Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Friday 17 May 2019 (afternoon)

1 hour 15 minutes

Candidate session number

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]**.

2219–6517

12 pages

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

1. A student strikes a tennis ball that is initially at rest so that it leaves the racquet at a speed of 64 m s^{-1}. The ball has a mass of 0.058 kg and the contact between the ball and the racquet lasts for 25 ms.

(a) Calculate the

(i) average force exerted by the racquet on the ball. [2]

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(ii) average power delivered to the ball during the impact. [2]

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(b) The student strikes the tennis ball at point P. The tennis ball is initially directed at an angle of 7.00° to the horizontal.

diagram not to scale

The following data are available.

Height of P = 2.80 m
Distance of student from net = 11.9 m
Height of net = 0.910 m
Initial speed of tennis ball = 64 m s^{-1}

(This question continues on the following page)

(Question 1 continued)

(i) Calculate the time it takes the tennis ball to reach the net. [2]

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(ii) Show that the tennis ball passes over the net. [3]

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(iii) Determine the speed of the tennis ball as it strikes the ground. [2]

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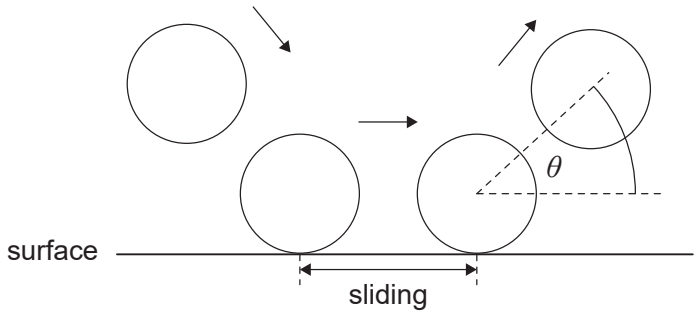
(Question 1 continued)

(c) The student models the bounce of the tennis ball to predict the angle θ at which the ball leaves a surface of clay and a surface of grass.



The model assumes

- during contact with the surface the ball slides.
- the sliding time is the same for both surfaces.
- the sliding frictional force is greater for clay than grass.
- the normal reaction force is the same for both surfaces.

Predict for the student's model, without calculation, whether θ is greater for a clay surface **or** for a grass surface. [3]

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2. A container of volume $3.2 \times 10^{-6}\,m^3$ is filled with helium gas at a pressure of $5.1 \times 10^5\,Pa$ and temperature 320 K. Assume that this sample of helium gas behaves as an ideal gas.

(a) The molar mass of helium is $4.0\,g\,mol^{-1}$. Show that the mass of a helium atom is $6.6 \times 10^{-27}\,kg$. [1]

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(b) Estimate the average speed of the helium atoms in the container. [2]

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(c) Show that the number of helium atoms in the container is about 4×10^{20}. [2]

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(d) A helium atom has a volume of $4.9 \times 10^{-31}\,m^3$.

(i) Calculate the ratio $\frac{\text{total volume of helium atoms}}{\text{volume of helium gas}}$. [1]

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(ii) Explain, using your answer to (d)(i) and with reference to the kinetic model, why this sample of helium can be assumed to be an ideal gas. [2]

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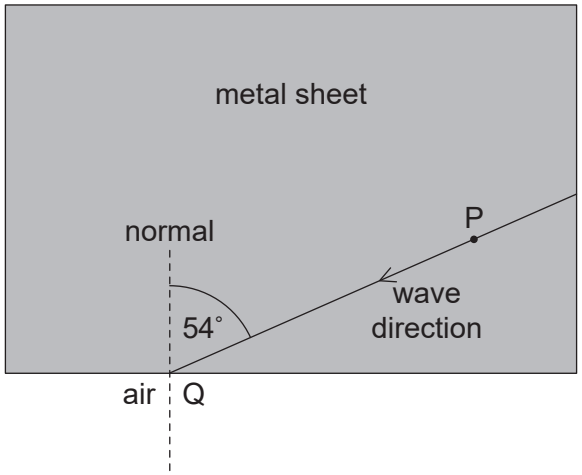
3. The diagram shows the direction of a sound wave travelling in a metal sheet.

diagram not to scale



(a) Particle P in the metal sheet performs simple harmonic oscillations. When the displacement of P is 3.2 μm the magnitude of its acceleration is 7.9 m s^{-2}. Calculate the magnitude of the acceleration of P when its displacement is 2.3 μm. [2]

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(b) The wave is incident at point Q on the metal–air boundary. The wave makes an angle of 54° with the normal at Q. The speed of sound in the metal is 6010 m s^{-1} and the speed of sound in air is 340 m s^{-1}. Calculate the angle between the normal at Q and the direction of the wave in air. [2]

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(This question continues on the following page)

(Question 3 continued)

(c) The frequency of the sound wave in the metal is 250 Hz.

