

# Markscheme

May 2022

Physics

Standard level

Paper 2

12 pages

© International Baccalaureate Organization 2022

All rights reserved. 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 the prior written permission from the IB. Additionally, the license tied with this product prohibits 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, whether fee-covered or not, is prohibited and is a criminal offense.

More information on how to request written permission in the form of a license can be obtained from <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

© Organisation du Baccalauréat International 2022

Tous droits réservés. 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 préalable de l'IB. De plus, la licence associée à ce produit interdit toute utilisation 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, moyennant paiement ou non, est interdite et constitue une infraction pénale.

Pour plus d'informations sur la procédure à suivre pour obtenir une autorisation écrite sous la forme d'une licence, rendez-vous à l'adresse <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

© Organización del Bachillerato Internacional, 2022

Todos los derechos reservados. 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 la previa autorización por escrito del IB. Además, la licencia vinculada a este producto prohíbe el uso 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—, ya sea incluido en tasas o no, está prohibido y constituye un delito.

En este enlace encontrará más información sobre cómo solicitar una autorización por escrito en forma de licencia: <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

**Subject Details: Physics SL Paper 2 Markscheme**

Candidates are required to answer **all** questions. Maximum total = **50 marks**.

1. Each row in the “Question” column relates to the smallest subpart of the question.
2. The maximum mark for each question subpart is indicated in the “Total” column.
3. Each marking point in the “Answers” column is shown by means of a tick (✓) at the end of the marking point.
4. A question subpart may have more marking points than the total allows. This will be indicated by “**max**” written after the mark in the “Total” column. The related rubric, if necessary, will be outlined in the “Notes” column.
5. An alternative wording is indicated in the “Answers” column by a slash (/). Either wording can be accepted.
6. An alternative answer is indicated in the “Answers” column by “**OR**”. Either answer can be accepted.
7. An alternative markscheme is indicated in the “Answers” column under heading **ALTERNATIVE 1** etc. Either alternative can be accepted.
8. Words inside chevrons « » in the “Answers” column are not necessary to gain the mark.
9. Words that are underlined are essential for the mark.
10. The order of marking points does not have to be as in the “Answers” column, unless stated otherwise in the “Notes” column.
11. If the candidate’s answer has the same “meaning” or can be clearly interpreted as being of equivalent significance, detail and validity as that in the “Answers” column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect) in the “Notes” column.
12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script. “ECF acceptable” will be displayed in the “Notes” column.
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the “Notes” column.

Question			Answers	Notes	Total
1.	a		<p><b>ALTERNATIVE 1</b>                      there is a force «by the fan» on the air / air is accelerated «to the rear» ✓                      by Newton 3 ✓                      there is an «equal and» opposite force on the boat ✓</p> <p><b>ALTERNATIVE 2</b>                      air gains momentum «backward» ✓                      by conservation of momentum / force is rate of change in momentum ✓                      boat gains momentum in the opposite direction ✓</p>	<p>Accept a reference to Newton's third law, e.g. N'3, or any correct statement of it for <b>MP2</b> in <b>ALT 1</b>.</p> <p>Allow any reasonable choice of object where the force of the air is acting on, e.g., fan or blades.</p>	3
1.	b	i	<p><math>\pi R^2</math> <b>OR</b> «mass of air through system per unit time =» <math>Av\rho</math> seen ✓                      244 «kg s<sup>-1</sup>» ✓</p>	<p>Accept use of Energy of air per second = <math>0.5 \rho Av^3 = 0.5 mv^2</math> for <b>MP1</b>.</p>	2
1.	b	ii	<p>«force = Momentum change per sec = <math>Av^2\rho</math> = » 244 x 20 <b>OR</b> 4.9 «kN» ✓</p>	<p>Allow use of 240</p>	1

