



No part of this product may be reproduced in any form or by any electronic or mechanical means, including information storage and retrieval systems, without written permission from the IB.

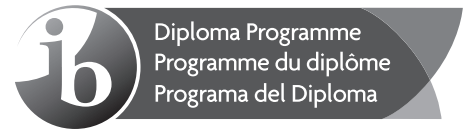
Additionally, the license tied with this product prohibits commercial use of any selected files or extracts from this product. Use by third parties, including but not limited to publishers, private teachers, tutoring or study services, preparatory schools, vendors operating curriculum mapping services or teacher resource digital platforms and app developers, is not permitted and is subject to the IB's prior written consent via a license. More information on how to request a license can be obtained from <http://www.ibo.org/contact-the-ib/media-inquiries/for-publishers/guidance-for-third-party-publishers-and-providers/how-to-apply-for-a-license>.

Aucune partie de ce produit ne peut être reproduite sous quelque forme ni par quelque moyen que ce soit, électronique ou mécanique, y compris des systèmes de stockage et de récupération d'informations, sans l'autorisation écrite de l'IB.

De plus, la licence associée à ce produit interdit toute utilisation commerciale de tout fichier ou extrait sélectionné dans ce produit. L'utilisation par des tiers, y compris, sans toutefois s'y limiter, des éditeurs, des professeurs particuliers, des services de tutorat ou d'aide aux études, des établissements de préparation à l'enseignement supérieur, des fournisseurs de services de planification des programmes d'études, des gestionnaires de plateformes pédagogiques en ligne, et des développeurs d'applications, n'est pas autorisée et est soumise au consentement écrit préalable de l'IB par l'intermédiaire d'une licence. Pour plus d'informations sur la procédure à suivre pour demander une licence, rendez-vous à l'adresse <http://www.ibo.org/fr/contact-the-ib/media-inquiries/for-publishers/guidance-for-third-party-publishers-and-providers/how-to-apply-for-a-license>.

No se podrá reproducir ninguna parte de este producto de ninguna forma ni por ningún medio electrónico o mecánico, incluidos los sistemas de almacenamiento y recuperación de información, sin que medie la autorización escrita del IB.

Además, la licencia vinculada a este producto prohíbe el uso con fines comerciales de todo archivo o fragmento seleccionado de este producto. El uso por parte de terceros —lo que incluye, a título enunciativo, editoriales, profesores particulares, servicios de apoyo académico o ayuda para el estudio, colegios preparatorios, desarrolladores de aplicaciones y entidades que presten servicios de planificación curricular u ofrezcan recursos para docentes mediante plataformas digitales— no está permitido y estará sujeto al otorgamiento previo de una licencia escrita por parte del IB. En este enlace encontrará más información sobre cómo solicitar una licencia: <http://www.ibo.org/es/contact-the-ib/media-inquiries/for-publishers/guidance-for-third-party-publishers-and-providers/how-to-apply-for-a-license>.



Physics
Standard level
Paper 2

Friday 17 May 2019 (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]**.



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]

.....

.....

.....

.....

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

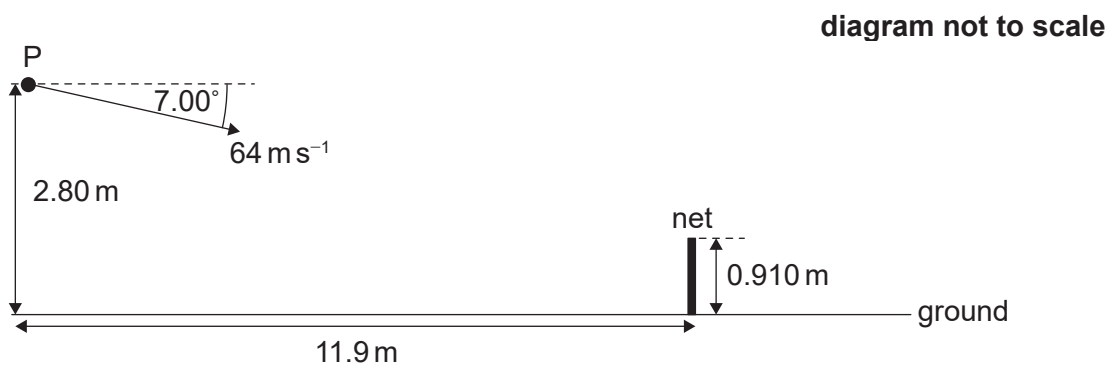
.....

.....

.....

.....

- (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.



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]

.....
.....
.....
.....

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

.....
.....
.....
.....
.....
.....
.....
.....

