

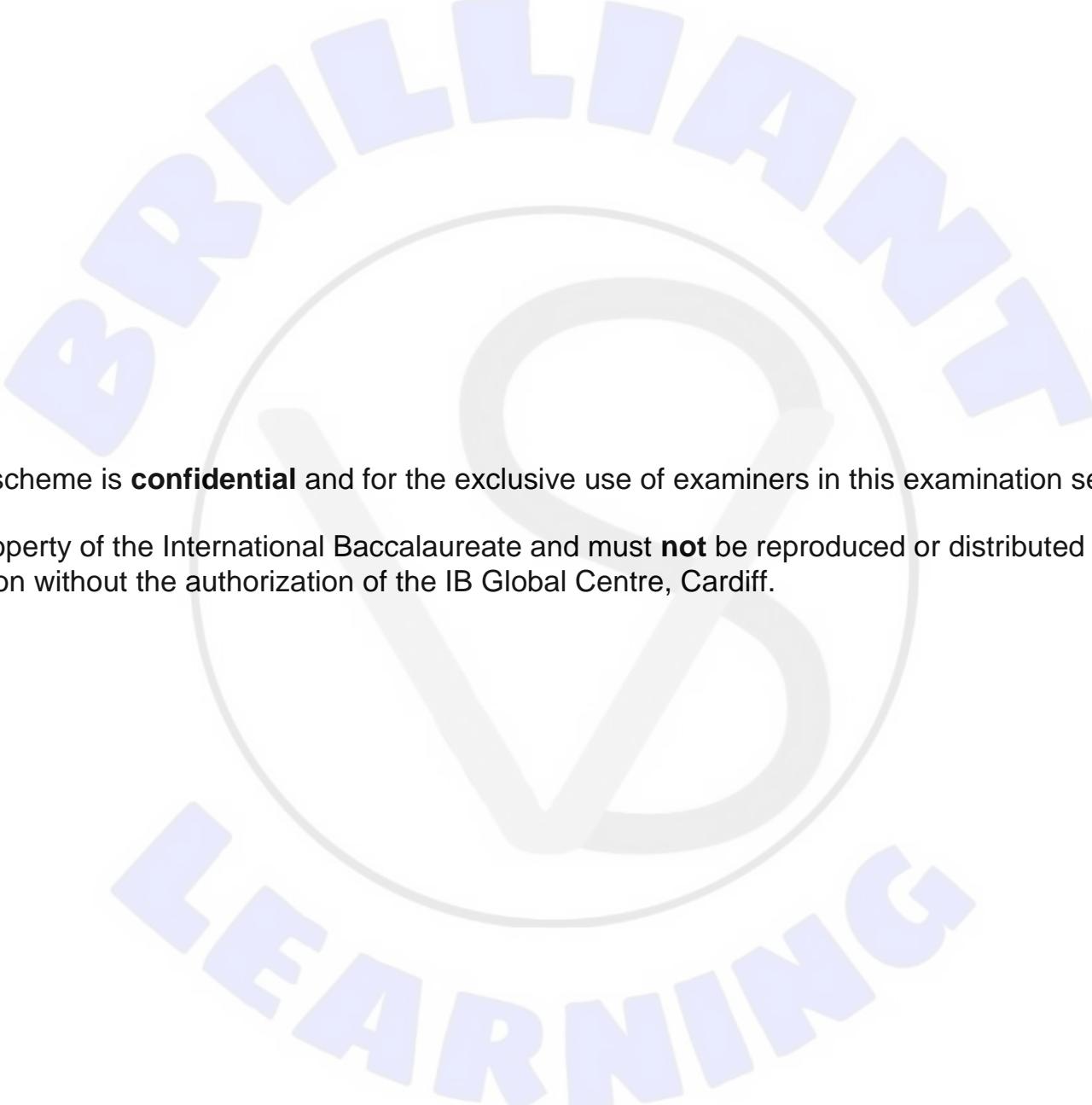
# Markscheme

November 2016

Physics

On-screen examination

13 pages



This markscheme is **confidential** and for the exclusive use of examiners in this examination session.  
It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

## Markscheme instructions

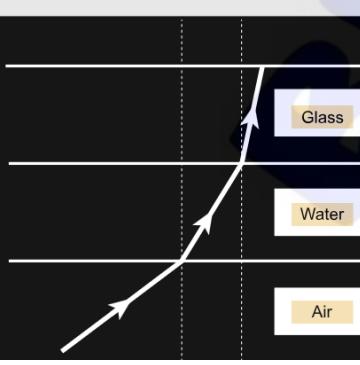
- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.

- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (or reverse argument) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate's response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (words to that effect) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add *ECF* (error carried forward) to the candidate response.
- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add *CON* to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. Candidate's work should be marked using a best fit approach. A candidate's response should be reviewed to determine holistically the band in which the response falls. Once this has been determined, each bullet point within that band should be assessed to see if the candidate has met the requirements of the statement. Where those requirements are met, marks should be awarded, starting from the lowest available mark for that band.

Once this process has been completed if the highest (or lowest) mark available for that band has been determined, the examiner must check the band above (or below) to ensure that the initially correct determination of the band was correctly allocated. For example, there may be sufficient detail in the candidate's response to award the lowest mark of the band above.

**NB. Marks are distributed unevenly across the mark bands as candidates have to include much more detail in their responses to access the highest mark bands.**

Question		Answers	Notes	Marks	Criterion
1	a	50 (km h <sup>-1</sup> )		1	A
	b	<b>any two reasonable suggestions, for example</b> • head wind • drag • different weather systems such as rain • increasing fatigue <b>or</b> other physiological feature as they fly • behavioural flight patterns eg flying in groups		2	A
	c	diagram 4		1	A
	d	<b>force:</b> between points C and D the retarding force is increasing <b>or</b> forces are no longer balanced  <b>speed:</b> reducing to <u>zero</u>  <b>acceleration:</b> deceleration / retardation / negative acceleration  <b>Newton's law:</b> second law <b>or</b> quoting F=ma	<i>ECF from 1<sup>st</sup> marking point for marking points 2, 3 and 4</i>	4	C
	e	(20*120*0.5) <b>or</b> 1200 <b>or</b> 1.2  m <b>or</b> km	<i>Unit to agree with numerical value</i>	2	C
2	a	<b>labels in order from top to bottom: wavelength – amplitude – compression - rarefaction</b>  any two labels correct  all labels correct		2	A
	b	12 (Hz)		1	C
	c	A <b>and</b> B		1	C
	d	6 waves in 1 second <b>or</b> f = 6 Hz  (wavelength = $\frac{330}{6} =$ ) <u>55 m</u>	<i>Unit required for 2<sup>nd</sup> mark            Award one mark only for correct wavelength without unit</i>	2	C
	e	wave D		1	C

	<b>f</b>	identification of <u>diffraction</u> general explanation of diffraction how diffraction relates to the specific situation		<b>3</b>	A
<b>3</b>	<b>a</b>	<p>Draggable items</p>  <p>air correctly identified</p> <p>water <b>and</b> glass correctly identified</p>		<b>2</b>	A
	<b>b</b>	<p>light refracts <b>or</b> changes direction <b>or</b> bends (when it changes medium)</p> <p>degree to which it refracts is dependent on change in density of the medium <b>or</b></p> <p>degree to which it refracts is dependent on the relative change in the refractive index of the materials <b>or</b></p> <p>degree to which it refracts is dependent on the change in its speed</p> <p>(because) the ray bends towards the <u>normal</u> as it slows down</p>	<p>WTTE but there must be an implied change in medium for marking point 2</p> <p>ORA</p>	<b>3</b>	A

4	a	<table border="1"> <thead> <tr> <th></th><th>Charge</th></tr> </thead> <tbody> <tr> <td>Electron</td><td>-1</td></tr> <tr> <td>Proton</td><td>+1</td></tr> <tr> <td>Neutron</td><td>0</td></tr> </tbody> </table>		Charge	Electron	-1	Proton	+1	Neutron	0		1	A
	Charge												
Electron	-1												
Proton	+1												
Neutron	0												
	b	<p>electrons are the only particle which can move</p> <p>electrons are transferred</p> <p>(so) a lack of electrons creates a positive charge</p>	Accept "negative charge in place of electron" for marks 2 and 3	3	A								
	c	<p>cat is charged by rubbing the carpet</p> <p>pellets are uncharged</p> <p>reference to the charge on the cat inducing <b>or</b> causing <b>or</b> creating an opposite charge in the pellets</p> <p>the charge on the cat is attracted to the electrons/protons/opposite charges in the pellets <b>or</b></p> <p>the pellets are then attracted to the cat</p>		4	A								
5	a	<p>conduction</p> <p>convection</p> <p>radiation</p>		3	A								
	b	<p><b>any reasonable suggestion of equipment, for example</b></p> <ul style="list-style-type: none"> <li>• timer</li> <li>• balance</li> </ul> <p><b>correctly linked justification</b></p>	<i>Do not accept ice or paper</i>	2	B								
	c	<p><b>statement of prediction that links number of sheets of paper and mass of ice that has melted, for example</b></p> <p>mass of ice melted decreases as number of sheets of paper increases</p> <p><b>correctly linked justification, for example</b></p> <p>number of sheets of paper is increasing gives more insulation which reduces mass of ice that melts</p>		2	B								

