Oxford Cambridge and RSA

Friday 14 June 2024 – Afternoon

GCSE (9–1) Physics A (Gateway Science)

J249/04 (Higher Tier)

Time allowed: 1 hour 45 minutes

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

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

H

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 answer 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 **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **32** pages.

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

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Section A

You should spend a **maximum** of **30 minutes** on this section.

Write your answer to each question in the box provided.

1 A force of 1200 N moves an object a distance of 16 m.

What is the work done on the object?

Use the equation: work done = force × distance

A 75 J

B 9600 J

C 19 200 J

D 153 600 J

Your answer ☐ **[1]**

2 Which row describes the potential difference for a washing machine and for a battery-operated torch?

	Washing machine	**Torch**
A	6 V a.c.	6 V a.c.
B	6 V d.c.	230 V d.c.
C	230 V a.c.	230 V d.c.
D	230 V a.c.	6 V d.c.

Your answer ☐ **[1]**

3 Which factor will **increase** the braking distance of a car travelling on a road?

A Drinking alcohol

B Driving when tired

C More people in the car

D Using new brake pads

Your answer ☐ **[1]**

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4 Which electromagnetic waves can cause cancer **and** help treat cancer?

A Gamma rays and X-rays

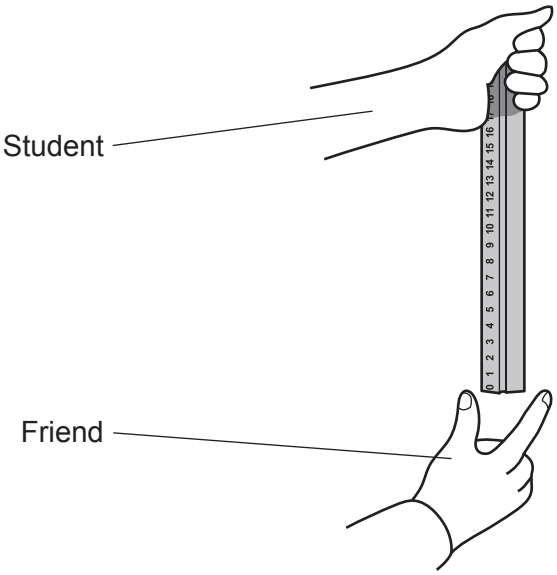
B Infrared and X-rays

C Microwaves and infrared

D Radio waves and gamma rays

Your answer ☐ **[1]**

5 A student drops a ruler and a friend catches it.



The reaction time of the friend is calculated from the distance the ruler has fallen. The experiment is repeated.

What does the student do to determine an accurate value for the reaction time?

A Check the reaction time with a stopwatch

B Drop the ruler at random times

C Drop the ruler from different heights above the friend's hand

D Tell the friend when the ruler will be dropped

Your answer ☐ **[1]**

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6 What causes the hearing range of humans to decrease as they age?

A Lower frequencies cannot be heard.

B The eardrum vibrates more quickly.

C The pinna gets smaller.

D The shorter hairs in the cochlea stop working first.

Your answer ☐ **[1]**

7 A motorcyclist has a mass of 80 kg and rides his motorcycle at 25 m / s.

The motorcycle has a mass of 160 kg.

What is the total kinetic energy of the motorcyclist **and** motorcycle?

Use the equation: kinetic energy = $\frac{1}{2}$ × mass × (speed)^2

A 3000 J

B 25 000 J

C 75 000 J

D 150 000 J

Your answer ☐ **[1]**

8 A radio wave has a frequency of 88 MHz.

What is 88 MHz converted to kHz?

A 0.088 kHz

B 88 000 kHz

C 88 000 000 kHz

D 88 000 000 000 kHz

Your answer ☐ **[1]**

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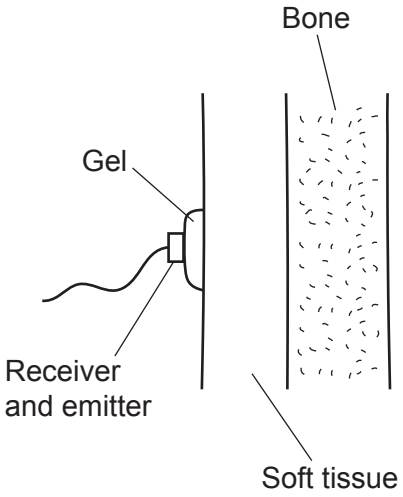
9 The diagram shows a patient having an ultrasound scan.



The speed of ultrasound in soft tissue is 1500 m / s.

