OCR
Oxford Cambridge and RSA

Wednesday 22 May 2024 – Morning

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

J259/03 Breadth in physics (Higher Tier)

Time allowed: 1 hour 45 minutes

H

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

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

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.

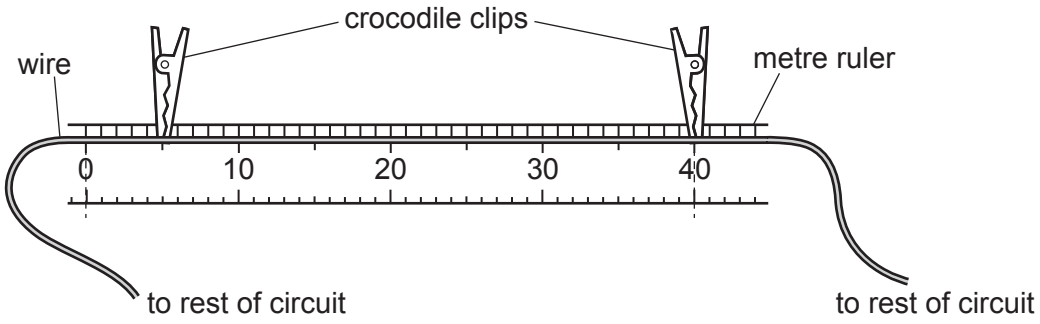
INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **32** pages.

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

1 A student wants to find the resistance of a piece of wire.

They clip the wire into a circuit with an **ammeter**, **voltmeter** and **variable power supply**.

The diagram shows how they clip the wire into the circuit.



(a) Draw a circuit diagram to show the full circuit they use.

Use:

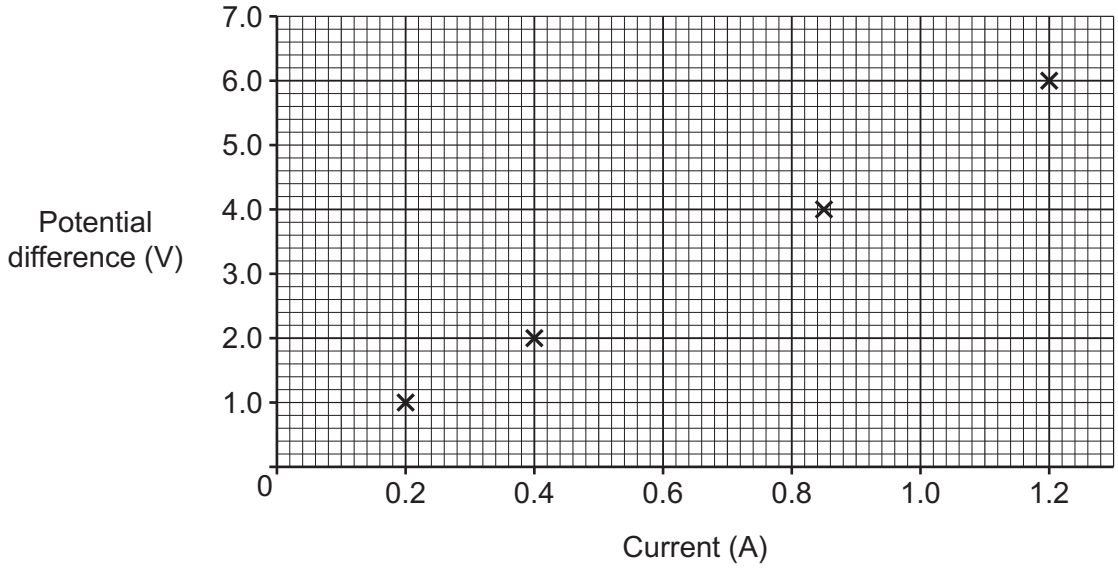
- this symbol for the wire —●—●—
- this symbol for the variable power supply —o o—

[3]

(b) The student records the data shown in the table and plots a graph.

Current (A)	Potential difference (V)
0.20	1.0
0.40	2.0
0.65	**3.2**
0.85	4.0
0.98	**4.8**
1.20	6.0

(i) Plot the **two** missing points on the graph.



[1]

(ii) Draw a line of best fit on the graph. **[1]**

(iii) Calculate the gradient of the line.

Gradient = ... **[2]**

(iv) Find the resistance of the wire.