	<b>d</b>	<p>statement of reasonable variable statement of how the variable should be controlled justification of why the variable should be controlled</p>		<b>3</b>	B
	<b>e</b>	<p>indication of how mass lost will be determined  collect at least five sets of data  repeat each set at least three times and average</p>		<b>3</b>	B
<b>6</b>	<b>a</b>	<p>(not supported because) as the thickness increases the time taken to cool down follows no trend <b>or</b> 2 mm coffee cup was the slowest to cool down</p>		<b>1</b>	C
	<b>b</b>	<p><b><i>Four weaknesses and correctly linked scientific explanation of the effect of each weakness, for example</i></b>  different thicknesses of cup were used  different materials were used which will have different thermal conductivities   different coloured materials were used  different coloured materials will radiate thermal energy / heat differently   volume was not the same each time  filling to the same height does not give the same volume as the dimensions are different   the cups were of different dimensions  the surface area exposed to the air was different for each cup   the room temperature was not measured  the room temperature may not have been controlled <b>or</b> could have varied</p>	Accept answers relating to number of trials even though this is a procedural weakness	<b>8</b>	C

7	a	IV – thickness of aluminium sheet  DV – amount / intensity of beta radiation absorbed <b>or</b> that penetrates		2	B
	b	electron  (that is) high-energy <b>or</b> fast-moving		2	A
	c	as the thickness of the aluminium sheet increases the intensity of the beta radiation that penetrates the sheet decreases  as the aluminium sheet is made thicker the electrons would have less chance of penetrating due to more energy loss <b>or</b> increased interaction <b>or</b> collisions with atoms	ORA	2	B
	d	<b>Four points describing the method given below</b> <ul style="list-style-type: none"><li>• at least five conditions of the independent variable</li><li>• measurements repeated at least three times <b>or</b> counts averaged</li><li>• count rate measured with no aluminium between source and GM tube</li><li>• measurements taken with aluminium sheets of increasing number between source and GM tube</li></ul> <b>Any two further reasonable points, for example</b> <ul style="list-style-type: none"><li>• control variable e.g. distance/orientation between source and GM tube should be fixed</li><li>• aluminium sheets of the same thickness</li><li>• same source should be used for each test</li></ul>		6	B
	e	<b>Any reasonable source of background radiation, for example</b> <ul style="list-style-type: none"><li>• cosmic rays</li><li>• rocks</li><li>• fallout from nuclear testing</li></ul>		1	A
	f	background radiation should be measured without the presence of the beta source  background count should be deducted from all future measurements		2	B

	<b>g</b>	<b>any two reasonable precautions and correctly related reason, for example</b>															
		<table border="1"> <thead> <tr> <th>Precaution</th><th>Reason</th></tr> </thead> <tbody> <tr> <td>minimize time of exposure</td><td>reduce dose because exposure~time</td></tr> <tr> <td>increase distance between source and person <b>or</b> use tongs</td><td>reduce dose because exposure~1/distance</td></tr> <tr> <td>shielding/protective clothing</td><td>reduce dose because radiation is absorbed by shielding</td></tr> <tr> <td>avoid pregnant women</td><td>reduce risk of genetic abnormality</td></tr> <tr> <td>do not point source towards body</td><td>reduce dose because <math>\beta</math> radiation is directional</td></tr> </tbody> </table>	Precaution	Reason	minimize time of exposure	reduce dose because exposure~time	increase distance between source and person <b>or</b> use tongs	reduce dose because exposure~1/distance	shielding/protective clothing	reduce dose because radiation is absorbed by shielding	avoid pregnant women	reduce risk of genetic abnormality	do not point source towards body	reduce dose because $\beta$ radiation is directional	<i>Do not accept gloves or goggles</i>	<b>4</b>	B
Precaution	Reason																
minimize time of exposure	reduce dose because exposure~time																
increase distance between source and person <b>or</b> use tongs	reduce dose because exposure~1/distance																
shielding/protective clothing	reduce dose because radiation is absorbed by shielding																
avoid pregnant women	reduce risk of genetic abnormality																
do not point source towards body	reduce dose because $\beta$ radiation is directional																
	<b>h</b>	<p><b><i>hypothesis</i></b> alpha particles would be stopped completely by the first aluminium sheet</p> <p><b><i>explanation</i></b> alpha particles are less penetrating than beta particles <b>or</b> alpha particles have higher mass and have more interaction with matter than beta</p>		<b>2</b>	B												
<b>8</b>	<b>a</b>	six times identified values ranging between 0 and 100 equally spaced values two averages calculated correctly all correct averages expressed as whole numbers		<b>6</b>	C												
	<b>b</b>	smooth curve	<i>Award the sig fig marks for any number correctly expressed</i>	<b>1</b>	C												

	<b>c</b>	one half life correctly read from graph  two further half lives calculated  correct calculation of average		<b>3</b>	C
	<b>d</b>	4 half lives  8 years	<i>Award only one mark for four years</i>	<b>2</b>	A
<b>9</b>	<b>a</b>	<b>Any two reasonable suggestions, for example</b> <ul style="list-style-type: none"><li>• pollution from smoke</li><li>• unsightly</li><li>• noisy operation</li><li>• large lorries delivering coal</li></ul>	<i>Do not accept “dangerous”</i>	<b>2</b>	D
	<b>b</b>	large quantity of water is required for cooling <b>or</b> large quantity of water is required to turn turbines <b>or</b> large quantity of water is required to generate steam	<i>Do not accept “use water to dispose of nuclear waste”</i>	<b>1</b>	D
	<b>c</b>	(the secondary current) halves		<b>1</b>	A
	<b>d</b>	energy loss is proportional to size of the current  increasing the voltage reduces the current  less heat is generated (so less energy is lost)	<i>WTTE</i>	<b>3</b>	D

	<p><b>e</b></p> <p><b>for any two gases:</b></p> <p><b>water vapour</b> greenhouse gas collects in the atmosphere and acts to stop heat from the Earth escaping leads to climate change</p> <p><b>CO<sub>2</sub></b> greenhouse gas collects in the atmosphere and acts to stop heat from the Earth escaping leads to climate change</p> <p><b>SO<sub>2</sub></b> acid rain reacts with rain water to produce an acid acid rain causes damage eg to buildings and forests</p>	<p><b>WTTE</b></p> <p><b>WTTE</b></p>	<p><b>6</b></p>	<p><b>D</b></p>
<b>f</b>	<p>there is an excess of electrical energy at night</p> <p><b>or</b></p> <p>lower demand at night time</p> <p>electrical energy cannot be stored</p> <p>in order to encourage people to use this energy it is sold more cheaply</p>		<p><b>3</b></p>	<p><b>D</b></p>

10	a	any reasonable application requiring a constant source of electricity		1	D
	b	<ul style="list-style-type: none"> <li>• incomplete statement of reason for constant source of electricity with no reference to application in 10a</li> <li>• advantage <b>or</b> disadvantage stated with no reference to 10a</li> </ul>	1–2		
		<ul style="list-style-type: none"> <li>• reason for a constant source of electricity related to application in 10a is stated</li> <li>• advantage <b>and</b> disadvantage related to 10a is stated</li> <li>• an impact on society <b>or</b> an economic impact</li> </ul>	3–5		
		<ul style="list-style-type: none"> <li>• reason for a constant source of electricity in application in 10a is clearly explained</li> <li>• advantage outlined</li> <li>• disadvantage outlined</li> <li>• an impact on society <b>and</b> an economic impact</li> </ul>	6–9		
		<ul style="list-style-type: none"> <li>• reason for a constant source of electricity in application in 10a is clearly explained and justified</li> <li>• advantage explained in detail</li> <li>• disadvantage explained in detail</li> <li>• a clearly reasoned impact on society</li> <li>• a clearly reasoned economic impact</li> <li>• a concluding appraisal</li> </ul>	10–15	15	D

