OCR
Oxford Cambridge and RSA

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Tuesday 23 November 2021 – Morning

GCSE (9–1) Physics B (Twenty First Century Science)

J259/03 Breadth in physics (Higher Tier)

Time allowed: 1 hour 45 minutes

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You must have:
- a ruler (cm/mm)
- the Data Sheet for GCSE (9–1) Physics B (inside this document)

You can use:
- a scientific or graphical calculator
- an HB pencil

J259/03

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks might be given for using a correct method even if your answer is wrong.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

Answer **all** the questions.

1 Sundip wants to measure Alex's reaction time.

Their teacher gives them a 30 cm ruler, and the table shown.

Reading on ruler (cm)	Reaction time (s)
12	0.15
15	0.17
18	0.19
21	0.20
24	0.22
27	0.23
30	0.24

(a) Explain how to use the ruler and the table to measure Alex's reaction time.

You can draw a diagram to support your answer.

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..... **[3]**

(b) Suggest why the table does **not** include values below 12 cm.

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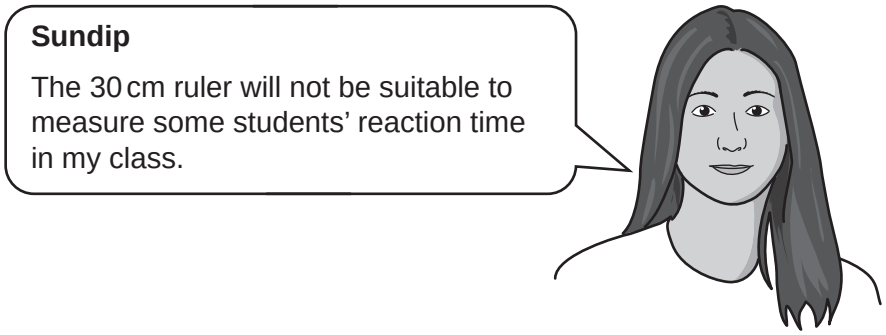
..... **[1]**

(c) Sundip wants to use the 30 cm ruler to measure the reaction times of her class.



Explain why Sundip is correct and suggest **one** solution to this problem.

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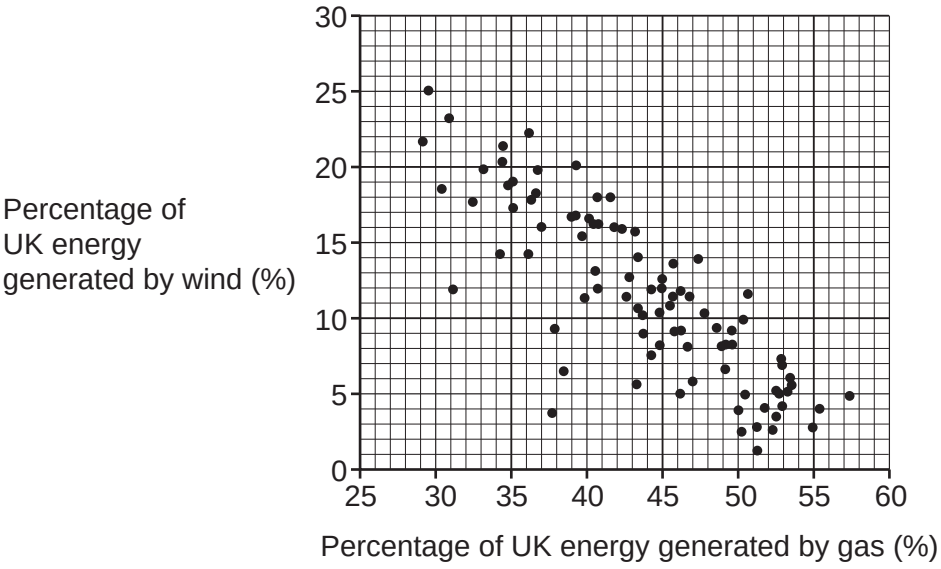
..... **[2]**

2 A large percentage of electricity in the UK is generated using wind turbines and gas-fired power stations.

The graph compares the percentage of UK energy generated by wind and gas from January to March 2017.

