Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Higher level
Paper 2

6 November 2025

Zone A morning | **Zone B** morning | **Zone C** morning

Candidate session number

2 hours 30 minutes

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 **[90 marks]**.

28 pages

8825 – 6721
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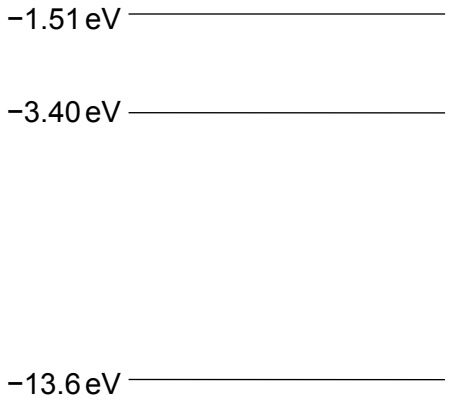
Please **do not** write on this page.

Answers written on this page
will not be marked.

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

1. The diagram shows the three lowest energy levels of the hydrogen atom.
The energy of each level is indicated.

diagram not to scale



(a) State the number of transitions between these levels that result in the emission of photons. [1]

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(b) Calculate the largest photon wavelength for these transitions. [3]

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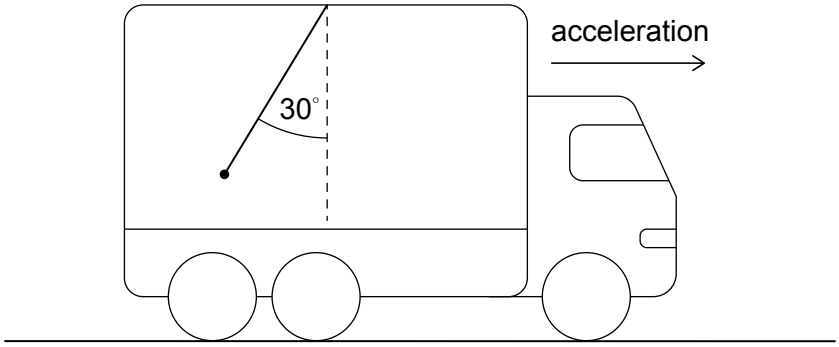
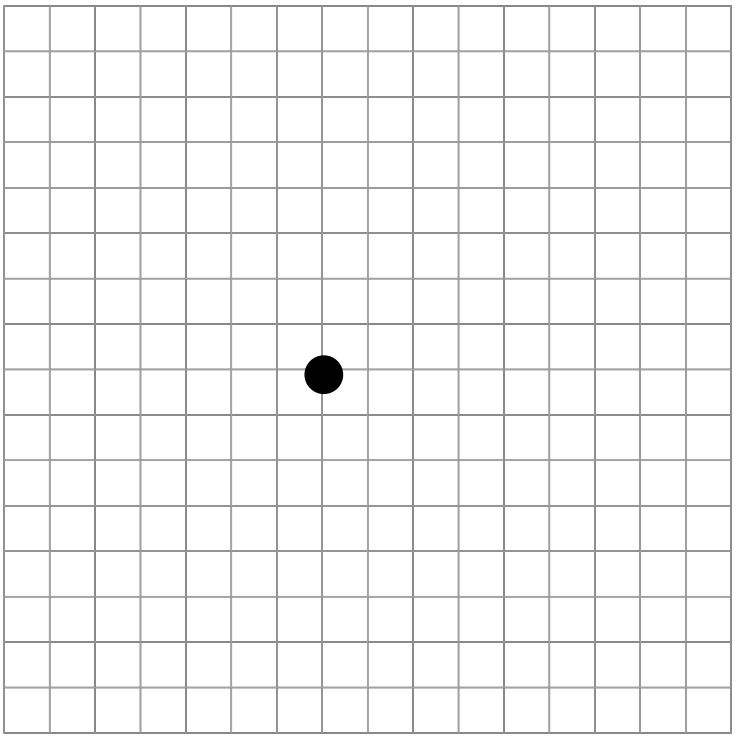
2. A ball is connected to a string that is attached to the ceiling of a truck. The truck accelerates to the right on a horizontal road. The string makes an angle of 30° with the vertical.