Resistance = ... Ω **[1]**

(c) The student clips a new piece of the same wire in the circuit and repeats their method to find the resistance.
The new piece of wire is double the length.

Describe how the resistance of the new length of wire is different to the resistance of the original length of wire.

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

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Turn over for the next question

2 The table shows information about some objects in the solar system.

Name	**Pluto**	**Charon**	**Earth**	**The Moon**
Type of object	dwarf planet	moon	planet	moon
Orbits around	The Sun	Pluto	The Sun	Earth
Diameter (km)	2370	1210	12700	3480
Mass (kg)	1.3×10^{22}	1.6×10^{21}	6.0×10^{24}	7.4×10^{22}
Radius of orbit (km)	5.9×10^{9}	2.0×10^{4}	1.5×10^{8}	3.9×10^{5}
Gravitational force between the two objects (N)	5.0×10^{16}	3.5×10^{18}	3.5×10^{22}	1.9×10^{20}

(a) Name another **type** of object in the solar system that is **not** listed in the table.

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

(b) A student looked at the data and said:
'A moon is always approximately half the diameter of the object it orbits.'

Show that the student is **incorrect**.

Use data from the table.

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

(c) Explain the difference in the time taken for Pluto and Earth to orbit the Sun.

Use data from the table.

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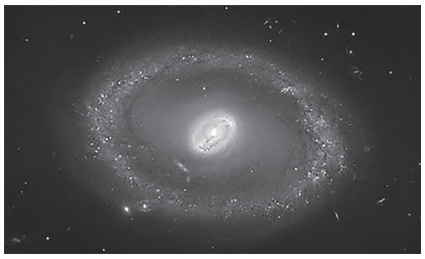
..... **[2]**

(d) The photo shows the formation of a star from a cloud of dust and gas.



Complete the sentences to explain the formation of the solar system and the birth of the Sun.

Use words from the list.

chemical	**combustion**	**friction**	**fusion**	**gravity**	**magnetism**

The objects in the solar system were formed over long periods of time from clouds of dust and gas drawn together by the force of ..... .

Particles at the centre collapsed together forcefully and increased the pressure and temperature until ..... reactions began, forming the Sun. **[2]**

(e) The diagrams represent the processes inside a star.

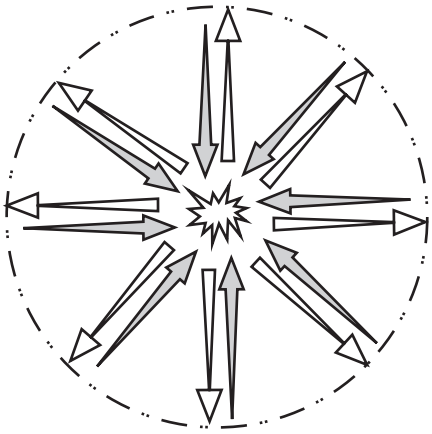
Which diagram shows how these processes keep a star, like the Sun, stable in size and shape for millions of years?

Tick (✓) **one** box.

Pressure

Gravity

☐



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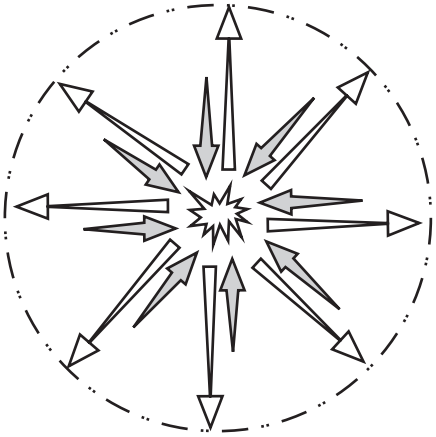

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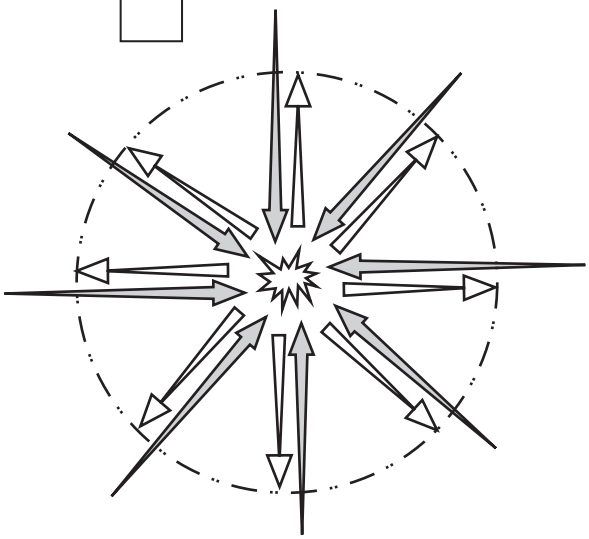