Each plot point shows the energy generated in one day.



(a) Describe and explain the relationship shown in the graph.

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..... **[3]**

(b) Mia and James discuss the data.

Mia

Gas power stations are bad for the environment.

(i) Give **one** reason why Mia is correct.

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..... **[1]**

James

In the future there will be more wind turbines, so we won't need gas power stations anymore.

(ii) Discuss James' comment.

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..... **[2]**

3 An atomic clock is a very accurate way of measuring time.

Many atomic clocks use electromagnetic radiation emitted from caesium atoms.

(a) Explain how an atom can emit electromagnetic radiation.

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..... **[2]**

(b) The frequency of electromagnetic radiation emitted from caesium atoms is 9.19×10^9 Hz.

Calculate the wavelength of this radiation.

Speed of light = 3.0×10^8 m/s.

Wavelength = ... m **[3]**

(c) Satellite navigation systems rely on atomic clocks for their accuracy.

Suggest **one** way that society has benefited from the invention of accurate satellite navigation systems.

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..... **[1]**

4 The Voyager 1 spacecraft was launched into space in 1977 to study the outer Solar System.

(a) Radio waves transfer information from Voyager 1 back to the Earth.

What else is transferred by the radio waves?

..... **[1]**

(b) **(i)** The radio waves emitted by Voyager 1 have a wavelength of approximately 14 cm. The distance between the Earth and Voyager 1 is approximately 2×10^{10} km.

Estimate the total number of complete wavelengths in the space between the Earth and Voyager 1.

Number of wavelengths = ... **[3]**

(ii) Define the **wavelength** of a radio wave.

You can draw a diagram to support your answer.

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..... **[2]**

(c) Voyager 1 is moving away from the Earth at a high speed. This causes the wavelength of the radio waves to change as they travel towards the Earth.

Explain how the wavelength of the radio waves has changed when they are received on the Earth.

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..... **[2]**

5 Hydroelectric power is a renewable source of energy. Hydroelectric power stations work by storing water in a reservoir behind a dam.

Fig. 5.1 shows an example of a hydroelectric power station.

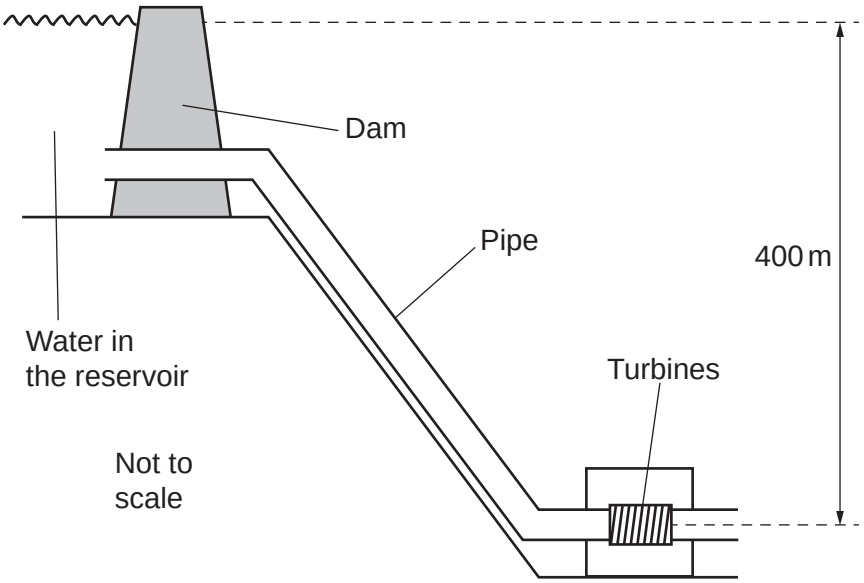

Fig. 5.1

(a) **Fig. 5.2** shows a representation of the reservoir in the hydroelectric power station.

