P2 Forces Revision Booklet

Physics Paper 2

AQA TRILOGY Physics (8464) from 2016 Topics T6.5. Forces				
Topic	**Student Checklist**	**R**	**A**	**G**
6.5.1 Forces and their interactions	Identify and describe scalar quantities and vector quantities			
	Identify and give examples of forces as contact or non-contact forces			
	Describe the interaction between two objects and the force produced on each as a vector			
	Describe weight and explain that its magnitude at a point depends on the gravitational field strength			
	Calculate weight by recalling and using the equation: ***[W = mg]***			
	Represent the weight of an object as acting at a single point which is referred to as the object's 'centre of mass'			
	Calculate the resultant of two forces that act in a straight line			
	HT ONLY: describe examples of the forces acting on an isolated object or system			
	HT ONLY: Use free body diagrams to qualitatively describe examples where several forces act on an object and explain how that leads to a single resultant force or no force			
	HT ONLY: Use free body diagrams and accurate vector diagrams to scale, to resolve multiple forces and show magnitude and direction of the resultant			
	HT ONLY: Use vector diagrams to illustrate resolution of forces, equilibrium situations and determine the resultant of two forces, to include both magnitude and direction			
6.5.2 Work done and energy	Describe energy transfers involved when work is done and calculate the work done by recalling and using the equation: *[W = Fs]*			
	Describe what a joule is and state what the joule is derived from			
	Convert between newton-metres and joules.			
	Explain why work done against the frictional forces acting on an object causes a rise in the temperature of the object			
6.5.3 Forces and elasticity	Describe examples of the forces involved in stretching, bending or compressing an object			
	Explain why, to change the shape of an object (by stretching, bending or compressing), more than one force has to be applied – this is limited to stationary objects only			
	Describe the difference between elastic deformation and inelastic deformation caused by stretching forces			
	Describe the extension of an elastic object below the limit of proportionality and calculate it by recalling and applying the equation: ***[F = ke]***			
	Explain why a change in the shape of an object only happens when more than one force is applied			
	Describe and interpret data from an investigation to explain possible causes of a linear and non-linear relationship between force and extension			
	Calculate work done in stretching (or compressing) a spring (up to the limit of proportionality) by applying, but not recalling, the equation: **[$E_e = ½ke^2$]**			
	Required practical 18: *investigate the relationship between force and extension for a spring.*			

4.5.4 Forces and motion	Define distance and displacement and explain why they are scalar or vector quantities			
	Express a displacement in terms of both the magnitude and direction			
	Explain that the speed at which a person can walk, run or cycle depends on a number of factors and recall some typical speeds for walking, running, cycling			
	Make measurements of distance and time and then calculate speeds of objects in calculating average speed for non-uniform motion			
	Explain why the speed of wind and of sound through air varies and calculate speed by recalling and applying the equation: ***[s = v t]***			
	Explain the vector–scalar distinction as it applies to displacement, distance, velocity and speed			
	HT ONLY: Explain qualitatively, with examples, that motion in a circle involves constant speed but changing velocity			
	Represent an object moving along a straight line using a distance-time graph, describing its motion and calculating its speed from the graph's gradient			
	Draw distance–time graphs from measurements and extract and interpret lines and slopes of distance–time graphs,			
	Describe an object which is slowing down as having a negative acceleration and estimate the magnitude of everyday accelerations			
	Calculate the average acceleration of an object by recalling and applying the equation: ***[a = Δv/t]***			
	Represent motion using velocity–time graphs, finding the acceleration from its gradient and distance travelled from the area underneath			
	HT ONLY: Interpret enclosed areas in velocity–time graphs to determine distance travelled (or displacement)			
	HT ONLY: Measure, when appropriate, the area under a velocity– time graph by counting square			
	Apply, but not recall, the equation: ***[$v^2 – u^2 = 2as$]***			
	Explain the motion of an object moving with a uniform velocity and identify that forces must be in effect if its velocity is changing, by stating and applying Newton’s First Law			
	Define and apply Newton's second law relating to the acceleration of an object			
	Recall and apply the equation: ***[F = ma]***			
	HT ONLY: Describe what inertia is and give a definition			
	Estimate the speed, accelerations and forces of large vehicles involved in everyday road transport			
	Required practical 19: *investigate the effect of varying the force on the acceleration of an object of constant mass, and the effect of varying the mass of an object on the acceleration*			
	Apply Newton’s Third Law to examples of equilibrium situations			
	Describe factors that can affect a driver’s reaction time			
	Explain methods used to measure human reaction times and recall typical results			
	Interpret and evaluate measurements from simple methods to measure the different reaction times of students			
	Evaluate the effect of various factors on thinking distance based on given data			
	State typical reaction times and describe how reaction time (and therefore stopping distance) can be affected by different factors			
	Explain methods used to measure human reaction times and take, interpret and evaluate measurements of the reaction times of students			
	Explain how the braking distance of a vehicle can be affected by different factors, including implications for road safety			
	Explain how a braking force applied to the wheel does work to reduce the vehicle's kinetic energy and increases the temperature of the brakes			
	Explain and apply the idea that a greater braking force causes a larger deceleration and explain how this might be dangerous for drivers			
	HT ONLY: Estimate the forces involved in the deceleration of road vehicles			

4.5.5 Momentum	HT ONLY: Calculate momentum by recalling and applying the equation: *[p = mv]*			
	HT ONLY: Explain and apply the idea that, in a closed system, the total momentum before an event is equal to the total momentum after the event			
	HT ONLY: Describe examples of momentum in a collision			

6.5.1 Forces and their interactions

Scalars and Vectors

Materials in a classroom can be grouped into two groups – metals and non-metals.

Things we measure can be put into two groups as well – scalars and vectors.

Scalars: Things that we measure that have a magnitude (size) only are scalars.

Vectors: Things that we measure that have both magnitude and direction are vectors.

Sometimes direction is really important. In a crash the direction, as well as the speed, of the vehicles will determine how much damage is caused.

Examples of Scalars and Vectors

Some examples of scalars and vectors are shown in the table below.

Scalars	Vectors
Time	Forces (including weight)
Mass	Displacement
Temperature	Velocity
Speed	Acceleration
Direction	Momentum

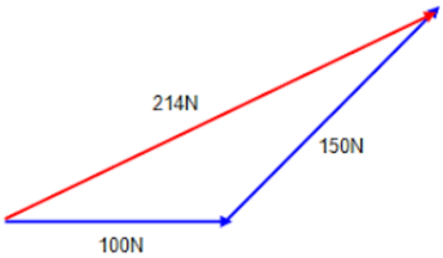
Representing Vectors

Vectors can be shown by arrows.

The length of the arrow shows the size, or magnitude, of the force.

The direction of the arrow shows the direction of the force.

The vector arrows can be added together to show the resultant of two of more vectors.



Contact and Non-contact Forces

Forces can be placed into two groups. There are forces that act on contact and there are forces that act at a distance.

Contact Forces	Non-Contact Forces
Air Resistance	Gravity
Friction	Magnetism
Tension	Electrical Force
Normal Force	Nuclear Force

Gravity

Gravity is a non-contact force.

Gravity is the force responsible for the formation of galaxies, stars and planets.

Weight is the force acting on an object due to gravity. The force of gravity close to the Earth is due to the gravitational field around the Earth.

The weight of an object depends on the gravitational field strength at the point where the object is.

Calculating Weight

The weight of an object can be calculated using the equation:

Weight (N) = Mass (kg) x Gravitational field strength (N/kg)

$$W = m\,g$$

It is useful to note that the gravitational field strength, g, on Earth is about 10 N/kg.
This means that a one kilogram mass would have a weight of 10 N. This can also be found using a calibrated spring balance (a newtonmeter).

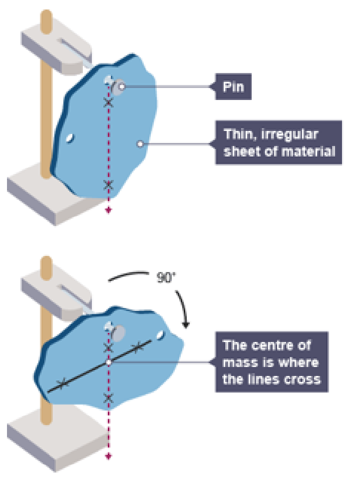
The value of the gravitational field strength will depend on where you are. Your weight on top of a mountain will differ slightly from your weight at sea level. On the Moon your weight will be approximately one sixth of your weight on Earth.

Weight and mass are directly proportional.

Centre of Mass

The weight of an object may be considered to act at a single point referred to as the object's 'centre of mass'.

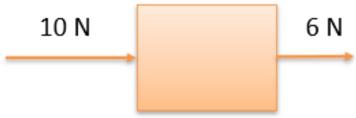
The centre of mass of an irregularly shaped 2-D object can be found by using a pin, some string and a small mass. By pinning the 2-D object up on a board with the string hanging from the pin (with the small mass on the end) the string will go through the centre of mass – mark with a line. Rotate the object and re-hang on the board. Draw a line to show where the string hangs. Where the lines cross is the centre of mass of the shape.



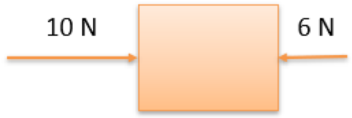
Resultant Forces

A number of forces acting on an object may be replaced by a single force that has the same effect as all the original forces acting together. This single force is called the resultant force.

When two forces act in a line the resultant force is the vector addition of the two vectors. Remember the direction is important.



R = 16 N to the right



R = 4 N to the right

Calculating Resultant Force

Example 1:

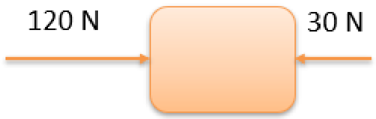
A box is pushed along the floor with a force of 120 N. There is a resistive force of 30 N. Work out the resultant force on the box.

Solution:

Resistive forces act in the opposing direction to motion.

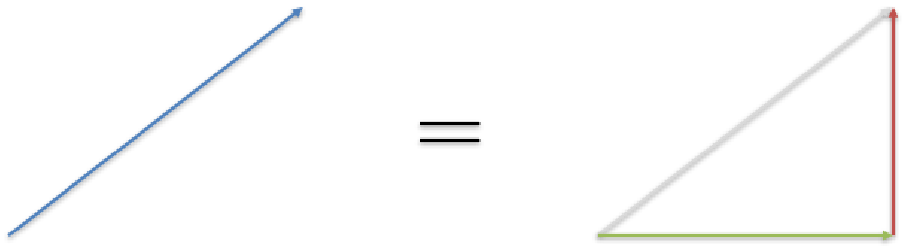
Addition of the forces gives:

120 N + -30 N = 90 N in direction of 120 N force



Calculating Resultant Force… continued

A single force can be resolved into two components acting at right angles to each other. The two component forces together have the same effect as the single force.



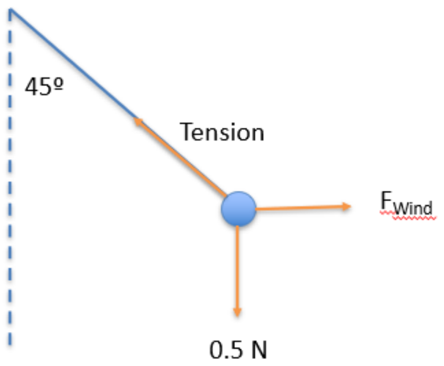
Example

A pendulum has a weight of 0.5 N.

On a windy day the pendulum is hung outside and the pendulum now hangs at an angle of 45º.

Assuming the wind hits the pendulum moving horizontally, draw a free body diagram to represent the forces acting.

Solution



Q1.

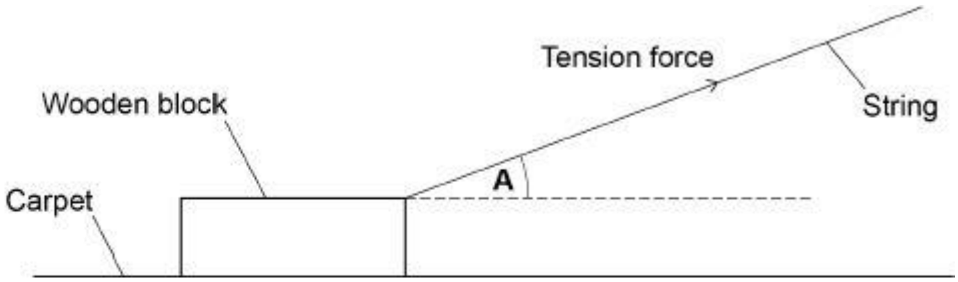
A student investigated the frictional force between an object and a surface.

The student used a string to pull a small wooden block across different surfaces.
The block was pulled at a constant speed in a straight line.

Pulling the block causes a tension force in the string.

The student kept the angle of the string the same each time.

The diagram below represents the block being pulled across a piece of carpet.



(a) Measure angle **A** on the diagram above.

Angle **A** = _______________ degrees

(1)

(b) Complete the sentences.

Choose answers from the box.

controlled	**dependent**	**scalar**	**valid**	**vector**

Force has both magnitude and direction, so is a _____________________ quantity.

A quantity with magnitude only is a _____________________ quantity.

(2)

(c) Two forces acting on the block are tension and friction.

Name **one** other force acting on the block.

____

(1)

(d) When the student pulled the block with a constant force, the velocity of the block did not change.

What is the best explanation for this?

Tick **one** box.

Force is directly proportional to velocity ☐

No work is done by the pulling force ☐

The block is moving in a straight line ☐

The resultant force on the block is zero ☐

(1)

The student pulled the block along four different surfaces:

- cardboard
- carpet
- glass
- sandpaper.

(e) Give **two** control variables for this investigation.

1. ______________________________

2. ______________________________

(2)

The table below shows the results.

Surface	**Force to pull the block in newtons**			**Mean force in newtons**
	Trial 1	**Trial 2**	**Trial 3**	
cardboard	1.4	1.6	1.5	1.5
carpet	2.5	3.0	3.9	3.2
glass	0.7	0.8	0.6	0.7
sandpaper	5.2	5.6	5.4	**X**

(f) Calculate value **X** in the table above.

