}$ $a = \frac{12 - 0}{3} = 4 \text{ ms}^{-2}$ <p>b) The change in acceleration could be due to the slope getting LESS steep, or the surface having an increase in friction.</p> <p>c) Between 7s and 10 s the skier travels at constant speed.</p> <p>d) distance travelled during the first 7s is found by the area under a v-t graph            area 1 + area 2+ area 3  <math>\frac{1}{2} bh + bh + \frac{1}{2} bh</math>  <math>(\frac{1}{2} \times 3 \times 12) + (4 \times 12) + (\frac{1}{2} \times 4 \times 8) = 82\text{m}</math>            time = 7 s</p> $\bar{v} = \frac{d}{t}$ $\bar{v} = \frac{82}{7} = 11.7 \text{ ms}^{-1}$
2.2.7	<p>State what quantity is found by calculating the area under the velocity time graph.</p> 
	<p>Displacement is found by calculating the area under the v-t graph. In this case the value is <math>(0.6 \times 8) + (\frac{1}{2} \times 2.2 \times 8) = 13.6 \text{ m}</math></p>
2.3	<p>I can find displacement from a velocity-time graph.</p>
2.3.1	<p>How can you calculate the displacement from a velocity-time graph?</p>
	<p>Displacement is calculated from the area under a velocity time graph.</p>

No.	CONTENT
2.3.2	 <p>Calculate how far the train travels in the 150 seconds shown in the graph above.</p>

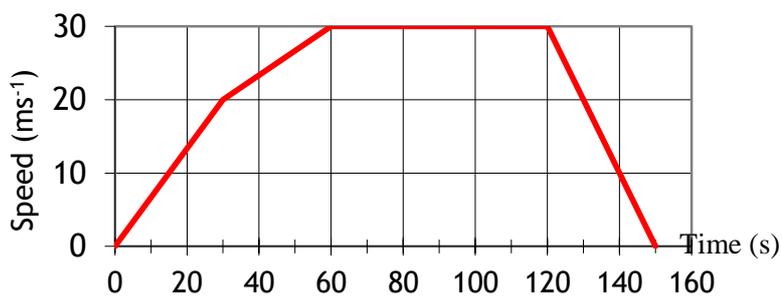
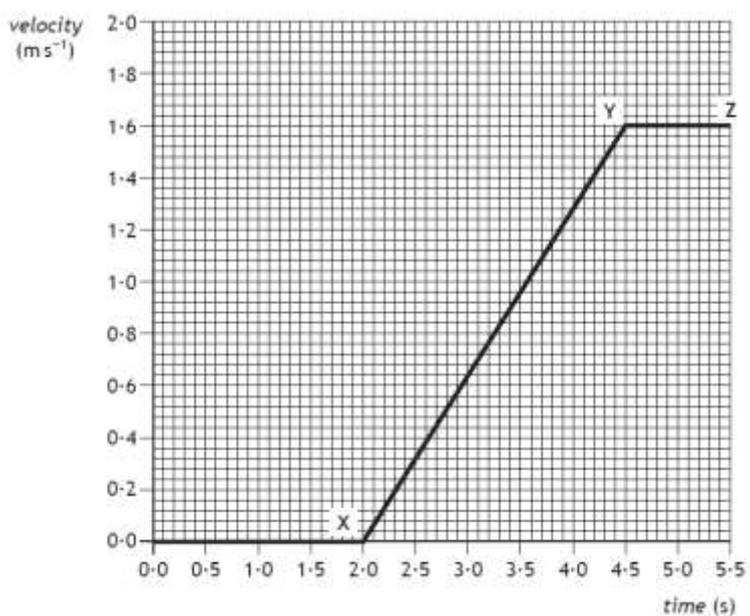
	 <p>Distance travelled = area under graph</p> $= \text{area of } \Delta ① + \text{area of } \square ② + \text{area of } \Delta ③ + \text{area of } \square ④ + \text{area of } \Delta ⑤$ $= (\frac{1}{2} \times 30 \times 20) + (30 \times 20) + (\frac{1}{2} \times 30 \times 10) + (60 \times 30) + (\frac{1}{2} \times 30 \times 30)$ $= 300 + 600 + 150 + 1800 + 450$ $= 3300 \text{ m}$
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## Acceleration

3.1	I can define acceleration as the final velocity subtract the initial velocity divided by the time for the change
3.1.1	State the meaning of the term “acceleration”.
	<b>Acceleration is the rate of change of velocity OR the change in velocity per second. It is measured in metres per second squared.</b>
3.1.2	Explain what is meant by a <i>uniform acceleration of 1.4 ms<sup>-2</sup></i>
	<b><i>A uniform acceleration of 1.4 ms<sup>-2</sup> means that every second the velocity <u>increases</u> by 1.4 ms<sup>-2</sup></i></b>

