

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**

Tuesday 5 November 2019 (afternoon)

Candidate session number

1 hour 15 minutes

--	--	--	--	--	--	--	--	--	--

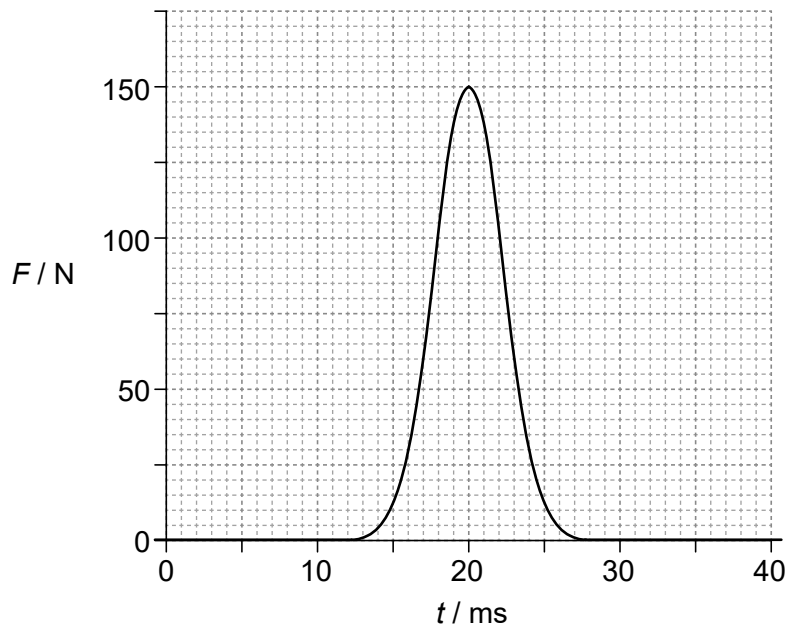
**Instructions to candidates**

- 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. The graph shows the variation with time  $t$  of the horizontal force  $F$  exerted on a tennis ball by a racket.



The tennis ball was stationary at the instant when it was hit. The mass of the tennis ball is  $5.8 \times 10^{-2}$  kg. The area under the curve is 0.84 N s.

- (a) Calculate the speed of the ball as it leaves the racket. [2]

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

- (b) Show that the average force exerted on the ball by the racket is about 50 N. [2]

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

(This question continues on the following page)



**(Question 1 continued)**

- (c) Determine, with reference to the work done by the average force, the horizontal distance travelled by the ball while it was in contact with the racket.

[3]

.....

.....

.....

.....

.....

.....

- (d) Draw a graph to show the variation with  $t$  of the horizontal speed  $v$  of the ball while it was in contact with the racket. Numbers are **not** required on the axes.

[2]



- 2. The air in a kitchen has pressure  $1.0 \times 10^5$  Pa and temperature  $22^\circ\text{C}$ . A refrigerator of internal volume  $0.36\text{m}^3$  is installed in the kitchen.

- (a) With the door open the air in the refrigerator is initially at the same temperature and pressure as the air in the kitchen. Calculate the number of molecules of air in the refrigerator.

[2]

.....

.....

.....

.....

**(This question continues on the following page)**



12EP03

Turn over

**(Question 2 continued)**

(b) The refrigerator door is closed. The air in the refrigerator is cooled to  $5.0^{\circ}\text{C}$  and the number of air molecules in the refrigerator stays the same.

(i) Determine the pressure of the air inside the refrigerator. [2]

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

(ii) The door of the refrigerator has an area of  $0.72\text{ m}^2$ . Show that the minimum force needed to open the refrigerator door is about 4 kN. [2]

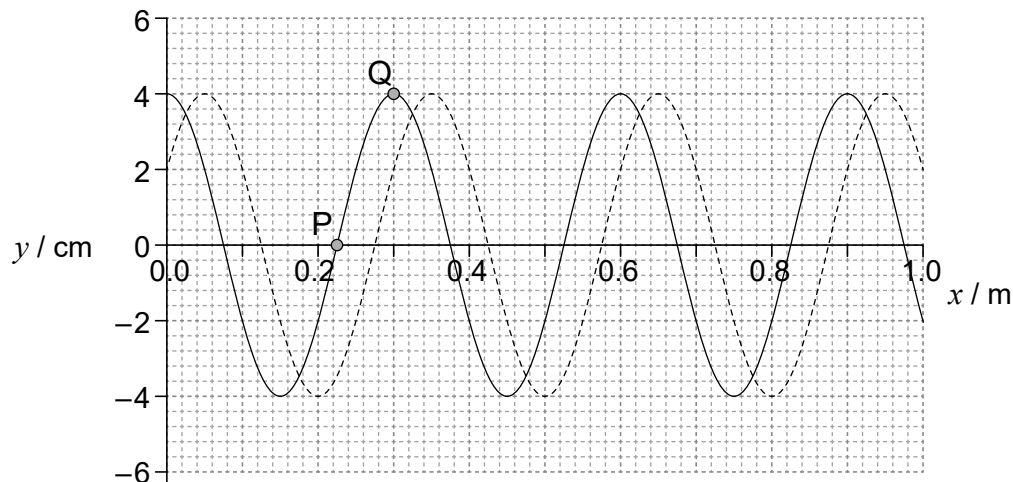
.....  
.....  
.....  
.....