Question			Answers	Notes	Total
1.	c	i	recognition that area under the graph is distance covered ✓  «Distance =» 480 - 560 «m» ✓	Accept graphical evidence or calculation of correct geometric areas for <b>MP1</b> .  <b>MP2</b> is numerical value within range.	2
1.	c	ii	calculation of acceleration as gradient at $t = 0$ «= 1 m s <sup>-2</sup> » ✓  use of $F=ma$ <b>OR</b> $\frac{4900}{1}$ seen ✓  4900 «kg» ✓	<b>MP1</b> can be shown on the graph. Allow an acceleration in the range 1 – 1.1 for <b>MP2</b> and consistent answer for <b>MP3</b> Allow <b>ECF</b> from <b>MP1</b> .  Allow use of average acceleration = $\frac{18}{40}$ or assumption of constant force to obtain 11000 «kg» for <b>[2]</b>  Allow use of 4800 or 5000 for <b>MP2</b>	3
1.	d		<b>ALTERNATE 1</b> « $\omega =$ » $4\pi$ rad s <sup>-1</sup> ✓ « $a = r\omega^2 =$ » 280 « m s <sup>-2</sup> » ✓  <b>ALTERNATE 2</b> « $v = \frac{2\pi r}{T}$ » = 22.6 m s <sup>-1</sup> ✓ « $a = \frac{v^2}{r}$ » = 280 « m s <sup>-2</sup> » ✓	Allow <b>ECF</b> from <b>MP1</b> for wrong $\omega$ (120 gives $2.6 \times 10^4$ « m s <sup>-2</sup> »)  Allow <b>ECF</b> from <b>MP1</b> for wrong $T$ (2 s gives 18 « m s <sup>-2</sup> »)	2

Question			Answers	Notes	Total
2.	a		Correct conversion of T «T = 310 K» seen ✓ « use of $N = \frac{pV}{kT}$ to get » $2.3 \times 10^{23}$ ✓	Allow <b>ECF</b> from <b>MP1</b> i.e., T in Celsius (Result is $2.7 \times 10^{24}$ )  Allow use of n, R and $N_A$	2
2.	b	i	density decreases ✓ volume is increased <b>AND</b> mass/number of particles remains constant ✓		2
2.	b	ii	internal energy is constant ✓ internal energy depends on kinetic energy/temperature «only» <b>OR</b> since temperature/kinetic energy is constant ✓	Do not award <b>MP2</b> for stating that “temperature is constant” unless linked to the correct conclusion, as that is mentioned in the stem.  Award <b>MP2</b> for stating that kinetic energy remains constant.	2

Question			Answers	Notes	Total
3.	a	i	<p>«incident and reflected» waves superpose/interfere/combine ✓</p> <p>«that leads to» standing waves formed <b>OR</b> nodes and antinodes present ✓</p> <p>at antinodes / maxima there is maximum intensity / constructive interference / «displacement» addition / louder sound ✓</p> <p>at nodes / minima there is minimum intensity / destructive interference / «displacement» cancellation / quieter sound ✓</p>	<p><b>OWTTE</b></p> <p><i>Allow a sketch of a standing wave for MP2</i></p> <p><i>Allow a correct reference to path or phase differences to identify constructive / destructive interference</i></p>	3 max
3.	a	ii	<p>wavelength = 0.24 «m» ✓</p> <p><math>f = \frac{340}{0.24} \Rightarrow 1.4 \text{ «kHz» OR } 1400 \text{ «Hz» ✓}</math></p>	<p><i>Allow ECF from MP1</i></p>	2
3.	b		<p>relates intensity to amplitude ✓</p> <p>antinodes / maximum intensity will be decreased / quieter ✓</p> <p>nodes / minimum will be increased / louder ✓</p> <p>difference in intensities will be less ✓</p> <p>maxima and minima are at the same positions ✓</p>	<p><b>OWTTE</b></p>	3 max

Question			Answers	Notes	Total
4.	a		« conservation of » charge ✓ « conservation of » energy ✓	<i>Allow [1] max if they explicitly refer to Kirchhoff' laws linking them to the conservation laws incorrectly.</i>	2
4.	b	i	12 V ✓		1
4.	b	ii	$I = 2.0 \text{ A}$ <b>OR</b> $12 = I(r+4)$ <b>OR</b> $4 = Ir$ <b>OR</b> $8 = 4I$ ✓ «Correct working to get » $r = 2.0 \text{ «}\Omega\text{»}$ ✓	<i>Allow ECF from (b)(i)</i>	2
4.	c		Loop equation showing <b>EITHER</b> correct voltages, i.e., 10 – 4 on one side or both emf's positive on different sides of the equation <b>OR</b> correct resistances, i.e. $I(1 + 2)$ ✓ $10 - 4 = I(1 + 2)$ <b>OR</b> $I = 2.0 \text{ «A»}$ seen ✓ $V = 8.0 \text{ «V»}$ ✓	<i>Allow any valid method</i>	3