No.	CONTENT
3.2	I can use the relationship involving acceleration, change in speed and time ( $a = \Delta v/t$ ).
3.2.1	A Jaguar can reach $27 \text{ ms}^{-1}$ from rest in 9.0 s. What is its acceleration?
3.2.2	The space shuttle reaches $1000 \text{ ms}^{-1}$ , 45 s after launch. What is its acceleration?
3.2.3	Starting from rest, the flea accelerates to $1.2 \text{ ms}^{-1}$ in a time of 0.001 s. Calculate the acceleration of the flea.
3.2.4	A car reaches a velocity of $30 \text{ ms}^{-1}$ from a velocity of $18 \text{ ms}^{-1}$ in 6 s. What is its acceleration?
3.2.5	A train moving at $10 \text{ ms}^{-1}$ increases its speed to $45 \text{ ms}^{-1}$ in 10 s. What is its acceleration?
3.2.6	A bullet travelling at $240 \text{ ms}^{-1}$ hits a wall and stops in 0.2 s. What is its acceleration?
3.2.7	A car travelling at $20 \text{ ms}^{-1}$ brakes and slows to a halt in 8 s. What is the acceleration?
3.3	I can use appropriate relationships to solve problems involving acceleration, initial velocity (or speed) final velocity (or speed) and time of change ( $a = (v - u)/t$ ).
3.3.1	Write down the formula linking velocity and acceleration. Explain what each letter stands for.
3.3.2	A girl is riding a bicycle. She starts at rest, and accelerates to $20 \text{ ms}^{-1}$ in 8 seconds. What is her acceleration?
3.3.3	A car increases its velocity from $30 \text{ ms}^{-1}$ to $80 \text{ ms}^{-1}$ in 20 seconds. What is its acceleration?

No.	CONTENT
3.3.4	When you drop a stone, it accelerates downwards at $9.8 \text{ ms}^{-2}$ . If the stone is initially at rest, what will be its speed after falling for 1.5 seconds?
3.3.5	A racing car can accelerate at $7 \text{ ms}^{-2}$ . How long will it take to increase its velocity from $20 \text{ ms}^{-1}$ to $60 \text{ ms}^{-1}$ ?
3.3.6	A rocket in orbit accelerates at $12 \text{ ms}^{-2}$ for 15 seconds. If its final velocity is $300 \text{ ms}^{-1}$ , what was its initial velocity?
3.3.7	On approaching the speed limit signs, a car slows from $30 \text{ m/s}$ to $12 \text{ m/s}$ in 5 s. What is its acceleration?
3.3.8	A bowling ball is accelerated from rest at $3 \text{ ms}^{-2}$ for 1.2 s. What final speed will it reach?
3.3.9	How long will it take a car to increase its speed from $8 \text{ ms}^{-1}$ to $20 \text{ ms}^{-1}$ if it accelerates at $3 \text{ ms}^{-2}$ ?
3.3.10	A cyclist can accelerate at $0.5 \text{ ms}^{-2}$ when cycling at $4 \text{ ms}^{-1}$ . How long will she take to reach $5.5 \text{ ms}^{-1}$ ?
3.3.11	The maximum deceleration a car's brakes can safely produce is $8 \text{ ms}^{-2}$ . What will be the minimum stopping time if the driver applies the brakes when travelling at 60 mph ( $27 \text{ ms}^{-1}$ ).
3.3.12	A car is stationary at a traffic light. When the light turns green the car accelerates, and reaches a speed of 30mph twenty seconds later. (i) What is its initial velocity? (ii) Calculate the cars acceleration in miles per hour per second.
3.4	I can find the acceleration as the gradient of a velocity-time graph.

No.	CONTENT
3.4.1	<p>This speed-time graph shows the changes in the speed of a train. Describe as fully as possible how the train is moving.</p>  <p>Using the graph above, calculate the acceleration of the train between                      (a) 0 and 30 seconds, (b) 30 and 60 seconds, (c) 120 and 150 seconds.</p>
3.4.2	 <p>(a) Calculate the acceleration of the vehicle between X and Y.                      (b) State the acceleration of the vehicle between Y and Z</p>

No.	CONTENT																				
3.4.3	<p>The graph shows how the speed of a car changes during a journey.</p> <div style="text-align: center;"> </div> <p>a) complete the following table</p> <table border="1" style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <tr> <td style="padding: 5px;"><i>time</i> in s</td> <td style="padding: 5px;">0</td> <td style="padding: 5px;">2</td> <td style="padding: 5px;">4</td> <td style="padding: 5px;">6</td> <td style="padding: 5px;">8</td> <td style="padding: 5px;">10</td> <td style="padding: 5px;">12</td> <td style="padding: 5px;">14</td> <td style="padding: 5px;">16</td> </tr> <tr> <td style="padding: 5px;"><i>speed</i> in m/s</td> <td style="padding: 5px;"></td> </tr> </table> <p>b) Calculate the acceleration during the first 4 seconds.</p> <p>c) The car travelled a total distance of 132 metres. Calculate the average speed of the journey.</p>	<i>time</i> in s	0	2	4	6	8	10	12	14	16	<i>speed</i> in m/s									
<i>time</i> in s	0	2	4	6	8	10	12	14	16												
<i>speed</i> in m/s																					

a)

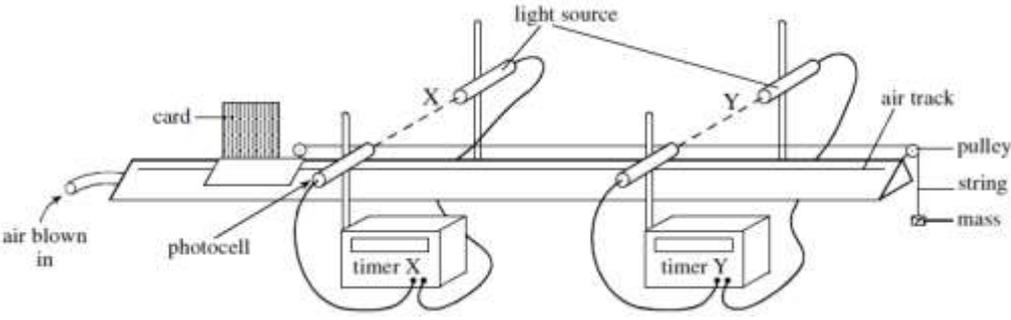
<b>Time (s)</b>	<b>0</b>	<b>2</b>	<b>4</b>	<b>6</b>	<b>8</b>	<b>10</b>	<b>12</b>	<b>14</b>	<b>16</b>
<b>Velocity (ms<sup>-1</sup>)</b>	<b>0</b>	<b>6</b>	<b>12</b>	<b>12</b>	<b>12</b>	<b>12</b>	<b>8</b>	<b>4</b>	<b>0</b>

b)

