

Physics
Standard level
Paper 2

30 April 2025

Zone A morning | Zone B morning | Zone C morning

Candidate session number

1 hour 30 minutes

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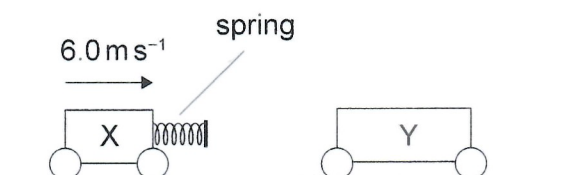
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

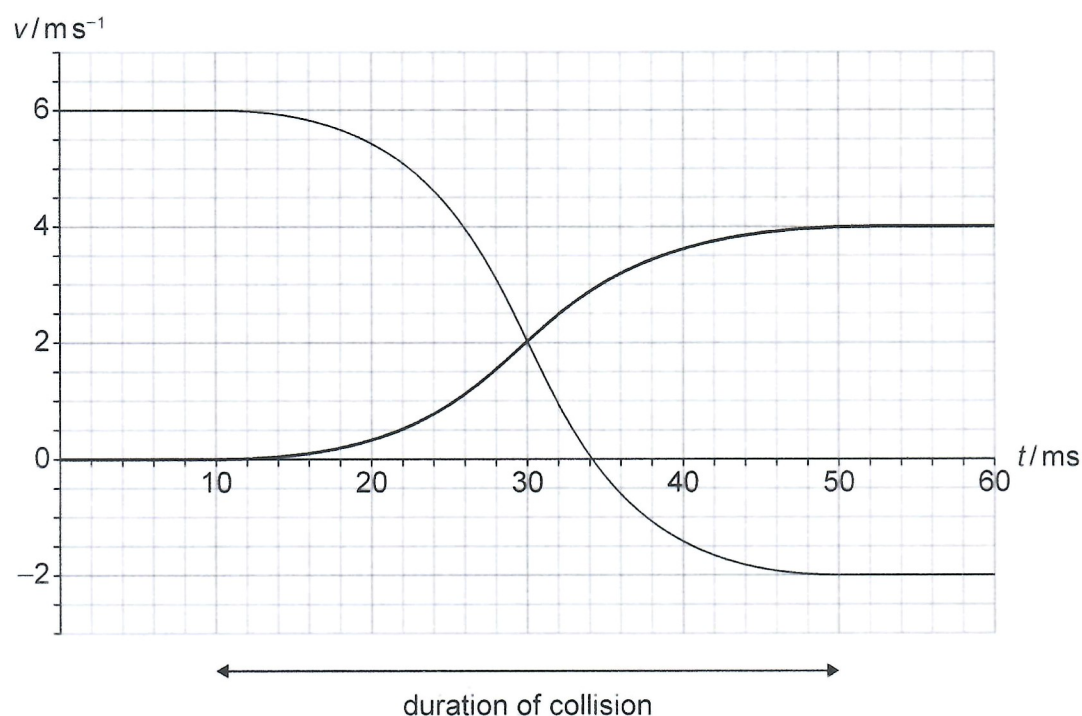


Answer **all** questions. Answers must be written within the answer boxes provided.

1. A cart X of mass 3.0 kg moving at 6.0 m s^{-1} collides with a stationary cart Y of mass 6.0 kg . A spring is attached to X as shown.



The graph shows the velocities of X and Y before, during and after the collision.



The collision lasted for 40 ms.

- (a) Show that the collision is elastic.

[2]

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(Question 1 continued)

(b) Determine

(i) the magnitude of the average force exerted on Y, [2]

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(ii) the average power delivered to Y, [2]

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(iii) the elastic energy stored in the spring at $t = 30 \text{ ms}$. [2]

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2. (a) Describe the mechanism of heat transfer by conduction.