The echo from the boundary between the soft tissue and the bone is received 2.0×10^{-5} s after the ultrasound is emitted.

What is the thickness of the soft tissue?

Ignore the thickness of the gel.

Use the equation: distance travelled = speed × time

A 0.015 m

B 0.030 m

C 0.060 m

D 0.075 m

Your answer ☐ **[1]**

10 Which answer shows 800 km / h converted into m / s?

A 0.22 m / s

B 13.3 m / s

C 222 m / s

D 13 333 m / s

Your answer ☐ **[1]**

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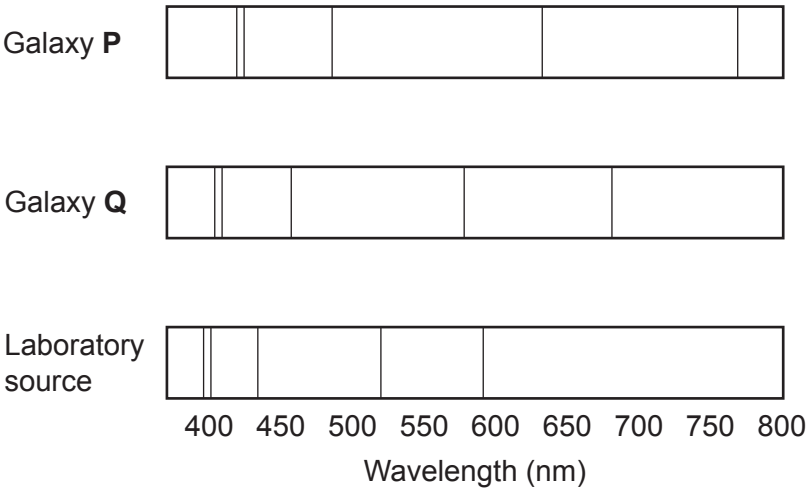
11 The diagram shows the emission spectra obtained from stars in two different galaxies.

The same spectrum is shown from a laboratory source on the Earth.



Which statement is correct?

A Galaxy **P** is further away from the Earth than galaxy **Q**.

B Galaxy **P** is moving away from the Earth more slowly than galaxy **Q**.

C Galaxy **P** is moving towards the Earth.

D Galaxy **P** shows a smaller red-shift than galaxy **Q**.

Your answer ☐ **[1]**

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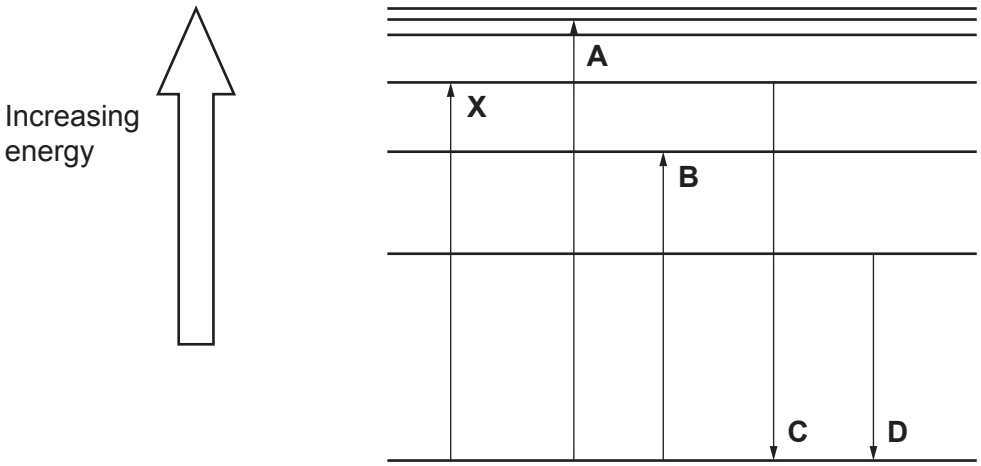
12 The diagram shows energy levels in an atom.

Arrow **X** shows the movement of an electron that has absorbed infrared radiation.



Which arrow shows the movement of the same electron if it had absorbed radiation with more energy?

Your answer ☐ **[1]**

13 In one month a wind turbine on a house generates 300 kW h of useful energy.

The efficiency of the wind turbine is 0.60.

What is the wasted energy in one month?

