Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Higher level
Paper 2

29 April 2026

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

Session number

2 hours 30 minutes

Instructions to students

- 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]**.

31 pages

2226 – 4718

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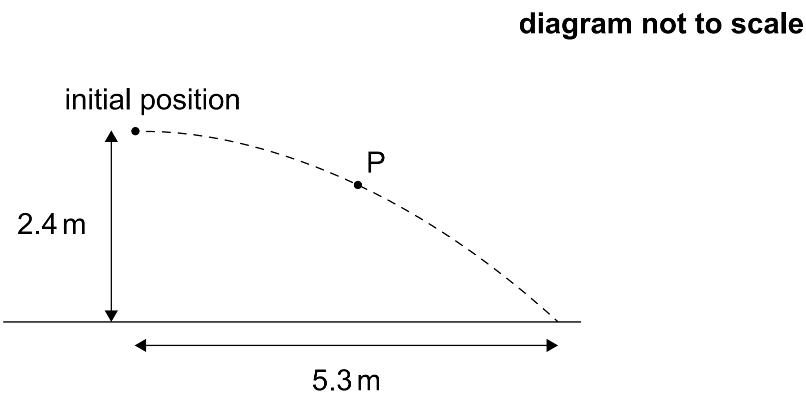
Answers written on this page
will not be marked.

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

1. A ball is thrown horizontally from a height of 2.4 m above the ground. The horizontal distance travelled by the ball is 5.3 m. Air resistance is negligible.

The diagram shows the path of the ball. P is an instantaneous position of the ball.



(a) Draw, on the diagram, labelled arrows to show

(i) the velocity *v* of the ball at P. [1]

(ii) the acceleration *a* of the ball at P. [1]

(b) Calculate

(i) the time the ball is in the air. [2]

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(ii) the initial speed of the ball. [1]

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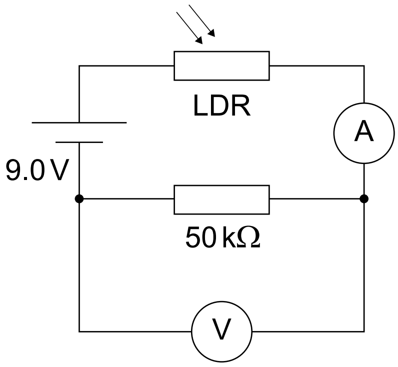
2. A light-dependent resistor (LDR) and a fixed 50 kΩ resistor are connected to a cell of emf 9.0 V, as shown.



The ammeter and the voltmeter are ideal. The cell has no internal resistance.

(a) State what is meant by an ideal ammeter. [1]

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The resistance of the LDR is 200 kΩ in complete darkness, and it decreases with increasing intensity of incident light.

(b) Calculate the reading of the ammeter when the LDR is in complete darkness. [2]

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(Question 2 continued)

The intensity of light incident on the LDR is increased.

(c) Explain the change, if any, to

(i) the reading of the voltmeter. [2]

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(ii) the power transferred from the cell. [1]

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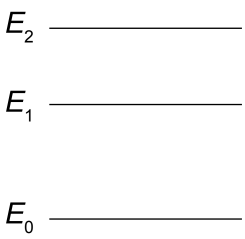
3. (a) Explain, with reference to energy levels, the formation of the **absorption** spectrum of a gas. [3]

The diagram shows some of the energy levels of an atom.



The wavelengths of photons emitted in some of the atomic transitions between these energy levels are given in the table.

Transition	**Wavelength / nm**
From E_1 to E_0	514
From E_2 to E_0	309

(b) Calculate, in eV, the energy difference $E_2 - E_1$. [2]

4. In an experiment to investigate the photoelectric effect, monochromatic electromagnetic radiation is incident on a metal surface.

When the frequency of radiation is 9.0×10^{14} Hz, photoelectrons of maximum kinetic energy 8.0×10^{-20} J are emitted from the metal surface.

(a) The maximum kinetic energy of the photoelectrons does not depend on the intensity of radiation. Explain how this observation supports the particle nature of light. [2]

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(b) Determine the threshold frequency of the metal surface. [3]

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(Question 4 continued)

The variation of the maximum kinetic energy of the photoelectrons is plotted against the frequency of radiation for two surfaces made of different metals.

(c) Identify **one** similarity and **one** difference between the graphs obtained. [2]

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In the Compton experiment, X-rays are scattered by electrons.