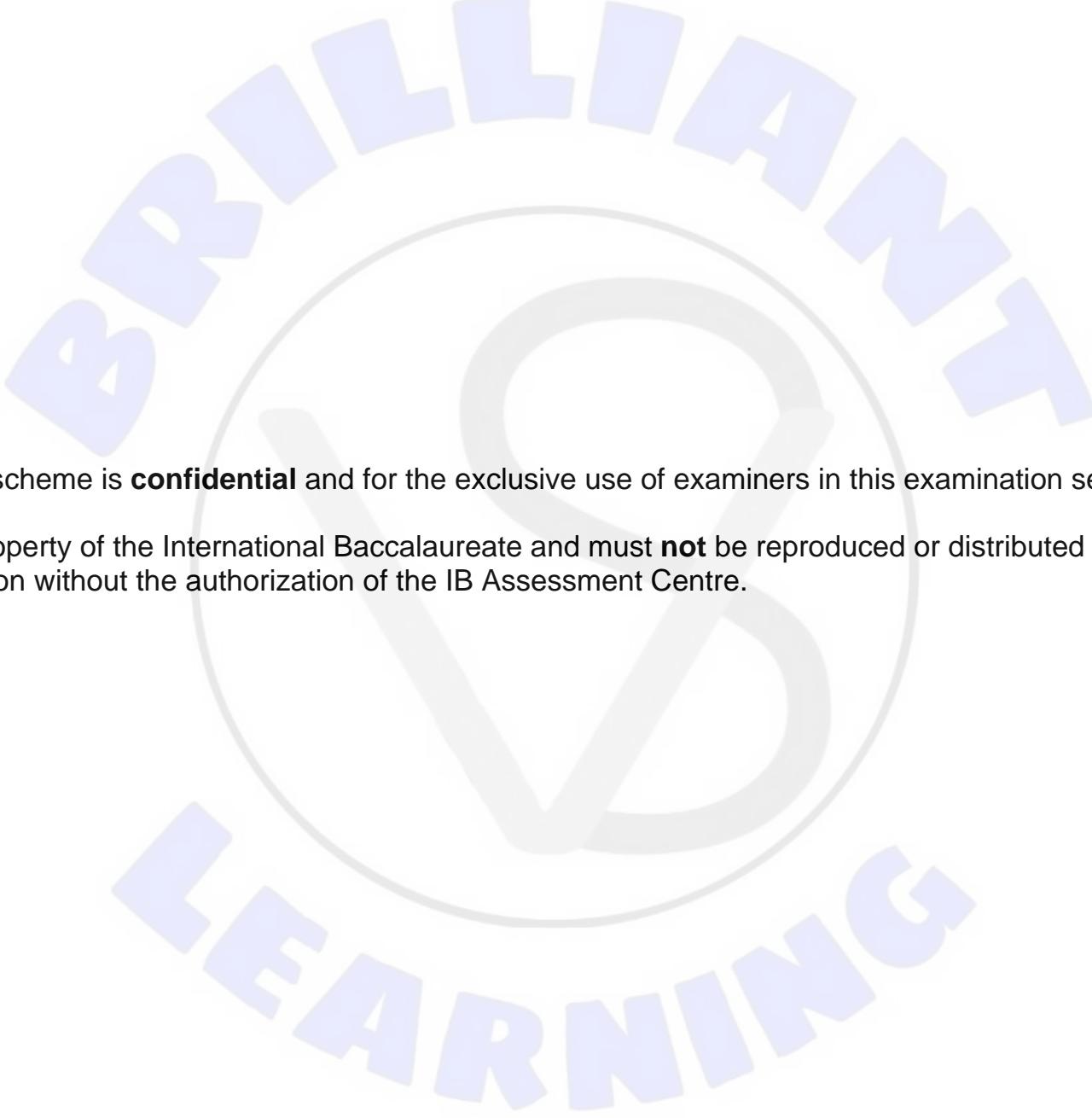
# MARKSCHEME

MAY 2016

MYP PHYSICS

ON-SCREEN EXAMINATION

17 pages



This markscheme is **confidential** and for the exclusive use of examiners in this examination session.  
It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Assessment Centre.

## Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.

- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (*or reverse argument*) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate's response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (*words to that effect*) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add ECF (error carried forward) to the candidate response.
- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. Candidate's work should be marked using a best fit approach.

NB Marks are distributed unevenly across the mark bands as candidates have to include much more detail in their responses to access the highest mark bands. Examiners should consider every statement in the holistic grid and identify the most appropriate mark band corresponding to the Candidate's response. Once the mark band is identified, the final mark is determined using a best fit approach.

Question		Answers	Notes	Total	Criteria
1	a	two rows correct  all correct		2	A
	b	<b>Venus – Neptune – Jupiter</b> one correct  all correct		2	A
	c	they are further from the sun/star	ORA	1	A
2	a	Mercury = 3.7 ( $\text{ms}^{-2}$ )  Mars = 3.8 ( $\text{ms}^{-2}$ )  $\text{ms}^{-2}$	<i>Maximum 2 if more than two significant figures are recorded.</i>  <i>Accept m/s<sup>2</sup></i>	3	A
	b	a reference to the relationship between $g$ and density <i>or</i> a reference to the relationship between $r$ and density  (So) Mars must have a much lower density	<i>Accept mass per unit volume in place of density</i>	2	A
	c	$E_p = mgh$ – correct equation selected  3600(J) / 3.6(kJ)  unit correct as J or kJ as appropriate	<i>Seen or implied by correct substitution</i>  <i>Award 1 mark only for 3600(J)/3.6 (kJ) if no working is shown</i>  <i>accept Nm or kNm</i>	3	A
	d	as $g$ on Ganymede is smaller, GPE would be smaller  as all GPE becomes KE probe would have less KE  as all other quantities are the same, velocity must be smaller	<i>Or reverse argument</i>	3	A

		<p><i>or</i></p> <p>as g on Ganymede is smaller, acceleration is lower</p> <p>there are no other forces acting</p> <p>lower acceleration leads to lower final/terminal velocity</p>	<p><i>Or reverse argument</i></p>		
--	--	---	-----------------------------------	--	--

3	a	<p><b>Equipment and reason, for example</b></p> <ul style="list-style-type: none"> <li>• equipment: stop watch/timing device</li> <li>• this equipment is needed in order to measure the time it takes for the parachute to fall</li> </ul> <p><b>or</b></p> <ul style="list-style-type: none"> <li>• equipment: metre rule or device to measure length</li> <li>• this is needed to measure the height fallen by the parachute</li> </ul> <p><b>or</b></p> <ul style="list-style-type: none"> <li>• equipment: data logger with sensor to measure velocity</li> <li>• this is needed to measure the speed of the parachute</li> </ul> <p><b>or</b></p> <ul style="list-style-type: none"> <li>• equipment: metre rule or device to measure length</li> <li>• this is needed to measure the area of the parachute</li> </ul>	Accept answer that describes the equipment needed to make the parachute (cloth or mass) only where correct explanation is given	2	B
	b	<p>statement of prediction that links area and terminal velocity eg terminal velocity decreases as area increases</p> <p>area increases so will air resistance/drag force</p> <p>(increased air resistance) increases the upward force on the parachute and reduces the acceleration</p>		3	B
		<p><b>one variable from</b></p> <ul style="list-style-type: none"> <li>• mass</li> <li>• weight of parachute</li> <li>• shape of the parachute</li> </ul> <p><b>one description of how variable should be controlled</b></p> <ul style="list-style-type: none"> <li>• measure the mass/weight each time</li> <li>• use the same mass/weight</li> <li>• use the same shape for the parachute</li> </ul>	<p>Detailed explanation is not required</p> <p>For example: temperature can only be accepted if it is correctly linked to the density of air.</p>	3	B

		<p><b>reason correctly linked to description of how variable should be controlled, either</b></p> <ul style="list-style-type: none"> <li>the greater the mass/weight the greater the downward force on the parachute (this affects the terminal velocity)</li> </ul> <p><b>or</b></p> <ul style="list-style-type: none"> <li>the shape of the parachute will affect the aerodynamics of the parachute (this affects the terminal velocity)</li> </ul>		
	<b>d</b>	<p>at least five different values of area for the parachute</p> <p>values evenly spread over a range</p> <p>repetitions of each measurement</p>	<b>3</b>	B
<b>4</b>	<b>a</b>	<p>the moon orbits the Earth</p> <p><b>or</b></p> <p>as its position changes</p> <p>(therefore) different bright sections are visible from the Earth</p>	<b>2</b>	A
	<b>b</b>	gravitational force/pull/attraction	Accept gravity	1 A
<b>5</b>		<p><b>Any two from [2 max]</b></p> <ul style="list-style-type: none"> <li>the big bang theory states that the universe has a moment of beginning</li> <li>the universe is cooling over time</li> <li>the density of the universe is not constant</li> <li>matter is not being created</li> <li>new evidence about cosmic microwave background radiation does not support “steady-state” theory</li> </ul>	WTTE	2 A

<b>6</b>	<b>a</b>	<p>in the incorrect diagram the ammeter is not in series with the bulb the ammeter is not measuring the current through the bulb <b>or</b> ammeters have a negligible resistance (so in the incorrect diagram) all/most of the current would flow through it and not through the lamp</p>	ORA	<b>2</b>	B
	<b>b</b>	<p>(independent variable =) voltage (dependent variable=) current</p>	<i>Accept potential difference</i> <i>Accept “temperature”</i>	<b>2</b>	B
	<b>c</b>	<p>collected data is sufficient as 9 measurements (constitute a sample that allows for analysis) voltage values cover the range proposed by the experiment (but) are not distributed evenly <b>or</b> are clustered around some areas and there are gaps in some others</p>		<b>3</b>	B

7	a	<p>at least 5 values of voltage covering range from 0 to 12 V values are evenly distributed correct observation about the light level for all data points</p>	<i>all data points above 10.4 V should indicate that the light is illuminated</i>	3	C
	b	<p><b><i>if data has been recorded over the full range:</i></b> current increases with voltage/p.d  relation between p.d and current is linear for p.d below 8V  relation between p.d and current is not linear for p.d 8V  <b><i>If only data below 10.4V has been recorded:</i></b> current increases with voltage/p.d  relation between p.d and current is linear  (relation between p.d and current is linear) over the range measured  <b><i>If 5 data points above 9.6V have been recorded:</i></b> current increases with voltage/p.d  relation between p.d and current is non-linear  (relation between p.d and current is non-linear) over the range measured</p>	<i>WTTE</i>  $\pm 0.5 \text{ V}$  $\pm 0.5 \text{ V}$  <i>do not award any marks if fewer than 5 data points have been recorded</i>	3	C
	c	<p>one correct calculation of resistance a correctly linked comment or observation a second correct calculation of resistance a correctly linked comment or observation for the second calculation</p>	<i>Unit not necessary here</i>	4	C

	<p><b>d</b></p> <p>for directly proportional relationship the graph of the two factors should be a straight line</p> <p><b><i>Either, as appropriate to the data recorded:</i></b></p> <p>the graph is not a straight line so the relationship is not directly proportional</p> <p>(so) the hypothesis is not supported</p> <p><b><i>or</i></b></p> <p>the graph is a straight line so the relationship is directly proportional</p> <p>(so) the hypothesis is supported</p>	<p><i>Give credit where reference is made to <b>not all materials</b> have been tested</i></p> <p><i>Do not award this mark alone</i></p> <p><i>Do not award this mark alone</i></p>	<p>3</p>	<p>C</p>
--	--	--	----------	----------