(iii) Comment on the magnitude of the force in (b)(ii). [2]

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



3. The solid line in the graph shows the variation with distance  $x$  of the displacement  $y$  of a travelling wave at  $t = 0$ . The dotted line shows the wave 0.20 ms later. The period of the wave is longer than 0.20 ms.



- (a) (i) Calculate, in  $\text{ms}^{-1}$ , the speed for this wave. [1]

.....  
.....

- (ii) Calculate, in Hz, the frequency for this wave. [2]

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

- (b) The graph also shows the displacement of two particles, P and Q, in the medium at  $t = 0$ . State and explain which particle has the larger magnitude of acceleration at  $t = 0$ . [2]

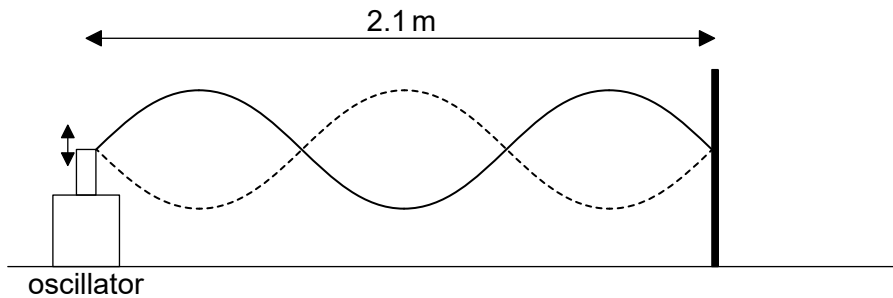
.....  
.....  
.....  
.....

(This question continues on the following page)



**(Question 3 continued)**

- (c) One end of a string is attached to an oscillator and the other is fixed to a wall. When the frequency of the oscillator is 360 Hz the standing wave shown is formed on the string.



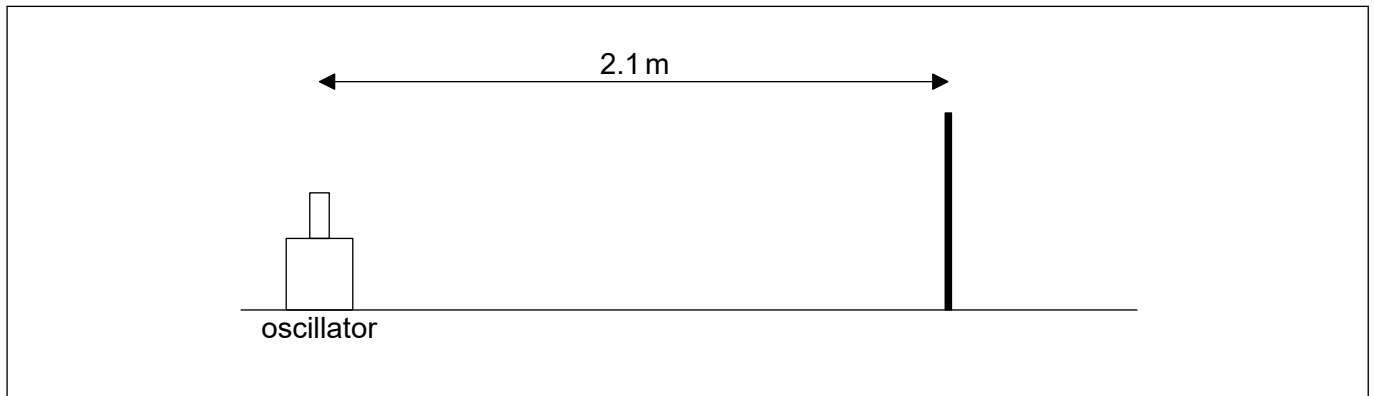
Point X (not shown) is a point on the string at a distance of 10 cm from the oscillator.

- (i) State the number of all other points on the string that have the same amplitude and phase as X. [1]