(a) (i) Draw a labelled free-body diagram of the forces on the ball. [2]



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(Question 2 continued)

(ii) Determine the acceleration of the truck. [2]

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(b) The truck now moves at **constant** speed up an incline that makes an angle of 10° to the horizontal. State and explain the angle between the string and the vertical. [2]

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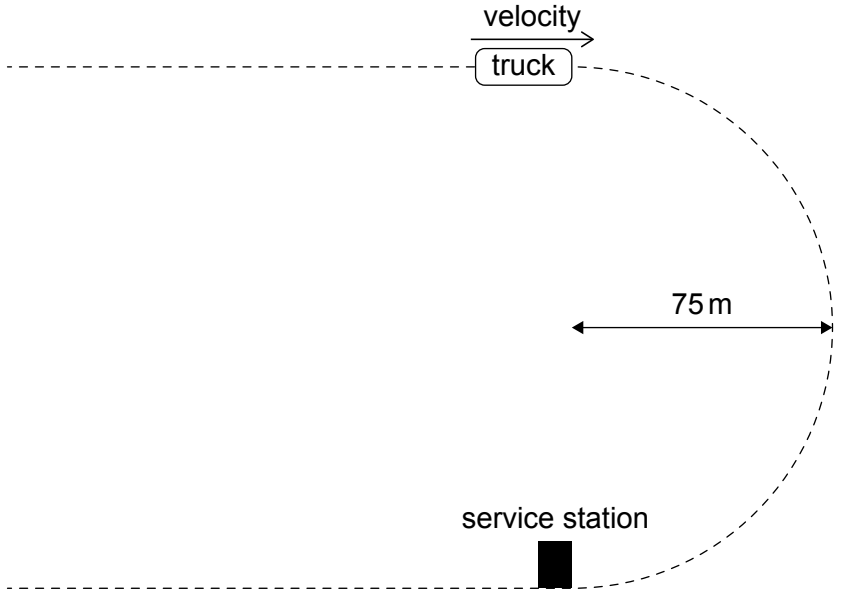
will not be marked.

(Question 2 continued)

On another occasion, the truck enters a horizontal semicircular road of radius of 75 m. The coefficient of static friction between the road and the tyres is 0.60.



(c) Calculate the maximum speed at which the truck can travel on this road. [2]

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(d) The truck runs out of fuel just as it enters the semicircle with speed $15\,m\,s^{-1}$. The resultant force opposing the motion has magnitude 520 N. The mass of the truck is 1400 kg. A service station is at the other end of the semicircle.

Determine whether the truck will be able to reach the service station. [3]

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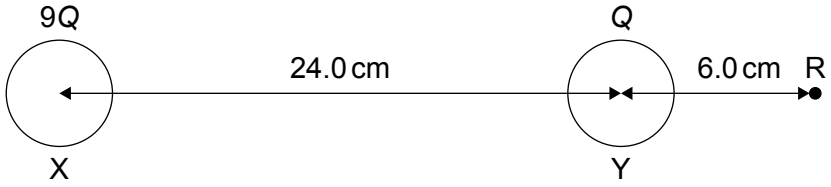
3. (a) Two identical conducting spheres X and Y that carry positive charges are separated by a centre-to-centre distance of 24.0 cm in a vacuum. The charge on X is 9*Q* and the charge on Y is *Q*. Point R is 6.0 cm from the centre of Y, as shown.



The resultant electric field at R is 32.6 MN C^{-1}. Determine *Q*, giving an appropriate unit. [2]

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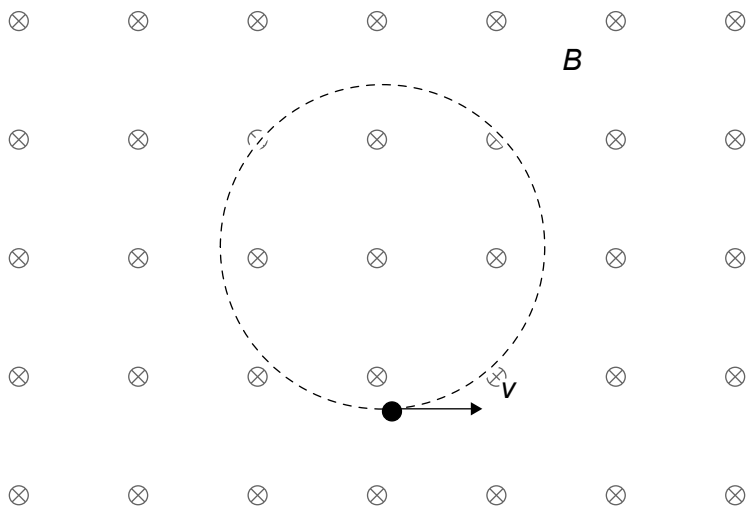
(Question 3 continued)

(b) A particle of mass m and positive charge q moves on a circular path with speed v in a vacuum. A uniform magnetic field B is directed into the plane of the page.