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

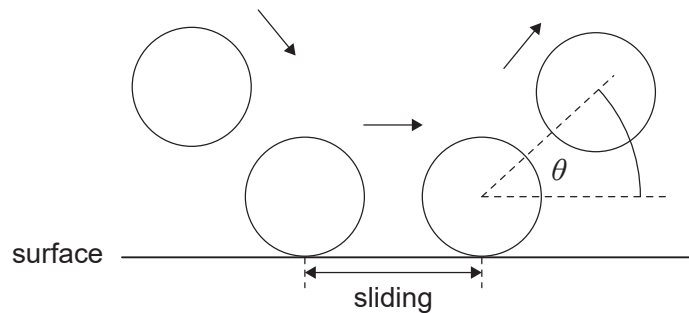
.....
.....
.....
.....
.....
.....

(This question continues on the following page)



(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]

.....

.....

.....

.....

.....

.....



2. A container of volume $3.2 \times 10^{-6} \text{ m}^3$ is filled with helium gas at a pressure of $5.1 \times 10^5 \text{ Pa}$ 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 $6.6 \times 10^{-27} \text{ kg}$. [1]

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

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

.....

.....

(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]

.....

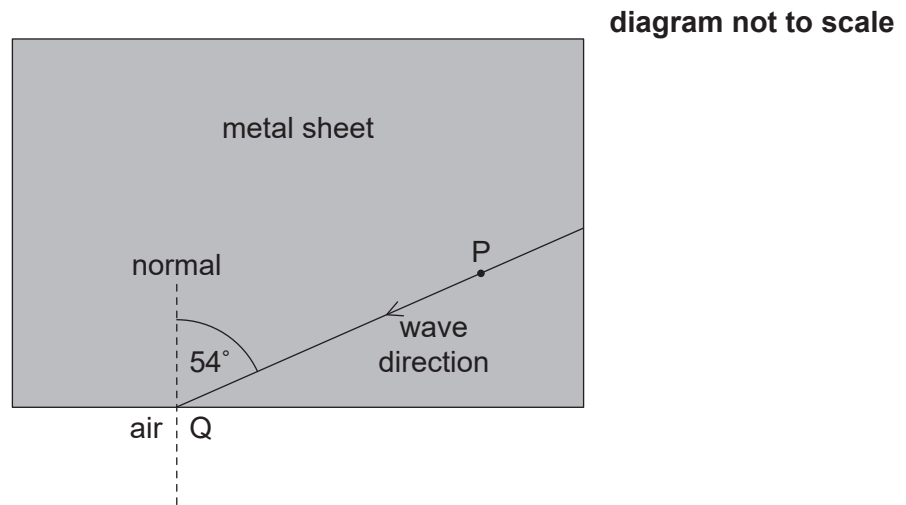
.....

.....

.....



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



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

.....

.....

.....

.....

- (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 $6010\ \text{ms}^{-1}$ and the speed of sound in air is $340\ \text{ms}^{-1}$. Calculate the angle between the normal at Q and the direction of the wave in air. [2]

.....

.....

.....

.....

(This question continues on the following page)



(Question 3 continued)

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

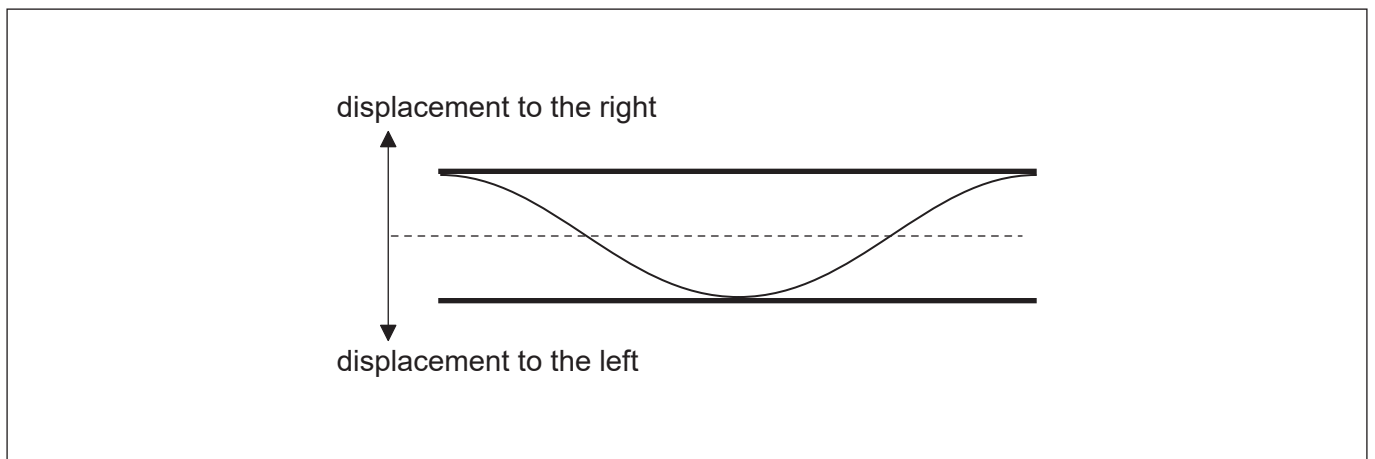
(i) State the frequency of the wave in air. [1]

.....
.....