3.5	I can describe an experiment to measure acceleration
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3.5.1	Describe an experiment using <b>two</b> light gates to measure the acceleration of a vehicle as it rolls down a slope. Draw a diagram of the set-up, note what measurements you would need to make and how the acceleration will be calculated.
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3.5.2	Describe an experiment using <b>one</b> light gate to measure the acceleration of a vehicle as it rolls down a slope. Draw a diagram of the set-up, note what measurements you would need to make and how the acceleration will be calculated.
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No.	CONTENT
3.5.3	 <p>The apparatus shown in the Figure above is used to find the acceleration of a vehicle moving along a linear air track.</p> <p>State two ways of modifying the experiment to produce an acceleration which is double the acceleration.</p>
	<p>1) <b>Double the mass on the end of the pulley (doubling the Force)</b></p> <p>2) <b>Halve the mass of the vehicle</b></p>

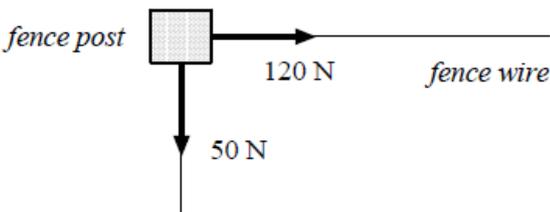
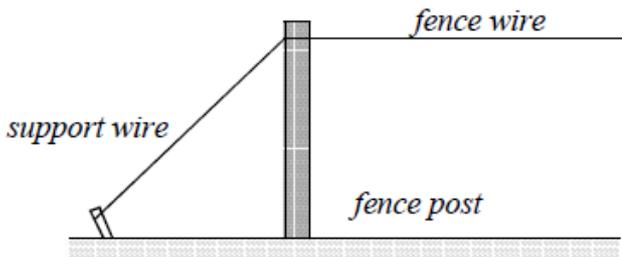
## Newton's Laws

4.1	I can give applications and use Newton's laws and balanced forces to explain constant velocity (or speed), making reference to frictional forces of this.
4.1.1	<p>(a) What is a force?</p> <p>(b) What effects can a force have on an object?</p>
	<p><b>(a) A force is a push or a pull</b></p> <p><b>(b) A force can make an object change its speed, its shape, or its direction of travel.</b></p>
4.1.2	Describe how you can measure a force.
	<p><b>You can measure a force using a spring balance or Newtonbalance dynamometer. The extension of the spring is directly proportional to the applied force.</b></p>
4.1.3	<p>(a) What is friction?</p> <p>(b) How does friction effect movement?</p>
	<p><b>(a) Friction is a contact force which opposes motion. It is caused when one surface slides (or tries to slide) over another.</b></p> <p><b>(b) Friction opposes motion and causes things to slow down. Friction will try to stop a moving object.</b></p>
4.1.4	<p>(a) If you increase the unbalanced force acting on an object while its mass remains constant, what happens to its acceleration?</p> <p>(b) If you increase the mass of an object, while keeping the unbalanced force the same, what happens to its acceleration?</p>

No.	CONTENT
	<p>(a) As <math>F=ma</math> as <math>F</math> increases, <math>a</math> will increase if mass remains constant.            (b) As <math>m=F/a</math> as <math>m</math> increases, and <math>F</math> remains constant then <math>a</math> will decrease</p>
4.1.5	State Newton's First Law of Motion
	<p>An object will remain at rest or move at steady speed in a straight line unless acted upon by an unbalanced force.</p> <p>Or</p> <p>Unless an unbalanced force acts on an object the object will move at constant velocity (which means constant speed in a straight line)</p> <p>Or</p> <p>An object will remain at rest or move at constant velocity unless acted upon by an unbalanced force.</p>
4.1.6	State Newton's Second Law of Motion
	<p><b>Force=mass <math>\times</math> acceleration</b></p> <p><b><math>F = m a</math></b></p>
4.1.7	Use Newton's first law to explain why a passenger in a train appears to be pushed backwards when the train suddenly starts, and why they appear to be pushed forwards when the train brakes.
	<p><b>When the train starts, the passenger remains stationary until the seat produces a force to accelerate them. Relative to the train, they appear to move backwards. When the train stops, the passenger continues to move forward until the seat applies a force to decelerate them. They appear to move forwards because of this.</b></p> <p><b>When a train suddenly starts the people on the train will remain at rest as there is no force acting on them. The train will accelerate as the engine provides an unbalanced force. This makes the people appear to move backwards.</b></p> <p><b>When a train brakes, the people on the train will continue to move at their original speed until something provides a force to decelerate them.</b></p> <p><b>Hence the people appear to be pushed forward but are just remaining at the same speed.</b></p>
4.1.8	A boy of mass 45 kg pulls a sledge of mass 15 kg up a slope at a constant velocity of $0.5 \text{ ms}^{-1}$ . Are the forces acting on the sledge balanced or unbalanced? Explain your answer.
	<b>The forces are balanced as the boy is moving at constant velocity.</b>
4.2	I can give applications of Newton's laws and balanced forces to explain and or determine acceleration for situations where more than one force is acting, ( $F=ma$ )
4.2.1	What are balanced forces?