Question			Answers	Notes	Total
4.	d	i	is generated from primary/other sources ✓		1
4.	d	ii	<p>«a fuel » that can be replenished/replaced within a reasonable time span</p> <p><b>OR</b></p> <p>«a fuel» that can be replaced faster than the rate at which it is consumed</p> <p><b>OR</b></p> <p>renewables are limitless/never run out</p> <p><b>OR</b></p> <p>«a fuel» produced from renewable sources</p> <p><b>OR</b></p> <p>gives an example of a renewable (biofuel, hydrogen, wood, wind, solar, tidal, hydro etc..) ✓</p>	<b>OWTTE</b>	1

Question			Answers	Notes	Total
4.	e	i	<p><b>ALTERNATIVE 1</b></p> <p>«energy output of the panel =&gt; <math>VIt</math> <b>OR</b> <math>6 \times 5 \times 0.25 \times 3600</math> <b>OR</b> <math>27000</math> «J» ✓</p> <p>«available power =&gt; <math>380 \times 0.4 \times 0.15 \times 0.18</math> <b>OR</b> <math>4.1</math> «W» ✓</p> <p><math>t = \frac{27000}{4.1} \Rightarrow 6600</math> «s» ✓</p> <p><b>ALTERNATIVE 2</b></p> <p>«energy needed from Sun =&gt; <math>\frac{VIt}{eff}</math> <b>OR</b> <math>\frac{6 \times 5 \times 0.25 \times 3600}{0.18}</math> <b>OR</b> <math>150000</math> «J» ✓</p> <p>« incident power=&gt; <math>380 \times 0.4 \times 0.15</math> <b>OR</b> <math>22.8</math> «W» ✓</p> <p><math>t = \frac{150000}{22.8} \Rightarrow 6600</math> «s» ✓</p>	<p>Allow <b>ECF</b> for <b>MP3</b></p> <p>Accept final answer in minutes (110) or hours (1.8).</p>	3
4.	e	ii	<p>coherent reason ✓</p> <p>e.g., to improve efficiency, is non-polluting, is renewable, does not produce greenhouse gases, reduce use of fossil fuels,</p>	Do <b>not</b> allow economic reasons	1

Question		Answers	Notes	Total
5.	a	background count rate is subtracted «from each reading» ✓	<b>OWTTE</b>	1
5.	b	thickness is 0.25 «mm» ✓ 380 «count min <sup>-1</sup> » ✓	<b>MP1 and MP2 can be shown on the graph</b> Allow a range of 0.23 to 0.27 mm for <b>MP1</b> Allow <b>ECF</b> from <b>MP1</b> . Accept a final answer in the range 350 – 420	2
5.	c	lead better absorber than copper ✓ not alpha ✓ as it does not go through the foil / it is easily stopped / it is stopped by paper ✓ there is gamma ✓ as it goes through lead ✓  <b>ALTERNATIVE 1</b> can be beta ✓ as it is attenuated by «thin» metal / can go through «thin» metal ✓  <b>ALTERNATIVE 2</b> not beta ✓ it is stopped by «thin» metal ✓		4 max

Question			Answers	Notes	Total
5.	d		${}_{55}^{137}\text{Cs} \rightarrow {}_{56}^{137}\text{Ba} + {}_{-1}^0\beta$ <p style="text-align: right;">✓</p> $+ \bar{\nu}_e$ <p style="text-align: right;">✓</p>	<p>Accept <math>\beta</math> or e in <b>MP1</b>.</p> <p>Do <b>not</b> penalize if proton / nucleon numbers or electron subscript in antineutrino are missing.</p>	2