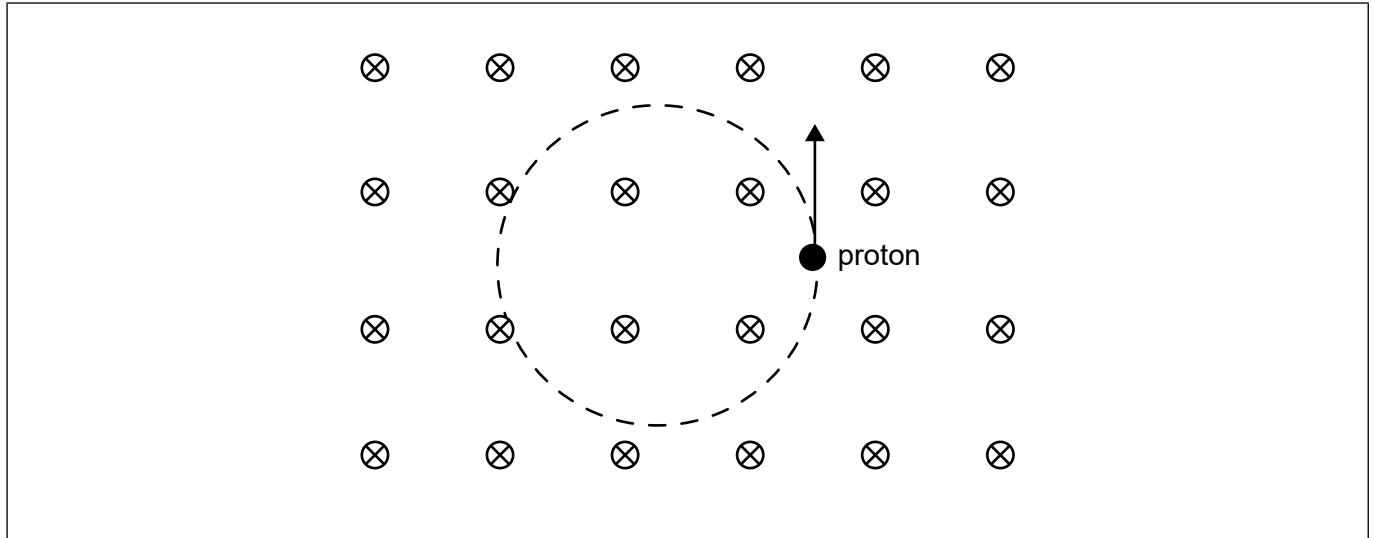
.....

.....

- (ii) The frequency of the oscillator is reduced to 120 Hz. On the diagram, draw the standing wave that will be formed on the string. [1]



4. A proton is moving in a region of uniform magnetic field. The magnetic field is directed into the plane of the paper. The arrow shows the velocity of the proton at one instant and the dotted circle gives the path followed by the proton.



- (a) Explain why the path of the proton is a circle. [2]

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

- (b) The speed of the proton is  $2.0 \times 10^6 \text{ ms}^{-1}$  and the magnetic field strength  $B$  is  $0.35 \text{ T}$ .

- (i) Show that the radius of the path is about  $6 \text{ cm}$ . [2]

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

(This question continues on the following page)





**(Question 4 continued)**

- (ii) Calculate the time for **one** complete revolution. [2]

.....

.....

.....

.....

- (c) Explain why the kinetic energy of the proton is constant. [2]

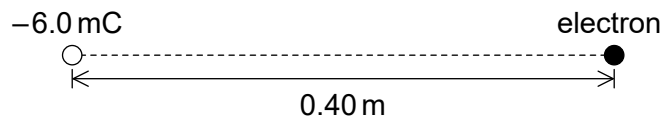
.....

.....

.....

.....

5. An electron is placed at a distance of 0.40 m from a fixed point charge of  $-6.0 \text{ mC}$ .



- (a) Show that the electric field strength due to the point charge at the position of the electron is  $3.4 \times 10^8 \text{ NC}^{-1}$ . [2]

.....

.....

.....

.....

- (b) (i) Calculate the magnitude of the initial acceleration of the electron. [2]

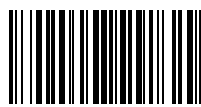
.....

.....

.....

.....

**(This question continues on the following page)**



12EP08

**(Question 5 continued)**

(ii) Describe the subsequent motion of the electron. [3]

.....

.....

.....

.....

.....

.....

6. Wind is incident on the blades of a wind turbine. The radius of the blades is 12 m. The following data are available for the air immediately before and after impact with the blades.

	Before	After
Density of air	1.20 kg m <sup>-3</sup>	1.32 kg m <sup>-3</sup>
Wind speed	8.0 ms <sup>-1</sup>	4.0 ms <sup>-1</sup>

(a) Determine the maximum power that can be extracted from the wind by this turbine. [3]

.....

.....

.....

.....

.....

.....

.....

(b) Suggest why the answer in (a) is a maximum. [1]

.....

.....



7. (a) Radioactive decay is said to be “random” and “spontaneous”. Outline what is meant by each of these terms. [2]

Random: .....

Spontaneous: .....

- (b) A stationary nucleus of uranium-238 undergoes alpha decay to form thorium-234.

The following data are available.

Energy released in decay	4.27 MeV
Binding energy per nucleon for helium	7.07 MeV
Binding energy per nucleon for thorium	7.60 MeV

- (i) Calculate the binding energy per nucleon for uranium-238. [3]

.....

.....

.....

.....

.....

.....

- (ii) Calculate the ratio  $\frac{\text{kinetic energy of alpha particle}}{\text{kinetic energy of thorium nucleus}}$ . [2]

.....

.....

.....

.....



Please **do not** write on this page.

Answers written on this page  
will not be marked.



12EP11

Please **do not** write on this page.

Answers written on this page  
will not be marked.



12EP12