(d) State which feature of this experiment **cannot** be explained using the wave model of light. [1]

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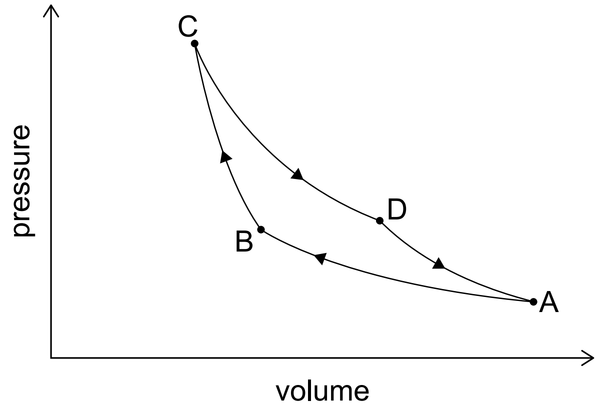
5. The working substance of a heat engine is 0.12 mol of an ideal gas.

The engine can be modelled as a Carnot cycle, shown in the pressure–volume diagram. Processes AB and CD are isothermal. Processes BC and DA are adiabatic.



During one cycle of the engine, the gas receives thermal energy of 0.75 J from a hot reservoir and discards thermal energy of 0.45 J to the cold reservoir.

(a) (i) Calculate the efficiency of the engine. [1]

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(ii) Identify the process of the cycle during which the working substance of the engine has the greatest internal energy. [1]

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At point A, the pressure of the gas is 3.0×10^{5} Pa and the volume of the gas is $1.8 \times 10^{-3}\,\text{m}^{3}$.

(iii) Calculate the temperature of the gas at point A. [2]

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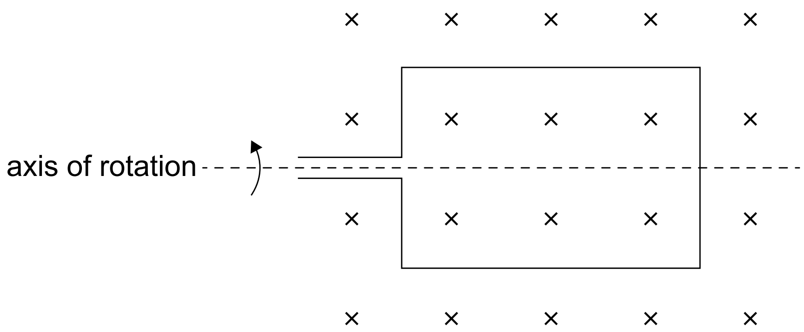
(Question 5 continued)

The engine powers an electric generator, which consists of a rectangular coil rotating in a uniform magnetic field.



(b) (i) Explain how an emf is induced in the coil. [3]

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(ii) State the angle between the normal to the plane of the coil and the magnetic field vector at which the instantaneous emf induced in the coil is greatest. [1]

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(Question 5 continued)

At $t = 0$ the coil is perpendicular to the magnetic field, as shown in the diagram.
At $t = 7.0 \times 10^{-3}$ s the coil has rotated through an angle of 120°.

The following data are given:

surface area of the coil $= 5.0 \times 10^{-2}\,\mathrm{m}^2$

number of turns of the coil $= 1500$

magnetic field strength $= 0.040\,\mathrm{T}$

(iii) Determine the average emf induced in the coil between $t = 0$ and $t = 7.0 \times 10^{-3}$ s. [2]

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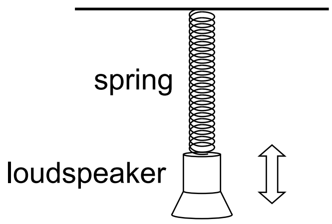
6. A loudspeaker oscillates with simple harmonic motion at the end of a spring.



The displacement x, in metres, of the loudspeaker is modelled by $x = 0.450\sin\left(15.7t + \frac{\pi}{2}\right)$, where t is the time in seconds.

(a) Show that

(i) the frequency of the oscillations is 2.5 Hz. [1]

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(ii) the maximum speed of the loudspeaker is about $7\,\mathrm{m\,s^{-1}}$. [1]

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(b) Calculate the maximum acceleration of the loudspeaker. [2]

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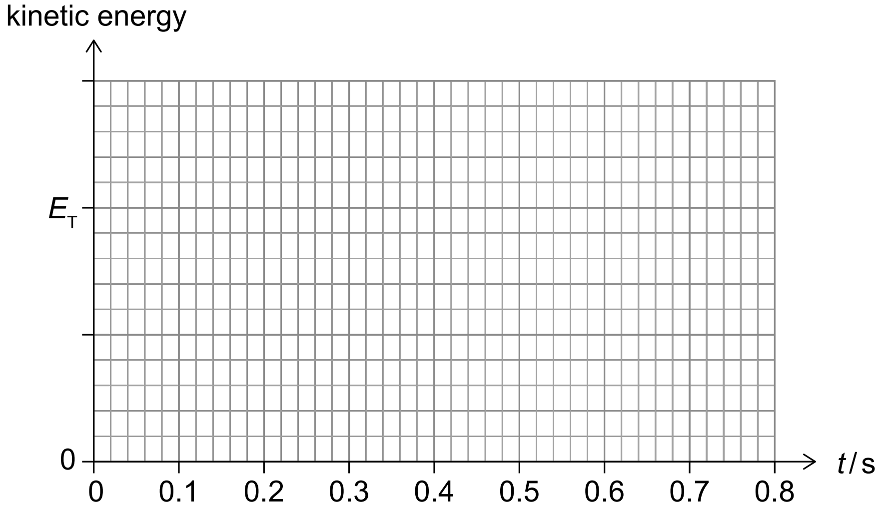
(Question 6 continued)