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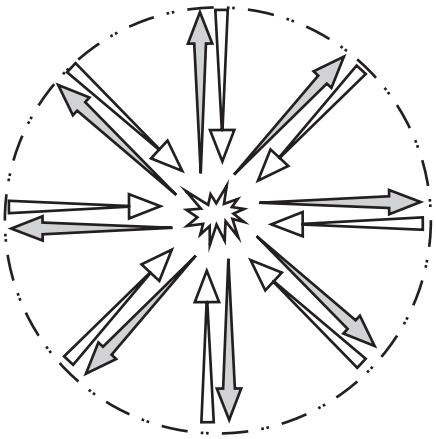

[1]

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3 Many bikes use disc brakes.

Fig. 3.1 shows a diagram of a braking system fitted to a wheel.

Fig. 3.2 shows a thermal image of the same wheel, taken just after braking. On the right-hand side there is a temperature scale showing the shading.

Fig. 3.1

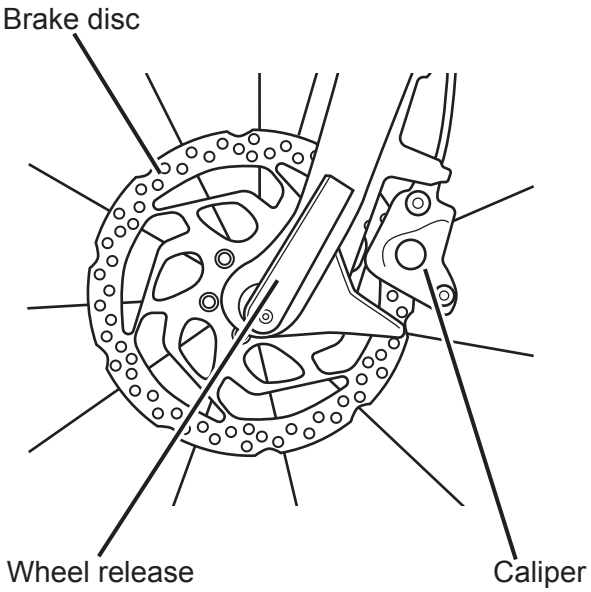
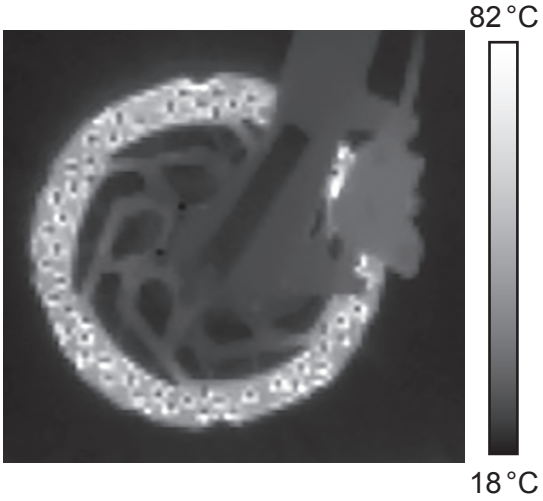


Fig. 3.2



(a) Which part of the bike visible in **Fig. 3.2** gets hottest during braking?

Tick (✓) **one** box.

Brake disc ☐

Caliper ☐

Wheel release ☐

[1]

(b) The brake disc is attached to the wheel. When the brakes are applied, calipers clamp onto the disc to slow it down.

Explain how brakes slow a bike down.

Use ideas about forces.

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

(c) Complete the sentence to explain why brakes get hot.

Use words from the list.

chemical	**elastic**	**gravitational**	**kinetic**	**thermal**

The brakes transfer energy from the ..... store of the bike to the

..... store of the brake disc.

[2]

(d) A brake disc increases in temperature by 60 °C during braking.

Calculate the change in internal energy of the brake disc.

The mass of the brake disc is 0.2 kg.
The specific heat capacity of the brake disc steel is 500 J / kg °C.

Use the Equation Sheet.