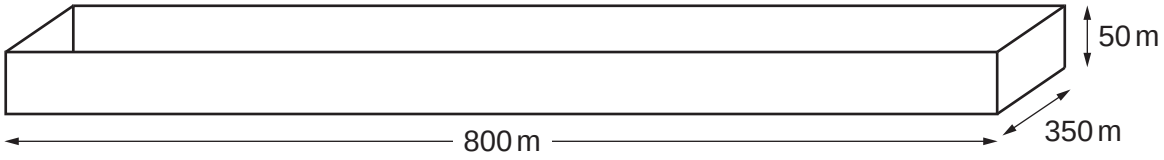

Fig. 5.2

Calculate the total mass of water that can be held in the reservoir.

Density of water = 1000 kg / m^3.

Mass = ... kg **[3]**

(b) The water in the reservoir is a store of gravitational energy. The water falls a vertical distance of 400 m from the reservoir to the turbines, as shown in **Fig. 5.1**.

Calculate the total available gravitational energy when the reservoir is holding 8.0×10^9 kg of water.

Gravitational field strength = 10 N / kg

Gravitational energy = ... J **[3]**

(c) The efficiency of the hydroelectric power station is 75%.

On one occasion, the hydroelectric power station has an output power of 140 MW for a time of 1 hour.

Calculate the total **energy input** required for this output power.

Use the equation: energy transferred = power × time

Give your answer in **joules**.

Total energy input = ... J **[4]**

6 This question is about X-rays.

(a) Give **two** examples of practical uses of X-rays

1. .....

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2. .....

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[2]

(b) X-rays are produced by firing electrons at a metal target in a high-voltage electrical circuit.

When the electrons hit the metal target, their kinetic energy is converted into X-rays.

(i) Calculate the work done on an electron when it moves across a potential difference of 50 000 V.

The charge on an electron is 1.6×10^{-19} C.

Work done = ... J **[3]**

(ii) Suggest how the energy of the X-rays could be increased.

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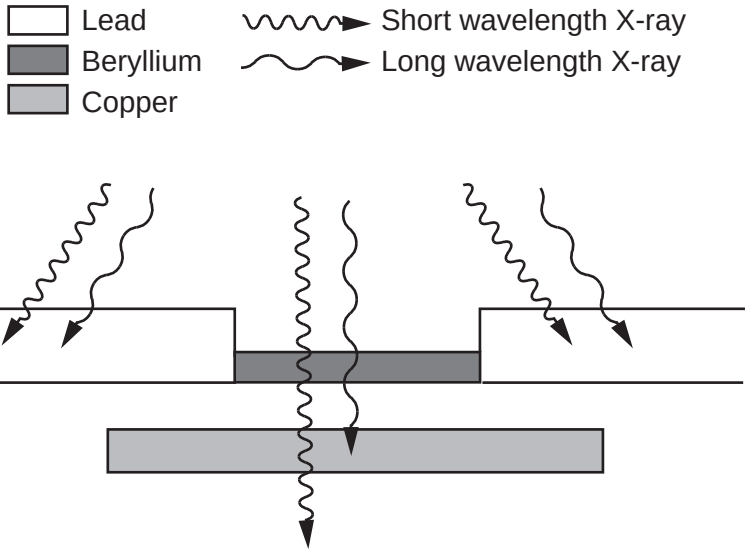
..... **[1]**

(c) An X-ray machine contains lead, beryllium, and copper, as shown in the diagram.



Describe how X-rays of different wavelengths are affected by the three different materials.

Use the diagram to support your answer.