Use the equation: $\text{efficiency} = \dfrac{\text{useful output energy transfer}}{\text{input energy transfer}}$

A 120 kW h

B 180 kW h

C 200 kW h

D 450 kW h

Your answer ☐ **[1]**

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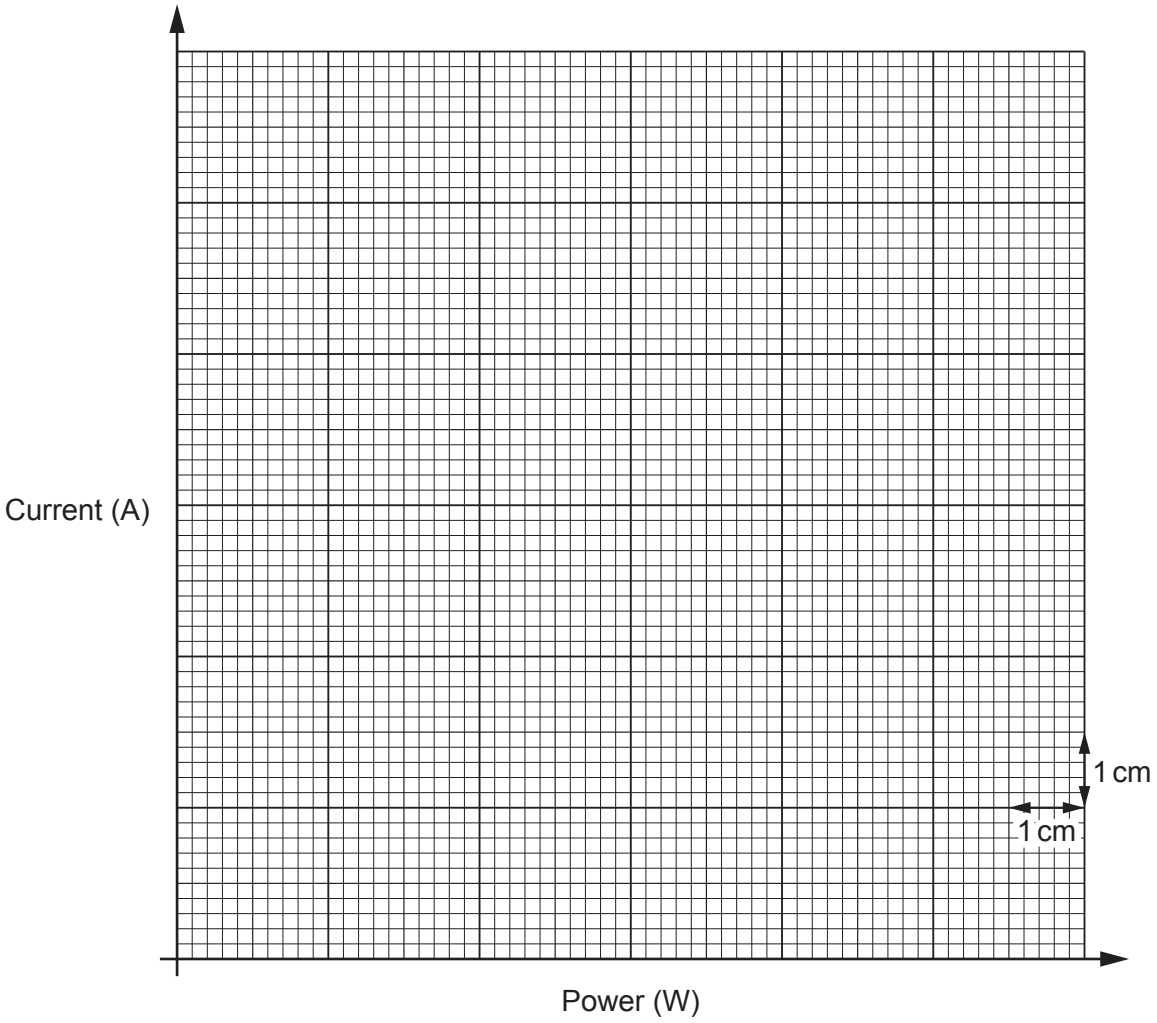
14 A student investigates how the power of an appliance changes the current in the live wire.

Power (W)	Current (A)
70	0.3
160	0.7
600	2.6
900	3.9
1200	5.2

The student plots a graph of the results using this graph paper.



Which scales should the student use for each axis?

