Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Thursday 4 November 2021 (afternoon)

Candidate session number

1 hour 15 minutes

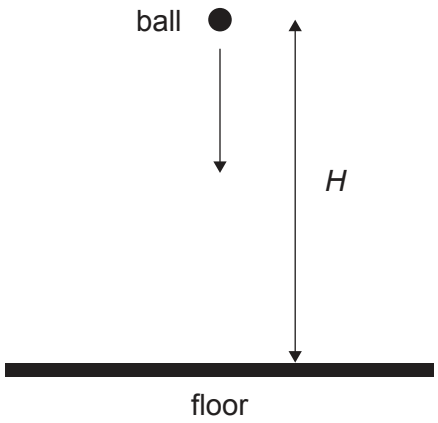
Instructions to candidates

- 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 **[50 marks]**.

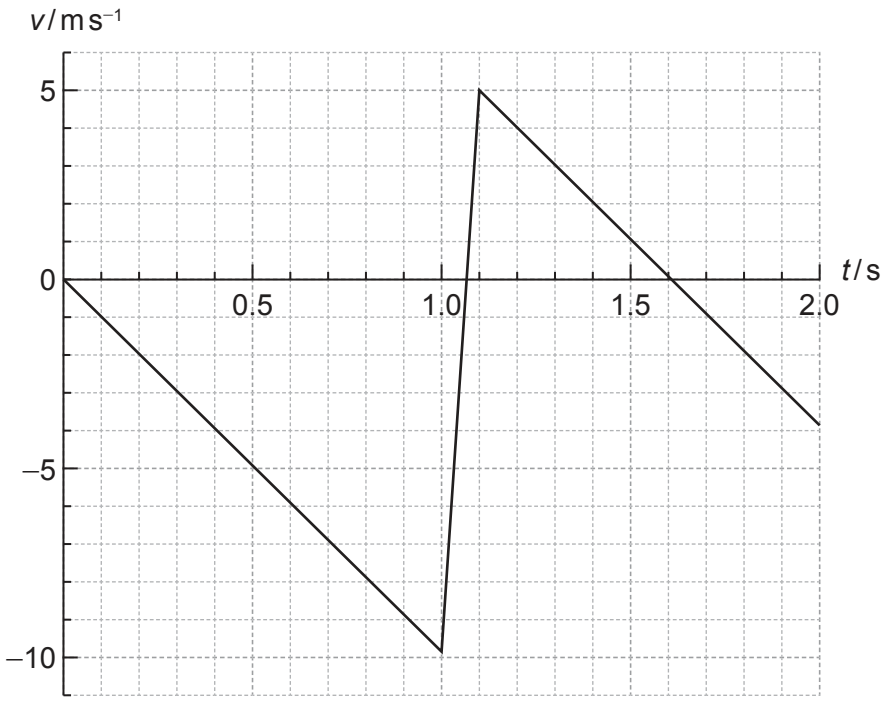
8821 – 6505

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

1. A ball of mass 0.250 kg is released from rest at time $t = 0$, from a height H above a horizontal floor.



The graph shows the variation with time t of the velocity v of the ball. Air resistance is negligible. Take $g = -9.80\,\text{m s}^{-2}$. The ball reaches the floor after 1.0 s.



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(Question 1 continued)

(a) Determine *H*. [1]

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(b) (i) Label the time and velocity graph, using the letter M, the point where the ball reaches the maximum rebound height. [1]

(ii) State the acceleration of the ball at the maximum rebound height. [1]