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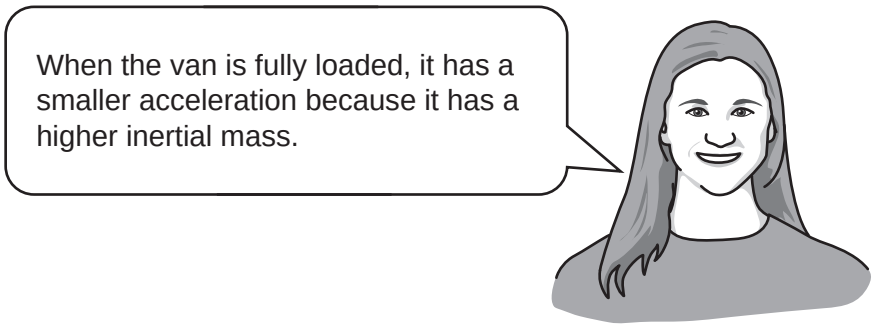
..... **[3]**

7 Layla uses a van to deliver parcels.

(a)



Explain what is meant by inertial mass **and** how it can be calculated.

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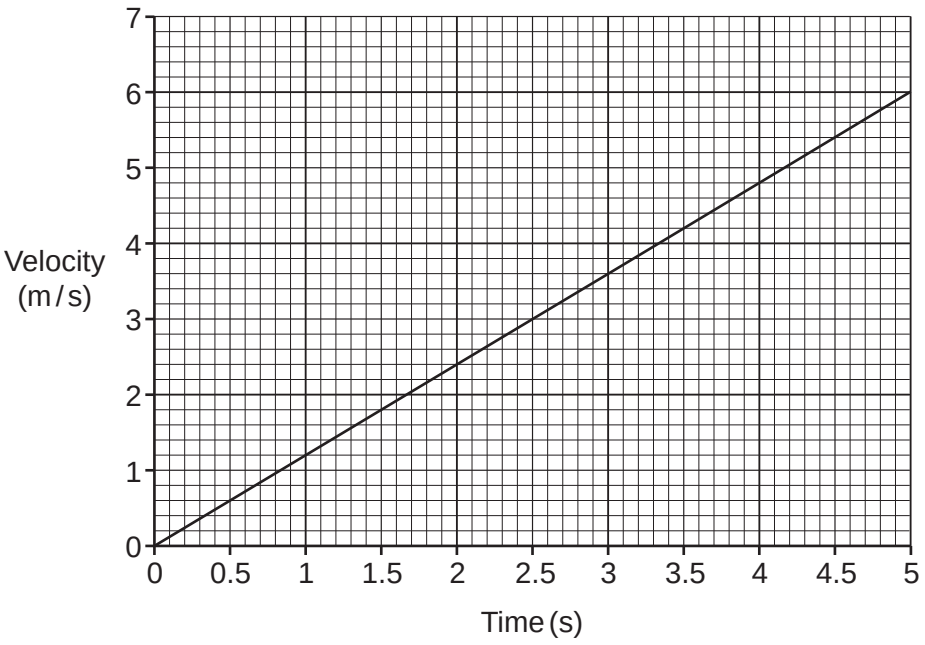
(b) This is a velocity-time graph for the first 5 seconds of the van's motion.



(i) Calculate the acceleration of the van during the first 5 seconds of its motion.

Acceleration = ... m/s^2 **[3]**

(ii) What does the velocity-time graph show about the resultant force acting on the van in the first 5 seconds of its motion?

Use Newton's second law to explain your answer.

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..... **[2]**

(iii) After 4.0 seconds the kinetic energy of the van is 40 000 J.

Calculate the mass of the van.

Use the equation: kinetic energy = 0.5 × mass × (speed)^2

Use the graph.

Mass = ... kg **[2]**

8 Ali investigates different types of lenses.

Fig. 8.1 shows how rays of light are refracted by a **concave** lens.