	Power (W)	Current (A)
A	1 cm = 100 W	1 cm = 0.5 A
B	1 cm = 100 W	1 cm = 1.0 A
C	1 cm = 200 W	1 cm = 0.5 A
D	1 cm = 200 W	1 cm = 1.0 A

Your answer ☐ **[1]**

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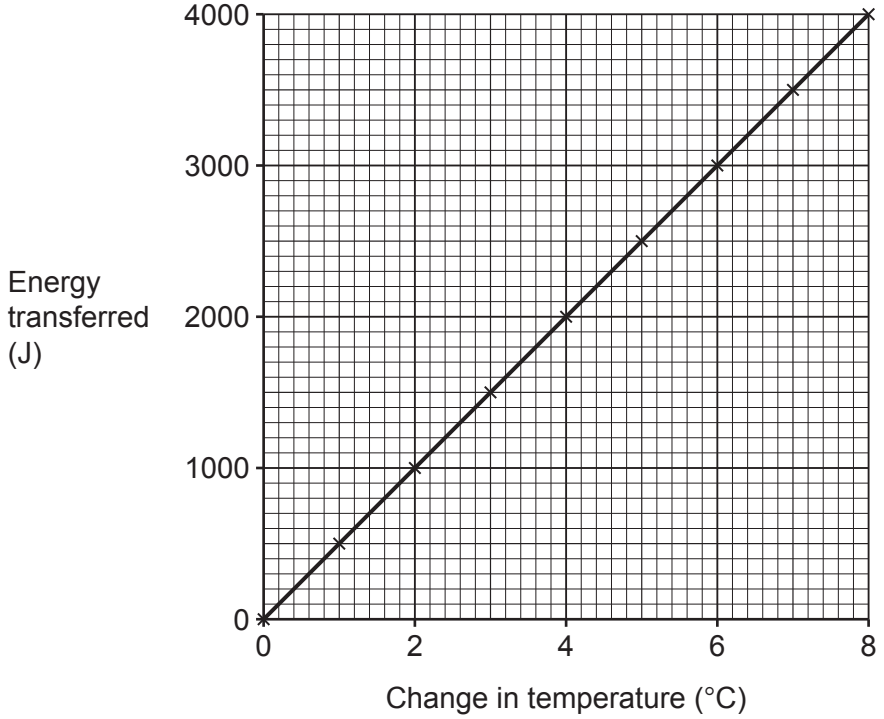
15 A student uses an immersion heater to increase the temperature of 0.25 kg of oil.

The student calculates the energy transferred to the oil.

This is a graph of the student's results.



What is the specific heat capacity of the oil?

Use the graph and the Equation Sheet.

A 500 J / kg °C

B 2000 J / kg °C

C 4200 J / kg °C

D 16 000 J / kg °C

Your answer ☐ **[1]**

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Section B

16 This question is about how electricity is transferred from a power station to homes.

(a) Draw:
- **one** line to connect **each** type of transformer with the **one** box that describes what it does
- **one** line to connect what each type of transformer does with the **one** box that gives the reason for its use.

Type of transformer	What it does	Reason for its use
	Decreases current	For safety
Step-down transformer	Decreases potential difference	Increases heat losses
Step-up transformer	Generates current	Reduces heat losses

[2]

(b) The table shows information for a transformer.

Potential difference across primary coil	132 000 V
Current in secondary coil	1800 A
Potential difference across secondary coil	33 000 V

Calculate the current in the primary coil of the transformer.

Use the Equation Sheet.

Current in primary coil = ... A **[2]**

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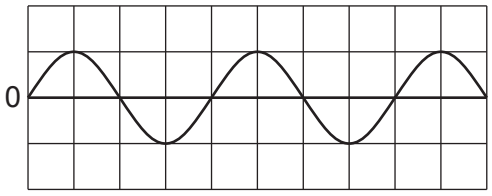
(c) A teacher connects the primary coil of a transformer to the domestic mains supply.

The teacher uses an oscilloscope to view the potential difference across the secondary coil of the transformer.

The graph shows the oscilloscope trace.



Use the graph to explain which type of current is supplied by the mains supply.

Type of current .....

Explanation .....

[2]

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17 In 1986, there was an accident when a nuclear reactor in a power station exploded.

In the explosion, radioactive materials from inside the reactor were spread over the power station.

(a) Explain why workers at the power station were both contaminated **and** irradiated in the accident.

Contaminated because .....

.....

Irradiated because .....

.....

[2]

(b) The flow diagram shows energy transfers when electricity is generated in a nuclear power station.

Nuclear reaction	→	**Water is heated and changes into steam**	→	**Steam turns turbine**	→	**Generator produces electricity**
..... store of uranium decreases.		..... store of water increases.		..... store of turbine increases as it starts to turn.		Energy transferred electrically.

Complete the flow diagram to show the changes in energy stores. **[3]**

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(c) One of the elements released in the accident when the nuclear reactor exploded was caesium-137.

Caesium-137 has a half-life of 30 years.

(i) Explain what is meant by the phrase ‘a half-life of 30 years’.