____

____

X = ______________ N

(1)

(g) Which surface produced the lowest friction force?

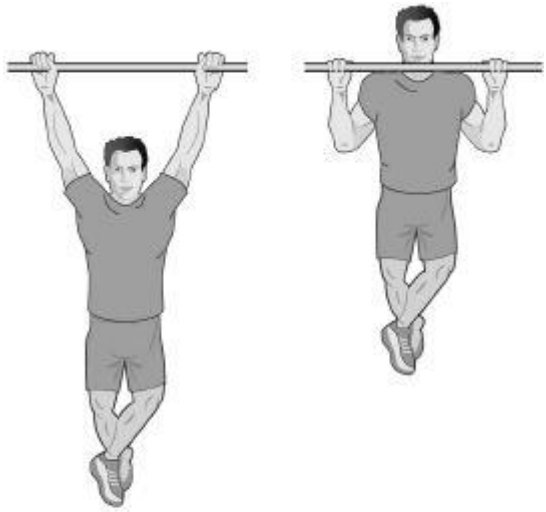
____

(1)

(Total 9 marks)

Q2.

The diagram below shows a man doing two stages of a pull up. In both diagrams the man is stationary.



Stage 1 Stage 2

(a) Complete the sentence.

Choose the answers from the box.

equal to	**less than**	**more than**

In stage 1 the downwards force of the man on the bar is ____________________

the upwards force of the bar on the man.

(1)

(b) The man has a mass of 85 kg

Gravitational field strength = 9.8 N/kg

Calculate the weight of the man.

Use the equation:

weight = mass × gravitational field strength

____

____

Weight = __________________ N

(2)

(c) The man raises his body a vertical distance of 0.63 m to go from stage 1 to stage 2

Calculate the work done by the man.

Use your answer to part **(b)**

Use the equation:

$$\text{work done} = \text{force} \times \text{distance}$$

____

____

Work done = ____________________ J

(2)

(d) The man was **not** moving at stage 2

How much work is done by the man at stage 2?

Work done = ____________________ J

(1)

(e) A woman uses the bar to do a pull up.

The woman has a mass of 62 kg

She accelerates at 11 m/s^2

Calculate the resultant force on the woman.

Use the equation:

$$\text{force} = \text{mass} \times \text{acceleration}$$

____

____

Force = ____________________ N

(2)

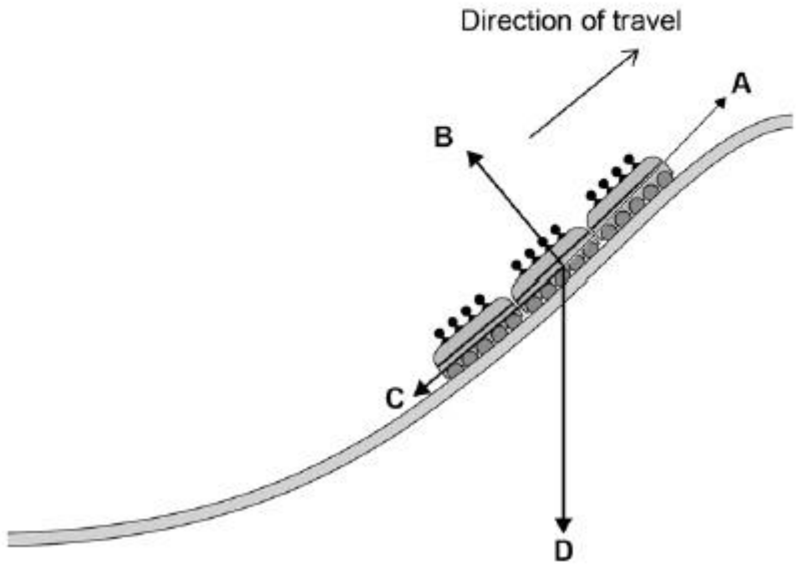
(Total 8 marks)

Q3.

Figure 1 shows a rollercoaster train as it is pulled up a slope on the track.

The arrows, **A**, **B**, **C** and **D**, represent the forces acting on the rollercoaster train.

Figure 1



(a) Give **two** ways that the force arrows show that forces are vector quantities.

1. ____

2. ____

(2)

(b) Which arrow shows the weight of the rollercoaster train?

Tick **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(c) Which arrow shows the normal contact force?

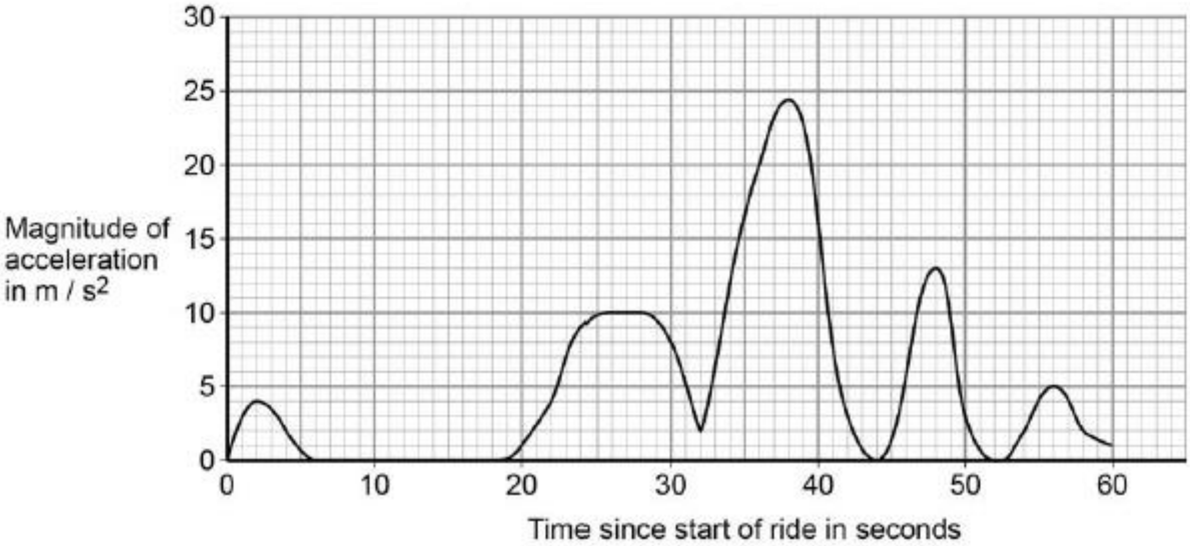
Tick **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

Figure 2 shows the magnitude of the acceleration of the rollercoaster train during the ride.

Figure 2



(d) Why has a line graph been drawn instead of a bar chart?

Tick **one** box.

Acceleration is a control variable.	☐
Both variables are continuous.	☐
Line graphs are easier to read.	☐
Time is a categoric variable.	☐

(1)

(e) What conclusion can be made from **Figure 2** about the motion of the rollercoaster train between 10 and 15 seconds?

Tick **one** box.

It is moving at a constant velocity.	☐
Its velocity is decreasing.	☐
Its velocity is increasing.	☐

(1)

(f) What is the maximum acceleration of the rollercoaster train?

Use **Figure 2**.

Acceleration = ____________________ m/s^2

(1)

(g) The maximum safe acceleration for most people is 5 times the acceleration due to gravity.

Acceleration due to gravity = 9.8 m/s^2

Explain whether the acceleration of this rollercoaster train is safe for most people

____

____

____

____

____

____

(3)

(h) One of the passengers on the rollercoaster train has a mass of 58 kg

Calculate the maximum force experienced by the passenger during the ride.

Use the equation:

force = mass × acceleration

Give the unit.

____

____

____

____

____

____

Maximum force = ____________________ Unit ____________________

(3)

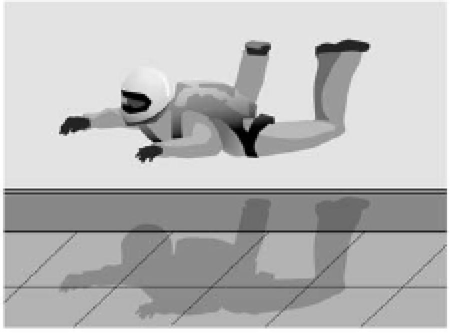
(Total 13 marks)

Q4.

Figure 1 shows a skydiver training in an indoor wind tunnel.

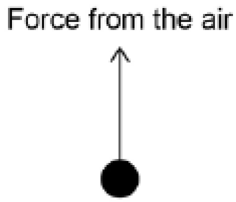
Large fans below the skydiver blow air upwards.

Figure 1



(a) The skydiver is in a stationary position.

Complete the free body diagram for the skydiver.



(2)

(b) The skydiver now straightens his legs to increase his surface area.

This causes the skydiver to accelerate upwards.

Explain why straightening his legs cause the skydiver to accelerate upwards.

___

___

___

___

(2)

(c) A small aeroplane used for skydiving moves along a runway.

The aeroplane accelerates at 2 m / s^2 from a velocity of 8 m / s.

After a distance of 209 m it reaches its take-off velocity.

Calculate the take-off velocity of the aeroplane.

___

___

____

Take-off velocity = ____________________ m / s

(3)

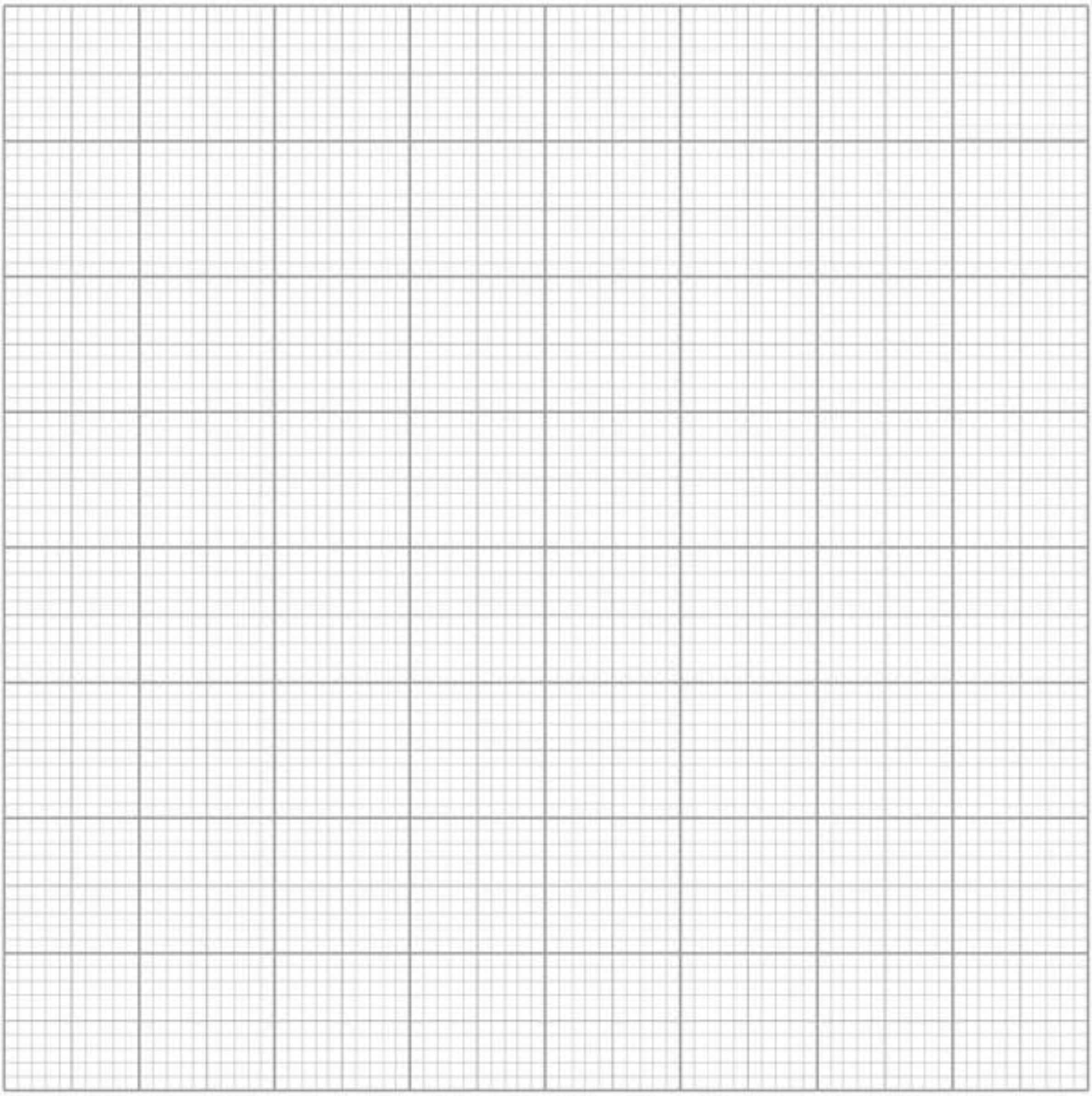
(d) A skydiver jumps from an aeroplane.

There is a resultant vertical force of 300 N on the skydiver.

There is a horizontal force from the wind of 60 N.

Draw a vector diagram on **Figure 2** to determine the magnitude and direction of the resultant force on the skydiver.

Figure 2



Magnitude of resultant force = ____________________ N

(5)(Total 12 marks)

Work Done

When a force causes an object to move through a distance work is done on the object. So a force does work on an object when the force causes a displacement of the object.

Work done can be calculated using the equation:

Work done (J) = Force (N) x Distance (m)

$$W = F\,s$$

Note: The distance moved has to be in the direction the force is acting on the object.

Work Done Calculations

A box is pushed 3 m across the floor with a force of 120 N.

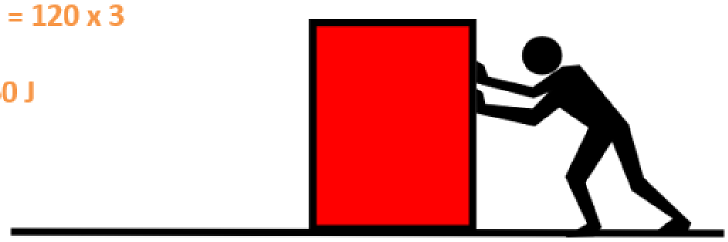
Work out the work done in moving the box.