(i) Show that the radius R of the circular path is given by $R = \frac{mv}{qB}$. [1]

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(ii) Suggest why the speed of the particle stays constant, even though a force acts on the particle. [1]

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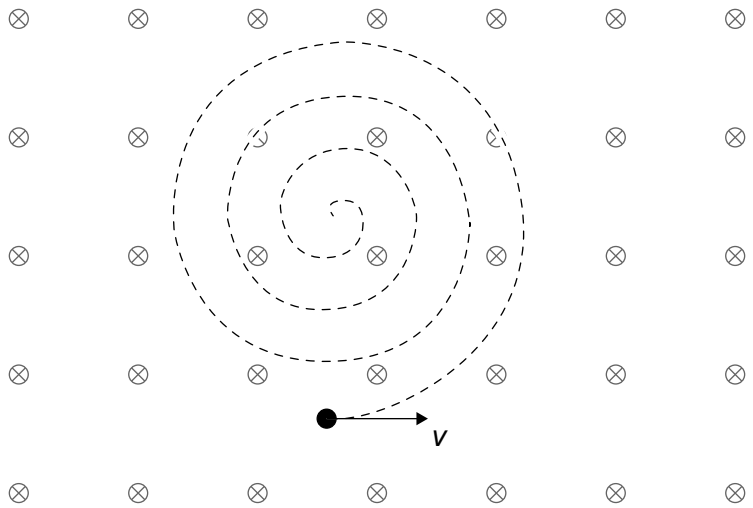
will not be marked.

(Question 3 continued)

(c) The particle in (b), now moving in a region of magnetic field **in air**, follows the path shown.



Explain the shape of this path. [2]

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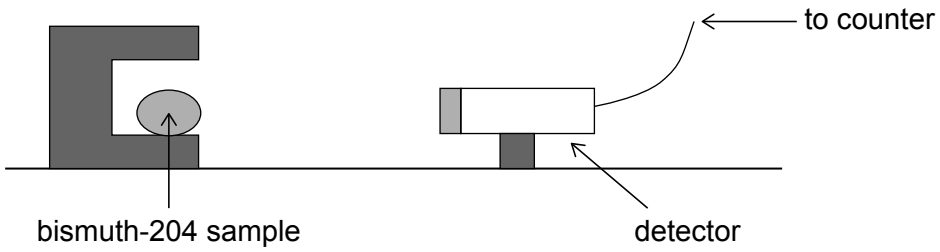
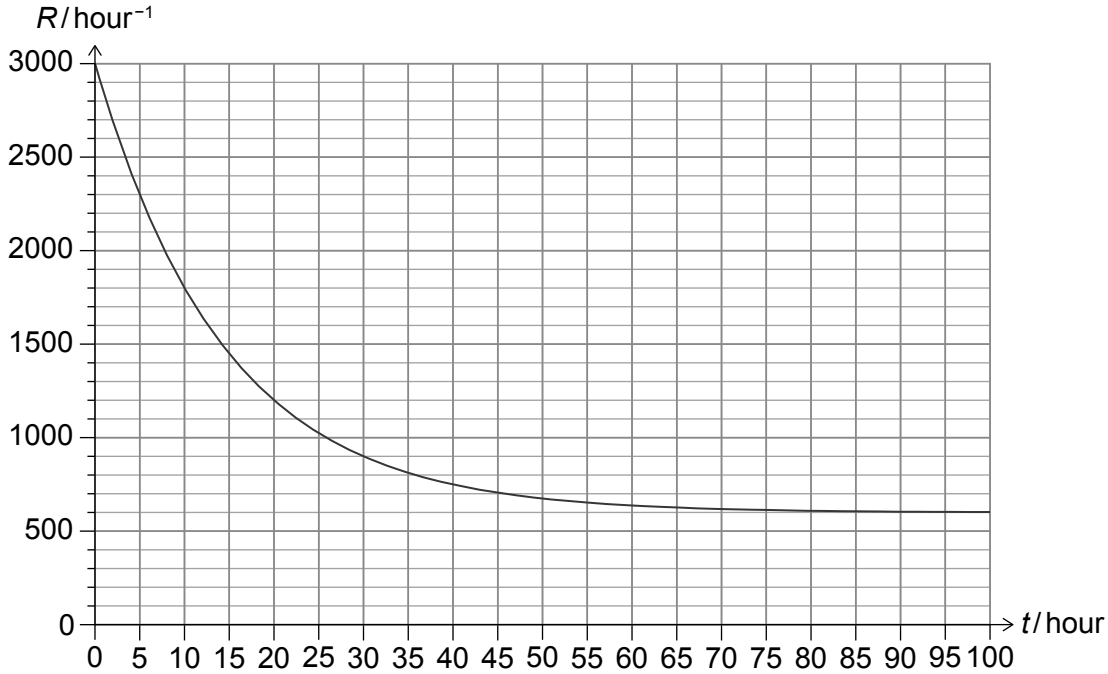
4. (a) A pure radioactive sample of bismuth-204 ($^{204}_{83}\text{Bi}$) is placed near a detector, which is connected to a counter.