.....

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

(ii) Which sentence explains why we use the idea of half-life in radioactive decay?

Tick (✓) **one** box.

Radioactive decay is a random process. ☐

When a nucleus decays, it splits in half. ☐

With large numbers, it is easier to count half of the nuclei. ☐

[1]

(iii) In the accident, 28 kg of caesium-137 was released into the atmosphere.

What mass of caesium-137 remains undecayed after 90 years?

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

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(d) A nuclear reactor needs neutrons to start a nuclear fission reaction.

A plutonium nucleus (Pu) decays into a uranium nucleus (U) and an alpha particle ($^{4}_{2}He$).

The alpha particle then joins with a beryllium nucleus (Be) to produce a carbon nucleus (C) and a neutron (n).

Complete the equations.

$$^{238}_{94}Pu \rightarrow \,^{\cdots\cdots}_{\cdots\cdots}U + \,^{4}_{2}He$$

$$^{9}_{4}Be + \,^{4}_{2}He \rightarrow \,^{12}_{6}C + \,^{\cdots\cdots}_{\cdots\cdots}n$$

[3]

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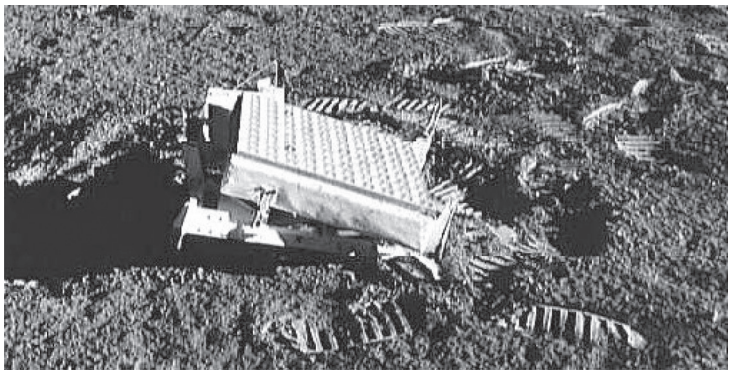
18 A space mission in 1969 placed an object called a retroreflector on the surface of the Moon.

Fig. 18.1 shows the retroreflector.

Fig. 18.1

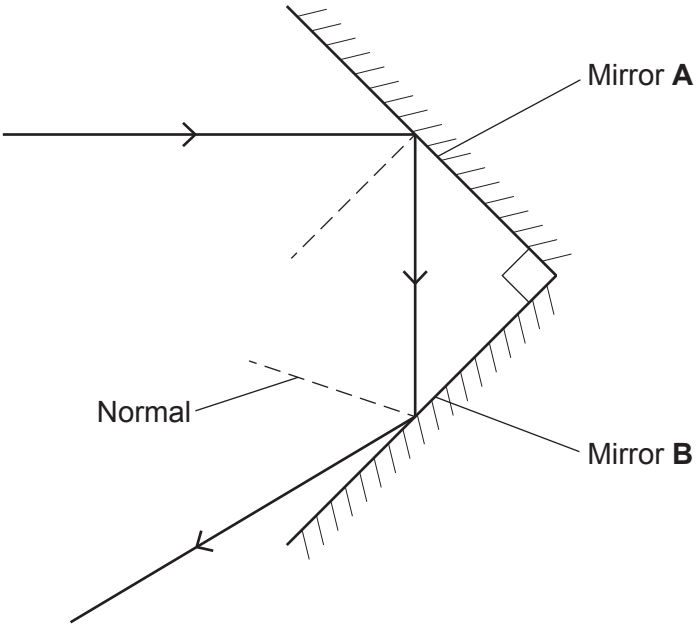


Laser light from the Earth is aimed at the retroreflector and reflects back to the Earth.

(a) A student draws a simple model of a retroreflector using two plane mirrors at right angles to each other.

Fig. 18.2 shows the student's model.

Fig. 18.2



Identify the **two** mistakes the student has made in **Fig. 18.2**.

Mistake 1 .....

.....

Mistake 2 .....

.....

[2]

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(b) The retroreflector was placed on a layer of dust on the surface of the Moon.

Since 1969, the efficiency of the retroreflector has decreased and it reflects less light back to the Earth.

Suggest why the retroreflector reflects less light.

.....

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

(c) The mass of the retroreflector is 77 kg.

An astronaut lifted the retroreflector a vertical distance of 0.50 m on the Moon.

Calculate the gravitational potential energy gained by the retroreflector.

The gravitational field strength on the Moon is 1.6 N / kg.

Use the Equation Sheet.