No.	CONTENT
	<b>Balanced forces are equal forces acting in opposite directions which are equivalent to no forces acting.</b>
4.2.2	What happens to the speed of an object when there is (a) no force acting on it, or (b) balanced forces acting on it?
	<b>(a) An object will continue at constant velocity or remain at rest.</b> <b>(b) An object will continue at constant velocity or remain at rest.</b>
4.2.3	A passenger in a lift has a mass of 50kg. As the lift starts its journey, it applies an upwards force of 600N to the passenger. (i) What is the force of gravity on the passenger? (ii) Draw a diagram showing the forces acting on the passenger as the lift starts to move. (iii) What is the unbalanced force on the passenger? (iv) Calculate the acceleration of the passenger. (v) In which direction is it?
	<b>(i) <math>W = mg = 50\text{kg} \times 9.8 \text{ N/kg} = 490\text{N}</math></b> <b>(ii)</b> <b>(iii) Unbalanced force = <math>600\text{N} - 490\text{N} = 110\text{N}</math> upwards</b> <b>(iv) upwards</b>
4.2.4	A boat has a mass of 700kg, and can accelerate at $3\text{ms}^{-2}$ . If the engines produce a force of 7000N, what is the size of (i) the unbalanced force on the boat, and (ii) the drag force of the water on the boat?
	<b>(i) <math>F = ma = 700\text{kg} \times 3\text{ms}^{-2} = 2100\text{N}</math></b> <b>(ii) Drag force = <math>7000\text{N} - 2100\text{N} = 5800\text{N}</math></b>
	(a) What is the purpose of a seatbelt? (b) Explain in terms of forces how a seatbelt fulfils this purpose.
	<b>(a) A seatbelt is a safety device. It prevents people being injured by certain things when a car crashes.</b> <b>(b) When a car crashes, the car stops suddenly. The people in the car however will continue to move at their original speed until something provides a force to decelerate them. The seat belt provides this force.</b>
4.2.5	The unbalanced force acting on an 800kg car is 1900N. Calculate its acceleration.

No.	CONTENT
	$a = \frac{F}{m} = \frac{1900N}{800kg} = 2.375m/s^2$ $a = 2.4 ms^{-2}$
4.2.6	Calculate the unbalanced force needed to accelerate a 6000kg lorry at $1.2ms^{-2}$
	$F = ma = 6000kg \times 1.2ms^{-2} = 7200N$
4.2.7	The unbalanced force on an object is 49N, and it accelerates at $9.8ms^{-2}$ . What is its mass?
	$m = \frac{F}{a}$ $a = \frac{49N}{9.8 ms^{-2}}$ $a = 5.0kg$
4.2	I can use $F=ma$ to solve problems involving unbalanced force, mass and acceleration for situations where more than one force is acting, in one dimension or at right angles.
4.2.1	<p>A space vehicle of mass 300 kg lifts off from the surface of Mars. At the instant of lift-off the acceleration of the vehicle is <math>6 ms^{-2}</math> vertically upwards.</p> <p>(i) Calculate the unbalanced force acting on the space vehicle at lift-off from Mars.</p> <p>(ii) Show that the force produced by the engine at lift-off is 3000 N. You must show clearly your working.</p>

No.	CONTENT
	<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="text-align: center;">  </div> <div style="width: 40%;"> <p>At the corner of a field two fencing wires meet at right angles. Both wires are joined to a fence post.</p> <p>The wires exert forces of 50 N and 120 N on the fence post as shown.</p> </div> </div> <p>(i) Find by scale diagram or otherwise the magnitude of the resultant force exerted on the fence post by the wires and its direction with reference to the 50 N force.</p> <p>(ii) At the corner of fields the fence posts usually have a support wire fitted as shown. The end of the support wire is pegged into the ground.</p> <p>Referring to the forces acting on the fence post explain why the support wire is fitted.</p> <div style="text-align: center; margin-top: 20px;">  </div>
4.3	I can use $W=mg$ to solve problems involving weight mass and gravitational field strength, including on different planets (where $g$ is given on page 2 of section1)
4.3.1	Explain the difference between mass and weight?
	<p><b>Mass is the amount of matter in an object, it is measured in kilograms. Weight is the force of gravity on an object, pulling it towards the centre of a large mass. It is measured in Newtons.</b></p>
4.3.2	What does the phrase 'Gravitational Field Strength' mean?
	<p><b>Gravitational field strength is the weight per unit mass, or the weight per kilogram. It is measured in <math>Nkg^{-1}</math></b></p>
4.3.3	<p style="text-align: center;"><i>Mars, Jupiter and Earth</i></p> <p>On which of the above planets would a 1 kg mass dropped near the surface of the planet have the greatest acceleration? Explain your answer.</p>
	<p><b>A 1 kg mass dropped on Jupiter would have the greatest acceleration as the gravitational field strength on Jupiter is the greatest. <math>W=mg</math> and <math>F=ma</math> are equivalent so the higher 'g', the higher 'a'.</b></p>
4.3.4	A car has a mass of 500kg and has 3 passengers, each of 80kg. The total weight on planet Kepler-10b is 723N. What is the gravitational field strength on Kepler-10b?