<b>8</b>	<b>a</b>	10.4 (V)		<b>1</b>	C
	<b>b</b>	only certain frequencies are visible <i>or</i> only certain wavelengths are visible  above a certain temperature the EM waves are in the visible range	<i>Or reverse argument</i>	<b>2</b>	C
	<b>c</b>	current increases with voltage/p.d.  the current doesn't increase as much as temperature increases/at higher temperature  A higher temperature means that atoms in the filament vibrate faster <i>or</i>  A higher temperature means that atoms in the filament have greater kinetic energy  flowing charges are slowed down by collisions with the vibrating atoms  resulting in a smaller increase of current	WTTE	<b>5</b>	C
	<b>d</b>	<b>any reasonable suggestion of an extension [1 max], for example</b> <ul style="list-style-type: none"><li>• different component</li><li>• different material</li><li>• greater range of voltage/p.d.</li></ul> correctly linked justification of the suggestion		<b>2</b>	C

9	a	<p><b>all correct – two</b>  <b>two correct – one mark</b></p> <p>transmission time – dependent  height – control  ground distance – independent</p>	ECF	2	B
	b	<p>statement of hypothesis: links independent and dependent variables</p> <p>correct relationship between variables: increase in ground distance increases transmission time</p> <p>justification: as distance travels increases so does the time taken</p>	<i>ECF from part (a)</i>  OR	3	B
	c	<p>ground distance/independent variable would be unaffected because it is not affected by the height of the satellite</p> <p>transmission time would change</p> <p>(transmission time would) increase if height is increased</p> <p><b>or</b></p> <p>(transmission time would) decrease if height is decreased</p>	<i>ECF from part (a)</i>	3	B
	d	<p>beyond the maximum distance the stations are outside the satellite footprint</p> <p>(so) signals cannot be transmitted (to the satellite)</p>	<i>Accept answer that describes effect of the curvature of the Earth on the footprint</i>	2	B
	e	<p>because for short distances, the transmission can be made from station to station</p> <p>using a satellite would cause transmission time to be longer making it inefficient</p>	WTTE	2	B
	f	<p>transmission time increases with ground station distance</p> <p>in a non-linear relationship/graph has a curved line</p>	WTTE	2	C
	g	<p>statement confirming or rejecting the hypothesis</p> <p>justification correctly comparing hypothesis to results</p>	<i>Refer to answer given in part b, no ecf</i>	2	C

10		<ul style="list-style-type: none"><li>• a statement of an advantage <b>or</b> a disadvantage of satellite internet access</li><li>• a statement of an advantage <b>or</b> a disadvantage of satellite internet access that is relevant and appropriate</li><li>• a statement of a technological consideration</li><li>• a statement of an economic factor</li></ul>	1							12	D
		<ul style="list-style-type: none"><li>• the advantage is relevant and appropriate</li><li>• the disadvantage is relevant and appropriate</li><li>• the technological consideration is justified</li><li>• the economic factor is justified</li></ul>	2-3								
		<ul style="list-style-type: none"><li>• the advantage is relevant, appropriate and justified</li><li>• the disadvantage is relevant, appropriate and justified</li><li>• more than one technological consideration is justified</li><li>• more than one economic factor is justified</li><li>• a concluding appraisal linking all the issues discussed previously</li></ul>	4-7								
			8-12								

11	a	<p>an atom absorbs energy from radiation <i>or</i> a charged particle collides (with an atom) an electron gains enough energy to escape an ion is left behind</p>	3	A
	b	<p><b><i>Any two linked points [2 max], for example</i></b></p> <ul style="list-style-type: none"><li>• damage to DNA can lead to mutations</li><li>• mutations can lead to cancer or health issues</li></ul> <p><i>or</i></p> <ul style="list-style-type: none"><li>• damage to cytoplasm can occur</li><li>• (damage to cytoplasm) leads to cell death</li></ul>	2	A
	c	<p><b><i>Ultraviolet – X-ray – gamma ray</i></b> all correct</p>	1	A
	d	<p>UV is blocked/absorbed by all materials gamma rays pass through all materials only x-rays give contrast between bone and soft tissue/skin</p>	3	A

	e	<ul style="list-style-type: none"><li>• a statement of chosen technique</li><li>• an advantage <b>or</b> disadvantage of chosen technique</li></ul>	1-2	<p>If candidate refers to more than one technique they are still able to receive maximum marks if advantages and disadvantages are given for any single technique</p>	14	D
		<ul style="list-style-type: none"><li>• a statement of chosen technique</li><li>• an advantage</li><li>• a disadvantage</li><li>• a comment relating to hospital <b>or</b> patient</li><li>• at least one piece of information from the table used to support a comment made above</li></ul>	3-5			
		<ul style="list-style-type: none"><li>• a statement of chosen technique</li><li>• an advantage justified with information from the table</li><li>• a disadvantage justified with information from the table</li><li>• a comment relating to the hospital</li><li>• a comment relating to the patient</li></ul>	6-9			
		<ul style="list-style-type: none"><li>• a statement of chosen technique</li><li>• more than one advantage justified with information from the table</li><li>• more than one disadvantage justified with information from the table</li><li>• a comment relating to the hospital justified with information from the table</li><li>• a comment relating to the patient justified with information from the table</li><li>• a concluding appraisal linking all the issues discussed relating to social or economic factors</li></ul>	10-14			

12		<p>Any relevant <b>scientific</b> point eg high detail in x-ray</p> <p><b><i>Two further reasonable points clearly linked to the image, for example</i></b></p> <ul style="list-style-type: none"><li>the x-ray shows the foot is in an unnatural/distorted position</li><li>information about the construction of the shoe is revealed</li></ul>	<p><i>first point must refer to the image</i></p>	3	D
13	a	<p>XRFS reveals image B not visible in image A</p> <p>image B resembles image C</p>		2	D
	b	<p><b><i>Two reasonable and valid comments [2 max], for example</i></b></p> <ul style="list-style-type: none"><li>painting is not damaged</li><li>hidden information is revealed</li><li>the whole painting not just a small area</li><li>painting is preserved for people to enjoy</li></ul>		2	D

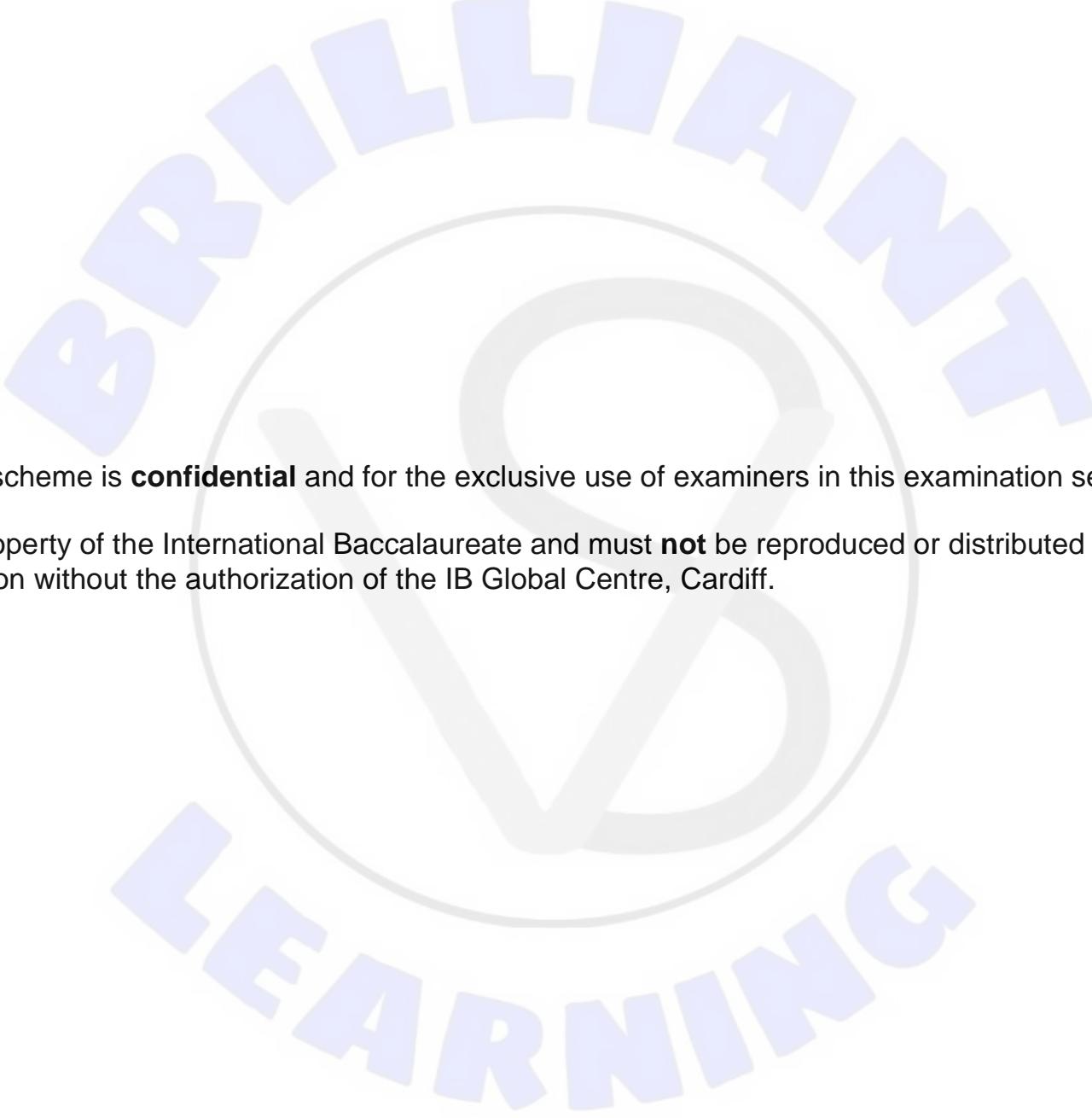
# Markscheme

November 2017

Physics

On-screen examination

16 pages



This markscheme is **confidential** and for the exclusive use of examiners in this examination session.  
It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