Change in internal energy = ... J **[3]**

4 Microwaves are transverse waves used for mobile phone communication.

(a) Describe a transverse wave.

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

(b) The signal strength on a mobile device is shown by the symbols below.

Good signal strength means that the microwaves have a high amplitude.

Define the amplitude of a wave.

You can include a diagram to support your answer.

.....

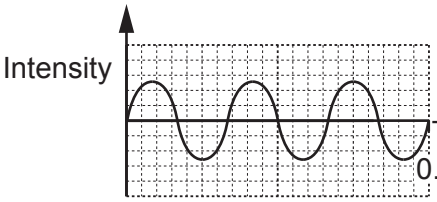
..... **[2]**

(c) The graph of a microwave signal is drawn with time on the x-axis.

The wave has a time period of 0.3 ns.

Which is the correct graph for this wave?

Tick (✓) **one** box.



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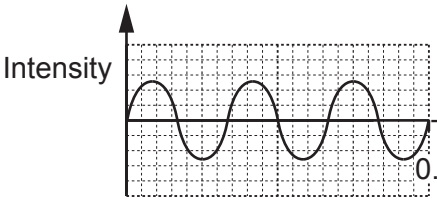

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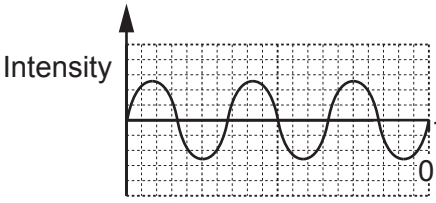

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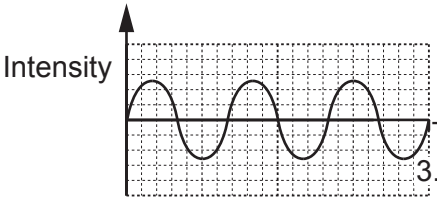

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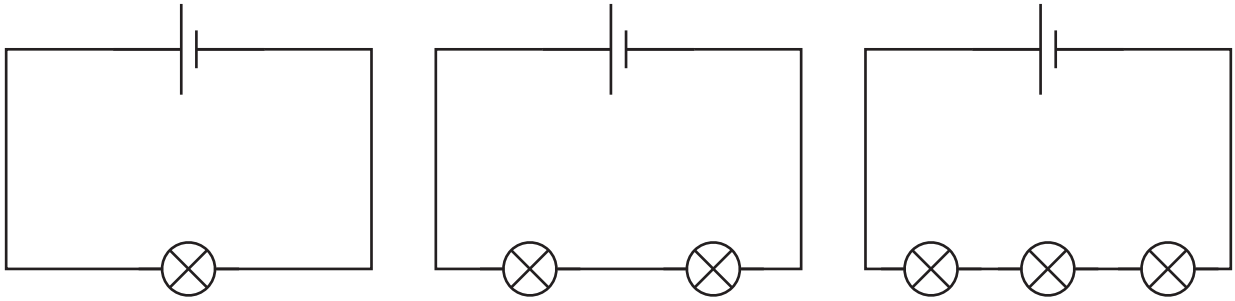
[1]

5 A student is investigating the brightness of lamps connected in different ways.

(a) The student makes the circuits shown in the diagram.

They observe the brightness of the lamps in each circuit and compare them by ranking them from brightest to dimmest.



Suggest how the method can be improved to give better quality data that does not rely on human judgement.

You can include diagrams to support your answer.

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(b) Explain how you expect the brightness to change as the number of lamps in the circuit increases.

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

(c) The table shows information for two types of lamp which have the same brightness.

Type	Lifetime in h	Energy transferred in one lifetime, in kWh
LED	24 000	432
Halogen	4 000	216

Evaluate which lamp is more sustainable.

Use data from the table.

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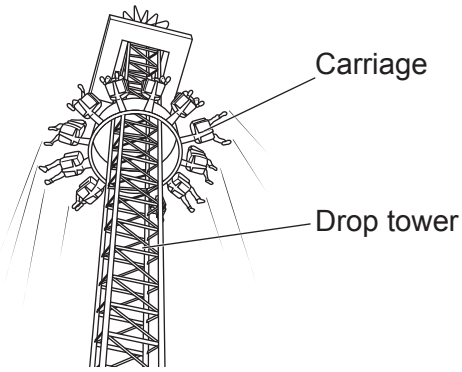
..... **[3]**

6 The diagram shows a fairground ride called the Drop Tower.

Riders are pulled up to the top by a pulley. The pulley is powered by an electric motor.