Solution

Equation: work done = force x distance

Substitution: work done = 120 x 3

Answer: work done = 360 J



Work Done Calculations

A man with a mass of 70 kg gets onto a moving escalator.

The escalator moves 15 m horizontally and 8 m vertically.

Calculate the work done by the motor against gravity.

Take g = 10 N/kg.

Solution

Gravity acts downwards, so the distance moved against gravity is 8 m.
Sine W = mg; the weight of the man is 700 N.

Using: work done = force x distance
work done = 700 x 8
work done = 5600 J

Work Done Against Frictional Forces

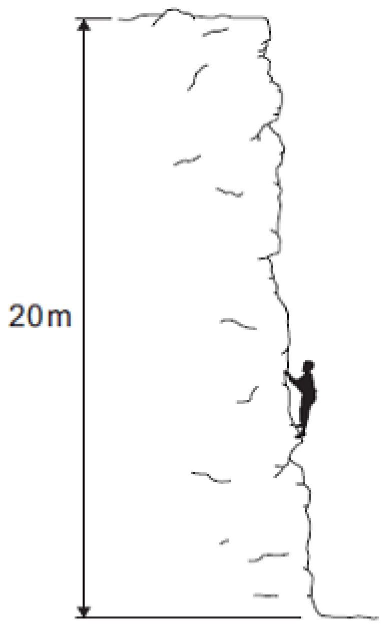
When work is done against frictional forces on an object there is a temperature increase of the object.

A bicycle pump gets hot in use as work is done in compressing the gas, causing the pump to get hotter.

EXAM QUESTIONS

Q1.

The diagram shows a climber part way up a cliff.



(a) Complete the sentence.

When the climber moves up the cliff, the climber

gains gravitational ______________________ energy.

(1)

(b) The climber weighs 660 N.

(i) Calculate the work the climber must do against gravity, to climb to the top of the cliff.

____

____

Work done = _________________________ J

(2)

(ii) It takes the climber 800 seconds to climb to the top of the cliff.
During this time the energy transferred to the climber equals the work done by the climber.

Calculate the power of the climber during the climb.

____

____

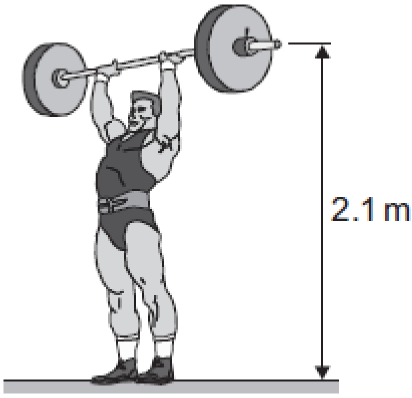
Power = _________________________ W

(2)

(Total 5 marks)

Q2.

A powerlifter lifts a 180 kg bar from the floor to above his head.



(a) Use the equation in the box to calculate the weight of the bar.

weight	=	mass	×	gravitational field strength

gravitational field strength = 10 N/kg

Show clearly how you work out your answer.

____

____

Weight = ______________________ N

(2)

(b) The powerlifter uses a constant force to lift the bar a distance of 2.1 m.

Use the equation in the box to calculate the work done by the powerlifter.

work done	=	force applied	×	distance moved in direction of force

Show clearly how you work out your answer and give the unit.

Choose the unit from the list below.

joule **newton** **watt**

____

____

Work done = ______________________

(3)

(c) At the end of the lift, the powerlifter holds the bar stationary, above his head, for two seconds.

How much work does the powerlifter do on the bar during these two seconds?

Draw a ring around your answer.

0 **90** **360** **900**

Give a reason for your answer.

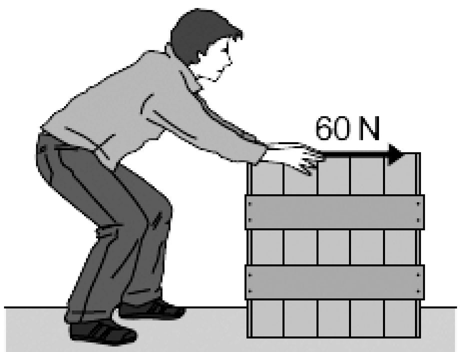
___

___

(2)
(Total 7 marks)

Q3.

The diagram shows a worker using a constant force of 60 N to push a crate across the floor.



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(a) The crate moves at a constant speed in a straight line

(i) Draw an arrow on the diagram to show the direction of the friction force acting on the moving crate.

(1)

(ii) State the size of the friction force acting on the moving crate.

___ N

Give the reason for your answer.

___

___

(2)

(b) Calculate the work done by the worker to push the crate 28 metres.

Show clearly how you work out your answer and give the unit.

Choose the unit from the list below.

joule **newton** **watt**

____

____

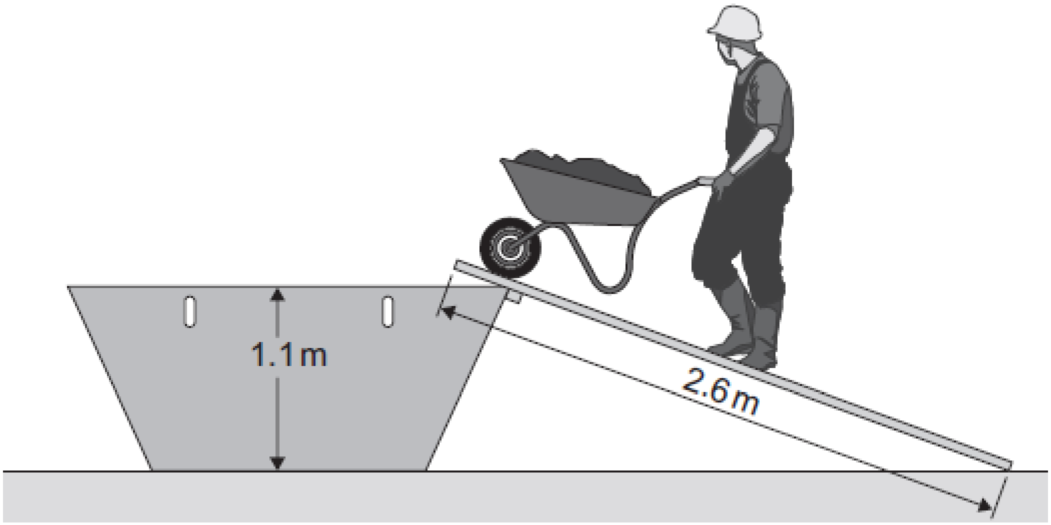
Work done = ______________________________

(3)

(Total 6 marks)

Q4.

(a) The diagram shows a builder using a plank to help load rubble into a skip.



The builder uses a force of 220 N to push the wheelbarrow up the plank.

Use information from the diagram to calculate the work done to push the wheelbarrow up the plank to the skip.

Show clearly how you work out your answer.

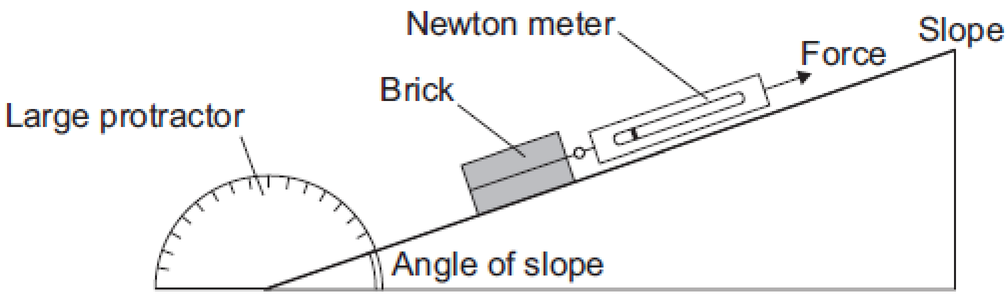
____

____

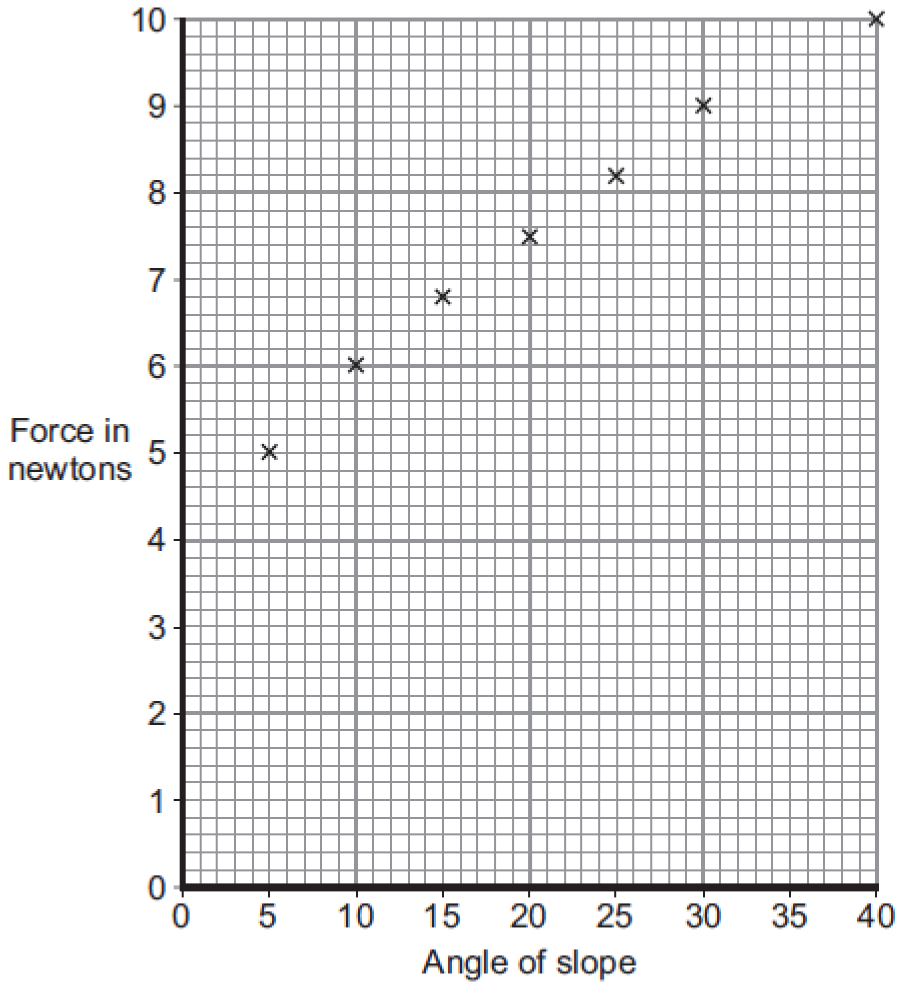
Work done = ______________________________ J

(2)

(b) A student investigated how the force needed to pull a brick up a slope, at a steady speed, depends on the angle of the slope.
The apparatus used by the student is shown in the diagram.



The student used the results from the investigation to plot the points for a graph of force used against the angle of the slope.



(i) Draw a line of best fit for these points.

(1)

(ii) How does the force used to pull the brick up the slope change as the angle of the slope increases?

____

____

(1)

(iii) Consider the results from this experiment.
Should the student recommend that the builder use a long plank or a short plank to help load the skip?

Draw a ring around your answer.

long plank **short plank**

Explain the reason for your answer.

____

____

____

____

(2)

(Total 6 marks)

6.5.3 Forces and elasticity

Springs

Springs are used in many everyday objects. Springs are found in beds, in motorcycle and bike suspension, weighing scales and trampolines.

Springs can either be used in tension (where the spring is stretched) or compression (where the spring is squashed).

Springs have a store of elastic potential energy when they have changed shape.

Not all springs are cylindrical in shape.

Uses of Springs

Some common uses of springs, in compression and tension, include:

Uses of Springs in Compression	Uses of Springs in Tension
Ball Point Pen	Trampolines
Beds (mattresses)	Garage Doors
Suspension Springs (bikes)	Newtonmeter
Electrical Switches	Exercise Equipment (Chest Expander)

Elastic and Inelastic Deformation

To stretch a spring at least two forces are required – otherwise the whole spring will move.

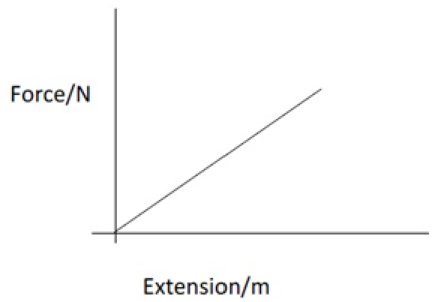
When a spring is stretched, the spring may return to it's original shape. In this case the deformation of the spring is said to be elastic.

If the spring is stretched too far then the spring will never return to it's original length. The deformation is said to be inelastic.

Limit of Proportionality

The extension (the length of a spring minus the original length) of a spring is directly proportional to the force applied – provided that the limit of proportionality is not exceeded.

This means that if the force on the spring is doubled then the extension of the spring will be doubled too.



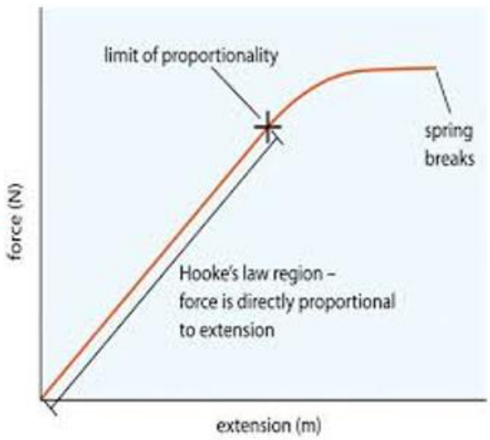
A graph of force against extension for a spring that has not been stretched beyond the limit of proportionality.