Annotation	Explanation	Shortcut	Annotation	Explanation	Shortcut
✓	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.	Alt+1	NBOD	No benefit of the doubt	Alt+4
AEr	Arithmetic error		NEX	No explanation given	
BOD	Benefit of the doubt	Alt+3	NGE	Not good enough	
✗	Omission, incomplete	Alt+7	0	Not worthy of any marks	
CON	Contradiction	Alt+6	NWS	No working shown	
○	Valid part (to be used when more than one element is required to gain the mark)		T	Test box used for additional marking comments	
ECF	Error carried forward	Alt+8	?	Unclear	Alt+2
○	Dynamic annotation, it can be expanded to surround work		SEEN	Seen; must be stamped on all blank response areas	Alt+9
~~~~	Horizontal wavy line that can be expanded			Vertical wavy line that can be expanded	
■	Highlight tool that can be expanded to mark an area of a response		WTTE	Words to that effect	
NAQ	Not answered the question		✓ 1 ✓ 2 ✓ 3 ✓ 4	Award 1, 2, 3, 4 marks. For use in holistically marked questions only.	

## Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (or reverse argument) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (words to that effect) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add *ECF* (error carried forward) to the candidate response.

- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate's work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

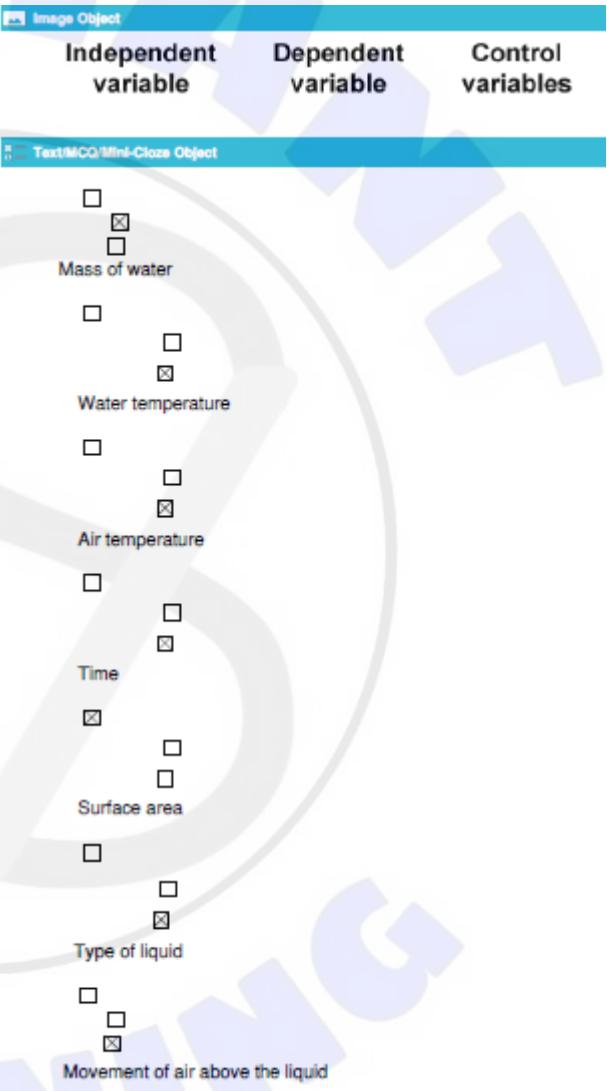
Question	Answers	Notes	Total	Criterion
1	a A proton is a particle found in the <b>nucleus</b> of an atom. It has a relative mass of <b>1</b> and a charge of <b>+1</b> .  A neutron is a particle found in the <b>nucleus</b> of an atom. It has a relative mass of <b>1</b> and a charge of <b>0</b> .  An electron is a particle found in the <b>orbitals</b> of an atom. It has a relative mass of <b>0</b> and a charge of <b>-1</b> .	Award <b>(1 mark)</b> for each correct row.	3	A
	b the electrons were transferred <b>or</b> moved (from the cloth to the nylon)	Accept electrons transferred from nylon to the cloth.	1	A
	c there will be repulsion  because the two pieces of nylon must be the same charge	Accept either positive or negative charge if given to the nylon, but they <b>must</b> be the same.	2	A
d  nothing would happen because the nylon pieces have the same charge <b>or</b> no particles would exchange because the nylon pieces have the same charge			1	A

<b>2</b>	<b>a</b>	<p>selecting the correct equation: <math>v^2 = u^2 + 2as</math> <b>or</b> <math>mgh = 1/2 mv^2</math></p> <p>rearrange equation: <math>v = \sqrt{2gh}</math></p> <p>substitute correctly and calculate: 100 (<math>\text{ms}^{-1}</math>)</p>	Award (1 mark) only if only 100 is seen	<b>3</b>	<b>A</b>
	<b>b</b>	diagram 1		<b>1</b>	<b>A</b>
	<b>c</b>	Force A: air resistance / drag <b>and</b> Force B: weight / gravitational force	<i>Do not accept gravity.</i>	<b>1</b>	<b>A</b>
	<b>d</b>	$0.03 / 3.0 \times 10^{-2} / 3 \times 10^{-2}(\text{g})$		<b>1</b>	<b>A</b>
	<b>e</b>	<p>uses correct equation</p> <p><math>p = 3 \times 10^{-5} \text{ kg} \times 100 \text{ ms}^{-1} = 3 \times 10^{-3} \text{ kgms}^{-1}</math> <b>or</b> 0.003 <math>\text{kgms}^{-1}</math></p> <p><b>or</b></p> <p><math>p = 0.03 \text{ g} \times 100 \text{ ms}^{-1} = 3 \text{ gms}^{-1}</math></p>	<i>Seen or implied</i> <i>ECF from a and d</i> <i>Unit must be included and must agree with the value.</i>	<b>2</b>	<b>A</b>
	<b>f</b>	<p>the graph should be a straight line <b>and</b> go through the origin</p> <p>as a straight line could not be drawn, the hypothesis is incorrect</p>		<b>2</b>	<b>C</b>
	<b>g</b>	<p>the graph shows a straight line through the origin</p> <p>(so) <math>v^2</math> proportional to <math>r</math></p>		<b>2</b>	<b>C</b>

3	a	chemical – electrical – light		1	A
	b	$12 \times 0.5 = 6$ Watts / W		2	A
	c	50 (coulombs)	Ignore all units	1	A
	d	<p>a fixed voltage is supplied by the cell/battery</p> <p><b>Either</b> the voltage drops across the resistor</p> <p>as the resistance increases, so does the voltage drop</p> <p>(hence) the voltage across the bulb decreases</p> <p>(bulbs brightness decreases because) brightness is related to voltage</p> <p><b>or</b> the total resistance in the circuit is now greater</p> <p>the current flowing will now be smaller</p> <p>(as all circuit components are connected in series) the bulb draws smaller current</p> <p>(because bulbs brightness decreases because) brightness is related to current</p> <p><b>or</b> energy is lost as the current travels through the resistor</p> <p>as resistance increases the energy loss increases</p> <p>(hence) the energy available for the bulb decreases</p> <p>(brightness decreases because) brightness is related to available energy</p>		5	A

	e	<b>Any four reasonable points, for example:</b> <ul style="list-style-type: none"> <li>the gradients of the lines are related to running costs</li> <li>identification of bulb with the greatest running cost has the steepest gradient</li> <li>that the <math>y</math> intercept indicates the initial cost</li> <li>recognition that when the lines cross the total prices of cost and use are the same</li> <li>even though the brightness is the same, the energy used is different.</li> </ul>	<b>Do not accept “LED bulbs are more economical over time even though they are more expensive to buy” alone, as this is given in the question.</b>	4	A
	f	life span of bulb		1	D

<b>4</b>	a	How does the surface area affect the mass of water evaporated <b>or</b> remaining?	<b>WTTE</b>	1	
	b	$\text{rate} = \frac{\text{mass}}{\text{time}}$ $\frac{0.25}{0.20}$ $1.25 (\text{g h}^{-1})$	<i>Seen or implied</i>	3	A
	c	<b>Any simple prediction, for example:</b> <ul style="list-style-type: none"> <li>as the surface area increases the rate of evaporation increases.</li> </ul> <b>Explanation contains relevant scientific knowledge:</b> <ul style="list-style-type: none"> <li>(because) the water molecules/particles have a greater area from which to escape.</li> </ul> <b>Quantitative element to prediction, for example:</b> <ul style="list-style-type: none"> <li>as the area doubles the rate of evaporation doubles</li> <li>as double the area means double the opportunities for the particles to escape.</li> </ul>		3	B

d	<p>Only <b>one</b> each of independent and dependent variable identified – the variables do not need to be correct for this mark.</p> <p>Independent variable identified as surface area <b>only</b></p> <p>Dependent variable identified as mass <b>only</b></p>  <table border="1"><thead><tr><th>Independent variable</th><th>Dependent variable</th><th>Control variables</th></tr></thead><tbody><tr><td><input type="checkbox"/> Mass of water</td><td><input checked="" type="checkbox"/> Mass</td><td></td></tr><tr><td><input type="checkbox"/> Water temperature</td><td><input checked="" type="checkbox"/> Temperature</td><td></td></tr><tr><td><input type="checkbox"/> Air temperature</td><td><input checked="" type="checkbox"/> Temperature</td><td></td></tr><tr><td><input type="checkbox"/> Time</td><td><input checked="" type="checkbox"/> Time</td><td></td></tr><tr><td><input checked="" type="checkbox"/> Surface area</td><td><input type="checkbox"/> Surface area</td><td></td></tr><tr><td><input type="checkbox"/> Type of liquid</td><td><input checked="" type="checkbox"/> Liquid</td><td></td></tr><tr><td><input type="checkbox"/> Movement of air above the liquid</td><td><input checked="" type="checkbox"/> Movement of air</td><td></td></tr></tbody></table> <p>Mass of water Water temperature Air temperature Time Surface area Type of liquid Movement of air above the liquid</p>	Independent variable	Dependent variable	Control variables	<input type="checkbox"/> Mass of water	<input checked="" type="checkbox"/> Mass		<input type="checkbox"/> Water temperature	<input checked="" type="checkbox"/> Temperature		<input type="checkbox"/> Air temperature	<input checked="" type="checkbox"/> Temperature		<input type="checkbox"/> Time	<input checked="" type="checkbox"/> Time		<input checked="" type="checkbox"/> Surface area	<input type="checkbox"/> Surface area		<input type="checkbox"/> Type of liquid	<input checked="" type="checkbox"/> Liquid		<input type="checkbox"/> Movement of air above the liquid	<input checked="" type="checkbox"/> Movement of air		3 B
Independent variable	Dependent variable	Control variables																								
<input type="checkbox"/> Mass of water	<input checked="" type="checkbox"/> Mass																									
<input type="checkbox"/> Water temperature	<input checked="" type="checkbox"/> Temperature																									
<input type="checkbox"/> Air temperature	<input checked="" type="checkbox"/> Temperature																									
<input type="checkbox"/> Time	<input checked="" type="checkbox"/> Time																									
<input checked="" type="checkbox"/> Surface area	<input type="checkbox"/> Surface area																									
<input type="checkbox"/> Type of liquid	<input checked="" type="checkbox"/> Liquid																									
<input type="checkbox"/> Movement of air above the liquid	<input checked="" type="checkbox"/> Movement of air																									

e	at least five increments measurements of both mass and diameter/radius at least three repeated trials		3	B
f	as area increases mass of water evaporated increases (mass evaporated is) proportional (to area) <b>or</b> there is a linear relationship between (area) and (mass of water evaporated) that goes through zero	"The mass of water evaporated after one hour is proportional to area" scores both marks.	2	C