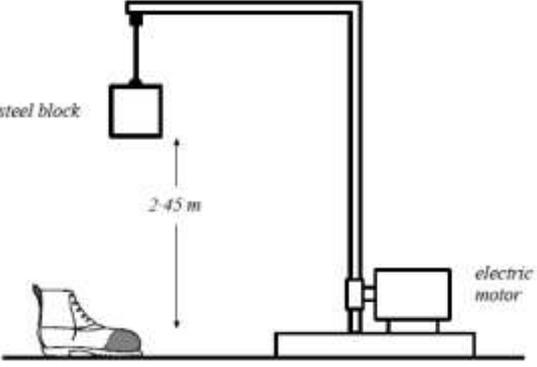
No.	CONTENT
	<p><b>Total mass = (3 x 80) + 500 = 740 kg</b></p> $W = mg$ $723 = 740 \times g$ $g = \frac{723}{740} = 0.98 \text{ N kg}^{-1}$
4.3.5	What is the cause of gravitational field strength?
4.4	I can use Newton's 3 <sup>rd</sup> law and its application to explain motion resulting from a 'reaction' force.
4.4.1	State Newton's Third Law of Motion
	<p><b>For every action there is an equal but opposite reaction.</b></p> <p><b>Or</b></p> <p><b>A &amp; B are objects!</b></p> <p><b>If A exerts a force on B, B exerts an equal but opposite force on A.</b></p>
4.4.2	<p>In terms of Newton's third law, what is the 'equal and opposite force' in each of these situations:-</p> <p>(i) A ship's propeller pushes on the water,</p> <p>(ii) A rocket pushes on the exhaust gasses,</p> <p>(iii) The earth's gravity pulls on the moon,</p> <p>(iv) The Earth's gravity pulls</p>
4.4.3	
4.5	I can use Newton's laws to explain free-fall and terminal velocity.
<b>Energy</b>	
5.1	I can state that energy is never created or destroyed, it is conserved.
5.1.1	State the Law of Conservation of Energy

No.	CONTENT
5.2	I can identify and explain energy conversions and transfer.
5.3	I can apply the principle of 'conservation of energy' to examples where energy is transferred between stores.
5.4	I can use appropriate relationships to solve problems involving work done, unbalanced force, and distance or displacement. ( $E_w = Fd$ )
5.4.1	State the appropriate relationship to involving work done, unbalanced force, and distance or displacement.
5.4.2	A locomotive exerts a pull of 10000 N to pull a train a distance of 400 m. How much work is done?
	<b><math>E_w = F \times d = 10000 \times 400 = 4.0 \times 10^6 J</math></b>
5.4.3	A gardener does 1200 J pushing a wheelbarrow with a force of 100 N. How far did she push the barrow?
	<b><math>E_w = F \times d</math> <math>1200 = 100 \times d</math> <math>d = 12m</math></b>
5.4.4	A man uses up 1000 J by pulling a heavy load for 20 m. What force did he use?
5.4.5	A girl is pushing her bike with a force of 80 N and uses up 4000 J of energy. How far did she push the bike?
5.4.6	A man weighing 600 N climbs stairs in an office block which are 40 m high. How much work does he do?
5.4.7	A worker pushes a 4 kg crate along the ground for 3 m using a force of 20 N, then lifts the crate up to a ledge 1 m high. How much work does he do altogether?
5.4.8	(a) An average force of 120N is used to push a supermarket trolley 30m. How much work is done?
5.4.9	(b) A force of 24N is needed to pull open a drawer. If the drawer moves 35cm, how much energy is used moving it?
5.4.10	c) A girl does 900kJ of work cycling to school. If she uses an average force of 200N, how far does she pedal?
5.4.11	(d) A boy does 5000J of work climbing the stairs. If the distance climbed is 9m, what force is he having to produce?
5.5	I can identify and explain 'loss' of energy where energy is transferred.

No.	CONTENT
5.5.1	<p>A lorry of mass 5000kg rolls down a hill 20m high. The lorry rolls a distance of 300m, and is initially stationary. The average force of friction on the lorry is 500N.</p> <p>(i) Draw a diagram showing the journey of the lorry and mark on it the information given above.</p> <p>(ii) What is the change in the gravitational potential energy of the lorry as it rolls down the hill?</p> <p>(iii) What happens to this energy?</p> <p>(iv) How much work is done against friction?</p> <p>(v) What is the change in the kinetic energy of the lorry?</p> <p>(vi) What is the speed of the lorry at the bottom of the hill?</p>
5.5.2	<p>Explain why the gravitational potential energy lost does not equal the kinetic energy gained in a rollercoaster.</p>
5.6	<p>I can define gravitational potential energy. <math>E_p</math> is the energy an object has because of its position above the Earth's surface and its mass</p>
5.6.1	<p>Define the term gravitation potential energy</p>
5.6.2	<p>State the relationship used to calculate the gravitational potential energy, include what each term means and the units used to measure each term</p>
5.7	<p>I can use <math>E_p = mgh</math> to solve problems on involving gravitational potential energy, mass, gravitational field strength and height</p>
5.7.1	<p>A mass of 4kg is released from a height of 2m. What is the gravitational potential energy of the mass before it is released?</p>
5.7.2	<p>An object has a gravitational potential energy of 502J. It is dropped from a height of 20m.</p>
5.8	<p>I can define kinetic energy as the energy an object has because of its speed.</p>
	<p>(a) What is kinetic energy?</p>