Bismuth-204 decays into lead ($^{204}_{82}\text{Pb}$) by beta-plus decay according to the equation $^{204}_{83}\text{Bi} \rightarrow {}^{204}_{82}\text{Pb} + e^{+} + \nu$. The graph shows the variation with time *t* of the count rate *R*.



(i) State the background count rate. [1]

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(Question 4 continued)

(ii) Estimate the half-life of $^{204}_{83}Bi$. [3]

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(iii) State and explain how the binding energy per nucleon of $^{204}_{83}Bi$ compares with that of $^{204}_{82}Pb$. [2]

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(iv) The distance between the sample and the detector is 20 cm. State why this would be an inappropriate distance for a sample that decayed by alpha decay. [1]

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(b) The following data are available for **nuclear** masses:

bismuth = 203.932254 u
lead = 203.928034 u

Calculate the energy released in the decay of one nucleus of bismuth-204. [2]

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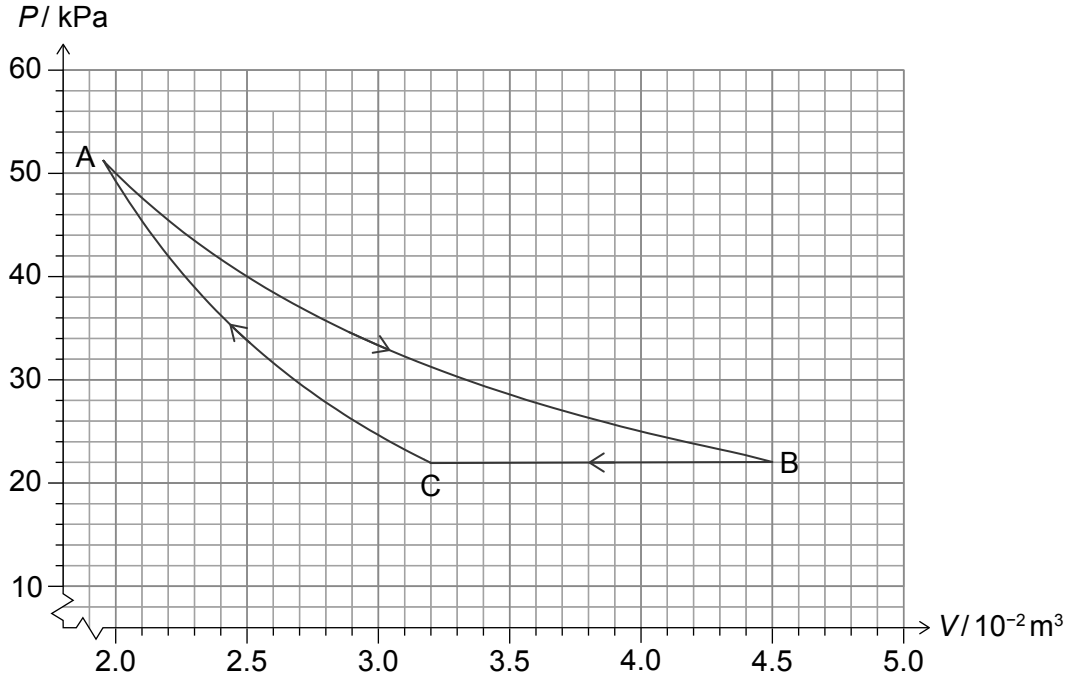
5. The graph shows the cycle of a heat engine operating with an ideal monatomic gas. It consists of three stages: an isothermal A → B, an isobaric B → C and an adiabatic C → A. The temperature at A is 560 K.