[2]

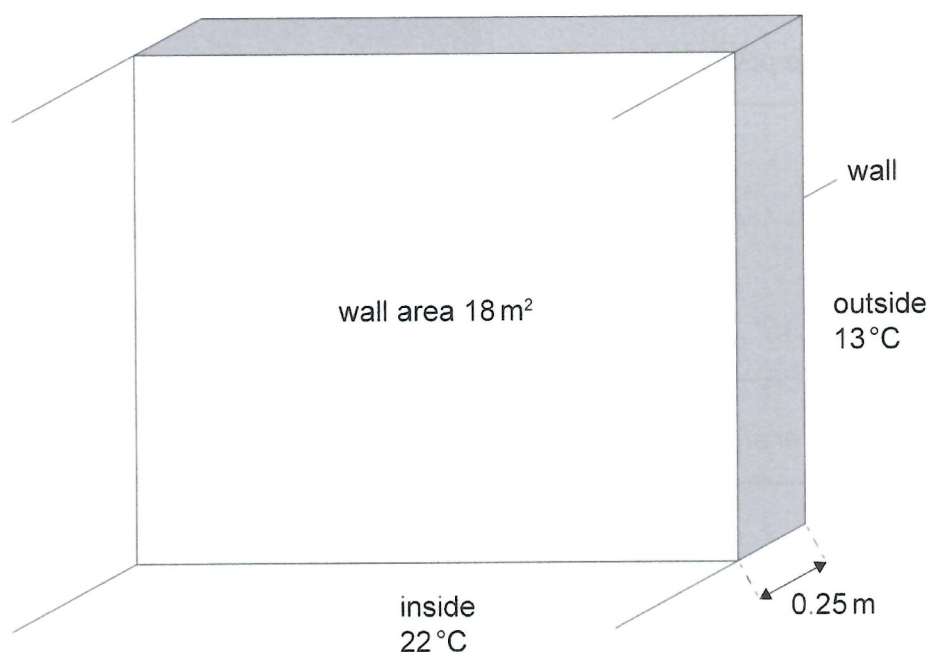
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The diagram shows a wall separating the inside of a room from the outside. The temperature of the room is kept constant by a heater.



The following data are available:

- Thickness of wall = 0.25 m
- Area of wall = 18 m²
- Thermal conductivity of wall = 1.3 W m⁻¹ K⁻¹
- Constant room temperature = 22 °C
- Constant outside temperature = 13 °C

(This question continues on the following page)



(Question 2 continued)

- (b) Estimate the rate at which thermal energy leaves the room through the wall giving the answer with an appropriate unit.

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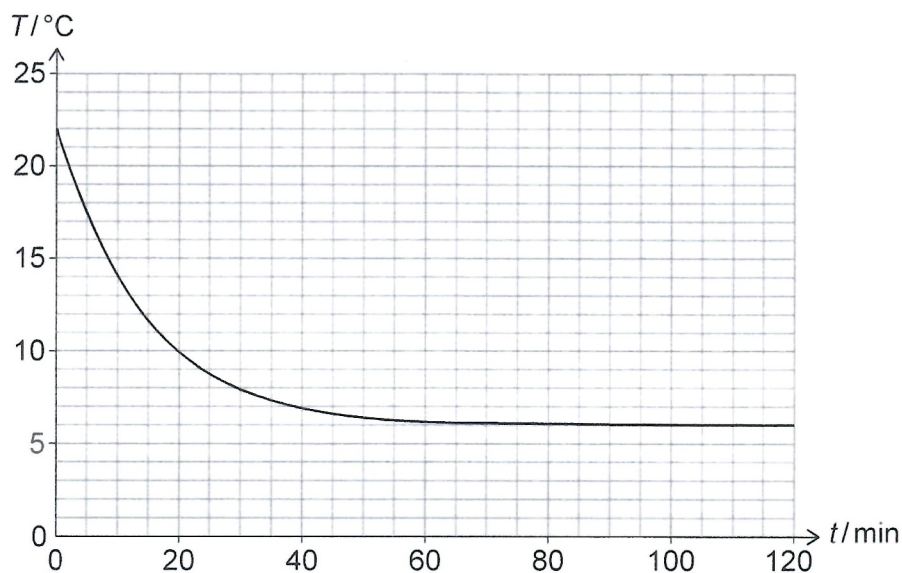


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Turn over

(Question 2 continued)

- (c) At night the outside temperature falls below 13°C . The heater is turned off at time $t = 0$. The graph shows the variation with time t of the temperature T of the room.