(a) The ride takes 30 s to get to the top of the tower.
The pulley operates at a power of 40 kW.

Calculate the energy transferred by the pulley.

Use the Equation Sheet.

Energy transferred = ... J **[4]**

(b) The ride drops from rest at the top of the tower.
The carriage falls under freefall for 40 m before the brakes are applied.

Calculate the maximum possible speed it could reach, assuming there is no air resistance.

Use the Equation Sheet.
The acceleration due to gravity is 10 m / s^2.

Maximum speed = ... m / s **[4]**

(c) The carriage reaches a maximum speed of only 25 m/s because of air resistance.

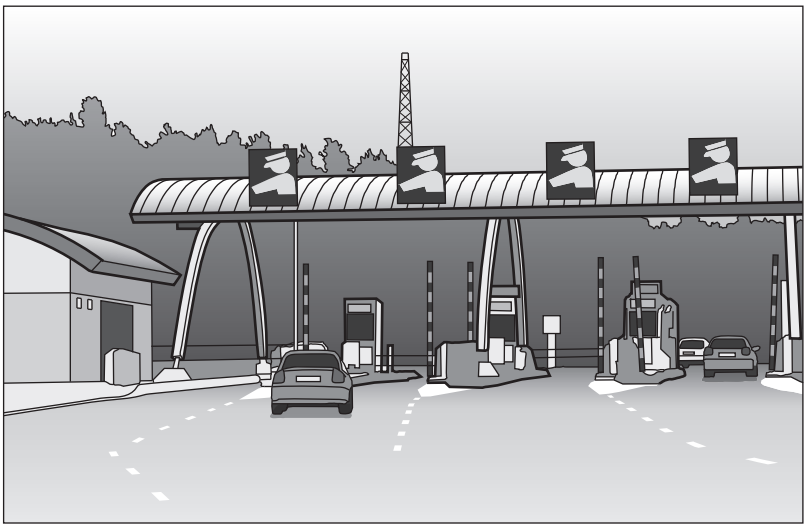
Calculate the total kinetic energy gained by the carriage and the riders between the top of the tower and when they reach a speed of 25 m/s.

The mass of the carriage is 1500 kg.
The mass of the riders is 840 kg.

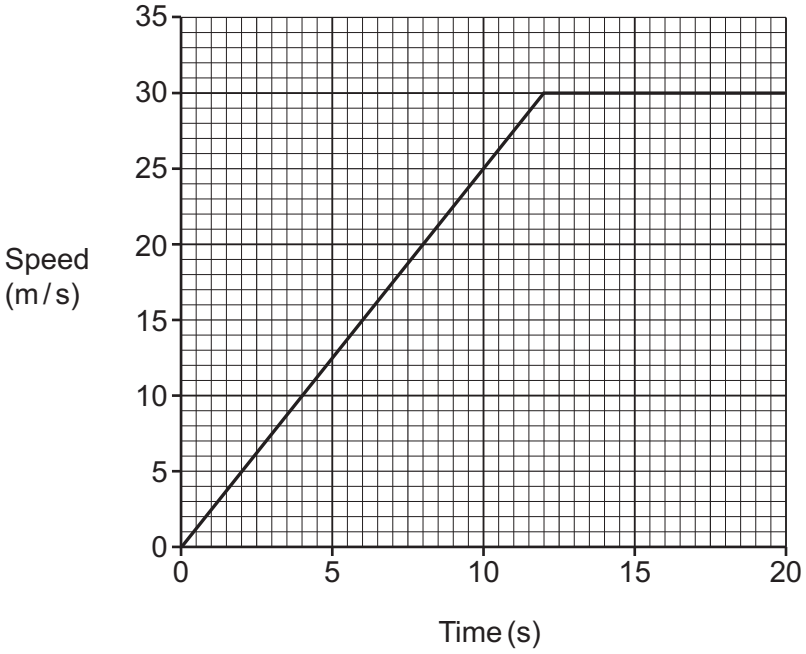
Use the Equation Sheet.

Kinetic energy gained = ... J **[3]**

7 Drivers pay to use a toll road. Cars stop at a payment point and then accelerate to the usual road speed.



(a) The graph shows the speed-time graph of a car after leaving the payment point.