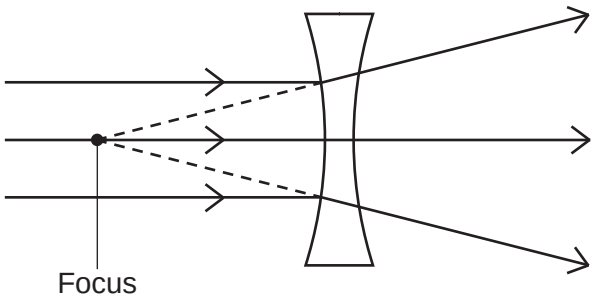


Fig. 8.1

Fig. 8.2 shows rays of light directed at a convex lens.

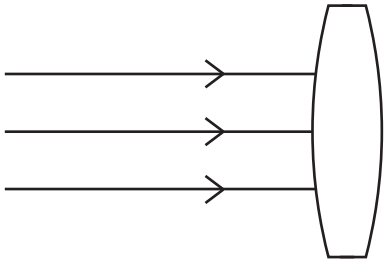
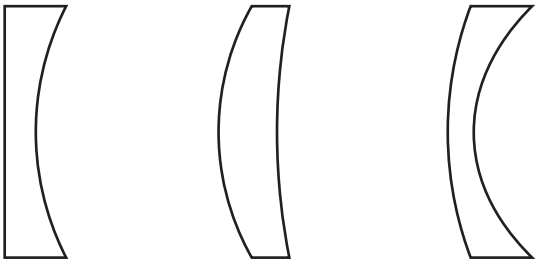


Fig. 8.2

(a) Complete **Fig. 8.2** to show how rays of light are refracted by a **convex** lens.

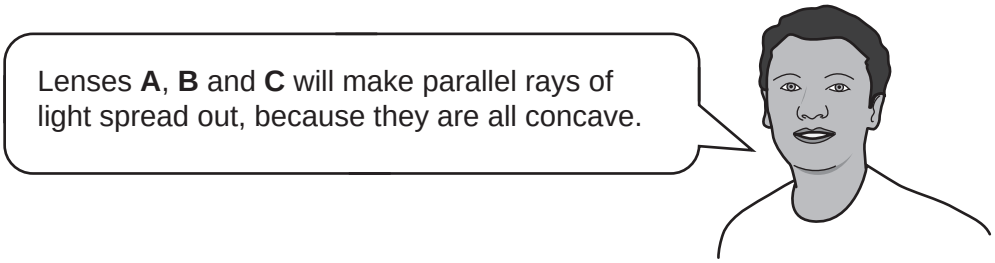
Clearly label the **focus** of the lens. **[2]**

(b) Ali looks at three more lenses, as shown in **Fig. 8.3**.



Lens A **Lens B** **Lens C**

Fig. 8.3



Explain why Ali is wrong.

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..... **[2]**

(c) Ali wants to make a lens to focus sound waves.
He uses a large convex glass lens that is designed to focus light.

Sound travels faster in glass than in air.

Suggest what will happen to sound waves when they arrive at the lens.

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..... **[2]**

9 Jamal and Beth want to install a boiler to heat their house.

They consider using wood pellets or heating oil as an energy source for their new boiler.

(a) Wood pellets are a type of biofuel. Heating oil is a fossil fuel.

Give the similarities and differences between biofuels and fossil fuels as energy sources.

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..... **[3]**

(b) They find the information shown in the table.

	Wood pellets	**Heating oil**
Energy density (MJ / kg)	20	40
Density (kg / m^3)	760	950
Cost (p / kg)	25	55

Which energy source should they use for their new boiler?

Wood pellets ☐

Heating oil ☐

Use calculations in your answer.

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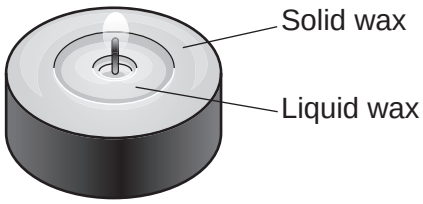
10 Ling lights a candle.

After a few minutes, some of the wax close to the flame has melted.



(a) **(i)** What is the difference between specific heat capacity and specific latent heat?