- (i) Outline why the magnitude of the gradient of the graph decreases.

[1]

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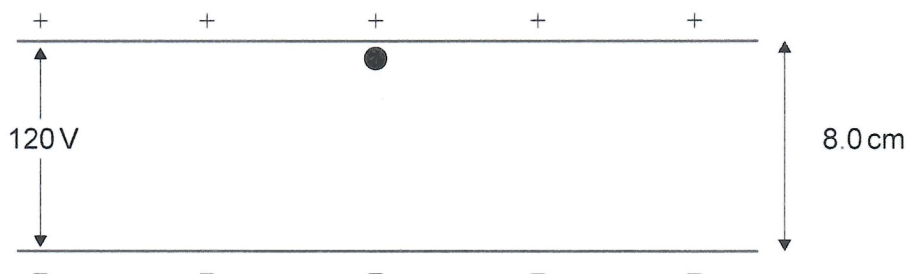
- (ii) The pressure and volume of the air in the room remain constant but the number of molecules has increased. Determine the percentage increase in the number of molecules of air in the room between $t = 0$ and $t = 120$ min.

[3]

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3. Two oppositely charged parallel plates are a distance 8.0 cm apart. The potential difference between the plates is 120 V. An alpha particle is placed on the positively charged plate and released from rest. Gravity is ignored.



- (a) Calculate the electric field between the plates.

[1]

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- (b) (i) Show that the acceleration of the alpha particle is about $7 \times 10^{10} \text{ m s}^{-2}$.

[2]

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- (ii) Calculate the time taken for the alpha particle to reach the negative plate.

[2]

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- (iii) State, in eV, the kinetic energy of the alpha particle when it arrives at the negative plate.

[1]

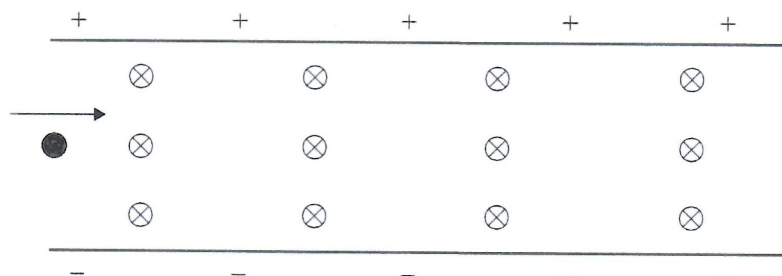
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(Question 3 continued)

- (c) A magnetic field directed into the plane of the page is now established between the plates. An alpha particle enters the region between the plates with a horizontal speed of $5.0 \times 10^5 \text{ m s}^{-1}$. The particle is not deflected.



Calculate the magnitude of the magnetic field.

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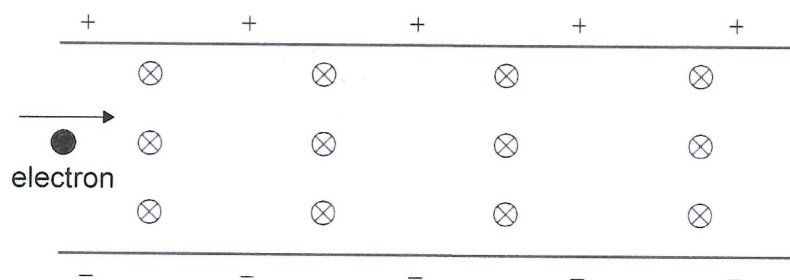
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- (d) The alpha particle in (c) is replaced by an electron. The electron enters the region between the plates with the same velocity as the alpha particle.

Draw, on the diagram, the path of the electron.

[1]



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4. Two sources of light produce an interference pattern on a screen.

- (a) Explain why the two sources need to be coherent for the interference pattern to be observed.