(i) Calculate the acceleration of the car between 0 and 12 s.

Use data from the graph.

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

(ii) Which feature of the graph will give the distance the car has travelled?

Tick (✓) **one** box.

Area between the line and the x-axis ☐

Area between the line and the y-axis ☐

Gradient ☐

y-intercept ☐

[1]

(iii) Calculate the momentum of the car when it reaches a constant speed of 30 m / s.

The mass of the car is 950 kg.

Use the Equation Sheet.

Momentum = ... kg m / s **[3]**

(b) Later in the journey, the car is driving with a momentum of 14 250 kg m / s.
The driver brakes sharply and the car comes to a stop in 3 s.

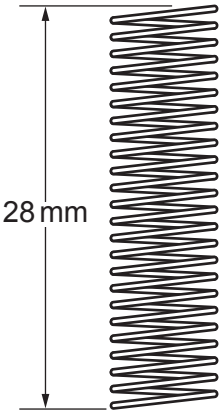
Calculate the force that stops the car.

Use the Equation Sheet.

Force = ... N **[3]**

8 A student investigates a spring from a ball point pen.

They put small weights on top of the spring to compress it.



uncompressed spring

spring fully compressed

The table shows their results.

Force (N)	Height of spring (mm)	Compression (mm)
0.00	28	0
0.05	27	
0.10	26	
0.15	25	
0.20	24	
0.25	23	

(a) Complete the table by working out the values of compression (mm) for the spring. **[1]**

(b) The student concludes that force is directly proportional to compression.

Explain how the data shows this.

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

(c) Compression and extension both have the same relationship with the force on a spring.

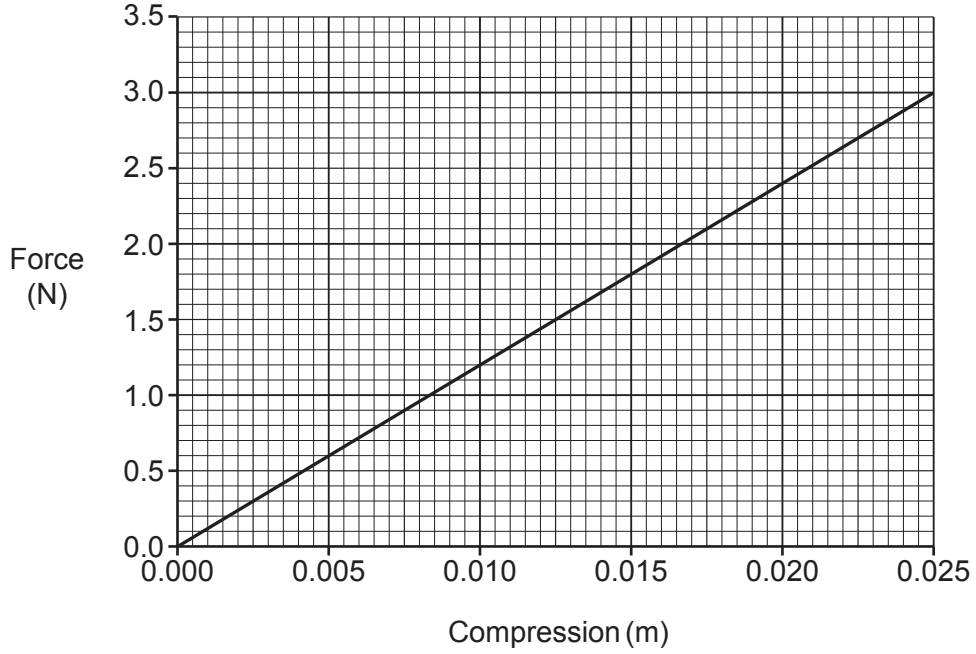
Calculate the spring constant for this spring.

Use data from the table.
Use the Equation Sheet.

Spring constant = ... N / m **[4]**

(d) Another spring has a different spring constant.

The force-compression graph is shown below.