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

(d) A green laser emits light with a wavelength of 5.32×10^{-7} m.

The speed of the green light is 3.0×10^{8} m / s.

Calculate the frequency of the laser light.

Use the Equation Sheet.

Give your answer to **2** significant figures.

Frequency = ... Hz **[4]**

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(e) Recently scientists have aimed infrared lasers at the Moon.

Explain why infrared radiation **cannot** be seen in the sky.

.....

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

(f) Visible light and infrared radiation are transverse waves.

(i) Describe the difference between visible light and infrared radiation using the words **frequency** and **wavelength**.

.....

.....

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

(ii) Water waves are also transverse waves.

A scientist standing near the sea observes water waves moving past them.

Explain how the scientist can measure the **frequency** of the water waves.

.....

.....

.....

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

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19 The national grid makes predictions about the electrical power it can supply and the electrical power customers demand for two different winters.

The national grid calculates the system margin using the equation:

system margin = electrical power supplied – electrical power demanded

(a) The predictions for **winter 1** are:

Predicted supply = 64.2 GW
Predicted demand = 60.0 GW

Calculate the percentage system margin for **winter 1**.

Use the equation:

$$\text{percentage system margin} = \frac{(\text{predicted supply} - \text{predicted demand})}{\text{predicted demand}} \times 100\%$$

Percentage system margin = ... % **[2]**

(b) The predictions for **winter 2** are:

Lowest predicted system margin = 3.0 GW
Highest predicted system margin = 6.2 GW
Mean predicted system margin = 4.6 GW

(i) Suggest **two** reasons why the national grid predicts a range of values for the system margin.

1 .....

.....

2 .....

.....
[2]

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(ii) Calculate the percentage uncertainty in the predicted system margin for **winter 2**.

Use the equation: percentage uncertainty = $\frac{1}{2} \times \frac{\text{range of values}}{\text{mean value}} \times 100\%$

Percentage uncertainty = ... % **[2]**

(c)

(i) Suggest why people working for the national grid may worry if the system margin is small.

.....

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

(ii) The electrical power that hydroelectric power stations are able to supply can be increased to help meet the customer demand.

On one winter's day:

- the electrical power demanded by customers = 1.0 GW
- the electrical power that can be supplied by a hydroelectric power station = 5.5 GW
- the system margin = 4.5 GW.

The electrical power that the hydroelectric power station is able to supply is then increased so that the system margin is increased by 4.0%.

Calculate the electrical power that the hydroelectric power station is able to supply after the system margin has been increased.

Electrical power supplied = ... GW **[2]**

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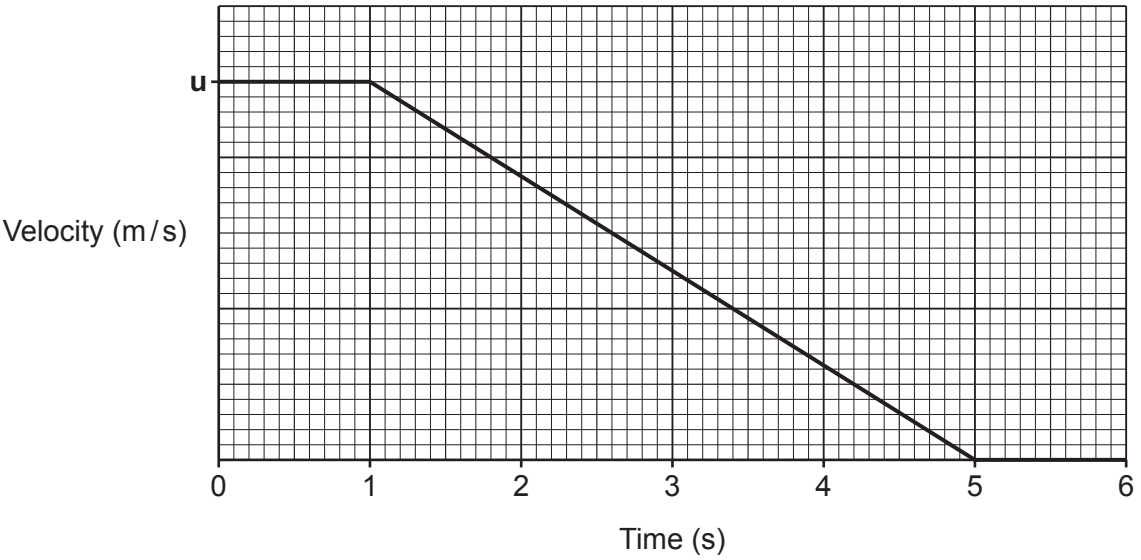
20

(a) The graph shows how the velocity of car **A** changes when the driver sees a hazard in the road at time = 0 seconds.