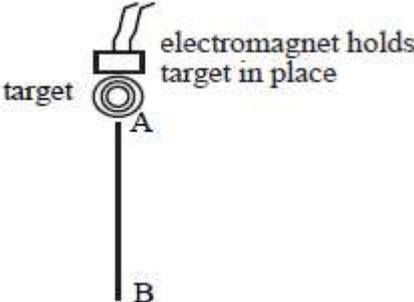
No.	CONTENT
	(b) How does the kinetic energy of an object change when (i) it's speed increases, and (ii) it's mass increases?
5.8.1	Define the term kinetic energy
5.9	I can use $E_k = \frac{1}{2} mv^2$ to solve problems involving kinetic energy, mass and speed
5.9.1	You are provided with an air track and vehicles, a light gate and timer and some elastic bands. Describe how you could use this apparatus to establish how kinetic energy depends on velocity. Include details of any measurements you would take and any additional measuring equipment needed.
5.9.2	Calculate the kinetic energy of the following: a) a 5 kg bowling ball moving at $4 \text{ ms}^{-1}$ b) a 50 kg skier moving at $20 \text{ ms}^{-1}$ c) a 0.02 kg bullet moving at $100 \text{ ms}^{-1}$ .
5.9.3	a) How much kinetic energy does a 800 kg car have at a velocity of $10 \text{ ms}^{-1}$ ? b) If it doubles its velocity to $20 \text{ ms}^{-1}$ , calculate its new kinetic energy?
5.9.4	A cyclist who is pedalling down a slope reaches a speed of $15 \text{ ms}^{-1}$ . The cyclist and her cycle together have a mass of 80 kg. a) Calculate the total kinetic energy. b) Name two sources of this kinetic energy.
5.9.5	Calculate an <b>approximate</b> value for the kinetic energy of an Olympic 100 m sprinter as he crosses the line (time for race is about 10 s).
5.9.6	What is the velocity of a stone of mass 2 kg if it has 36 J of kinetic energy?
5.9.7	A motor cyclist and his bike have a total mass of 360 kg and kinetic energy of 87120 J. What is his speed?
5.9.8	A car has a mass of 900kg and is moving at $30 \text{ ms}^{-1}$ , calculate its kinetic energy.
5.9.9	What is the kinetic energy of a rifle bullet with a mass of 20g and a speed of 400m/s?
5.9.10	A car has a kinetic energy of 100kJ and a mass of 800kg. At what speed is it moving?
5.10	I can use $E_w = Fd$ , $E_p = mgh$ , $E_k = \frac{1}{2} mv^2$ to solve problems involving conservation of energy

No.	CONTENT
5.10.1	<p>An apple of mass 100g is dropped from the top of the Eiffel Tower, a height of approximately 300m. a) How much kinetic energy would it have just before hitting the ground?</p> <p>b) What will be its velocity as it hits the ground?</p> <p>What would be its speed on landing? If all the potential energy is converted to kinetic energy</p>
5.10.2	<p>A car of mass 1000 kg is travelling at <math>20 \text{ ms}^{-1}</math>.</p> <p>(a) How much kinetic energy does it have?</p> <p>(b) If the maximum braking force is 5 kN, what will be the minimum braking distance?</p> <p>(c) If the driver has a reaction time of 0.7 s, how far will the car travel during this 'thinking time'?</p> <p>(d) What will the total stopping distance be?</p>
5.10.3	<p>A boy of mass 45 kg pulls a sledge of mass 15 kg up a slope at a constant velocity of <math>0.5 \text{ ms}^{-1}</math>. The boy then lies on the sledge and slides down the slope. When the boy and sledge are moving with a speed of <math>4.0 \text{ ms}^{-1}</math>, they run into a small snow drift which brings them to rest in a distance of 3.5 m.</p> <p>(i) Calculate the kinetic energy of the boy and sledge together, when they are travelling at a speed of <math>4.0 \text{ ms}^{-1}</math>.</p> <p>(ii) Calculate the average force required to bring the sledge and the boy to rest in 3.5 m.</p>
5.10.4	<p>A lorry of mass 5000 kg rolls down a hill 20m high. The lorry rolls a distance of 300m, and is initially stationary. The average force of friction on the lorry is 500N.</p> <p>(i) Draw a diagram showing the journey of the lorry and mark on it the information given above.</p> <p>(ii) What is the change in the gravitational potential energy of the lorry as it rolls down the hill?</p> <p>(iii) What happens to this energy?</p> <p>(iv) How much work is done against friction?</p> <p>(v) What is the change in the kinetic energy of the lorry?</p> <p>(vi) What is the speed of the lorry at the bottom of the hill?</p>
5.10.5	<p>An arrow of mass 60g is fired vertically upwards with a speed of <math>30 \text{ ms}^{-1}</math>. The arrow rises upwards, reaches its maximum height, and then falls straight downwards. Assuming there is no air resistance, calculate</p> <p>(i) the initial kinetic energy of the arrow,</p> <p>(ii) the kinetic energy of the arrow at its highest point,</p> <p>(iii) the potential energy of the arrow at its highest point,</p> <p>(iv) the position of the highest point.</p>

No.	CONTENT
5.10.6	 <p>The diagram shows a safety boot on the left. Above it, a steel block is suspended from a horizontal arm. A vertical double-headed arrow indicates the height from the top of the boot to the bottom of the steel block is 2.45 m. The steel block is labeled 'steel block'. The arm is supported by a vertical post that is connected to an electric motor labeled 'electric motor' at the base.</p> <p>The toe protectors in safety boots are tested by dropping a 30 kg steel block through a height of 2.45 m onto the boots.</p> <p>(a) Calculate the potential energy of the steel block just before it is released.</p> <p>(b) Calculate the speed of the steel block as it hits the toe protector.</p>

## Projectile Motion

6.1	I can explain projectile motion
6.1.1	What is a projectile?
6.1.2	What is special about its motion?
6.2	I can use appropriate relationships to solve problems involving projectile motion from a horizontal launch, including the use of motion graphs.
6.2.1	<p>A stone thrown horizontally from a cliff lands 24 m out from the cliff after 3 s. Find:</p> <p>a) the horizontal speed of the stone</p> <p>b) the vertical speed at impact.</p>
6.2.2	<p>A ball is thrown horizontally from a high window at 6 m/s and reaches the ground after 2 s. Calculate</p> <p>a) the horizontal distance travelled</p> <p>b) the vertical speed at impact.</p>