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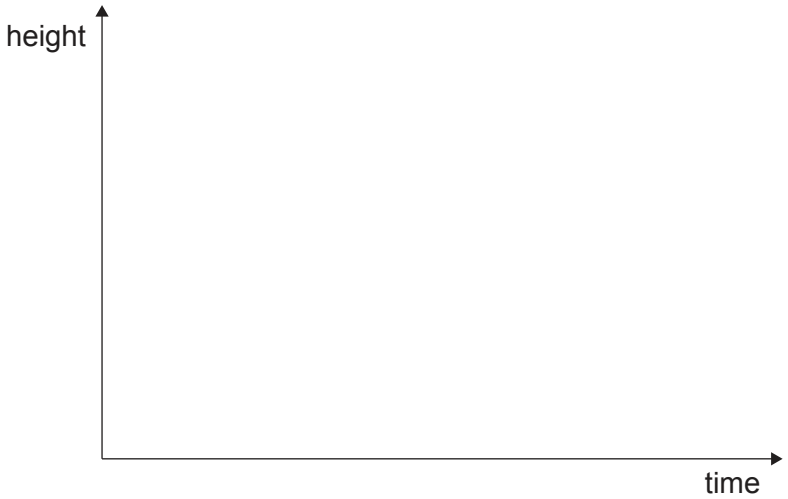
(iii) Draw, on the axes, a graph to show the variation with time of the height of the ball from the instant it rebounds from the floor until the instant it reaches the maximum rebound height. No numbers are required on the axes. [1]



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(Question 1 continued)

(c) Estimate the loss in the mechanical energy of the ball as a result of the collision with the floor. [1]

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(d) (i) Determine the average force exerted on the floor by the ball. [3]

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(ii) Suggest why the momentum of the ball was not conserved during the collision with the floor. [1]

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2. (a) State what is meant by the internal energy of an ideal gas. [1]

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(b) A quantity of 0.24 mol of an ideal gas of constant volume 0.20 m^3 is kept at a temperature of 300 K.

(i) Calculate the pressure of the gas. [1]

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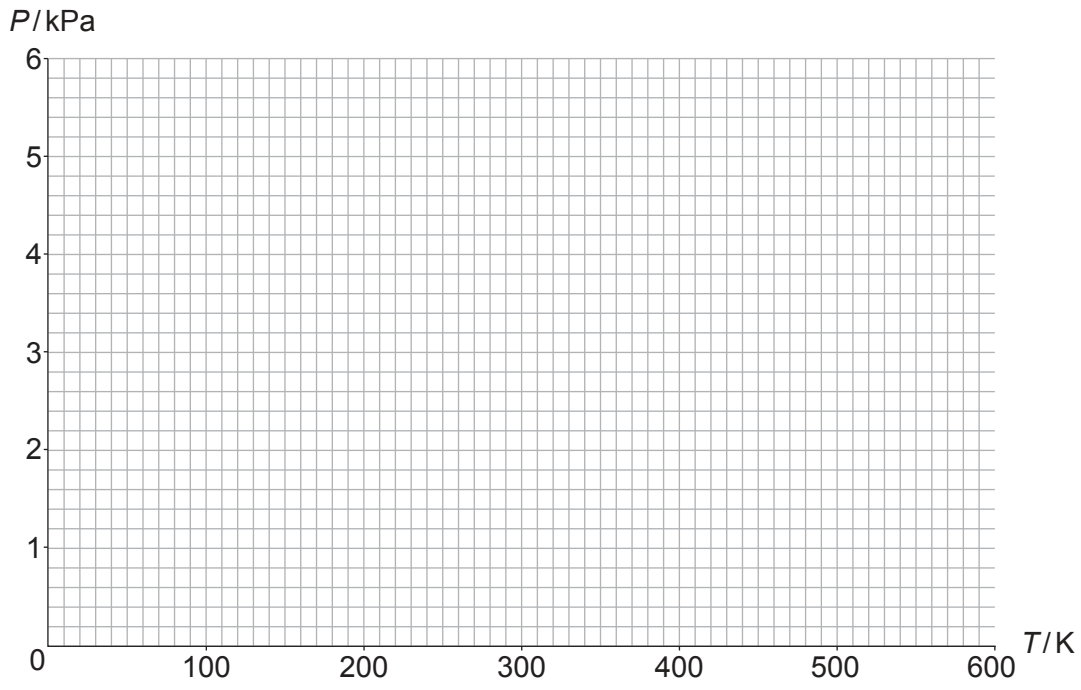
(ii) The temperature of the gas is increased to 500 K. Sketch, on the axes, a graph to show the variation with temperature T of the pressure P of the gas during this change. [2]