The braking distance is 30 m.

Calculate the initial velocity **u** of car **A**.

Use the graph.

Initial velocity **u** = ... m / s **[3]**

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(b) Car **B** brakes and comes to a stop.

(i) The deceleration of car **B** is $6\,m/s^2$.

The initial speed of the car is $18\,m/s$.

Calculate the braking distance of car **B**.

Use the Equation Sheet.

Braking distance = ... m **[3]**

(ii) Estimate the force acting on car **B** when it decelerates at $6\,m/s^2$.

Use the equation: force = mass × acceleration

For the mass in the equation, use an estimate of the mass of car **B**.

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

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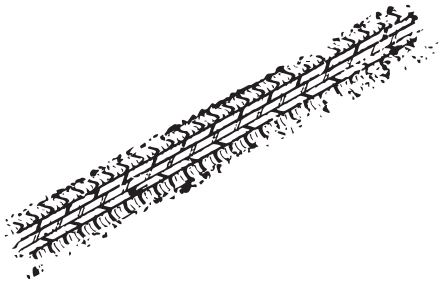
(iii) The diagram shows a skid mark that car **B**'s tyre makes on the road when the car brakes.



The length of the skid mark is 25 m.

Suggest **two** reasons why the braking distance and the length of the skid mark are **not** the same.

1 .....

.....

2 .....

.....

[2]

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21

(a) The Earth orbits the Sun.

Which statement is correct?

Tick (✓) **one** box.

The direction of the velocity of the Earth is towards the Sun. ☐

The Earth is accelerating. ☐

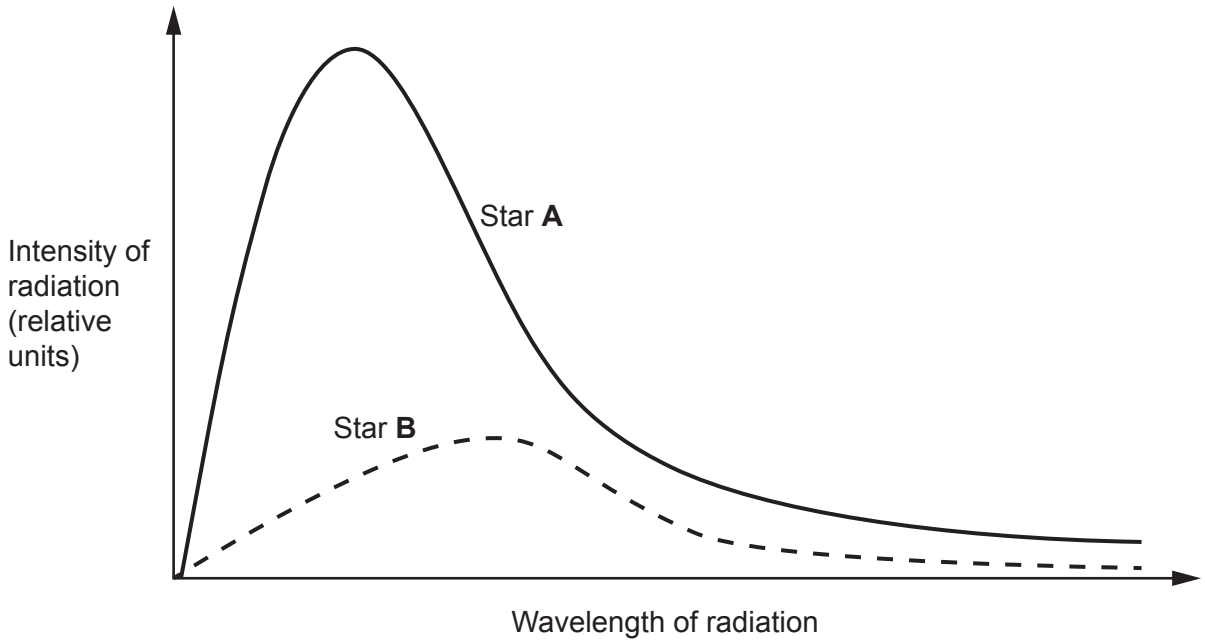
The Earth's velocity is the same as its speed. ☐

The velocity of the Earth stays constant. ☐

[1]

(b) All objects emit radiation.

The graph shows how the intensity of the radiation emitted by star **A** and star **B** varies with the wavelength of the radiation.



Describe **two** differences between the graph for star **A** and the graph for star **B**.