(a) Show that the thermal energy transferred from the gas along B → C is about 700 J. [3]

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(b) The work done along A → B is 840 J. Calculate the efficiency of the engine. [3]

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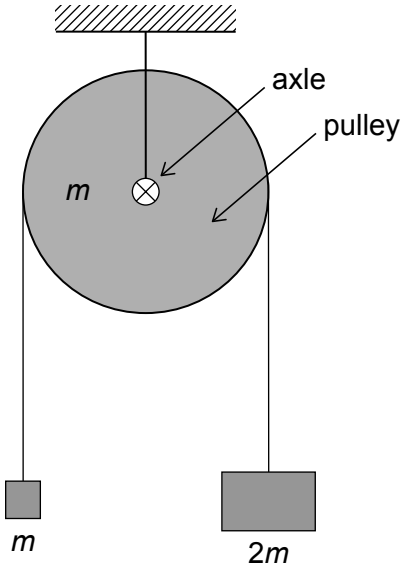
6. Two blocks of mass m and $2m$ are connected with a string that goes over a pulley of mass m.

diagram not to scale



When the blocks are released, the pulley turns about the axle as the blocks move. The string does not slip relative to the pulley. The radius of the pulley is r and its moment of inertia about the axle is $\frac{mr^2}{2}$.

(a) Show that the acceleration a of the blocks is given by $a = \frac{2g}{7}$. [3]

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(b) Suggest whether the angular momentum of the pulley–blocks system is conserved. [1]

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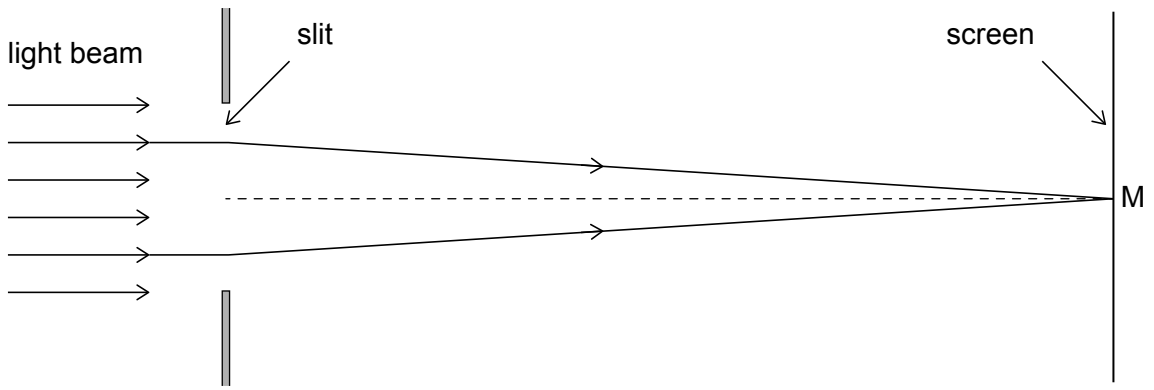
7. A monochromatic light beam is incident on a single slit. M is the point on a screen far from the slit, directly across from the mid-point of the slit. The diagram shows two of the incident rays that reach M after they have diffracted at the slit. These rays are symmetrical with respect to the dotted line.

diagram not to scale



(a) Outline, by considering pairs of rays arriving at M such as the ones shown, why a maximum in intensity will be observed at M. [2]