The total energy of the oscillating system is E_T.

(c) Sketch, on the axes, a graph to show how the kinetic energy of the loudspeaker varies with t. [2]



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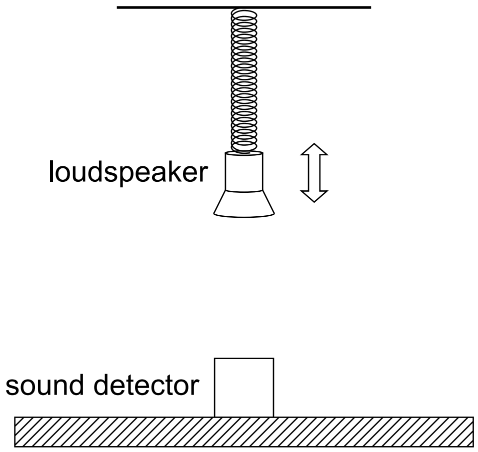
(Question 6 continued)

The loudspeaker emits a sound of frequency 500 Hz.

A stationary sound detector is placed along the line of oscillations of the loudspeaker as shown.



(d) Calculate the minimum frequency of the sound recorded by the detector. The speed of sound in air is $340\,m\,s^{-1}$. [2]

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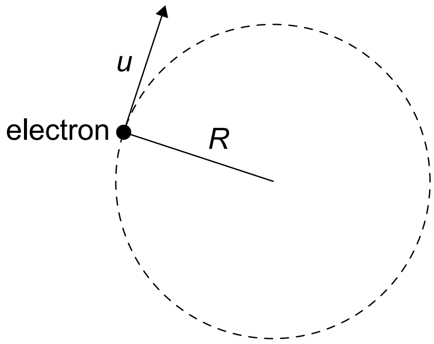
7. An electron is moving in a uniform magnetic field of strength B. The path of the electron is a circle of radius R. The diagram shows the path of the electron and the direction of the electron's velocity, u, at one instant.



(a) (i) State the direction of the magnetic field. [1]

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(ii) Outline why the kinetic energy of the electron remains constant. [1]

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It is given that $B = 1.5\,\text{mT}$ and $R = 4.0\,\text{cm}$.

(iii) Determine u. [2]

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(Question 7 continued)

Electrons used in the experiment were accelerated from rest to speed u by an electric potential difference V.

V is related to B and R by the equation $V = kB^2R^2$, where k is a constant.

(b) (i) Derive an expression for k, giving the answer in terms of the elementary charge e and the mass of the electron m_e. [3]

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(ii) State the units of k. [1]

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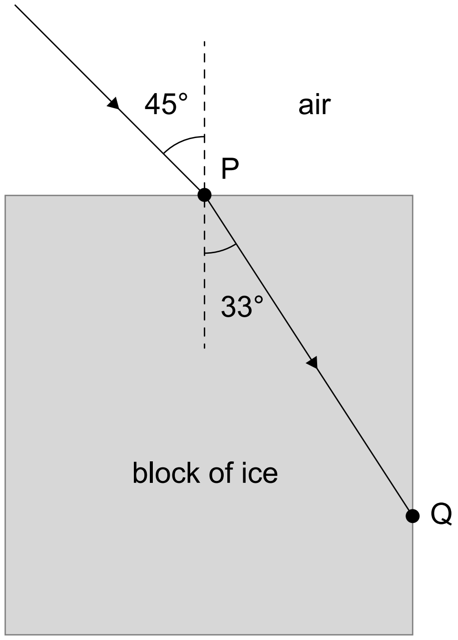
8. A ray of light enters a rectangular block of ice from the air at point P, as shown. The angle of incidence at P is 45° and the angle of refraction is 33°. The refracted ray is incident on the adjacent ice–air boundary at point Q.



The speed of light in air is *c*.

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(Question 8 continued)

(a) (i) Calculate the speed of light in the ice. [2]

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(ii) State and explain the change in the wavelength of light as it enters the ice from the air. [2]

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(iii) Deduce whether the light will emerge from the block of ice at Q. [3]

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(Question 8 continued)

The block of ice is then fully submerged in cold water and released from rest.