No.	CONTENT
6.2.3	<p>An aircraft flying horizontally at 150 m/s, drops a bomb which hits the target after 8 s.</p> <p>Find:</p> <ol style="list-style-type: none"> <li>the distance travelled horizontally by the bomb</li> <li>the vertical speed of the bomb at impact</li> <li>the distance travelled horizontally by the aircraft as the bomb fell</li> <li>the position of the aircraft relative to the bomb at impact</li> </ol>
6.2.4	<p>A ball is projected horizontally at 15 m/s from the top of a vertical cliff. It reaches the ground 5 s later. For the period between projection until it hits the ground, draw graphs with numerical values on the scales of the ball's</p> <ol style="list-style-type: none"> <li>horizontal velocity against time</li> <li>vertical velocity against time</li> <li>From the graphs calculate the horizontal and vertical distances travelled.</li> </ol>
6.2.5	<p>A projectile is fired horizontally at 100m/s.</p> <ol style="list-style-type: none"> <li>How long will it take it to travel a horizontal distance of 50m?</li> <li>What will its vertical velocity be when it hits the ground?</li> <li>What will be its average vertical speed?</li> <li>How far will it fall in the 50m?</li> </ol>
6.2.6	<p>A ball rolls along a flat roof at 2m/s and rolls off the edge.</p> <ol style="list-style-type: none"> <li>If the ball takes 1.5seconds to fall what is the final vertical speed of the ball on landing?</li> <li>How high is the roof from the ground?</li> <li>How far away from the base of the building will it land?</li> </ol>
6.2.7	<p>In the experimental set-up shown below, the arrow is lined up towards the target. As it is fired, the arrow breaks the circuit supplying the electromagnet, and the target falls downwards from A to B.</p> <div style="display: flex; justify-content: space-around; align-items: center;">   </div> <ol style="list-style-type: none"> <li>Explain why the arrow will hit the target.</li> <li>Suggest one set of circumstances when the arrow would fail to hit the target (you must assume it is always lined up correctly).</li> </ol>

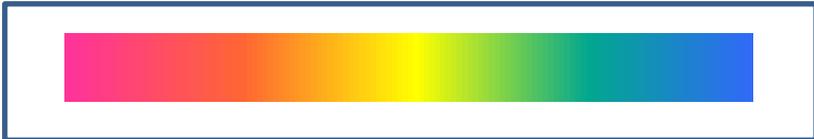
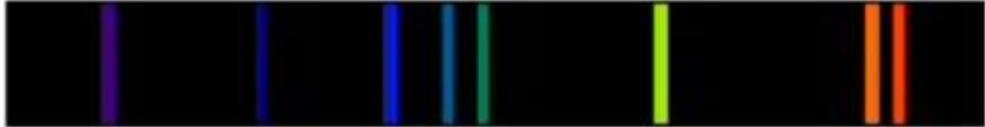
No.	CONTENT
6.3	I can state what is represented by the area under $v_h$ -t graph.
6.3.1	state what is represented by the area under $v_h$ -t graph
6.4	I can make calculations from the area under a $v_h$ -t graphs
6.5	I can state what can be found from the area under $v_v$ -t graph.
6.5.1	State what can be found from the area under $v_v$ -t graph.
6.6	I can calculate the height, and acceleration from $v_v$ -t graphs
6.7	I can state and use the relationships from $v_h$ -t graphs and $v_v$ -t graphs
6.8	I can explain satellite orbits in terms of projectile motion, horizontal velocity and weight.
6.8.1	Explain how gravity keeps a satellite in orbit.