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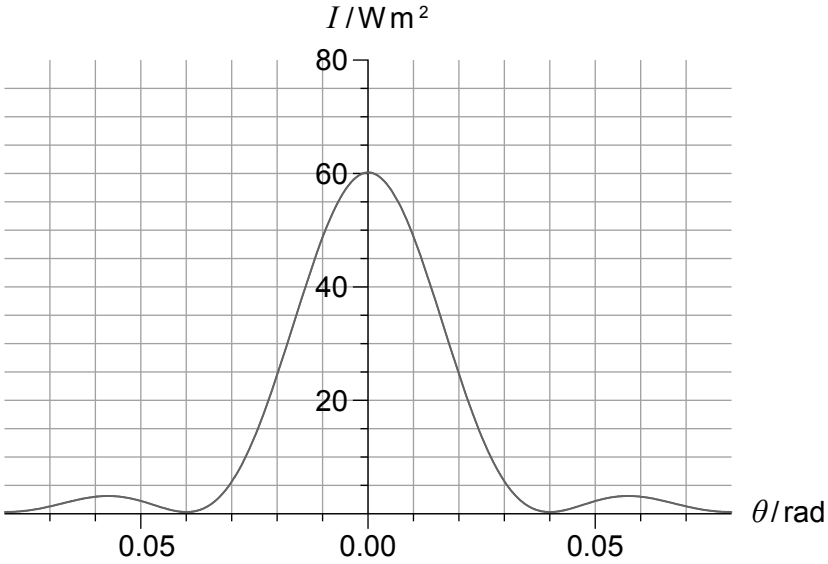
(Question 7 continued)

(b) The graph shows the variation with diffraction angle θ of the intensity I on the screen.



The slit width is 1.3×10^{-5} m. Calculate the wavelength of the light. [2]

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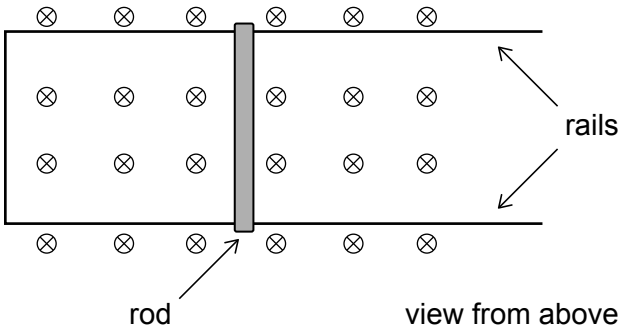
8. (a) A conducting rod is placed on horizontal, conducting, frictionless rails.



A uniform magnetic field is directed into the plane of the page.

The rod begins to move to the right after it is given a short push. Explain why the rod will quickly stop moving. [3]

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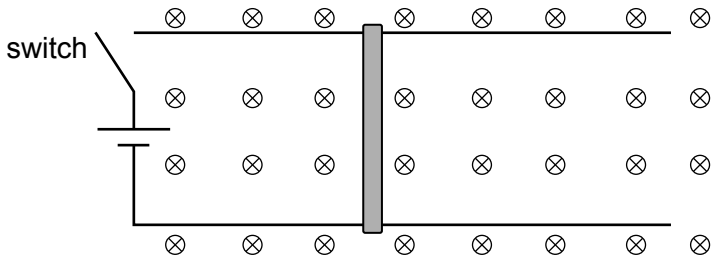
(Question 8 continued)

(b) In another experiment, the rod is at rest on the rails. A cell and a switch are inserted as shown.



The switch is closed.

(i) Suggest what happens to the rod. [1]

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(ii) Explain why the rod will eventually reach terminal speed. [2]

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9. (a) A copper rod has mass 0.400 kg. The density of solid copper is $8.94 \times 10^3\,\text{kg}\,\text{m}^{-3}$. The molar mass (the mass of a mole) of copper is $63.5\,\text{g}\,\text{mol}^{-1}$.

Estimate

(i) the mass of a copper atom; [2]

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(ii) the volume corresponding to each atom, given by $\dfrac{\text{volume of copper}}{\text{number of copper atoms}}$; [2]

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(iii) the average separation of two neighbouring copper atoms, assuming that the volume corresponding to each atom is a cube. [1]

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(b) The specific latent heat of fusion of copper is $206\,\text{kJ}\,\text{kg}^{-1}$. Calculate the energy needed to completely melt 0.400 kg of solid copper at its melting point. [1]

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(This question continues on the following page)

(Question 9 continued)

(c) Copper atoms in the solid and liquid phase coexist at the melting point. Comparing equal numbers of atoms in the solid and liquid phase at the melting point, state and explain which atoms have the greater internal energy. [3]