The following data are given:

$$\text{density of ice} = 920\,\text{kg}\,\text{m}^{-3}$$

$$\text{density of water} = 1000\,\text{kg}\,\text{m}^{-3}$$

(b) (i) Determine the initial acceleration of the block of ice. [3]

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(Question 8 continued)

A drag force acts on the block of ice. The magnitude of the drag force increases with the speed of the block. The block is released from a sufficient depth that it can reach terminal speed.

(ii) State how the acceleration of the block of ice changes with time. [1]

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(iii) Draw, in the box below, a free-body diagram of the forces acting on the block of ice when it is moving at terminal speed. [2]

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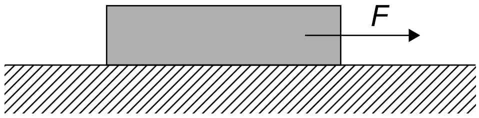
(Question 8 continued)

Another block of ice is pulled across a rough horizontal table by a constant force *F*. The block moves at a constant speed.



The following data are given:

rate of work done by $F = 3.1\,\text{W}$

speed of the block $= 0.50\,\text{m}\,\text{s}^{-1}$

mass of the block $= 5.5\,\text{kg}$

height of the block $= 8.0 \times 10^{-2}\,\text{m}$

contact area of the block and the surface $= 7.5 \times 10^{-2}\,\text{m}^2$

thermal conductivity of ice $= 2.3\,\text{W}\,\text{m}^{-1}\,\text{K}^{-1}$

(c) Calculate

(i) the magnitude of *F*. [1]

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(ii) the coefficient of dynamic friction between the block of ice and the table. [1]

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(Question 8 continued)

The initial temperature of the block of ice is –8.0 °C, which is the same as the temperature of the surrounding air and the table.

(d) (i) Explain why, as the block of ice is pulled across the table, there will be a temperature gradient through the ice. [2]

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(ii) Estimate the temperature of the bottom surface of the block of ice. Assume that the top surface of the block remains at the temperature of the environment, and that thermal conduction vertically through the ice is the primary route of energy transfer in the system. [2]

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(iii) Suggest one other way in which energy is transferred through conduction in the system. [1]

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9. (a) Outline the differences between a red giant star and the Sun, with reference to their

(i) physical properties. [2]

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(ii) evolutionary stage. [1]

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(Question 9 continued)

One process that takes place in red giants is nuclear fusion of beryllium-8 (Be-8) nuclei and alpha particles. The equation for this reaction is

$$^{8}_{4}\text{Be} + \alpha \rightarrow {}^{12}_{6}\text{C} + \gamma$$

The following data are given about binding energy per nucleon.

Nuclide	**Binding energy / *A***
$^{8}_{4}\text{Be}$	7.062 MeV
α	7.074 MeV
$^{12}_{6}\text{C}$	7.680 MeV

(b) (i) Calculate the energy released in the reaction. [2]

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(Question 9 continued)

(ii) Sketch, on the axes, a graph to show how the electric potential V_e, due to a Be-8 nucleus, varies with distance r from the nucleus. Assume that the nucleus is a point particle. No numbers are necessary on the axes. [2]

(iii) State the quantity represented by the gradient of the graph. [1]

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The fusion reaction is only possible if the distance between the centres of the Be-8 nucleus and the alpha particle is less than about 4.5×10^{-15} m.

The particles approach each other head-on from a large initial separation.

(iv) Estimate, in MeV, the minimum combined initial kinetic energy of the particles necessary for the fusion reaction to take place. [2]

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(Question 9 continued)

(c) Be-8 is radioactive and has a decay constant of about $8 \times 10^{15}\,s^{-1}$.

(i) State the conditions in the centre of a star necessary for the fusion reaction to take place. [1]

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(ii) Suggest, with reference to the nuclear half-life of Be-8, why these conditions must be met. [2]

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The remnant of a massive super giant star collapses gravitationally and forms a neutron star. During the collapse of the star, its radius decreases by a factor of 25, its mass is unchanged and its temperature increases.

The star can be modelled as a uniform sphere of mass M, radius R and moment of inertia $\frac{2}{5}MR^2$.

The period of rotation of the star just before the collapse is 5.0 s.

(d) (i) Show that the collapsed neutron star rotates at a rate of about 100 revolutions per second. Assume that no external torque acts on the star during the collapse. [3]

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(Question 9 continued)

The initial rotational kinetic energy of the star is E_0.

(ii) Determine, in terms of E_0, the final rotational kinetic energy of the neutron star. [2]

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(iii) Identify **two** energy changes that take place during the collapse of the star. [2]

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