1 .....

.....

2 .....

.....

[2]

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(c)* Explain why the average temperature of the Earth is increasing.

In your answer, write about:

- the radiation absorbed and emitted by the Earth
- the effect of the Earth's atmosphere.

.....

.....

.....

.....

.....

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..... **[6]**

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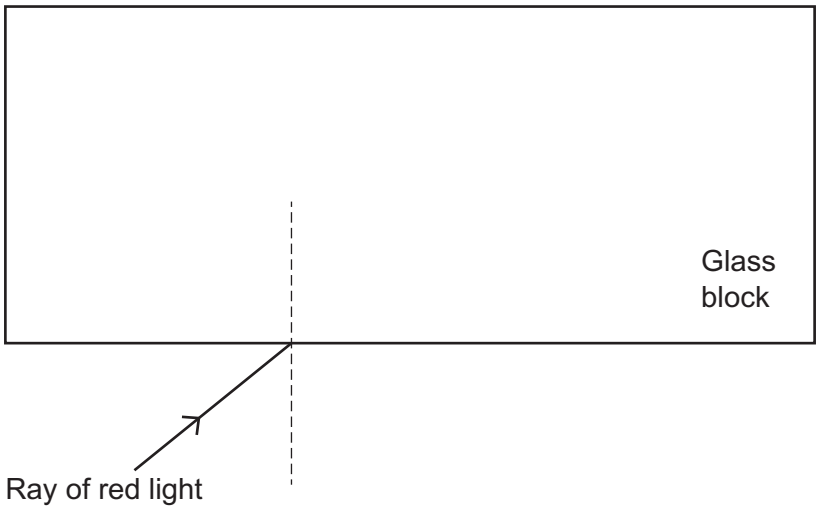
22 **Fig. 22.1** shows a ray of red light from a laser entering a rectangular glass block from the air.

Fig. 22.1



When the red light enters the glass block from the air it will refract.

(a) Draw the path of the refracted ray inside the glass block in **Fig. 22.1**. **[1]**

(b) Explain why red light refracts as it enters the glass block.

.....

.....

.....

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

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(c) A student uses the red laser and glass block to investigate the relationship between the angle of incidence and angle of refraction for the glass.

The table shows the student's results.

Angle of incidence (°)	Angle of refraction (°)
22	14
34	22
48	30
55	33
62	36

(i) Describe a method the student could have used to investigate this relationship.

You can draw on **Fig. 22.1** to help explain your answer.

.....

.....

.....

.....

.....

.....

.....

.....

..... **[4]**

(ii) The student concludes that the angle of incidence is directly proportional to the angle of refraction.

Show that the student is **incorrect**.

Use data from the table.

.....

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

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(d) The student replaces the red laser with a **green** laser and repeats the experiment for the same angles of incidence.

The student notices that the angles of refraction for the green light are all different from the angles of refraction for the red light.

Explain why the angles of refraction are different when light of a different colour is used.

.....

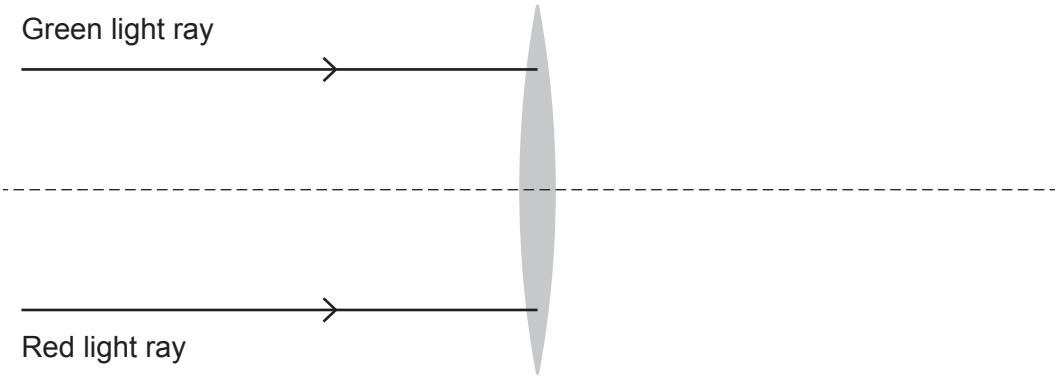
.....

.....

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

(e) The student replaces the glass block with a glass lens and directs both the red and green lasers into the lens at the same time as shown in **Fig. 22.2**.

Fig. 22.2



Complete **Fig. 22.2** by continuing the paths of the red and green light rays. **[2]**

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

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

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