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(Question 2 continued)

(c) A container is filled with 1 mole of helium (molar mass $4\,g\,mol^{-1}$) and 1 mole of neon (molar mass $20\,g\,mol^{-1}$). Compare the average kinetic energy of helium atoms to that of neon atoms. [2]

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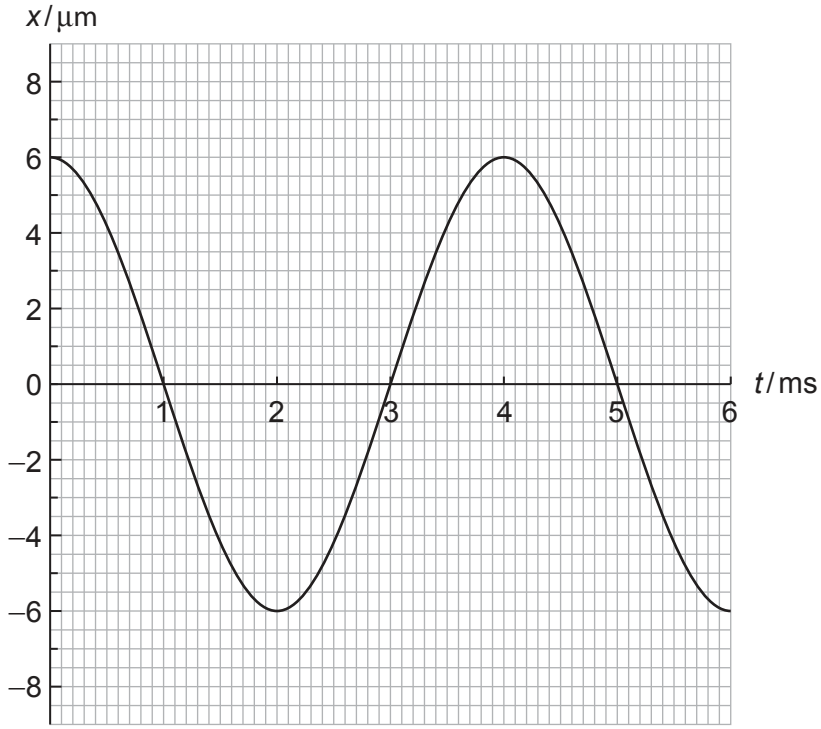
3. A longitudinal wave travels in a medium with speed $340\,m\,s^{-1}$. The graph shows the variation with time t of the displacement x of a particle P in the medium. Positive displacements on the graph correspond to displacements to the right for particle P.



(a) Calculate the wavelength of the wave. [2]

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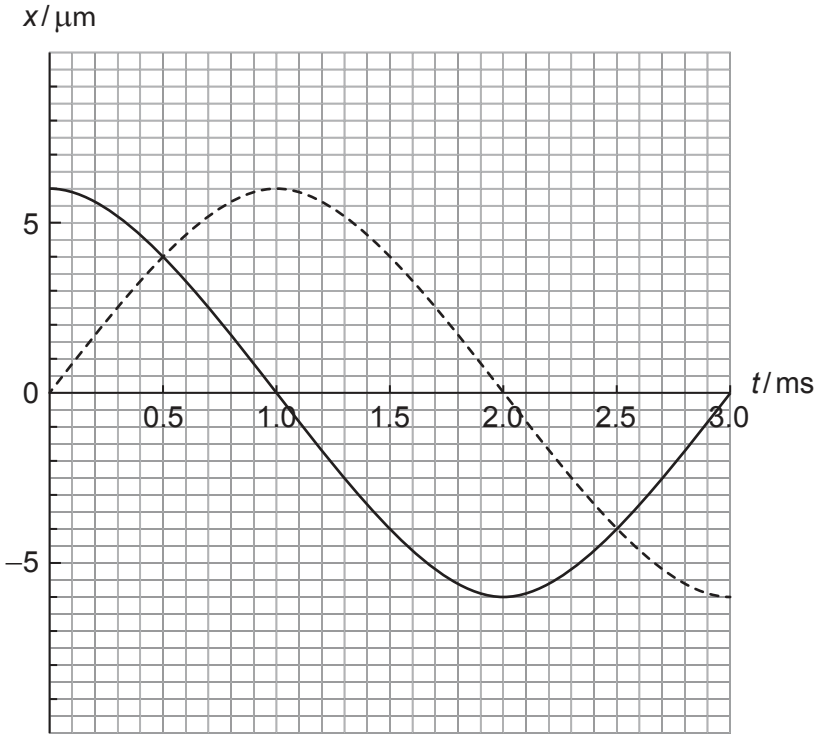
(Question 3 continued)