g	indication of calculation of the ratio of mass and area gradient calculated from two sufficiently spaced points $0.0284 \text{ (g cm}^{-2}\text{)}$	Seen or implied Accept the use of data points Units not needed	3	C
h	$0.0284 \times 4 \times 10^4$ <b>Either</b> 1.1 (kg) <b>or</b> 1136 (g) unit agrees with value	Calculation seen or implied, ECF from h Accept answer in the range 1.0 to 1.2 kg.	3	C D

5	a	<p>How does the temperature affect the rate of evaporation <b>or</b> mass evaporated in an hour?  <b>or</b>          How does the movement of air above the liquid affect the rate of evaporation <b>or</b> mass evaporated in an hour?</p>		1	B
	b	<p><b>Any simple prediction correctly linked to the answer given in part (a), for example:</b></p> <ul style="list-style-type: none"> <li>• as the temperature increases the rate of evaporation increases</li> <li>• as the speed of air above the liquid increases the rate of evaporation increases.</li> </ul> <p><b>Explanation contains relevant scientific knowledge correctly linked to part (a), for example:</b></p> <ul style="list-style-type: none"> <li>• (because) the water molecules/particles have a greater velocity/speed they will find it easier to escape</li> <li>• (because) the water molecules/particles which have escaped will not re-enter the liquid.</li> </ul> <p><b>Quantitative element to prediction, correctly linked to part (a), for example:</b></p> <ul style="list-style-type: none"> <li>• as the temperature doubles the rate of evaporation doubles</li> <li>• as the speed of air doubles the rate of evaporation doubles.</li> </ul>		3	B
	c	<p><b>First response box (independent variable):</b> temperature <b>or</b> air speed</p> <p><b>Second response box (control variable), any one variable from the list:</b></p> <ul style="list-style-type: none"> <li>• type of liquid</li> <li>• air speed</li> <li>• air temperature</li> <li>• surface area</li> </ul>	<p><i>Any control variable with corresponding independent variables</i></p>	2	B

<b>6</b>	<b>a</b>	<p><u>83.5</u></p> <p>altitude <b>or</b> height <b>and</b> m</p> <p>temperature <b>and</b> °C</p>	<p>Needs to be stated to this precision</p> <p>Ignore incorrect use of brackets</p>	<b>3</b>	C
	<b>b</b>	<p><b>Any two from:</b></p> <ul style="list-style-type: none"> <li>• a bar chart is used to represent discrete data</li> <li>• a line of best fit cannot be drawn on a bar chart</li> <li>• a bar chart cannot be used to determine a relationship between the independent and dependent variables.</li> </ul>	WTTE	<b>2</b>	C
	<b>c</b>	<p>4200 (m)</p> <p>this value does not lie on the line of best fit</p>		<b>2</b>	C
	<b>d</b>	<p>as the altitude increases the boiling temperature decreases</p> <p>this is a linear relationship</p>		<b>2</b>	C
	<b>e</b>	<p>water particles need sufficient energy to escape the surface of the water</p> <p>there are fewer air particles at higher altitude</p> <p>so there are fewer collisions with water particles which prevent their escape</p> <p><b>Any additional reasonable suggestion, for example:</b></p> <ul style="list-style-type: none"> <li>• energy of particles is related to temperature</li> <li>• at lower temperatures a greater proportion of water particles will have enough energy to escape the surface</li> <li>• so the boiling point is lower <b>and</b> justified with reference to particles.</li> </ul>		<b>4</b>	C
	<b>f</b>	<p>the hypothesis is incorrect / not supported</p> <p>(because) as the altitude increases the boiling point decreases</p>		<b>2</b>	C
	<b>g</b>	<b>Accept any reasonable extension with the same independent variable</b>		<b>1</b>	C

		1	2	3	4		
7	Independent and dependent variables	Altitude/height identified as a variable	Altitude/height is identified as the independent variable	Altitude/height is identified as the independent variable <b>and</b> the dependent variable is volume/diameter			
	Control variables	A control variable is mentioned	A control variable is identified	A control variable is identified and attempt of discussion of assumptions eg spherical, constant temp etc	A control variable is identified and clearly reasoned discussion of assumptions eg spherical, constant temperature etc		
	Equipment	Some equipment is selected	Appropriate equipment is selected	Appropriate and complete equipment is selected			
	Measurements	Attempt at a method but detail is insufficient for another student to follow	Method is described and could easily be followed by another student	Complete method is described, fully explained and could easily be followed by another student;			
	Data collection	Appropriate number <b>or</b> range of data is stated	Appropriate number <b>and</b> range of data is stated	Appropriate number and range of data is stated and plans to repeat	Appropriate number and range of data is stated and justified and plans to repeat		

17

B

8	a	<p><b>Any two reasonable advantages of using solar tubes for lighting, for example:</b></p> <ul style="list-style-type: none"> <li>• free light</li> <li>• natural light</li> <li>• no light bulbs needed</li> <li>• no electricity supply needed.</li> </ul> <p><b>Any two reasonable disadvantages of using solar tubes for lighting, for example:</b></p> <ul style="list-style-type: none"> <li>• limit to how far light can go</li> <li>• hole needed for solar tube</li> <li>• only suitable for daytime use</li> <li>• external surface will need cleaning.</li> </ul>	4	D																				
	b	<table border="1"> <thead> <tr> <th></th><th>1</th><th>2</th><th>3</th></tr> </thead> <tbody> <tr> <td><b>Advantage and disadvantage</b></td><td>An advantage or a disadvantage</td><td>An advantage and a disadvantage</td><td>More than one advantage and more than one disadvantage</td></tr> <tr> <td><b>Scientific justification</b></td><td>A simple scientific statement</td><td>A scientific statement supported by a specific example</td><td></td></tr> <tr> <td><b>Environmental consideration</b></td><td>An environmental consideration is stated</td><td>An environmental consideration is discussed</td><td></td></tr> <tr> <td><b>Social consideration</b></td><td>A social consideration is stated</td><td>A social consideration is discussed</td><td></td></tr> </tbody> </table>		1	2	3	<b>Advantage and disadvantage</b>	An advantage or a disadvantage	An advantage and a disadvantage	More than one advantage and more than one disadvantage	<b>Scientific justification</b>	A simple scientific statement	A scientific statement supported by a specific example		<b>Environmental consideration</b>	An environmental consideration is stated	An environmental consideration is discussed		<b>Social consideration</b>	A social consideration is stated	A social consideration is discussed		9	D D
	1	2	3																					
<b>Advantage and disadvantage</b>	An advantage or a disadvantage	An advantage and a disadvantage	More than one advantage and more than one disadvantage																					
<b>Scientific justification</b>	A simple scientific statement	A scientific statement supported by a specific example																						
<b>Environmental consideration</b>	An environmental consideration is stated	An environmental consideration is discussed																						
<b>Social consideration</b>	A social consideration is stated	A social consideration is discussed																						

9		1	2	3	4	14	D
	<b>Strengths and limitations</b>	A strength <b>or</b> a limitation	A strength <b>and</b> a limitation	a strength, a limitation <b>and</b> any additional relevant point (either strength or limitation)	more than one strength <b>and</b> more than one limitation		
	<b>Environmental implication</b>	An environmental implication is implied	An environmental implication is explicitly stated	An environmental implication is discussed			
	<b>Economic consideration</b>	An economic consideration is implied	An economic consideration is explicitly stated	An economic consideration is explicitly discussed			
	<b>Scientific reasoning</b>	A simple scientific statement	A scientific statement supported by a specific example	A detailed scientific statement supported by a specific example			
	<b>Concluding appraisal</b>	A concluding appraisal linking strengths and considerations					

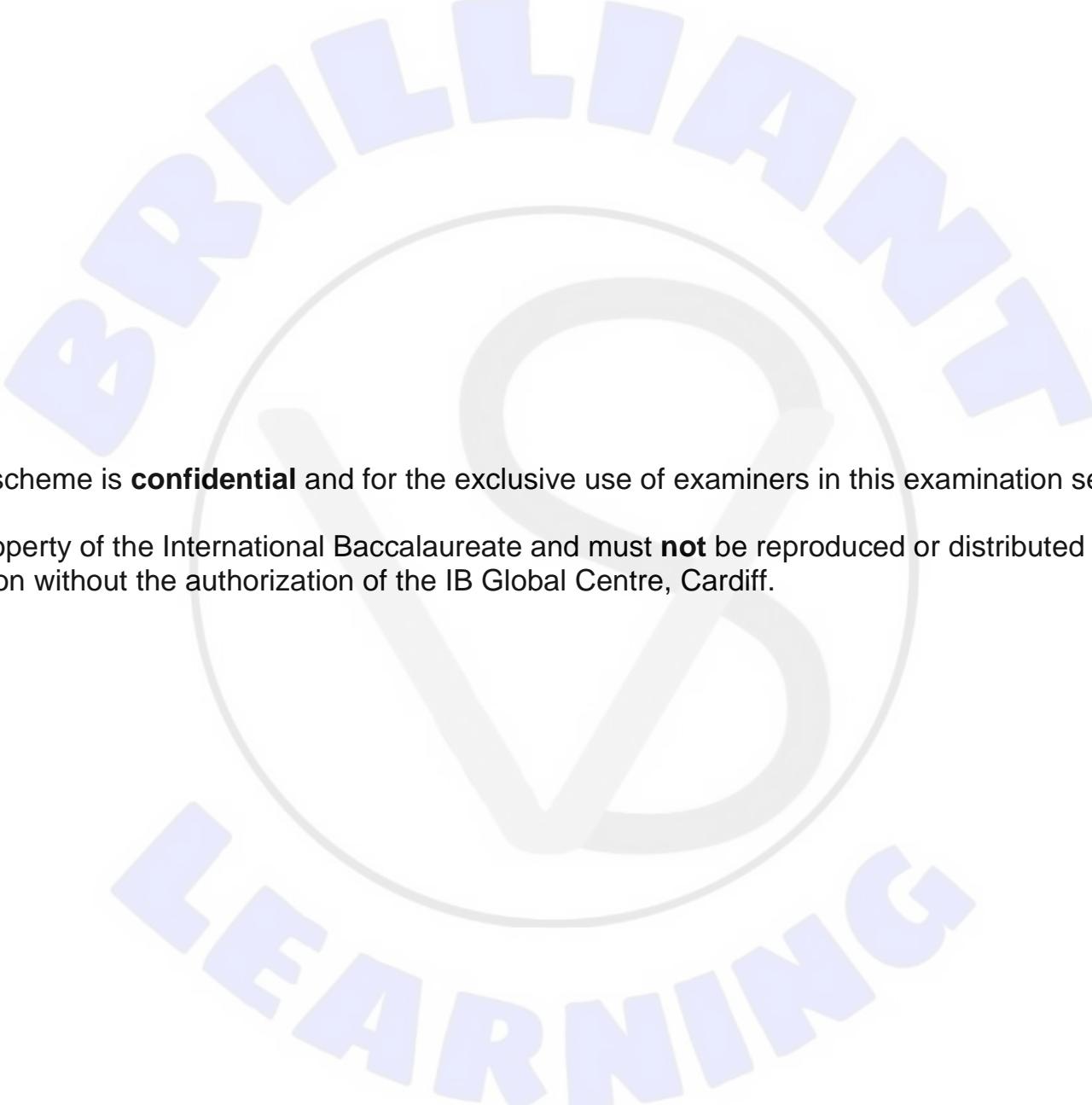
# Markscheme

May 2017

Physics

On-screen examination

14 pages



This markscheme is **confidential** and for the exclusive use of examiners in this examination session.  
It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

Annotation	Explanation	Shortcut	Annotation	Explanation	Shortcut
✓	Correct point, place at the point in the response where it is clear that the candidate deserves the mark	Alt+1	NBOD	No benefit of the doubt	Alt+4
AEr	Arithmetic error		NEX	No explanation given	
BOD	Benefit of the doubt	Alt+3	NGE	Not good enough	
✗	Omission, incomplete	Alt+7	0	Not worthy of any marks	
CON	Contradiction	Alt+6	NWS	No working shown	
○	Valid part (to be used when more than one element is required to gain the mark)		T	Test box used for additional marking comments	
ECF	Error carried forward	Alt+8	?	Unclear	Alt+2
○	Dynamic annotation, it can be expanded to surround work		SEEN	Seen; must be stamped on all blank response areas	Alt+9
~~~~	Horizontal wavy line that can be expanded			Vertical wavy line that can be expanded	
■■■	Highlight tool that can be expanded to mark an area of a response		WTE	Words to that effect	
NAQ	Not answered the question				