Permanent Deformation of a Spring

If the force applied to a spring is too great the the spring will be inelastically deformed.

A graph showing force against extension for a spring stretched beyond it's limit of proportionality will no longer be a straight line through 0,0.

The graph opposite shows the force – extension graph for a spring stretched beyond it's limit of proportionality.

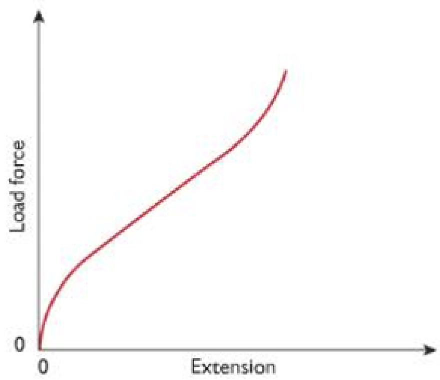


Stretching Other Materials

Objects and materials other than metal springs can be stretched.

An elastic band is an example of a material that can be stretched and stores elastic potential energy.

The extension of an elastic band is <u>not</u> directly proportional to the force applied. A graph of extension against length for an elastic band will produce a curve, yet the material may still go back to it's original shape.



Spring Constant

The amount a spring stretches depends on the force applied to the spring and also to the spring constant of the spring.

The spring constant of a spring is measured in newtons per meter (N/m). The higher the spring constant the greater the force required to produce a given extension, in metres.

The spring constant can be found using the equation:

Force (N) = Spring Constant (N/m) x Extension (m)

$$F = k\,e$$

This relationship can be applied to springs in both compression and tension, as long as the limit of proportionality is not exceeded.

Spring Constant Calculation

Example:

A trampoline spring has a spring constant of 2200 N/m.

Work out the extension of the trampoline spring if a weight of 600 N is applied.

Solution:

Using the equation

$F = k\,e$

Substitution gives

$600 = 2200 \times e$

Rearranging

$600 / 2200 = e$

Answer:

0.27 m

Energy Stored in a Spring

To stretch or compress a spring you must do work on it. This means that you have transferred energy to the spring, so the spring now has a store of elastic potential energy. Provided the spring is not inelastically deformed the work done in stretching the spring is equal to the elastic potential energy stored in the spring.

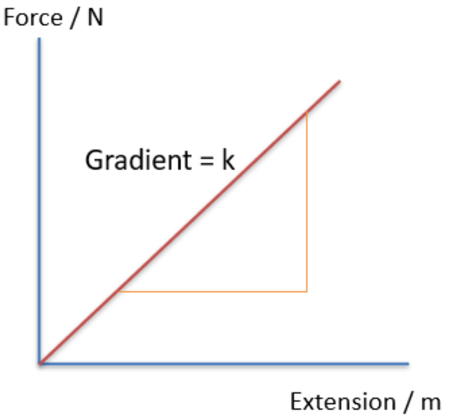
To calculate the amount of energy stored in a spring you need to use the equation:

Elastic Potential Energy (J) = 0.5 x spring constant (N/m) x (extension)^2 (m)

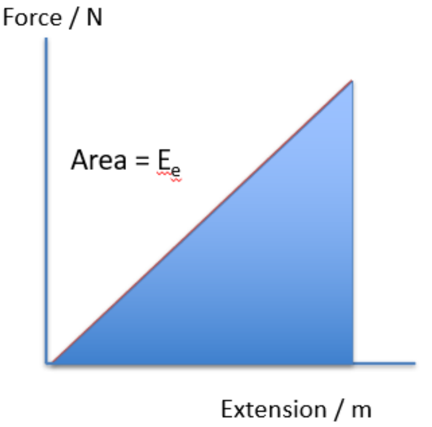
$$E_e = \frac{1}{2} k e^2$$

Graphs of Force Against Extension

The gradient of a force against extension graph gives you the spring constant of the spring.



The energy stored as elastic potential energy is the area under a force against extension graph.



Energy Stored in a Spring Calculations

Example:

A trampoline spring has a spring constant of 1400 N/m.

The spring has a 50 N load added to the spring.

Work out the amount of elastic potential energy stored in the spring when the 50 N load is added to the spring.

Solution:

Step 1: Determine the extension of the spring using $F = k\,e$

Extension = 50 / 1400
Extension = 0.0357 m

Step 2: Calculate the energy stored in the spring using $E_e = ½\,k\,e^2$

$$E_e = ½ \times 1400 \times 0.0357^2$$
$$E_e = 0.9\text{ J}$$

6.5.3 Forces and elasticity

EXAM QUESTIONS

Q1.

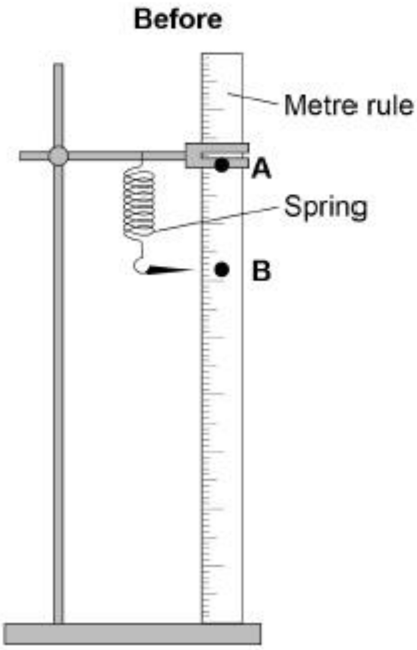
A student investigated the relationship between the force applied to a spring and the extension of the spring.

This is the method used.

1. Hang a spring from a rod.
2. Hang a mass from the spring.
3. Measure the extension of the spring.
4. Repeat steps 2 and 3 using different masses.

Figure 1 shows a spring before and after a mass had been hung from it.

Figure 1



(a) Give **two** ways in which the appearance of the spring has changed.

1. ____

____

2. ____

____

(2)

(b) The extension of the spring is the distance between which **two** points on the metre rule?

Use letters from the diagram in **Figure 1**.

____________________ and ____________________

(1)

(c) The force applied to the spring is the weight of the mass hanging from the spring.

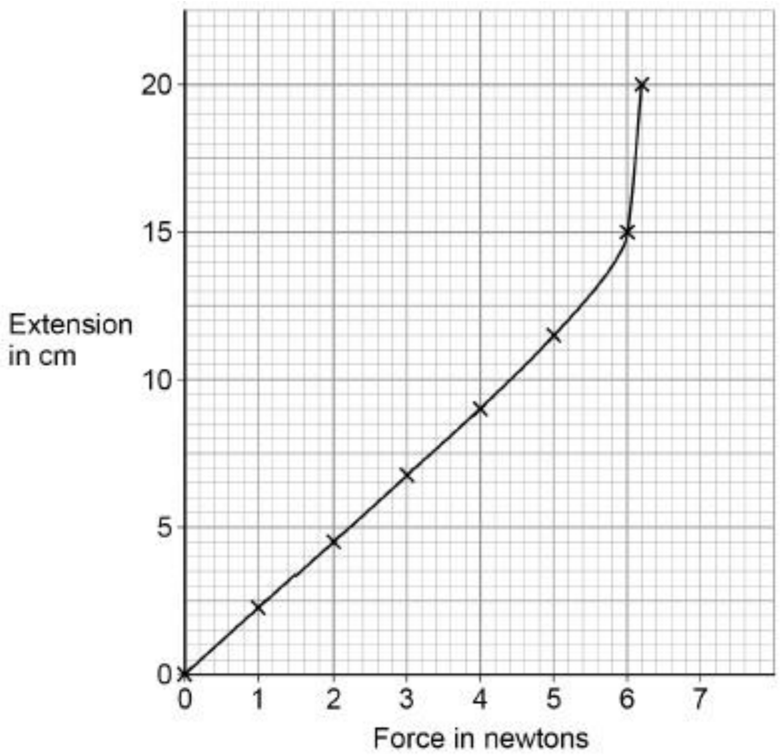
Write the equation that links gravitational field strength, mass and weight.

____

(1)

Figure 2 shows the student's results.

Figure 2



(d) During the investigation the limit of proportionality of the spring was exceeded.

What is the value of force at which this happened?

Give a reason for your choice.

Force = ____________________ N

Reason ____

____

(2)

(e) Suggest how the student could obtain a more accurate answer for the limit of proportionality of the spring.

You should include the additional readings the student should take.

____

____

____

____

(2)

(f) Write the equation that links extension, force and the spring constant.

____

(1)

(g) A different spring has a spring constant of 18 N/m

When an apple is hung from the spring, the spring extends 6.4 cm

The spring does not go past the limit of proportionality.

Calculate the force exerted by the apple on the spring.

____

____

____

____

Force = ____________________ N

(3)

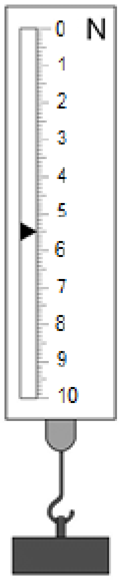
(Total 12 marks)

Q2.

A newtonmeter measures the weight of objects.

Look at **Figure 1**.

Figure 1



(a) What is the weight of the object in **Figure 1**?

Weight = ____________________ N

(1)

(b) The spring inside the newtonmeter behaves elastically.

What happens to the length of the spring when the object is removed from the newtonmeter?

Tick **one** box.

The spring gets longer ☐

The spring gets shorter ☐

The spring stays the same length ☐

(1)

(c) A student carried out a practical to investigate the extension of a spring.

Write a method the student could have used.

____

____

____

____

____

____

____

____

____

____

(4)

(d) What could be done to improve the accuracy in this investigation?

Tick **two** boxes.

Use a pointer from the spring to measure the length. ☐

Use a stronger spring in the practical. ☐

Use a new spring between each reading. ☐

Make sure the spring is stationary before measuring length. ☐

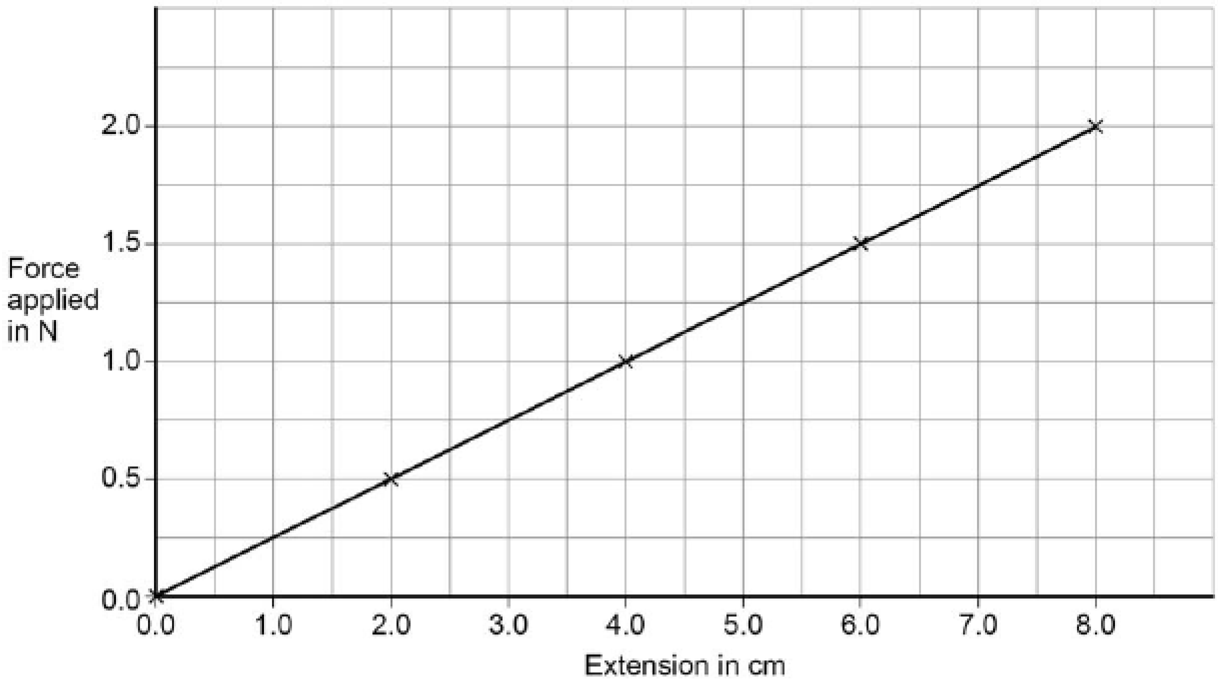
Use a longer rule when measuring length. ☐

(2)

(e) The student added weights to a spring and measured the extension of the spring.

Figure 2 shows his results.

Figure 2



What is the relationship between force applied and extension?

Tick **one** box.

Extension is inversely proportional to force	☐
Extension increases by smaller values as force increases	☐
Extension is directly proportional to force	☐

(1)

(f) Use **Figure 2** to determine the additional force needed to increase the extension in the spring from 5.0 cm to 7.0 cm.

Force needed = ____________________ N

(1)

(g) The table below shows some results with a different spring.

Force applied in N	**Extension in m**
0.0	0.000
0.5	0.025
1.0	0.050
1.5	0.075

What would the extension be with a force of 2.0 N?

Tick **one** box.

0.080 m ☐

0.080 m ☐

0.095 m ☐

0.100 m ☐

(1)

(h) The spring constant for the spring in above **Table** is 20 N / m.

Calculate the work done in stretching the spring until the extension of the spring is 0.050m

Use the correct equation from the Physics Equation Sheet.