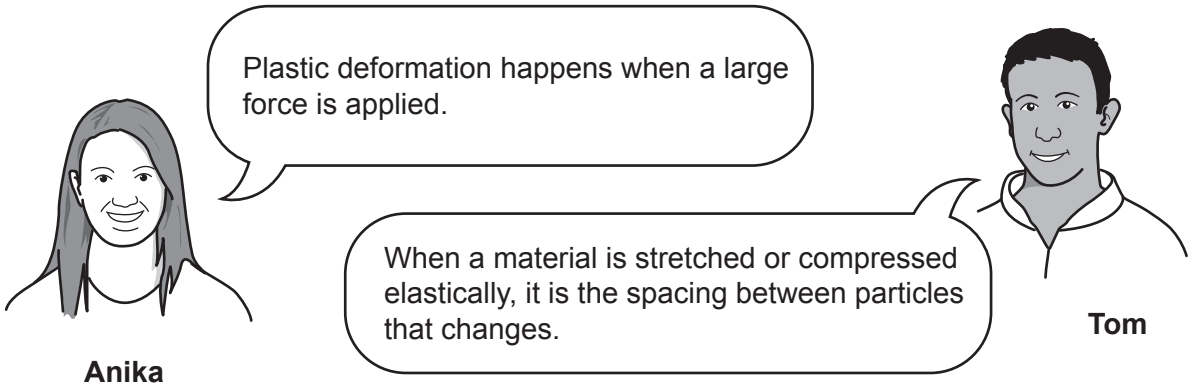


(i) Calculate the energy stored in this spring at a compression of 0.01 m.

Energy = ... J **[3]**

(ii) **Draw** a second line on the graph to represent a spring with a lower stiffness. **[1]**

(e) Two students are discussing plastic and elastic deformation of materials when a force is applied.



Discuss whether the students are correct.

Use the particle model to explain your answer.

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

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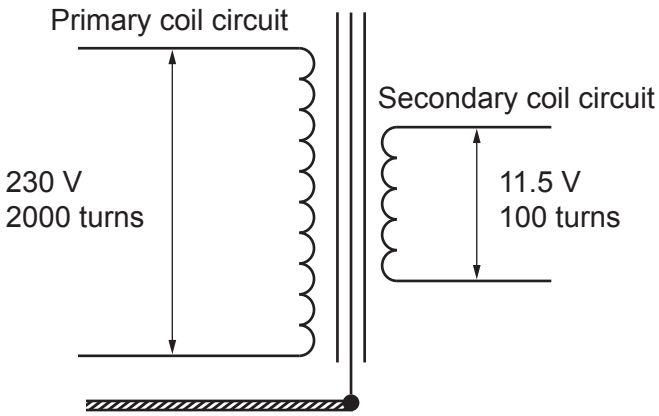
9 Engineers are designing a transformer to go inside a light fitting for a low voltage ceiling light.



(a) Explain why a battery cannot be used in a transformer.

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

(b) Show how the potential differences of the primary and secondary coils relate to the number of turns on each coil.

Use data from the diagram in your answer.

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

(c) This transformer is only 85% efficient.
The engineers want to make it more efficient to make the light fitting safer for household use.

Explain why transformers are not 100% efficient and what risk this presents.

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

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Turn over for the next question

10 This question is about neutrons.

(a) Neutrons are involved in beta decay.

Explain why the atomic mass number does **not** change when a nucleus emits a beta particle.

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

(b) Beryllium-13 is an unstable isotope of beryllium.
It emits a neutron by neutron decay to turn into a more stable nucleus.

(i) Complete the equation for beryllium-13 when it decays.

$$^{13}_{4}Be \rightarrow \square^{\square}_{4}\square + {}^{1}_{0}n$$

[2]

(ii) The half-life of beryllium-13 is 3×10^{-21} seconds.

Describe what is meant by half-life.

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

(c) Neutron beam therapy is used to treat tumour cells in the neck and brain.
It includes these steps:

- A patient is injected with a solution of boron-10.
- The boron-10 becomes concentrated in the tumour cells.
- The neutron beam is aimed at the tumour.
- The neutrons cause the boron-10 to emit alpha and gamma radiation at the site of the tumour.

(i) Explain why the alpha radiation causes more damage to body tissues in the patient than the gamma radiation.

.....

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

(ii) Which radiation presents the most risk to the medical staff who give this treatment?

Tick (✓) **one** box.

Explain your answer.

Alpha particles ☐

Gamma radiation ☐

Explanation .....

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

(iii) Suggest **one** way the risk to the medical staff can be minimised.

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

(iv) When boron-10 absorbs a neutron, it decays to become stable lithium-7 by emitting alpha and gamma radiation.

Show that total mass is conserved in the decay of boron-10 to lithium-7.

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

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.