## Markscheme instructions

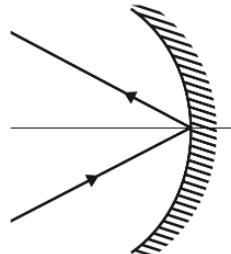
- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.

- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (or reverse argument) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate's response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (words to that effect) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add *ECF* (error carried forward) to the candidate response.
- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add *CON* to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. Candidate's work should be marked using a best fit approach. A candidate's response should be reviewed to determine holistically the band in which the response falls. Once this has been determined, each bullet point within that band should be assessed to see if the candidate has met the requirements of the statement. Where those requirements are met, marks should be awarded, starting from the lowest available mark for that band.

Once this process has been completed if the highest (or lowest) mark available for that band has been determined, the examiner must check the band above (or below) to ensure that the initially correct determination of the band was correctly allocated. For example, there may be sufficient detail in the candidate's response to award the lowest mark of the band above.

**NB. Marks are distributed unevenly across the mark bands as candidates have to include much more detail in their responses to access the highest mark bands.**

Question	Answers	Notes	Marks	Criterion
1	a <b>any one correct scores one mark</b>  <b>all three correct scores two marks</b> <ul style="list-style-type: none"><li>• equal to</li><li>• greater than</li><li>• less than</li></ul>		2	A
	b less than 3200 ( $^{\circ}\text{C}$ ) <b>or</b> < 3200 ( $^{\circ}\text{C}$ )	<i>Do not accept 3200 (<math>^{\circ}\text{C}</math>) alone</i>		
	c white			
2	a white light <b>or</b> sunlight is a mixture of different colours <b>or</b> frequencies <b>or</b> wavelengths  light of different colour/frequency/wavelength is <u>refracted</u> by different amounts <b>or</b> light of different colour/frequency/wavelength <u>slows down</u> by different amounts	<i>Do not accept "light" alone</i> <i>Do not reward a repeat of the question</i>	2	A
	b he had discovered <u>infra-red</u> waves <b>or</b> light  <b>any additional point from the following list</b> <ul style="list-style-type: none"><li>• a reference to the discovery that the EM spectrum extended beyond visible light</li><li>• the light <b>or</b> waves were invisible but were detected due to their heating effect</li><li>• the light <b>or</b> waves were invisible but were detected due to the temperature change</li></ul>	WTTE		
	c the colour <b>and</b> surface of the bulb both affect the temperature rise  the temperature rise is caused by the absorption of (infra-red) radiation  as <u>black matt</u> surfaces absorb best, these experience the highest temperature rise	<i>Accept transfer of heat from wave to the bulb is caused by absorption of radiation</i>  ORA		

3	a	 A. (a)		1	A
	b	Angle of both reflected rays from curved mirror are approximately correct Rays reflected from secondary mirror towards the lens are approximately correct Correct direction of arrows	<i>Award 1 mark if one ray is completely correct</i>  <i>Award the 3<sup>rd</sup> marking point <b>only</b> if points 1 and 2 are also awarded</i>	3	A
c	the stars appear to move across the sky as the Earth is rotating/spinning on its axis	<i>WTTE</i>  <i>Do not accept "orbit" in place of "axis"</i>		2	A
d	Polaris is in line with the axis of rotation of the Earth			1	A
e	from a distance the three stars cannot be seen as distinct with the naked eye (since) new technology (eg telescopes) has been developed it has become possible to see the separate stars			2	A
f	(time in 1 year = $365 \times 24 \times 60 \times 60 =$ ) 31536000s  distance = speed × time = $9.5 \times 10^{15}$ (m)  Any calculated answer expressed in standard form <b>and</b> to 2 or 3 sig fig $9.5 \times 10^{15}$ <b>or</b> $9.46 \times 10^{15}$ (m)	<i>Seen or implied</i>  <i>ECF from marking point 1</i> <i>Units not essential</i>		3	A D
g	$323 \times 9.5 \times 10^{15} = 3.1 \times 10^{18}$ (m)	<i>Allow ECF from part 3f</i>		1	A