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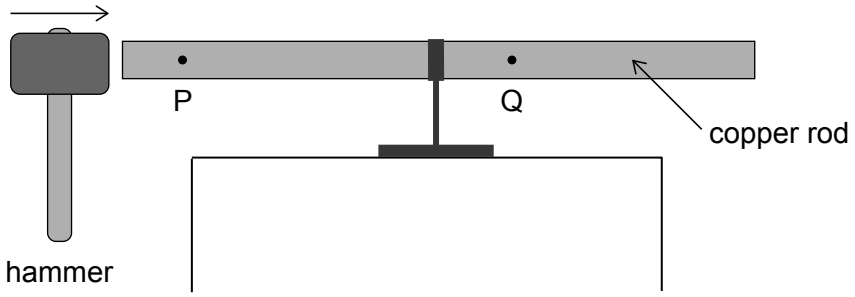
(d) A copper rod is suspended at its centre, as shown. P and Q are the equilibrium positions of two copper atoms in the rod. When a hammer taps the left-hand end of the rod, the first harmonic sound standing wave is formed in the rod. The longitudinal standing wave in this rod is identical to a standing wave in a pipe with both ends open.

diagram not to scale



(i) Explain, by reference to the principle of superposition, why a standing wave is set up in the pipe. [2]

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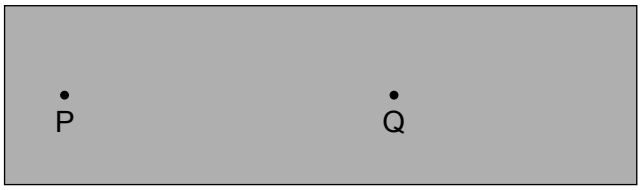
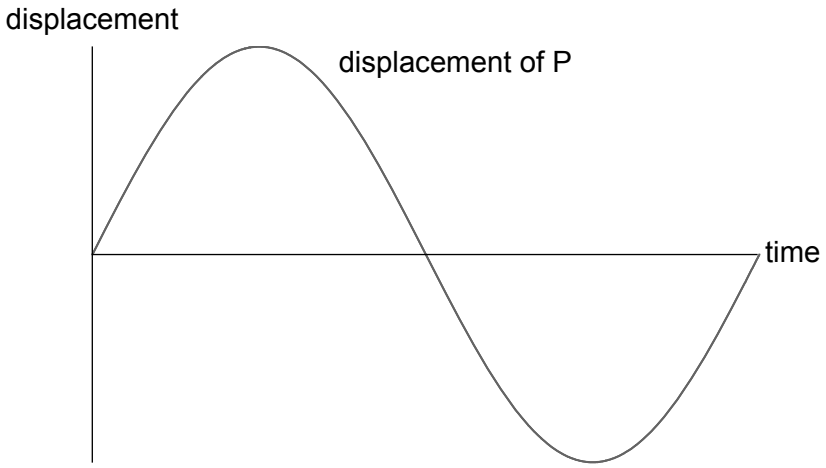
(Question 9 continued)

(ii) Draw, on the diagram, the standing wave in the rod. The width of the rod is shown larger to help with your drawing. [1]



(iii) The graph shows the variation with time of the displacement of the atom at P. Draw, on the same axes, the variation with time of the displacement of the atom at Q. [2]



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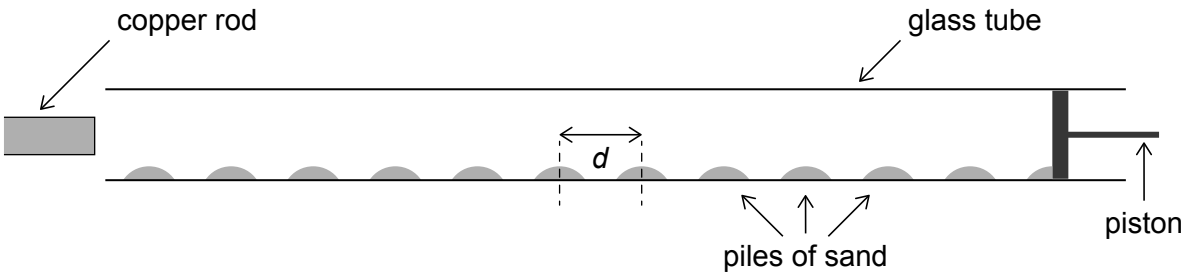
(Question 9 continued)

(e) The copper rod is brought close to a glass tube that contains light sand. When the left-hand end of the rod is tapped with a hammer and the length of the tube is adjusted by moving the piston, a standing wave is established in the tube. Sand collects in piles as shown. The distance between the centres of two consecutive piles of sand is *d*.