(i) State the frequency of the wave in air. [1]

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(ii) Determine the wavelength of the wave in air. [1]

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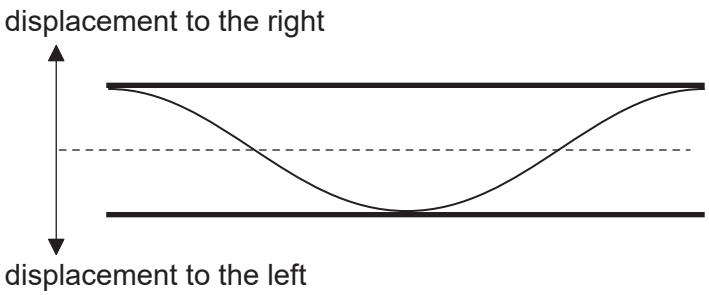
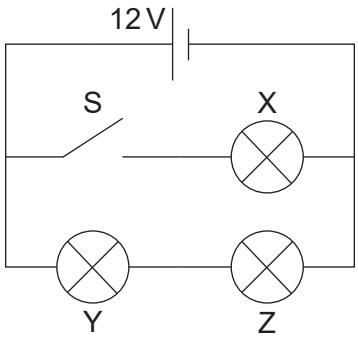
(d) The sound wave in air in (c) enters a pipe that is open at both ends. The diagram shows the displacement, at a particular time *T*, of the standing wave that is set up in the pipe.



On the diagram, at time *T*, label with the letter C a point in the pipe that is at the centre of a compression. [1]

4. Three identical light bulbs, X, Y and Z, each of resistance 4.0 Ω are connected to a cell of emf 12 V. The cell has negligible internal resistance.



(a) The switch S is initially open. Calculate the total power dissipated in the circuit. [2]

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(b) The switch is now closed.

(i) State, without calculation, why the current in the cell will increase. [1]

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(ii) Deduce the ratio $\frac{\text{power dissipated in Y with S open}}{\text{power dissipated in Y with S closed}}$. [2]

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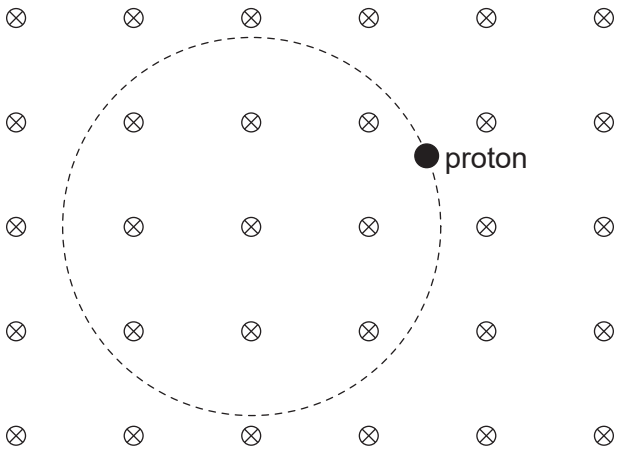
5. A proton moves along a circular path in a region of a uniform magnetic field. The magnetic field is directed into the plane of the page.



(a) Label with arrows on the diagram the

(i) magnetic force F on the proton. [1]

(ii) velocity vector v of the proton. [1]

(b) The speed of the proton is $2.16 \times 10^6\,\text{m}\,\text{s}^{-1}$ and the magnetic field strength is 0.042 T. For this proton, determine, in m, the radius of the circular path. Give your answer to an appropriate number of significant figures. [3]

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6. Deuterium, ${}^{2}_{1}\mathrm{H}$, undergoes fusion according to the following reaction.

$$ {}^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{3}_{1}\mathrm{H} + \mathrm{X} $$

(a) Identify particle X. [1]

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(b) The following data are available for binding energies per nucleon.

$$ {}^{2}_{1}\mathrm{H} = 1.12\,\mathrm{MeV} $$
$$ {}^{3}_{1}\mathrm{H} = 2.78\,\mathrm{MeV} $$

(i) Determine, in MeV, the energy released. [2]

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(ii) Suggest why, for the fusion reaction above to take place, the temperature of deuterium must be very high. [2]

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(This question continues on the following page)

(Question 6 continued)

(c) Particle Y is produced in the collision of a proton with a K^- in the following reaction.

$$K^- + p^+ \rightarrow K^0 + K^+ + Y$$

The quark content of some of the particles involved are

$$K^- = \bar{u}s \quad K^0 = d\bar{s}$$

Identify, for particle Y, the

(i) charge. [1]

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(ii) strangeness. [1]

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7. The average temperature of ocean surface water is 289 K. Oceans behave as black bodies.

(a) Show that the intensity radiated by the oceans is about 400 $W m^{-2}$. [1]

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(b) Explain why some of this radiation is returned to the oceans from the atmosphere. [3]

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