[2]

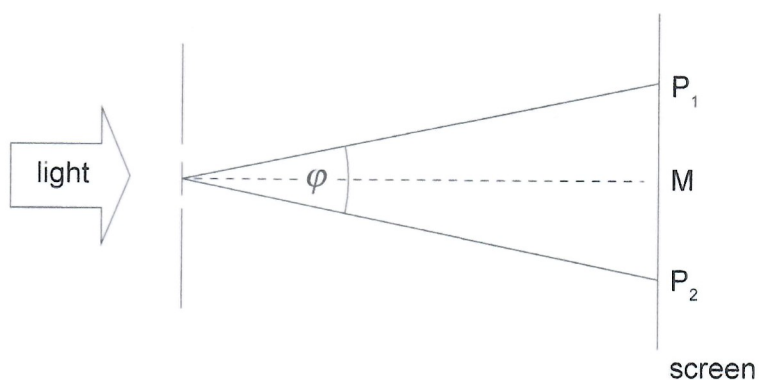
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- (b) Light of wavelength 720 nm is incident on two narrow slits that are separated by 0.12 mm. An interference pattern is observed on a screen. P_1 and P_2 are the points of destructive interference closest to the central maximum M.



- (i) Calculate, in radians, the angular separation ϕ of P_1 and P_2 .

[2]

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- (ii) Suggest how energy conservation is consistent with the fact that the energy at P_1 and P_2 is zero.

[1]

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5. The following data are available for the Sun when it entered the main sequence.

$$\text{Mass} = 2.0 \times 10^{30} \text{ kg}$$

$$\text{Radius} = 7.0 \times 10^8 \text{ m}$$

$$\text{Surface temperature} = 5800 \text{ K}$$

$$\text{Core temperature} = 1.5 \times 10^7 \text{ K}$$

$$\text{Core density} = 1.6 \times 10^5 \text{ kg m}^{-3}$$

- (a) (i) State and explain which of the above features make nuclear fusion in the Sun possible.

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- (ii) Outline how the Sun maintains its equilibrium state.

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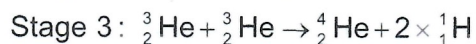
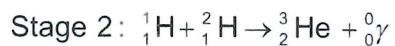
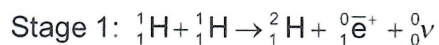
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(Question 5 continued)

- (b) The following sequence of nuclear fusion reactions takes place in the Sun.



The nuclear mass of ${}^1_1\text{H}$ is 1.007276 u and that of ${}^2_1\text{H}$ is 2.013550 u. Estimate the energy released in stage 1 of these reactions.

[2]

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(Question 5 continued)

- (c) The Sun will leave the main sequence when it has converted 10% of its hydrogen mass into helium. The **total** energy released in the reactions in (b) is 4.3×10^{12} J. The current luminosity of the Sun is 3.8×10^{26} W. When the Sun entered the main sequence its hydrogen mass was 1.5×10^{30} kg.

- (i) Show that the Sun will stay on the main sequence for about 8×10^9 years. [3]

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- (ii) State **one** assumption that was made in getting the answer to (c)(i). [1]

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- (iii) Estimate the total mass lost by the Sun in this time. [2]

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- (d) The surface temperature of the Sun is 5800 K. Determine the peak wavelength in the Sun's spectrum. [2]

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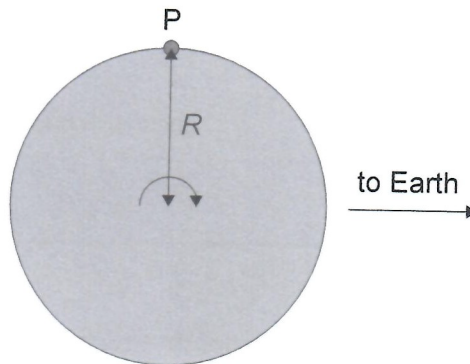
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(Question 5 continued)

- (e) The Sun rotates about its axis. P is a point on the Sun's equator.



A particular spectral line of hydrogen from a laboratory source has wavelength 656.2797 nm. The same spectral line emitted from P has wavelength 656.2753 nm when measured on Earth.

- (i) Explain this observation.

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- (ii) Calculate the period of revolution of the Sun.

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