(b) Another wave travels in the medium. The graph shows the variation with time t of the displacement of each wave at the position of P.



(i) State the phase difference between the two waves. [1]

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(ii) Identify a time at which the displacement of P is zero. [1]

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(iii) Estimate the amplitude of the resultant wave. [1]

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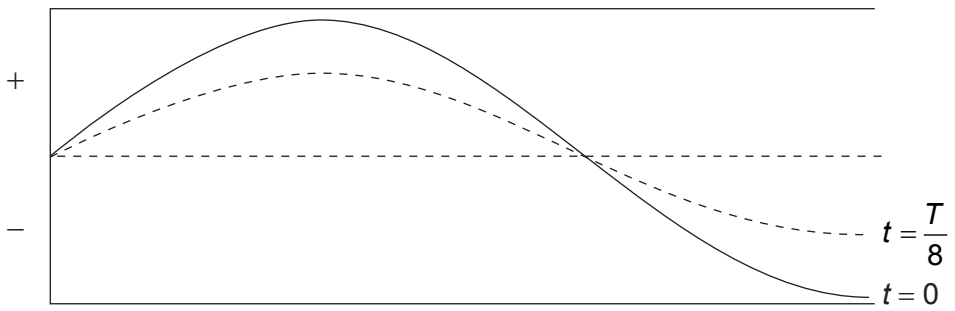
(Question 3 continued)

(c) A standing sound wave is established in a tube that is closed at one end and open at the other end. The period of the wave is T. The diagram represents the standing wave at $t = 0$ and at $t = \frac{T}{8}$. The wavelength of the wave is 1.20 m. Positive displacements mean displacements to the right.



(i) Calculate the length of the tube. [1]

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(ii) A particle in the tube has its equilibrium position at the open end of the tube. State and explain the direction of the velocity of this particle at time $t = \frac{T}{8}$ [2]

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(iii) Draw on the diagram the standing wave at time $t = \frac{T}{4}$ [1]

4. (a) The work done to move a particle of charge 0.25 μC from one point in an electric field to another is 4.5 μJ. Calculate the magnitude of the potential difference between the two points. [1]

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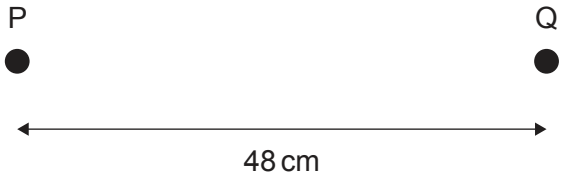
(b) A charged particle, P, of charge +68 μC is fixed in space. A second particle, Q, of charge +0.25 μC is held at a distance of 48 cm from P and is then released.