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(ii) The temperature of the room is 20 °C. The melting point of the wax is 52 °C. For the wax to melt, it must first increase in temperature to its melting point.

Calculate the value of the ratio:

$$\frac{\text{energy to melt 1 kg of wax at 52 °C}}{\text{energy to increase temperature of 1 kg of wax from 20 °C to 52°C}}$$

Use the Data Sheet.

Specific heat capacity of wax = 2300 J / kg °C

Specific latent heat of melting of wax = 210 000 J / kg

Ratio = ... **[3]**

(b) Describe what happens, in terms of energy, when Ling blows out the candle.

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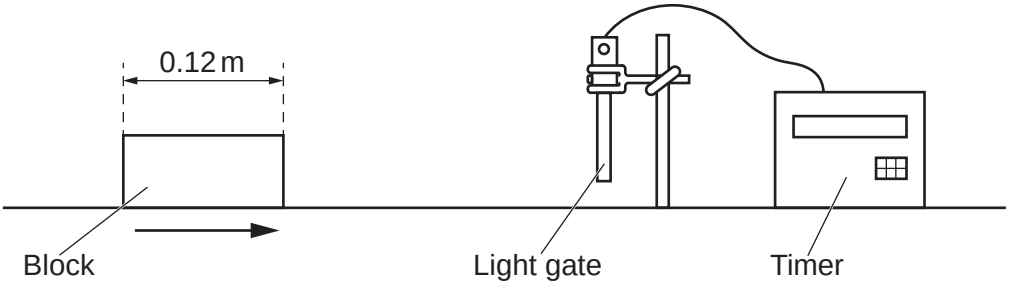
..... **[2]**

11 Nina investigates the effect of frictional forces on a sliding object. She uses a block of wood which is on a table, as shown in the diagram.

She pushes the block with her hand to start it moving. She then releases it and waits for it to come to rest.

To measure the speed of the block, she uses a light gate, as shown in the diagram.



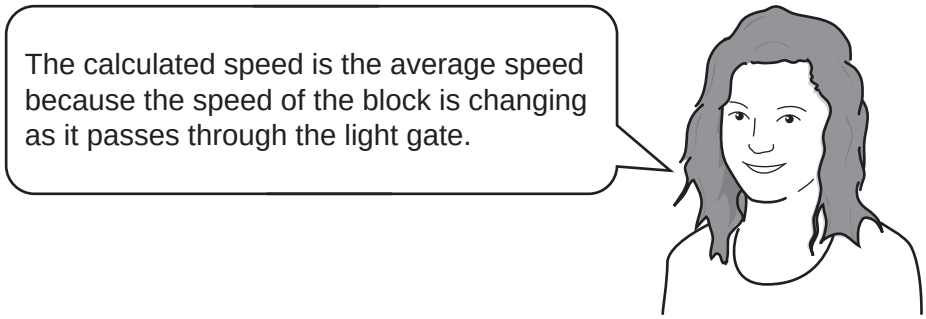
(a) The light gate measures the time that the block takes to pass through it.
In one test, the block takes 0.64 seconds to pass through the light gate.

The length of the block is 0.12 m.

(i) Calculate the average speed of the block as it passes through the light gate.

Average speed = ... m / s **[3]**

(ii) Nina comments on the average speed calculated in **(a)(i)**.



Explain why the speed of the block changes, as it passes through the light gate.

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..... **[2]**

(b) Nina wants to do an experiment to investigate how the mass of the block affects the distance travelled by the block before it stops.

Suggest how Nina could do this experiment.