____

____

Work done = ____________________ J

(2)

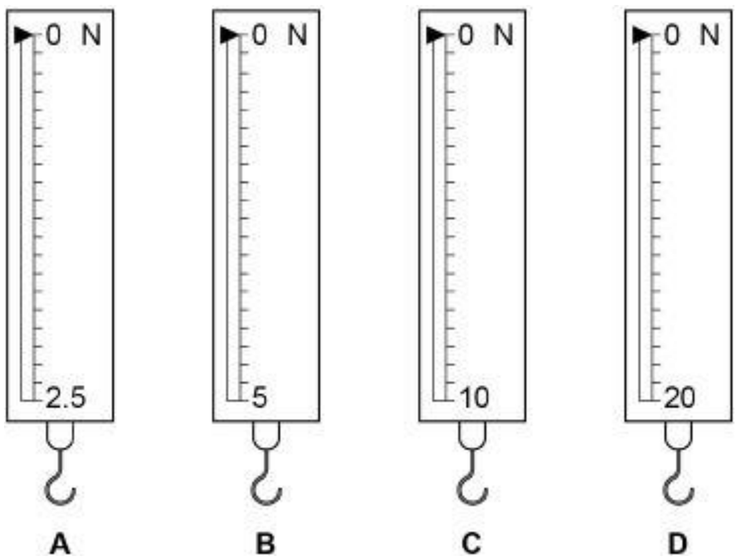
(Total 13 marks)

Q3.

(a) **Figure 1** shows four newtonmeters.

Each newtonmeter contains a spring.

Figure 1



Which newtonmeter has the spring with the greatest spring constant?

Give a reason for your answer.

Newtonmeter ___________

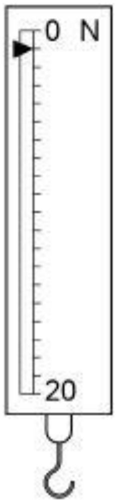
Reason ____

____

(2)

(b) The newtonmeter in **Figure 2** will give an error when used to make a measurement.

Figure 2



Name the type of error.

Describe how this error can be corrected.

Type of error ____

Correction ____

____

(2)

(c) A student hangs a weight on a newtonmeter.

The energy now stored in the spring in the newtonmeter is 4.5×10^{-2} J

The student then increases the weight on the newtonmeter by 2.0 N

Calculate the total extension of the spring.

Spring constant = 400 N/m

____

____

____

____

____

Total extension = ______________________ m

(6)

(Total 10 marks)

6.5.4 Forces and Motion

Definitions

Distance: How far an object has travelled. Distance is a scalar quantity.

Displacement: How far an object has travelled in a straight line from the starting point to the finishing point and the direction of that line. Displacement is a vector quantity.

Examples:

A runner runs around a track. The track is 400 m long.

After completing one complete circuit of the track the runner has travelled a distance of 400 m. After the one complete circuit the runner ends up at their starting point. This means that their displacement is 0 m.

Calculations

For an object moving at a constant speed the distance travelled in a specific time can be calculated using the equation:

Distance travelled (m) = Speed (m/s) x time (s)

$$s = v\,t$$

Definitions

Speed is the rate of change of distance. This can be found using the equation:

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

Speed is a scalar quantity which means that it has magnitude but no direction.

Velocity is the rate of change of distance. Velocity is found using the equation:

$$\text{velocity} = \frac{\text{displacement}}{\text{time taken}}$$

Velocity is a vector quantity which means that is has magnitude and direction.

Speed Calculations

Example 1:

A bike travels 800 m in 160 seconds. Calculate the speed of the bike.

Solution 1:

Using the equation:

Speed = distance / time
Speed = 800 / 160
Speed = 5 m/s

Example 2:

A car travels a distance of 300 miles at an average speed of 50 mph. Calculate how long it will take to complete the car journey.

Solution 2:

Rearranging the speed equation gives:

time = distance / speed
time = 300 / 50 = 6 hours

Velocity Calculations

Example 1:

A track runner runs around a 400 m athletics track 4 times in 3 minutes and 10 seconds.

Work out:

a) The speed of the track runner
Speed = distance / time
Speed = 1600 / 190
Speed = 8.4 m/s

b) The average velocity of track runner.
As the displacement at the end of the run is 0 m (they end up where they started after four loops of the track) their average velocity is 0 m/s.

Typical Speeds

These are the typical speeds of everyday situations that you should know for your exam.

Situation	Typical Speed/ m/s
Walking	1.5
Running	3
Cycling	6

The speed of sound in air is 330 m/s (though this does changes with temperature and pressure).

Average speed is the speed of an object over the entire journey. The average speed is found by using the total distance travelled divided by the total time taken.

$$\text{average speed} = \frac{\text{total distance travelled}}{\text{total time taken}}$$

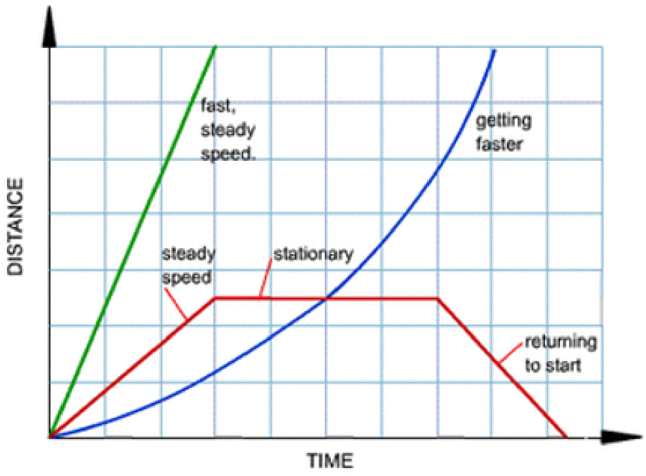
Instantaneous speed is the speed of an object at a given moment in time. The speedometer in a car gives the instantaneous speed of the car.

Distance-Time Graphs

Distance-time graphs can be used to represent the motion of an object.

The different gradients (steepness) of line on the graphs show different motions of the object.

The shapes of line that you need to know are shown opposite.



Calculating Speed from a Distance-Time Graph

From the shapes of distance-time graphs it is possible to compare the speeds of different objects. The steeper the gradient of a line on a distance-time graph the faster the object is travelling.

The gradient of the line on a distance-time graph is the speed of the object.

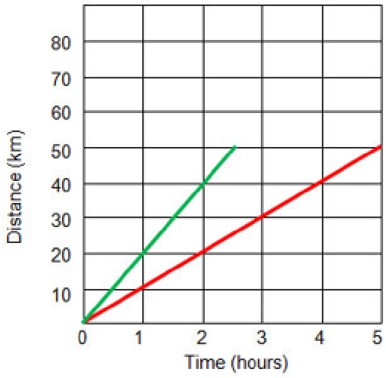
Example:

Work out the speed of the objects shown by the red and green line.

Solution:

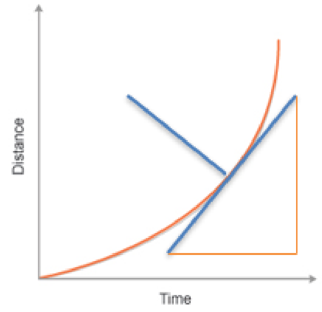
Red = distance / time = 30 / 3 = 10 km/h

Green = distance / time = 40 /2 = 20 km/h



Higher Tier Only
When an object is accelerating the line on a distance-time graph is curved.
To find the instantaneous speed of the object at any point along the curve the tangent to the line must first be found – then the gradient of the tangent shows the speed.

To draw the tangent of a curve you should draw a line perpendicular to your curve to start with, then draw a straight line at right-angles to this across your curve – this is your tangent. The longer the line that you draw at this point the easier and more accurate your speed calculation will be.



Acceleration

When objects accelerate they can be changing speed or changing direction or changing both speed and direction.

Acceleration is the rate of change of velocity, and since velocity is a vector so is acceleration.

The average acceleration of an object is found using the equation:

$$\text{Acceleration (m/s}^2\text{)} = \frac{\text{change in velocity (m/s)}}{\text{Time taken (s)}}$$

$$a = \frac{\Delta v}{t}$$

An acceleration of 3 m/s^2 means that an object is getting 3 m/s faster every second.

Equivalent units for acceleration are: m/s/s and ms^{-2}.

Negative Acceleration

As acceleration is a vector the direction is important.

When a moving object has a negative acceleration it can either be slowing down (often just called decelerating) or it could be increasing speed in the opposite direction.

If a car is moving along a straight motorway at 70 mph and then has a negative acceleration the car will slow down.

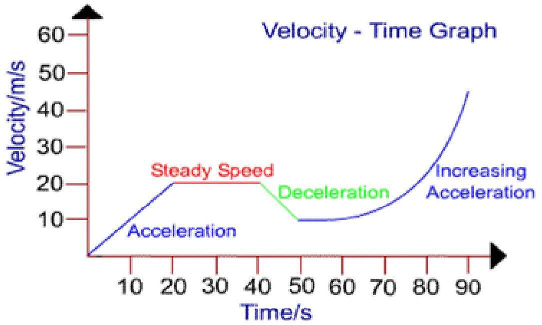
On the on the other hand if the positive direction is chosen to be upwards then a ball that is dropped will have a negative acceleration (as it is in the opposite direction) and will continue to speed up (accelerate) in the opposite direction.

Velocity-Time Graphs

A velocity-time graph gives more information than a distance-time graph. As well as speed, distance travelled and time, a velocity-time graph will give the acceleration of the object.

Although the line shapes look the same as a distance-time graph, as the axes are different the line meanings are different.

Below are the line shapes for velocity-time graphs.



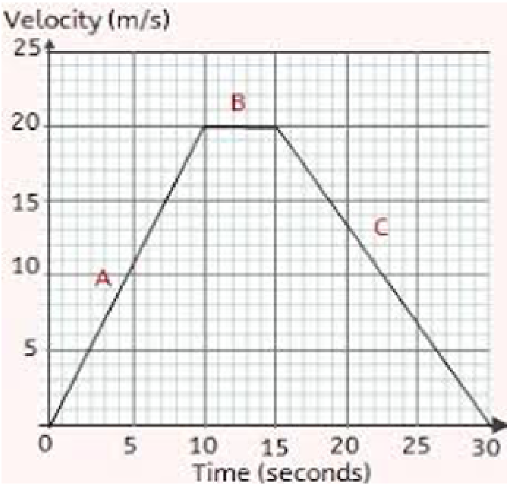
Velocity-Time Graph Calculations

The following information can be gathered from a velocity time graph:

The velocity: From reading off the axes on the graph.

The acceleration: Found from the gradient of the line on the velocity-time graph.

The distance travelled: The area under the line on a velocity-time graph is the distance travelled.

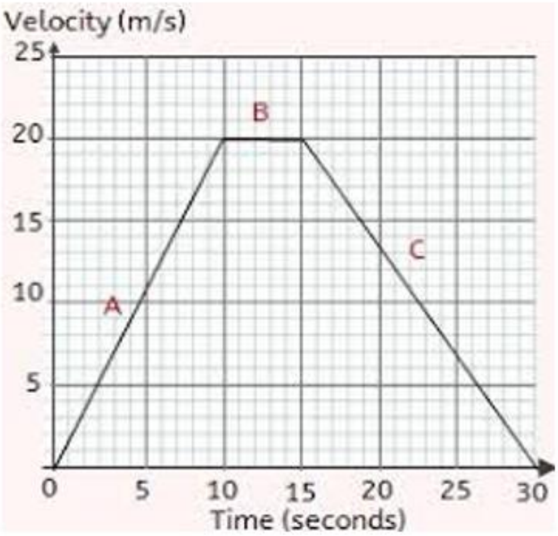


Interpreting Velocity-Time Graphs

Example:
Describe fully the motion shown in the velocity-time graph.

Solution:

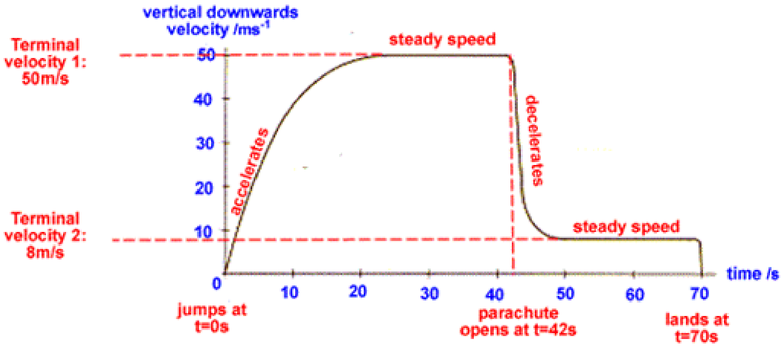
From 0 to 10 s: Constant rate of acceleration of 2 m/s^2.
From 10 to 15 s: Constant speed of 20 m/s.
From 15 to 30 s: Constant rate of deceleration of 1.33 m/s^2.
Distance-travelled is the area under the line = 100 m + 100 m + 150 m = 350 m



Terminal Velocity of Falling Objects

When a skydiver jumps out of a plane they may reach terminal velocity.

At terminal velocity the pull of gravity (the skydiver's weight) is equal in size and opposite in direction to the air resistance on the skydiver. As there is no resultant force there is no acceleration and the skydiver will fall at a steady speed.



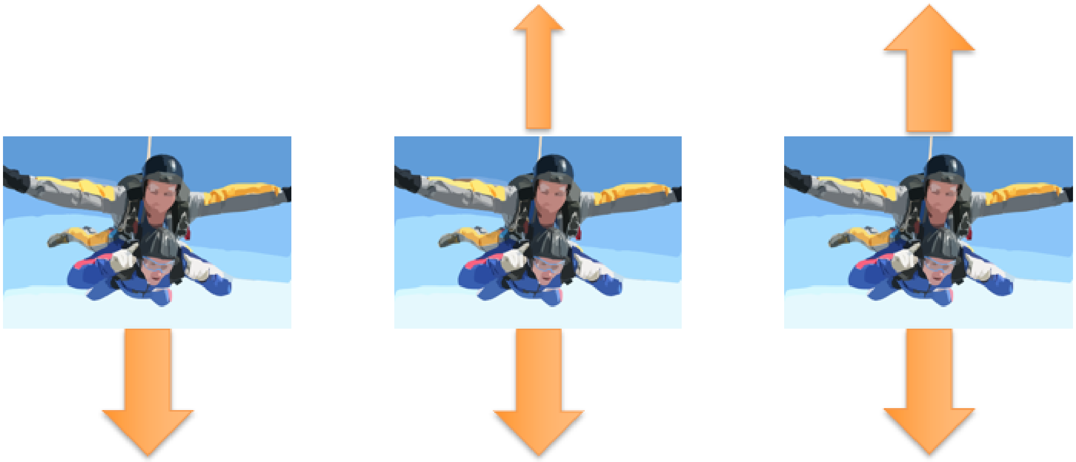
Forces acting on a Skydiver

During the course of a skydive the weight of a skydiver will not change. As a result of this the skydiver will have a constant pull downwards caused by the gravitational attraction of the Earth.