(i) Determine the force on Q at the instant it is released. [2]

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(ii) Describe the motion of Q after release. [2]

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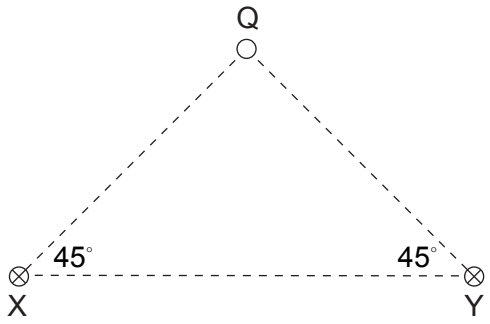
(Question 4 continued)

(c) The diagram shows two parallel wires X and Y that carry equal currents into the page.



Point Q is equidistant from the two wires. The magnetic field at Q due to wire X **alone** is 15 mT.

(i) On the diagram draw an arrow to show the direction of the magnetic field at Q due to wire X **alone**. [1]

(ii) Determine the magnitude and direction of the resultant magnetic field at Q. [2]

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5. (a) (i) State what is meant by the binding energy of a nucleus. [1]

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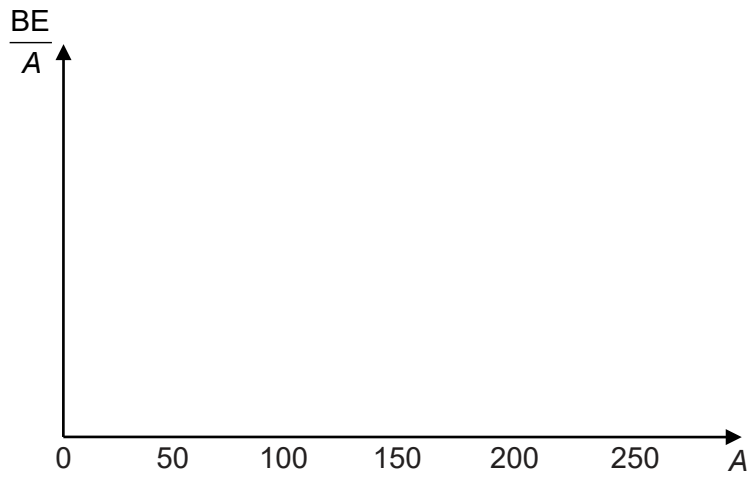
(ii) Draw, on the axes, a graph to show the variation with nucleon number A of the binding energy per nucleon, $\frac{BE}{A}$. Numbers are not required on the vertical axis. [2]



(iii) Identify, with a cross, on the graph in (a)(ii), the region of greatest stability. [1]

(This question continues on the following page)

(Question 5 continued)

(b) Plutonium-238 (Pu) decays by alpha (α) decay into uranium (U).

The following data are available for binding energies per nucleon:

plutonium	7.568 MeV
uranium	7.600 MeV
alpha particle	7.074 MeV

(i) Show that the energy released in this decay is about 6 MeV. [3]

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(ii) The plutonium nucleus is at rest when it decays.

Calculate the ratio $\frac{\text{kinetic energy of alpha particle}}{\text{kinetic energy of uranium}}$ [2]

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6. (a) Titan is a moon of Saturn. The Titan-Sun distance is 9.3 times greater than the Earth-Sun distance.

(i) Show that the intensity of the solar radiation at the location of Titan is $16\,W\,m^{-2}$ [1]

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(ii) Titan has an atmosphere of nitrogen. The albedo of the atmosphere is 0.22. The surface of Titan may be assumed to be a black body. Explain why the **average** intensity of solar radiation **absorbed** by the whole surface of Titan is $3.1\,W\,m^{-2}$ [3]

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(iii) Show that the equilibrium surface temperature of Titan is about 90 K. [1]

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(Question 6 continued)

(b) (i) The orbital radius of Titan around Saturn is R and the period of revolution is T.

Show that $T^2 = \frac{4\pi^2 R^3}{GM}$ where M is the mass of Saturn. [2]

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(ii) The orbital radius of Titan around Saturn is 1.2×10^9 m and the orbital period is 15.9 days. Estimate the mass of Saturn. [2]

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References:

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