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

.....
.....

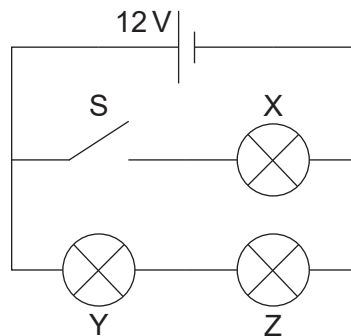
(d) The sound wave in air in (c) enters a pipe that is open at both ends. The diagram shows the displacement, at a particular time T , of the standing wave that is set up in the pipe.



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 $4.0\ \Omega$ are connected to a cell of emf 12V. The cell has negligible internal resistance.



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

.....

.....

.....

.....

- (b) The switch is now closed.

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

.....

.....

.....

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

.....

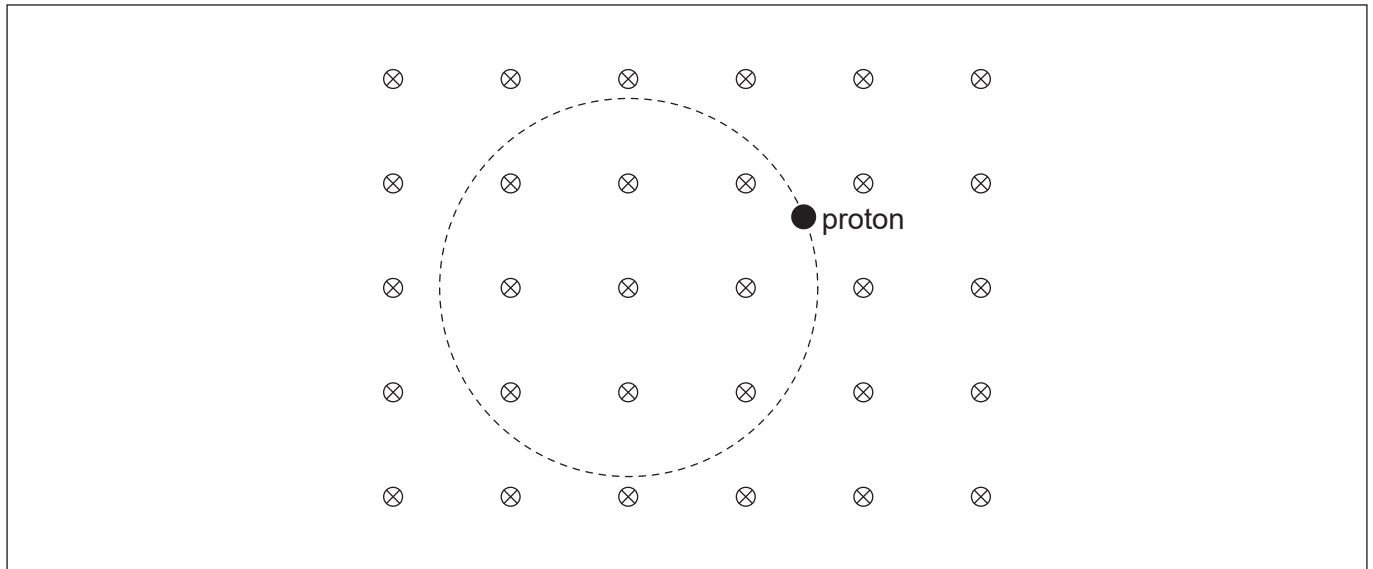
.....

.....

.....



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
- magnetic force F on the proton. [1]
 - velocity vector v of the proton. [1]
- (b) The speed of the proton is $2.16 \times 10^6 \text{ m s}^{-1}$ 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]

.....

.....

.....

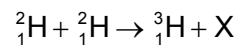
.....

.....

.....



6. Deuterium, ${}^2_1\text{H}$, undergoes fusion according to the following reaction.



- (a) Identify particle X.

[1]

.....

.....

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

$${}^2_1\text{H} = 1.12\text{MeV}$$

$${}^3_1\text{H} = 2.78\text{MeV}$$

- (i) Determine, in MeV, the energy released.

[2]

.....

.....

.....

.....

.....

.....

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

[2]

.....

.....

.....

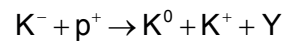
.....

(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.



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]

.....

- (ii) strangeness.

[1]

.....



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

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

.....
.....

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

.....
.....
.....
.....
.....
.....