Also acting on the skydiver is air resistance, or drag. As the skydiver moves through the air faster the skydiver will experience more drag.

Drag reduces the acceleration the skydiver experiences, from 10 m/s^2 when they have just jumped out of the plane to 0 m/s^2 when they reach terminal speed.

More Forces acting on a Skydiver



As the skydiver falls faster the amount of drag experienced increases, reducing the skydiver's acceleration, until weight and drag are equal in size. At this point the skydiver will be falling with terminal velocity.

Uniform Acceleration

The equation for uniform acceleration is:

(Final velocity)^2 – (Initial velocity)^2 = 2 x Acceleration x Distance
(m/s) (m/s) (m/s^2) (m)

$$v^2 - u^2 = 2\,a\,s$$

This equation is often used when an object is falling under gravity and assumes the acceleration due to gravity to be constant (so ignoring air resistance).

The acceleration of an object due to gravity is taken to be about 9.8 m/s^2. This is often rounded up to 10 m/s^2.

Uniform Acceleration Calculations

Example:

A stone is dropped off a 30 m high cliff.
The stone falls under gravity ($g = 9.8\ m/s^2$).
Work out the speed of the stone as it hits the floor.

Solution:

As the stone is dropped the initial speed is 0 m/s.
Using

$$v^2 - u^2 = 2as$$
$$v^2 = 2as + u^2$$
$$v^2 = 2 \times 9.8 \times 30 + 0^2$$
$$v^2 = 588$$
$$v = \sqrt{588} = 24.2\ m/s$$

6.5.4 Forces and Motion

EXAM QUESTIONS

Q1.

Speed and velocity are different quantities.

(a) Complete the sentence.

Choose the answers from the box.

distance	**direction**	**scalar**	**time**	**vector**

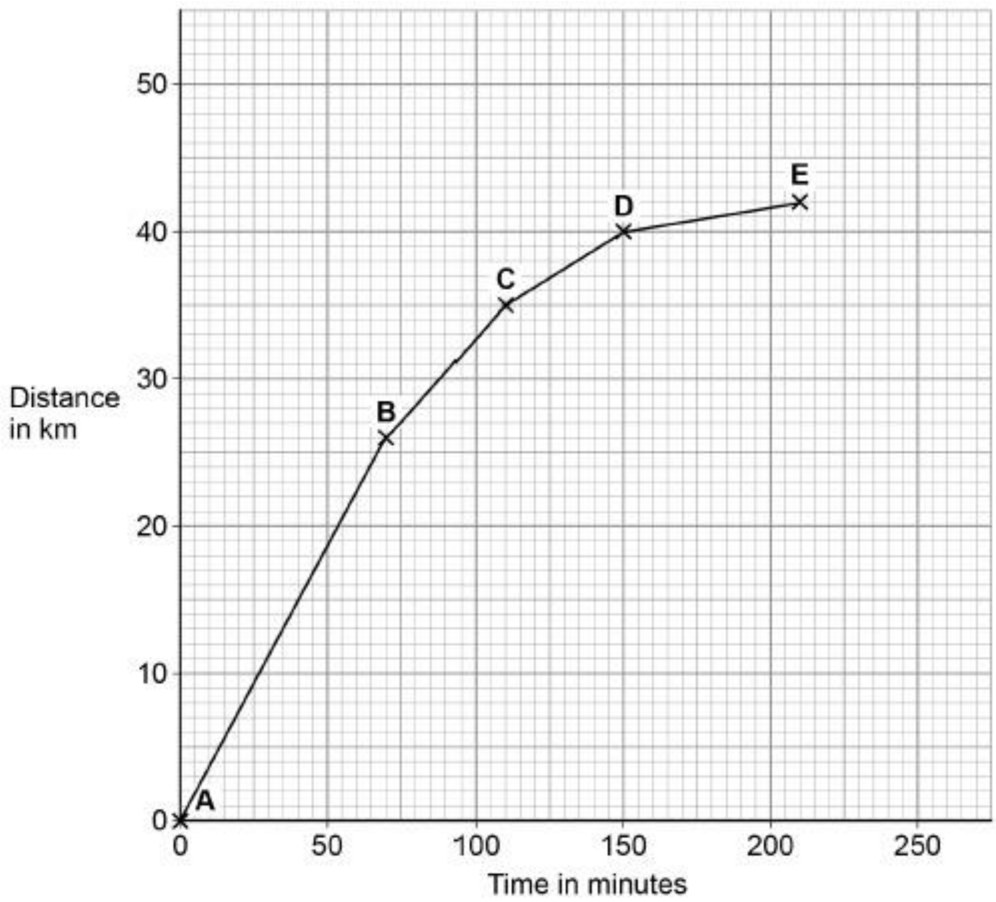
Velocity is a ________________________________ quantity.

The velocity of an object is its speed in a given ________________________________ .

(2)

Figure 1 shows the distance-time graph for an athlete in a running race.

Figure 1



(b) Determine the:

- distance of the race
- time taken for the athlete to complete the race.

Use **Figure 1**.

____

Distance = ____________________ km

Time taken = ____________________ minutes

(2)

(c) What is the motion of the athlete between points **B** and **C** on **Figure 1**?

Tick **one** box.

Moving at constant speed	☐
Moving with decreasing speed	☐
Moving with increasing speed	☐
Not moving	☐

(1)

(d) Which section on **Figure 1** shows the athlete moving at the highest speed?

Tick **one** box.

A to **B** ☐

B to **C** ☐

C to **D** ☐

D to **E** ☐

(1)

(e) How does the section you gave as your answer in part (d) show the highest speed?

____

____

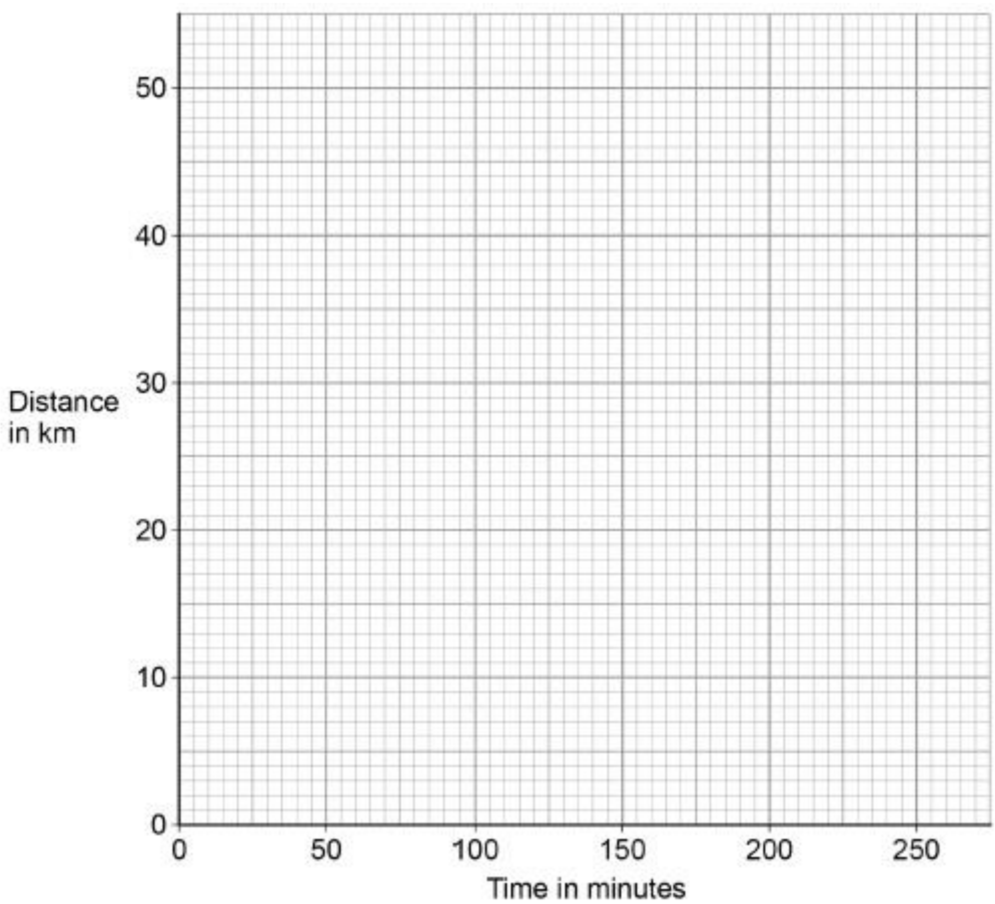
(1)

(f) A cyclist travelled the same distance as the athlete.

The cyclist travelled at a constant speed for 120 minutes.

Complete **Figure 2** to show a distance-time graph for the cyclist.

Figure 2



(2)

A car following the race accelerates at a constant rate in a straight line.

The velocity of the car increases from 1.9 m/s to 3.4 m/s in 60 seconds.

(g) Calculate the change in velocity of the car.

____

Change in velocity = ____________________ m/s

(1)

(h) Calculate the acceleration of the car.

Use your answer to part (g).

Use the equation:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

Give the unit.

____

____

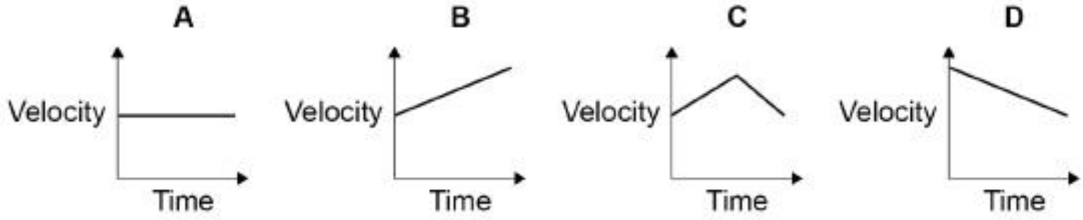
____

Acceleration = ____________________ unit ____________________

(3)

(i) Which graph shows how the velocity of the car changes as the car accelerates?

Tick **one** box.



(1)

(Total 14 marks)

Q2.

Figure 1 shows an electric wheelchair.

Figure 1

(a) The wheelchair moves at a constant speed of 2.4 m/s for 4.5 seconds.

Calculate the distance moved by the wheelchair.

Use the equation:

$$\text{distance} = \text{speed} \times \text{time}$$

____

____

____

____

Distance = ____________________ m

(2)

(b) What could be a reason for the speed of the wheelchair decreasing?

Tick **one** box.

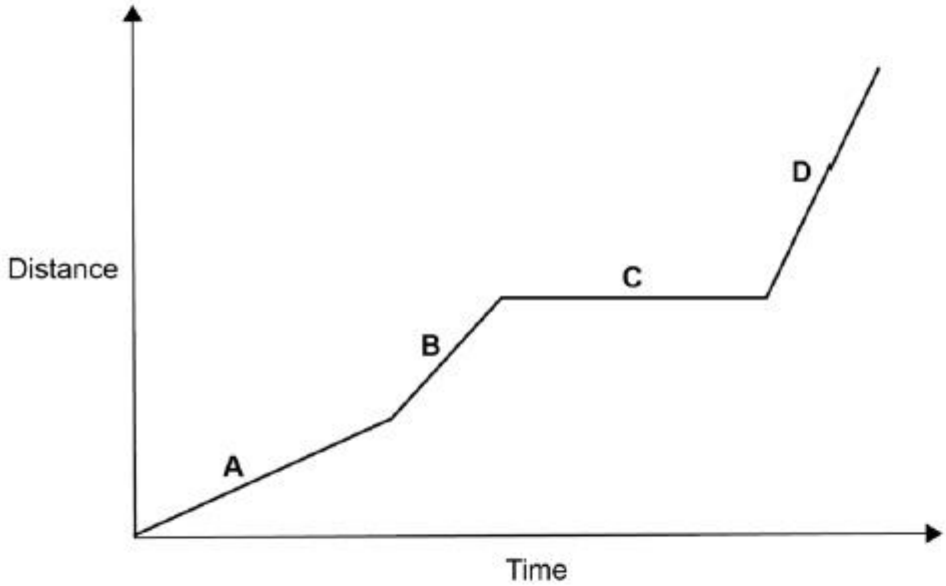
It started going downhill.	☐
It started going uphill.	☐
Its store of kinetic energy increased.	☐
It used more power from its battery.	☐

(1)

A student measured how the distance travelled by the wheelchair changed over time.

Figure 2 shows a sketch-graph of the results.

Figure 2



(c) In which section of the graph, **A**, **B**, **C**, or **D**, did the wheelchair travel fastest?

Give the reason for your answer.

Section ____________________

Reason ____

____

(2)

(d) The student used a data logger with a distance sensor to record the data.

Give **two** advantages of using a data logger rather than using a stopclock and tape measure.