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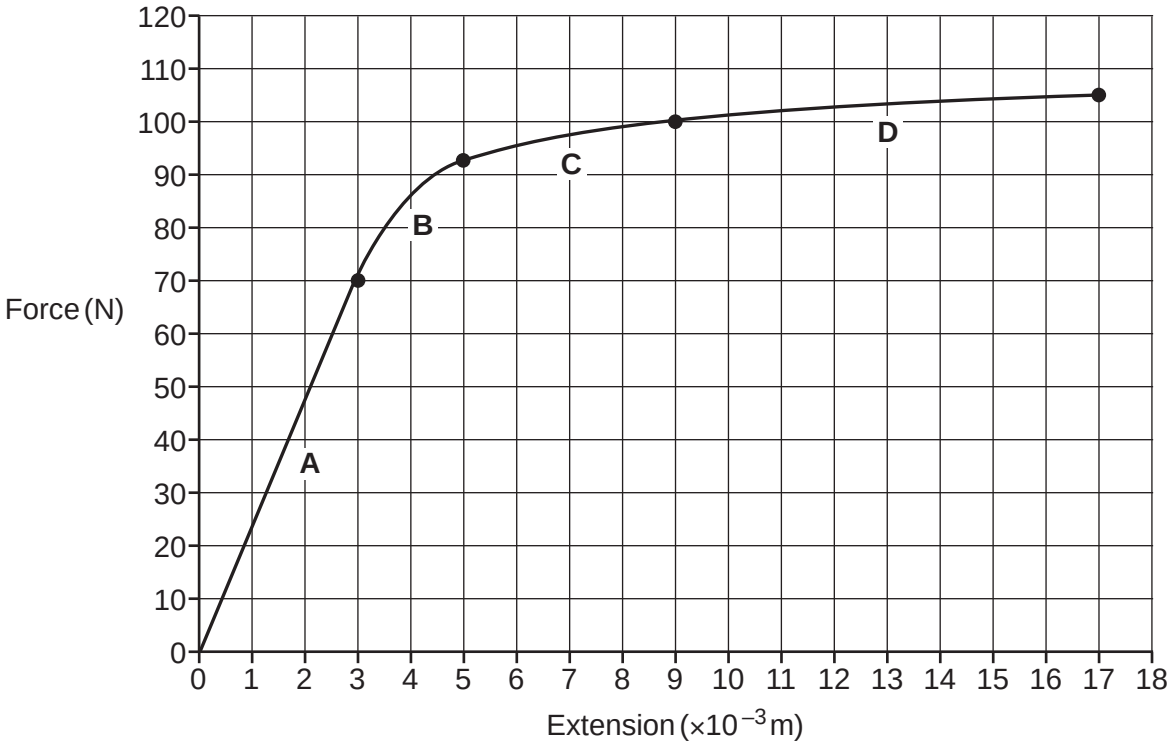
..... **[3]**

12 Amir investigates the properties of a metal wire.

He measures how the extension of the wire depends on the force applied to the wire.

The graph shows his results.

Four sections on the graph have been labelled **A**, **B**, **C** and **D**.



(a) Explain which section on the graph shows **linear** behaviour.

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..... **[2]**

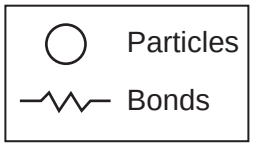
(b) Estimate the work done in stretching the wire, in section **D**.

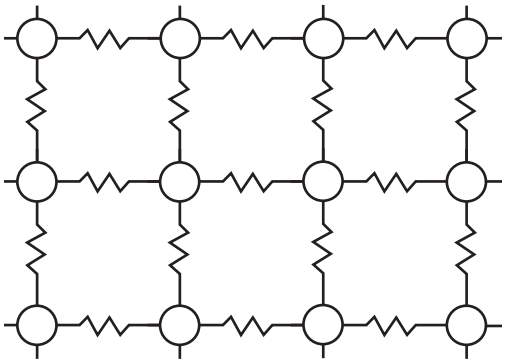
The area under the graph represents the work done in stretching the wire.

Work done = ... J **[3]**

(c) Amir draws a particle model of the metal.

Key:





(i) Explain the type of deformation in **Section A** of the graph.

Use ideas from the particle model in your answer.

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..... **[2]**

(ii) Explain the type of deformation in **Section C** of the graph.

Use ideas from the particle model in your answer.

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END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).