diagram not to scale



(i) Outline why the sand collects in piles. [2]

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(ii) The following data are available:

$d = 1.8\,\text{cm}$
speed of sound in air $= 330\,\text{m}\,\text{s}^{-1}$
length of copper rod $= 34\,\text{cm}$

Determine the speed of sound in copper. [4]

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10. (a) Outline **one** experimental piece of evidence that shows that photons have momentum. [2]

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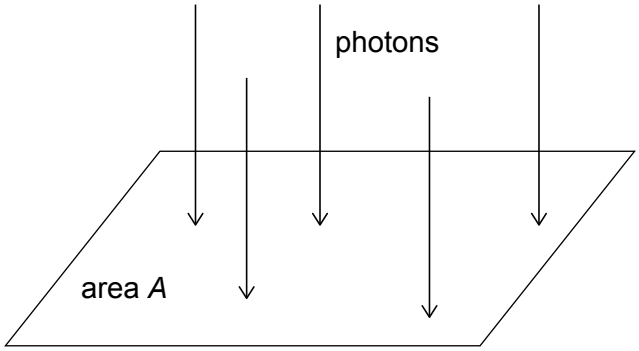
(b) Photons of wavelength λ are incident normally on a flat surface of area A.
The photons are reflected without change in wavelength.



There are N photons incident per second.

(i) Show that the intensity I that is incident on the surface is given by $I = \frac{N}{A}\frac{hc}{\lambda}$. [2]

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(Question 10 continued)

(ii) Deduce that the pressure P exerted on the surface is given by $P = \frac{2I}{c}$. [3]

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(Question 10 continued)

(c) It is proposed to send a spacecraft to Jupiter. The spacecraft would be launched to a point Q far from Earth and would then be accelerated by the pressure of the Sun's radiation on a sail attached to the spacecraft. The following data are available:

total mass of spacecraft = 1400 kg
sail area = 1600 m^2
solar radiation intensity at Q = 420 $W\,m^{-2}$

(i) Show that the acceleration of the spacecraft at Q due to solar radiation alone is about $3 \times 10^{-6}\,m\,s^{-2}$. [2]

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(ii) The distance between Q and Jupiter is 6.1×10^{11} m. Estimate the time, in years, it would take the spacecraft to reach Jupiter, assuming that the spacecraft moves with the acceleration in (i). [2]

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(iii) State **one** reason why the acceleration of the spacecraft will **not** be constant. [1]

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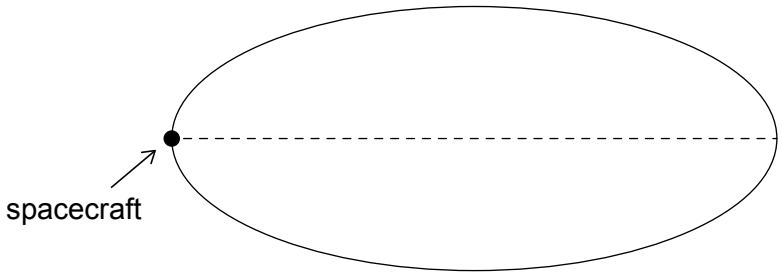
(Question 10 continued)

(d) The spacecraft enters an elliptical orbit around Jupiter.



At the position shown, the spacecraft has its maximum orbital speed.

(i) Draw, on the diagram, a possible position of Jupiter. [1]

(ii) Explain your answer to (d)(i). [2]

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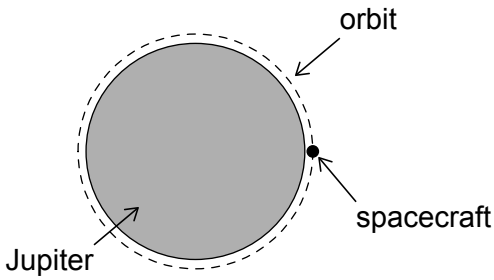
(This question continues on the following page)

(Question 10 continued)

(e) The spacecraft changes its orbit into a circular orbit just above the surface of Jupiter, so that the orbit radius is essentially equal to the radius of Jupiter.

diagram not to scale



(i) Show that the orbital period, T, of the spacecraft is given by $T = \sqrt{\dfrac{3\pi}{G\rho}}$, where ρ is the density of Jupiter. [3]

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(ii) The orbital period is 2.9 hours. Estimate the density of Jupiter. [2]

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