1. ____

____

2. ____

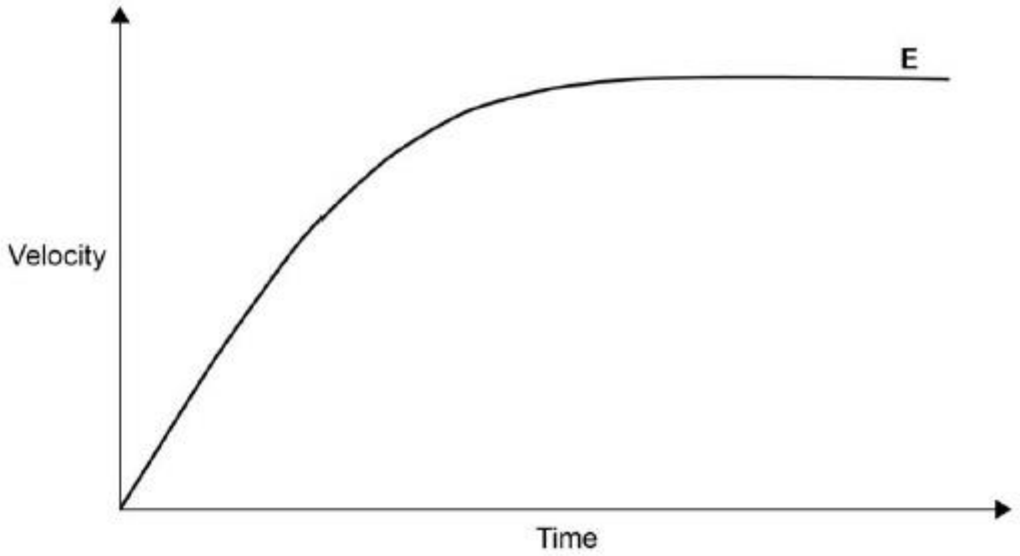
____

(2)

The velocity of the wheelchair changes as it accelerates to its top speed.

Figure 3 shows a sketch-graph of the changes.

Figure 3



(e) The forward force on the wheelchair is constant as it accelerates on flat ground.

Which force reduces the acceleration?

Tick **one** box.

Air resistance	☐
Magnetism	☐
Tension	☐
Weight	☐

(1)

(f) Explain the acceleration of the wheelchair at point **E** on **Figure 3**.

___

___

___

___

(2)

(g) The wheelchair starts from rest.

It accelerates at a constant rate until it has a speed of 1.5 m/s

The wheelchair travels a distance of 2.0 m while it is accelerating.

Calculate the acceleration of the wheelchair.

Using the Physics Equations Sheet.

___

____

____

____

____

____

Acceleration = ____________________ m/s^2

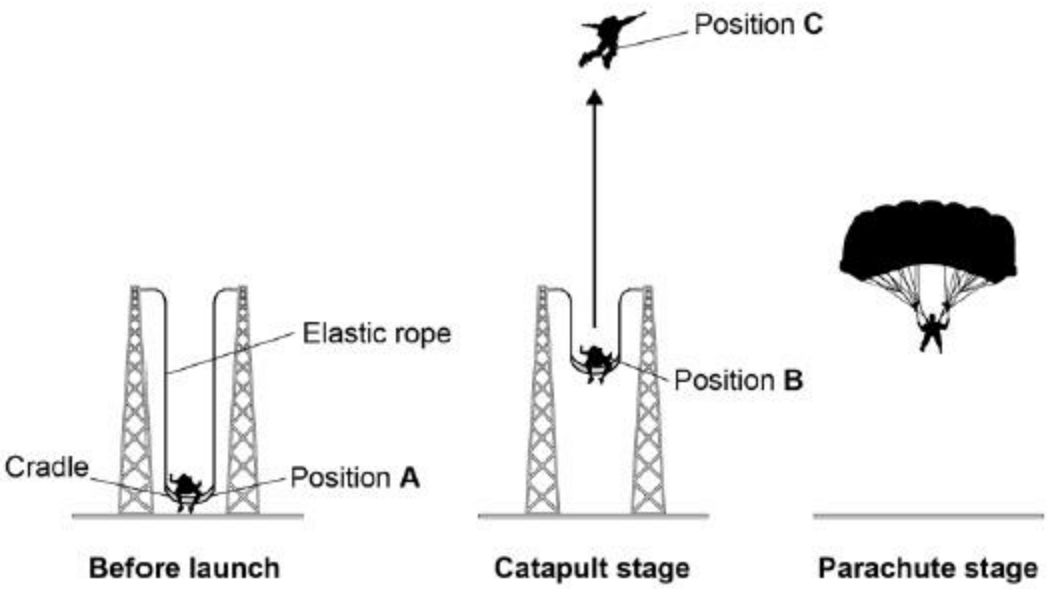
(3)

(Total 13 marks)

Q3.

The diagram shows the stages of an extreme sport called 'human catapult'.

- A person lies in a cradle which is held to the ground.
- The cradle is released.
- The person is launched vertically into the air by an elastic rope.
- The person then parachutes back to the ground.



(a) In position **A** there is a store of elastic energy.

Position **C** is the person's maximum height.

Describe the energy transfers from position **A**, through position **B**, to position **C**.

____

____

____

____

____

____

(3)

(b) In the last few metres of his descent during the parachute stage, the person travels at a terminal velocity.

Explain why.

____

____

____

____

(2)

(c) When stretched in position **A**, the elastic rope stores 25 000 joules.

The elastic rope behaves like a spring, with a spring constant of 125 N/m

Calculate the extension of the elastic rope.

Use the Physics Equations Sheet.

____

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Extension of elastic rope = ______________________ m

(4)

(d) The vertical velocity of the person at position **B** in the diagram is 26 m/s

The vertical velocity at position **C** is 0 m/s

Calculate the distance between position **B** and position **C**. Ignore the effect of air resistance.

Use the Physics Equations Sheet.

____

____

Distance = ____________________ m

(4)

(Total 13 marks)

6.5.5 Forces, accelerations and Newton's Law of Motion

Newton's First Law of Motion

If the resultant force acting on an object is zero and:

- **the object is stationary, the object remains stationary**
- **the object is moving, the object continues to move at the same speed and in the same direction. So the object continues to move at the same velocity.**

The velocity of a vehicle will only change if there is a resultant force acting upon it. If the driving and resistive forces are balanced (there is no resultant force) then the vehicle will continue with a steady velocity (speed and direction).

Inertia – Higher Tier Only

Inertia is a property of matter. It is the **resistance of the object to change its motion** (speed and/or direction).

Mass is a measure of the amount of inertia an object has. The more inertia (or mass) an object has the harder it is to get that object to change its motion.

To find out which of two objects has the most inertia:

- Apply an equal force to both of them when they are at rest.
- The one that has the greatest acceleration has the lowest inertia – it was easier to get it to change its motion.

Newton's Second Law of motion

The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object.

In equation form, Newton's Second Law is written as:

Force (N) = Mass (kg) x Acceleration (m/s²)

$$F = m\,a$$

Inertial mass is the ratio of force divided by acceleration.

Newton's Third Law of motion

Whenever two objects interact, the forces they exert on each other are equal in size and opposite in direction.

Examples:

When a car crashes into a crash barrier, the force acting on the car and the force acting on the barrier are equal and opposite.

A pen falling will be pulled down by the Earth, and the Earth will be pulled up by the pen.

6.5.5 Forces, accelerations and Newton's Law of Motion

EXAM QUESTIONS

Q1.

Figure 1 shows the horizontal forces acting on a man swimming in the sea.

Figure 1

(a) Describe the movement of the man when the resultant horizontal force is 0 N

____

(1)

(b) The man increases Force **A**.

Explain what happens to Force **B** and to the movement of the man.

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(4)

(c) A boat moves through the sea.

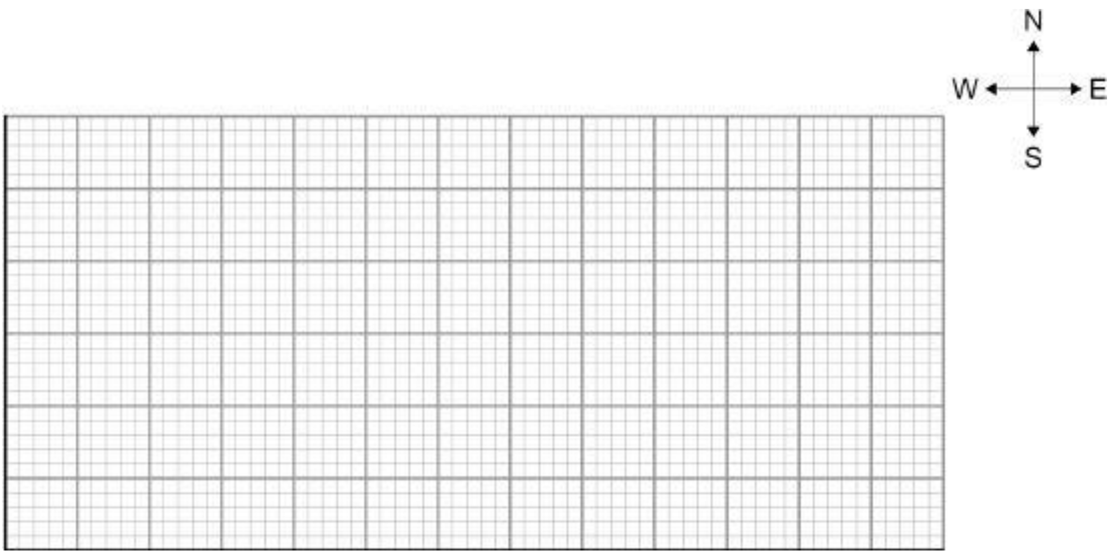
There is a 3000 N force to the west on the boat.

There is a 1000 N force to the south on the boat.

Determine the magnitude and direction of the resultant force on the boat.

Draw a vector diagram of these forces to scale on **Figure 2**

Figure 2



Magnitude of resultant force = ____________________________ N

Direction of resultant force = ____________________________ °

(3)

(d) The force to the south on the boat increases.

What effect does this have on the resultant force on the boat?

____

____

____

____

(2)

(Total 10 marks)

Q2.

The figure below shows an ice skater standing on the ice.

Mass
70 kg

(a) Write down the equation that links acceleration, change in velocity and time.

____

(1)

(b) As the skater pushes away across the ice there is a small frictional force.

After pushing, the skater starts to move with a velocity of 5 m / s.

He slows to 3 m / s in 6 seconds.

Calculate the acceleration of the skater.

____

____

____

Acceleration = __________________ m / s²

(2)

(c) Write down the equation that links acceleration, force and mass.

____

(1)

(d) Friction reduces the speed of the skater.

Calculate the frictional force acting on the skater to slow him down.

____

____

____

Frictional force = ____________ N

(2)

(e) The skater stands still on the ice.

He throws his bag to a friend.

As he throws his bag forwards, the skater moves backwards across the ice.

Use the idea of conservation of momentum to explain why he moves backwards.

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(4)
(Total 10 marks)

Q3.

When two objects interact, they exert forces on each other.

(a) Which statement about the forces is correct?

Tick (✓) **one** box.

	Tick (✓)
The forces are equal in size and act in the same direction.	
The forces are unequal in size and act in the same direction.	
The forces are equal in size and act in opposite directions.	
The forces are unequal in size and act in opposite directions.	

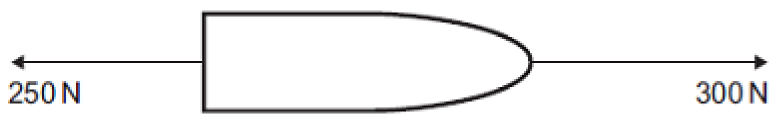
(1)

(b) A fisherman pulls a boat towards land.

The forces acting on the boat are shown in **Diagram 1**.

The fisherman exerts a force of 300 N on the boat.
The sea exerts a resistive force of 250 N on the boat.

Diagram 1



(i) Describe the motion of the boat.

____

____

____

____

(2)

(ii) When the boat reaches land, the resistive force increases to 300 N.
The fisherman continues to exert a force of 300 N.

Describe the motion of the boat.

Tick (✓) **one** box.

Accelerating to the right	☐
Constant velocity to the right	☐
Stationary	☐

(1)

(iii) Explain your answer to part **(b)(ii)**.

____

____

____

____

(2)

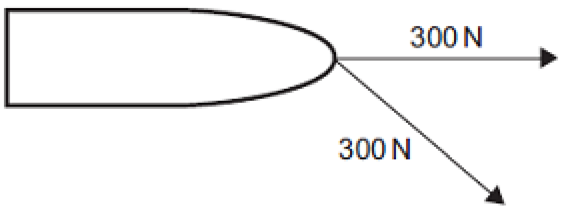
(iv) Another fisherman comes to help pull the boat. Each fisherman pulls with a force of 300 N, as shown in **Diagram 2**.

Diagram 2 is drawn to scale.

Add to **Diagram 2** to show the single force that has the same effect as the two 300 N forces.

Determine the value of this resultant force.

Diagram 2



Resultant force = ____________________ N

(4)

(Total 10 marks)

6.5.6 Forces and breaking

Definitions

Thinking Distance: **Thinking distance is the distance that you travel while reacting to a stimulus until you get your foot onto the brake pedal. Thinking distance depends on reaction time, but these are not the same thing.**

Braking Distance: **Braking distance is the distance you travel from pressing the brake pedal until you come to a stop.**

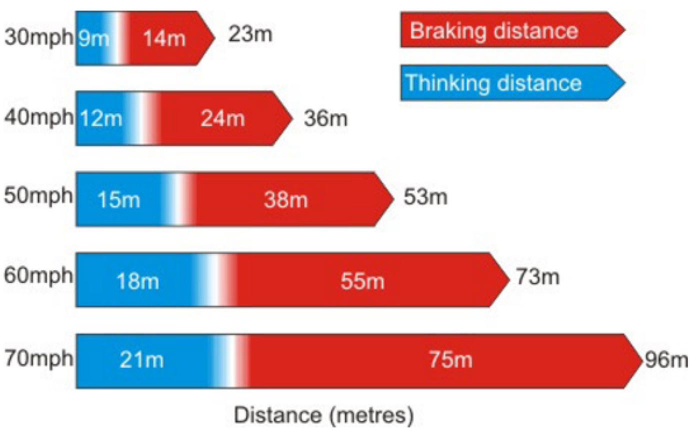
Stopping Distance: **Stopping distance is the sum of thinking distance and braking distance, usually shown as:**

Stopping distance = Thinking distance + Braking distance

How Speed Affects Stopping Distance

Increasing the speed of a vehicle will increase its stopping distance.

The highway code shows the stopping distances for cars at various speeds…



As you can see, when speed increases so does the overall stopping distance.

Also, it is both parts of the overall stopping distance – thinking and braking distance – that increases.