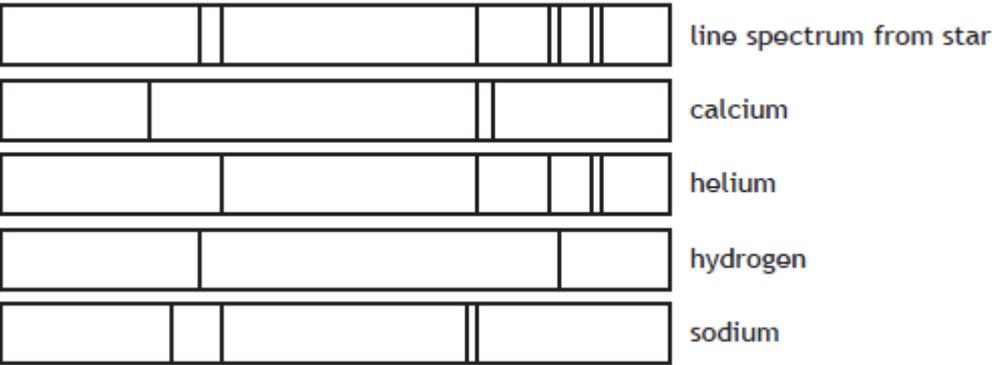
## SPACE

No.	Content
<b>Space Exploration</b>	
7.1	I have a basic understanding of the Universe <a href="https://map.gsfc.nasa.gov/universe/uni_life.html">https://map.gsfc.nasa.gov/universe/uni_life.html</a>
7.1.1	Write a paragraph explaining our current understanding of the Universe. <i>Reference correctly any source used.</i>
7.2	I can use the following terms correctly and in context: planet, dwarf planet, moon, Sun, asteroid, solar system, star, exoplanet, galaxy, and universe.
7.2.1	List the following in order of decreasing size: planet, dwarf planet, moon, sun, asteroid, solar system, star, exoplanet, galaxy, universe.
7.2.2	Define each of the following terms: planet, dwarf planet, moon, sun, asteroid, solar system, star, exoplanet, galaxy, universe.
7.3	I am aware of the benefits of satellites: for example for GPS, weather forecasting, communications, scientific discovery and space exploration (for example Hubble telescope, ISS).
7.3.1	Give some of the uses of satellites placed in orbit above the Earth.
7.3.2	Two examples of satellites placed in space are the ISS and the Hubble Telescope. For <b>each</b> of these satellites: a) State the purpose for it being placed in orbit. b) Describe when the satellite was placed in orbit c) How has our understanding of our Universe altered due to research from the satellite?
7.4	I know the period and orbital height of a geostationary satellite
7.4.1	Define the term geostationary or geosynchronous orbit
7.4.2	What is the height, above the Earth's surface of a satellite placed in geostationary orbit?
7.4.3	How long does a geostationary satellite take to orbit the Earth?
7.4.4	What is the period of a geostationary satellite?
7.4.5	Above which part of the Earth's surface are geostationary satellites placed?
7.5	I know that the period of a satellite changes with altitude.
7.5.1	Explain the term period of a satellite
7.5.2	How does the period of a satellite change with the height above the Earth's surface?
7.5.3	Does the height of the satellite above any planet affect the period?
7.6	I am aware of the challenges of space travel.

No.	Content
7.6.1	Describe some of the challenges on space travel, including the following a) take off b) during flight c) being in “zero gravity” d) during reentry
7.7	I am aware of potential space travel across large distances using ion drive.
	of attaining high velocity by using ion drive (producing a small unbalanced force over an extended period of time)
7.8	I have a basic awareness that travelling large distances through space using a ‘catapult’ method..
	using a ‘catapult’ from a fast moving asteroid, moon or planet might be possible.
7.9	I have a basic awareness of how astronauts manoeuvre a spacecraft in a zero friction environment, possibly to dock with the ISS
7.10	I have a basic awareness of maintaining sufficient energy to operate life support systems in a spacecraft, with the possible solution of using solar cells with area that varies with distance from the Sun
7.11	I can describe the risks associated with manned space exploration such as fuel load on take-off, potential exposure to radiation, pressure differential and re-entry through an atmosphere.
7.12	I have knowledge of Newton’s second and third laws and their application to space travel, rocket launch and landing.

No.	Content
7.13	I can use $W=mg$ to solve problems involving weight, mass and gravitational field strength, in different locations in the universe.
7.13.1	Near the earth, what is the weight of each 1kg?
7.13.2	What is the weight on earth of (i) a 30kg dog, (ii) a $\frac{1}{2}$ kg book, (iii) a 23g bag of crisps, (iv) a 2 tonne lorry? (1 tonne = 1000kg )
7.13.3	What is the weight of a 10 kg bag of potatoes on Earth?
7.13.4	What is the weight of a 250 g bag of sweets?
7.13.5	What is the mass of a 450 N girl?
7.13.6	What is the weight of a 10,000 kg spacecraft on a) Earth b) Mars c) Venus?
7.13.7	What would a 60 kg man weigh on Jupiter?
7.13.8	Which planet's gravitational field strength is closest to our own?
7.13.9	An astronaut who weighs 700 N on Earth goes to a planet where he weighs 266 N. Calculate his mass and state which planet he was on
7.13.10	What would an astronaut weigh on Earth, if his weight on Venus was 528 N?
7.13.11	The weight of a 20 kg mass on Europa, a moon of Jupiter, is 26.4 N. Calculate the gravitational field strength on Europa
<b>Cosmology</b>	
8.1	I can correctly use the term light year
8.1.1	Describe the term light year.
8.1.2	What are the units of light year?
8.1.3	Betelgeuse is 350 light years away, explain what this means.
8.2	I can convert between light years and metres
8.2.1	The star proxima Centauri is about 4.5 light years from the sun. What is this distance in metres?
8.3	I can give a basic description of the Big Bang theory of the origin of the Universe.
8.3.1	The term Big Bang has been use to described the origin of the Universe. Explain

No.	Content
	why this term appears appropriate.
8.4	I know the estimated age of the Universe.
8.4.1	State the approximate age of the Universe.
8.4.2	What evidence is there to support the age of the Universe?
8.5	I can describe how different parts of the electromagnetic spectrum are used to obtain information about astronomical objects.
8.6	I can identify continuous and line spectra.
8.6.1	State the type of spectrum shown in diagram below 
8.6.2	State the type of spectrum shown in diagrams below. 
8.6.3	
8.6.4	
8.6.5	
8.7	I can use spectral data for known elements, to identify the elements present in stars.
8.7.1	Light from a star is split into a line spectrum of different colours. The line spectrum from the star is shown, along with the line spectra of the elements calcium, helium, hydrogen

No.	Content
	<p>and sodium. State what elements are present in the star.</p>  <p>line spectrum from star</p> <p>calcium</p> <p>helium</p> <p>hydrogen</p> <p>sodium</p>
8.7.2	<p><b>Star</b> </p> <p>Known spectral data from a selection of elements is as follows:</p> <p><b>Helium</b> </p> <p><b>Sodium</b> </p> <p><b>Hydrogen</b> </p> <p><b>Calcium</b> </p> <p>A distant star produced spectral lines, as shown above, when viewed through a spectroscope. Identify the elements present in the star.</p>