Speed and Thinking Distance

From the highway code it is possible to see patterns in the data.

When you double your speed your thinking distance will also double. This is shown by the thinking distance being 9 m at 30 mph and 18 m at 60 mph. The reason this happens is because your reaction time does not change but you will now travel further while you react:

If you take 0.5 seconds to react then at a speed of 10 m/s you would travel 5 m while reacting to a stimulus. If the speed doubled to 20 m/s then you would now travel 10 m while reacting to the stimulus – the thinking distance has doubled when the speed has doubled.

Speed and Braking Distance

Doubling your speed will more than double your braking distance. In fact doubling the speed of a vehicle will cause the braking distance to quadruple.

At 30 mph the braking distance is 14 m and at 60 mph the braking distance is 55 m (according to the highway code) which is approximately four times greater: The difference of 1 m is accounted for by rounding.

When the speed of a vehicle doubles the kinetic energy of the vehicle is four times greater. This happens because kinetic energy is found using the equation:

$$\text{kinetic energy} = \tfrac{1}{2} \times \text{mass} \times (\text{velocity})^2$$

As there is four times the kinetic energy it takes four times longer to stop at a given braking force.

Reaction Time

A typical person's reaction time varies from 0.2 to 0.9 seconds.

There are a number of factors that will affect your reaction time, and in turn thinking distance.

These factors include:

Factor	Affect on Reaction Time
Alcohol	Increases
Caffeine	Decreases
Tiredness	Increases
Distractions	Increases

Drugs can either increase or decrease reaction times as some drugs are stimulants and some are depressants.

Measuring Reaction Time

A person's reaction time is very short. Trying to measure this reaction time is going to be difficult but there are ways of measuring it.

1. **There are online tests that display a stimulus and measures the time taken to respond to the stimulus – often by clicking a mouse button.**

2. **Ruler drop. This is where a ruler is dropped through your hand. As soon as you see the ruler move you close your hand. The distance that the ruler moves through your hand corresponds to a given reaction time - these can be found online at:**

   http://www.topendsports.com/testing/tests/reaction-stick.htm

Factors Affecting Braking Distance

There are a number of factors that affect the braking distance of a vehicle. Some of these are shown in the table below:

Factor Affecting Braking Distance	How this factor affects braking distance
Speed	Increasing speed increases braking distance
Weight of Vehicle	Increasing weight of vehicle increases braking distance
Icy Roads	Braking distance increases due to reduced friction between tyre and road
Wet Roads	Braking distance increases due to reduced friction between tyre and road
Poor Brake Condition	Braking distance increases
Bald Tyres	Braking distance increases when wet.

Braking Force

When a force is applied to the brakes of a vehicle, work done by the frictional forces between the brake pads and the brake disc reduces the kinetic energy of the vehicle and the temperature of the brakes increases.

The greater the speed of a vehicle the greater the braking force needed to stop the vehicle in a certain distance.

The greater the braking force the greater the deceleration of the vehicle. Large decelerations may lead to brakes overheating and/or loss of control.

6.5.6 Forces and breaking

EXAM QUESTIONS

Q1.

The image below shows a lorry.

(a) The brakes of the lorry are in a poor condition.

What effect will the condition of the brakes have on thinking distance and the braking distance of the lorry?

Thinking distance ____

____

Braking distance ____

____

(2)

(b) Using a hand-held mobile phone while driving is illegal in the United Kingdom.

The table below shows the effect of using a mobile phone on thinking distance.

	Thinking distance
Not using a mobile phone	19 m
Using a mobile phone with hands-free kit	23 m
Using a hand-held mobile phone	27 m

Explain why driving while using a hand-held mobile phone is more dangerous than using a mobile phone with a hands-free kit.

Use data from the table above.

____

(4)

(Total 6 marks)

Q2.

The stopping distance of a car depends on the thinking distance and the braking distance.

(a) Thinking distance depends on the driver's reaction time.

Give **two** factors that can affect reaction time.

1.____

2.____

(2)

(b) Give **one** factor that can affect the braking distance.

(1)

(c) The thinking distance is the distance travelled during the driver's reaction time.

A car was travelling at 13 m/s

The driver's reaction time was 0.6 s

Calculate the thinking distance.

Use the equation:

distance travelled = speed × time

Thinking distance = ____________________ m

(2)

(d) The braking distance of the car was 14.0 m

What was the stopping distance of the car?

____

____

Stopping distance = ____________________ m

(1)

(e) What is the link between speed and braking distance?

Complete the sentence.

The greater the speed, the

____

(1)

(f) If a large braking force is applied, the car decelerates and stops in a very short distance.

Give **two** disadvantages of applying a large braking force.

1. ____

____

2. ____

____

(2)

(Total 9 marks)

Q3.

A number of different forces act on a moving vehicle.

(a) A car moving at a steady speed has a driving force of 3000 N.

(i) What is the value of the resistive force acting on the car?

Tick (✓) **one** box.

	Tick (✓)
2000 N	
3000 N	
4000 N	

(1)

(ii) What causes most of the resistive force?

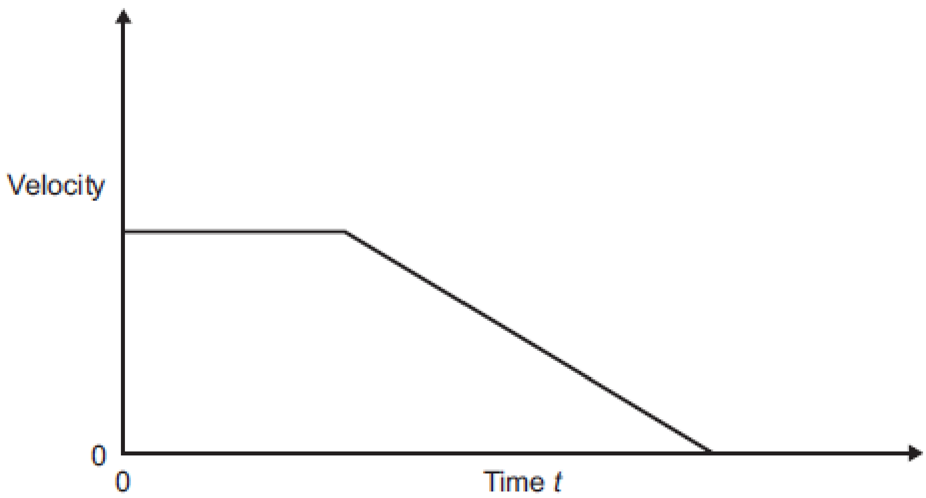
Tick (✓) **one** box.

	Tick (✓)
Air resistance	
Faulty brakes	
Poor condition of tyres	

(1)

(b) A car is moving along a road. The driver sees an obstacle in the road at time t = 0 and applies the brakes until the car stops.

The graph shows how the velocity of the car changes with time.



(i) Which feature of the graph represents the negative acceleration of the car?

Tick (✓) **one** box.

	Tick (✓)
The area under the graph	
The gradient of the sloping line	
The intercept on the y-axis	

(1)

(ii) Which feature of the graph represents the distance travelled by the car?

Tick (✓) **one** box.

	Tick (✓)
The area under the graph	
The gradient of the sloping line	
The intercept on the y-axis	

(1)

(iii) On a different journey, the car is moving at a **greater** steady speed.

The driver sees an obstacle in the road at time t = 0 and applies the brakes until the car stops.

The driver's reaction time and the braking distance are the same as shown the graph above.

On the graph above draw another graph to show the motion of the car.

(3)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Thinking distance and braking distance affect stopping distance.

Explain how the factors that affect thinking distance and braking distance affect stopping distance.

____

____

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____

(6)

6.5.7 Momentum (HT)

Momentum

Momentum is a vector quantity.

The momentum of an object only depends on it's mass and it's velocity.

The equation linking momentum, mass and velocity is:

Momentum (kg m/s) = Mass (kg) x Velocity (m/s)

$$p = m\,v$$

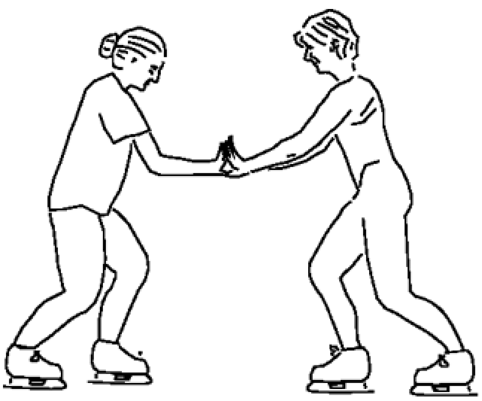
From this equation we can see that if an object is not moving (it has a velocity of 0 m/s) then it has no momentum.

Momentum is a conserved quantity. The momentum of a system remains the same before and after an event.

e.g. In a car crash the momentum of the vehicles before the crash equals the momentum of the vehicles after the crash.

In an explosion the momentum of the system is also conserved. This may seem strange as everything is stationary to begin with, but after the explosion parts are moving to the left and right and these cancel – since velocity is a vector and depends on direction.

An example of an explosive event is two ice skaters pushing themselves apart, where the momentum of each ice skater is equal in size and opposite in direction to the other. This then adds to be 0 kgm/s, which is what it was at the start.



6.5.7 Momentum (HT)

EXAM QUESTIONS

Q1.

Figure 1 shows a man using a resistance band when exercising.

The resistance band behaves elastically.

Figure 1

(a) What happens to the store of elastic potential energy of the resistance band when the band is stretched?

____

(1)

(b) Explain what happens to the resistance band as it is released.

____

____

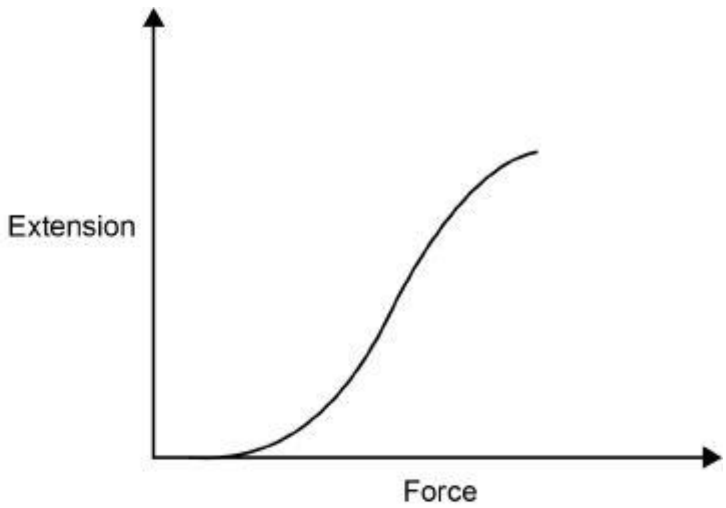
____

____

(2)

(c) **Figure 2** shows how the extension of the resistance band changes as the force applied changes.

Figure 2



Describe the trend shown in the graph.

____

____

____

____

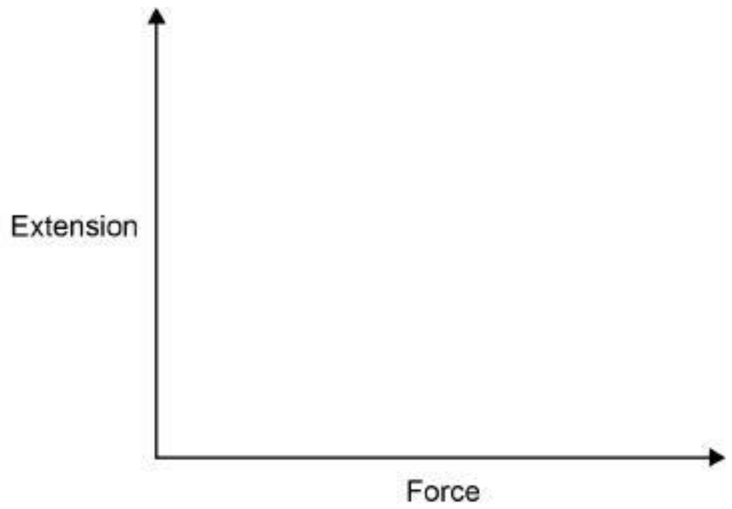
(2)

Figure 3 shows a chest expander.

Figure 3

(d) Sketch a graph on **Figure 4** to show how the extension of a spring in the chest expander changes as the force applied changes.

Figure 4



(2)

When a force is applied to a spring, the spring extends by 7.5 cm

(e) Write down the equation that links extension, force and spring constant.

____

(1)

(f) Calculate the force applied to the spring.

The spring has a spring constant of 1 600 N/m

Use your equation from part **(e)**

____

____

____

Force = ____________________ N

(3)

(Total 11 marks)

Q2.

The diagram below shows an ice skater, Skater A.

(a) Write down the equation that links mass, momentum and velocity.

___

(1)

(b) Skater **A** travels with a velocity of 3.2 m/s and has a momentum of 200 kg m/s

Calculate the mass of Skater **A**.

___

___

Mass = ______________________ kg

(3)

(c) Skater **A** bumps into another skater, Skater **B**. Skater **B** is stationary.

The skaters move off together in a straight line.

Explain what happens to the velocity of each of the skaters.

Use the idea of conservation of momentum.

___

___

___

___

___

___

(3)

(Total 7 marks)

Q3.

A paintball gun is used to fire a small ball of paint, called a paintball, at a target.

The figure below shows someone just about to fire a paintball gun.

The paintball is inside the gun.

(a) What is the momentum of the paintball before the gun is fired?

____

Give a reason for your answer.

____

____

(2)

(b) The gun fires the paintball forwards at a velocity of 90 m / s.

The paintball has a mass of 0.0030 kg.

Calculate the momentum of the paintball just after the gun is fired.

____

____

____

Momentum = ____________________ kg m / s

(2)

(c) The momentum of the gun and paintball is conserved.

Use the correct answer from the box to complete the sentence.

equal to	**greater than**	**less than**

The total momentum of the gun and paintball just after the gun is fired

will be ____________________________ the total momentum of the gun and paintball before the gun is fired.

(1)
(Total 5 marks)