4	a	planets are opaque <b>or</b> eclipse <b>or</b> would block some of the light  this means that there would be a reduction in the brightness that was measured		2	A
	b	planets are non-luminous objects so they cannot be seen directly  they can only be detected if they are illuminated by the light from a star <b>or</b> if they block the light from a star	WTTE	2	A
	c	it would be too hot  the water would evaporate <b>or</b> become vapour <b>or</b> boil away	WTTE	2	A
	d	the hotter the star, the further away the habitable zone  (because) the energy received by the planet is related to distance <b>or</b> (because) the surface temperature of the planet is related to distance		2	B

5	<b>a</b>	gravitational energy to kinetic energy		1	A
	<b>b</b>	GPE = mgh <b>or</b> GPE = $0.25 \times 10 \times 0.6$  1.5 (J)  J	Accept Nm <b>or</b> joules Do <b>not</b> accept j	3	A
	<b>c</b>	how does the height of the ramp affect the distance travelled by the block?	ORA	1	B
	<b>d</b>	<b>Any simple prediction, for example</b> <ul style="list-style-type: none"><li>• as the ramp gets higher the block travels further</li></ul> <b>Explanation contains relevant scientific knowledge</b> <ul style="list-style-type: none"><li>• (because) the block has a greater gravitational potential <b>or</b> kinetic energy</li></ul> <b>Quantitative element to prediction, for example</b> <ul style="list-style-type: none"><li>• as the height doubles, the distance travelled doubles</li><li>• as the height doubles, the gravitational potential energy also doubles</li><li>• as the height doubles the kinetic energy will also double</li></ul>	ECF from part 5c	3	B
	<b>e</b>	<b>Correct independent variable:</b> height  <b>Dependent variable:</b> distance travelled  <b>Two relevant control variables, for example (2 max)</b> <ul style="list-style-type: none"><li>• material of sliding block</li><li>• same distance slid down the ramp</li><li>• mass <b>or</b> weight</li></ul>	ECF from part 5c    <b>Do not accept temperature, colour <b>or</b> gravitational field strength</b>	4	B
	<b>f</b>	a ruler/measuring tape	ECF from part 5c	1	B
	<b>g</b>	at low heights the ramp will not be steep enough for the block to slide  force of friction will be too high (for the force of) gravity to overcome it	WTTE	2	B

	<b>h</b>	distance travelled at height 0.60 m <b>and</b> distance travelled at height at 0.35 m at least three values planned in between data values evenly spaced at least two trials		<b>4</b>	B
	<b>i</b>	as the ramp gets higher the wooden block slides further there is a linear relationship between the variables	<i>Do not accept proportional</i>	<b>2</b>	C
	<b>j</b>	Accept any number in the range: 0.29 – 0.31 (m)	<i>Units not essential for this mark</i>	<b>1</b>	C
	<b>k</b>	it is the minimum height of the ramp at which the block will travel in the flat section <b>or</b> beyond the ramp  <b><i>Brief explanation, for example</i></b> <ul style="list-style-type: none"><li>• all of the energy of the falling block will be lost</li><li>• frictional <b>or</b> retarding forces are too high</li><li>• ramp has to be high enough for the block to overcome friction</li></ul>		<b>2</b>	C
	<b>l</b>	the method produced sufficient data for a conclusion to be drawn <b>or</b> the method allowed for a suitable graph to be drawn	WTTE	<b>1</b>	C

6	a	<p><b>Any relevant question using a suitable alternative independent variable, for example (1 max)</b></p> <ul style="list-style-type: none"> <li>• surface material of sliding object</li> <li>• mass of sliding object</li> <li>• angle of ramp</li> <li>• length of ramp.</li> </ul>	<p>Change in the dependent variable should not be rewarded</p> <p>Accept weight Do <b>not</b> accept speed</p>	1	B
	b	<p>Any simple prediction linking the independent variable from part a with distance travelled</p> <p>Quantitative element to prediction</p> <p>Attempt at a scientific explanation</p>	<i>ECF for independent variable from 6a</i>	3	B
	c	<p>Any reasonable independent variable (1 max)</p> <p>Any reasonable control variable that can be measured (2 max)</p>	<i>ECF from part 6a</i> Do <b>not</b> accept height	3	B
	d	<p>Plans to use different conditions of the independent variable</p> <p><b>Any one from the following list (1 max)</b></p> <ul style="list-style-type: none"> <li>• Specifies at least 5 different conditions of independent variable</li> <li>• Specifies multiple trials</li> <li>• specifies relevant equipment</li> </ul>	<i>ECF from part 6a</i>	2	B

7	a	measurement of 6.28 or 6.13 (m) recorded stopping distance of 6.11 (m) correctly calculated unit of m included	Accept answers correctly expressed in cm	3	C D
	b	both radius <b>and</b> stopping distance table headers correct  table headers include units that agree with the data  only table headers include units  values recorded in order of increasing or decreasing radius  values have been recorded to a consistent number of decimal places	Accept either vertical or horizontal tables	5	C
	c	data collected is continuous  (scatter graph) allows us to draw a line of best fit <b>or</b> (scatter graph) allows us to determine the relationship between the two variables		2	C
	d	as the radius increases the stopping distance decreases  (but) this relationship is not linear/proportional	Award 2 marks for “there is an inverse square relationship”	2	C
	e	stopping distance is inversely proportional to radius squared <b>or</b> stopping distance is directly proportional to $1/R^2$		1	C
	f	larger radius of sail increases drag/air resistance  (because) there are more collisions with air particles  relating area to $R^2$ (seen or implied)		3	C
	g	stopping distance decreases as area (or radius) increases  (however) the results show that stopping distance is inversely proportional to radius squared (not radius)	<i>Do not accept “the hypothesis is supported” without qualifier</i>	2	C
	h	accept any reasonable extension eg change shape of sail		1	C
	i	prediction  justification  justification supported by scientific evidence		3	B

<b>8</b>	<b>a</b>	steel		<b>1</b>	C																						
	<b>b</b>	<b>Any relevant point, for example</b> <ul style="list-style-type: none"> <li>• too soft</li> <li>• less rigid</li> <li>• not able to support high forces during competition</li> </ul>		<b>1</b>	D																						
	<b>c</b>	<p>compares the density of material X to carbon fibre <b>or</b> to bone            suggestion of how this could affect the function of the prosthesis</p> <p>compares the E or stiffness <b>or</b> Young's modulus of material X to carbon fibre <b>or</b> to bone            suggestion of how this could affect the function of the prosthesis</p> <p><b>A concluding comment, for example</b></p> <ul style="list-style-type: none"> <li>• a leg is more complicated than the bone alone</li> <li>• muscles are also important</li> <li>• a recommendation suggesting which of the two materials would be better for performance in sport</li> </ul>	ORA	<b>5</b>	D																						
<b>9</b>		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 5px;">• an attempt to make an ethical or a social statement on prosthetic limbs</td><td style="text-align: center; padding: 5px;">1</td></tr> <tr> <td style="padding: 5px;">• an ethical statement on prosthetic limbs</td><td style="text-align: center; padding: 5px;">2-4</td></tr> <tr> <td style="padding: 5px;">• a social statement on prosthetic limbs</td><td style="text-align: center; padding: 5px;"></td></tr> <tr> <td style="padding: 5px;">• either statement is linked to fairness of the competition or inclusion</td><td style="text-align: center; padding: 5px;"></td></tr> <tr> <td style="padding: 5px;">• ethical statement is relevant to the fairness of the competition</td><td style="text-align: center; padding: 5px;">5-7</td></tr> <tr> <td style="padding: 5px;">• social statement is relevant linked to inclusion</td><td style="text-align: center; padding: 5px;"></td></tr> <tr> <td style="padding: 5px;">• an evaluative statement</td><td style="text-align: center; padding: 5px;"></td></tr> <tr> <td style="padding: 5px;">• ethical statement is relevant to the fairness of the competition and justified</td><td style="text-align: center; padding: 5px;">8-11</td></tr> <tr> <td style="padding: 5px;">• social statement is relevant linked to inclusion and justified</td><td style="text-align: center; padding: 5px;"></td></tr> <tr> <td style="padding: 5px;">• evaluative statement is justified with scientific reasoning</td><td style="text-align: center; padding: 5px;"></td></tr> <tr> <td style="padding: 5px;">• a concluding appraisal linking all the issues discussed previously</td><td style="text-align: center; padding: 5px;"></td></tr> </table>	• an attempt to make an ethical or a social statement on prosthetic limbs	1	• an ethical statement on prosthetic limbs	2-4	• a social statement on prosthetic limbs		• either statement is linked to fairness of the competition or inclusion		• ethical statement is relevant to the fairness of the competition	5-7	• social statement is relevant linked to inclusion		• an evaluative statement		• ethical statement is relevant to the fairness of the competition and justified	8-11	• social statement is relevant linked to inclusion and justified		• evaluative statement is justified with scientific reasoning		• a concluding appraisal linking all the issues discussed previously			<b>11</b>	D
• an attempt to make an ethical or a social statement on prosthetic limbs	1																										
• an ethical statement on prosthetic limbs	2-4																										
• a social statement on prosthetic limbs																											
• either statement is linked to fairness of the competition or inclusion																											
• ethical statement is relevant to the fairness of the competition	5-7																										
• social statement is relevant linked to inclusion																											
• an evaluative statement																											
• ethical statement is relevant to the fairness of the competition and justified	8-11																										
• social statement is relevant linked to inclusion and justified																											
• evaluative statement is justified with scientific reasoning																											
• a concluding appraisal linking all the issues discussed previously																											

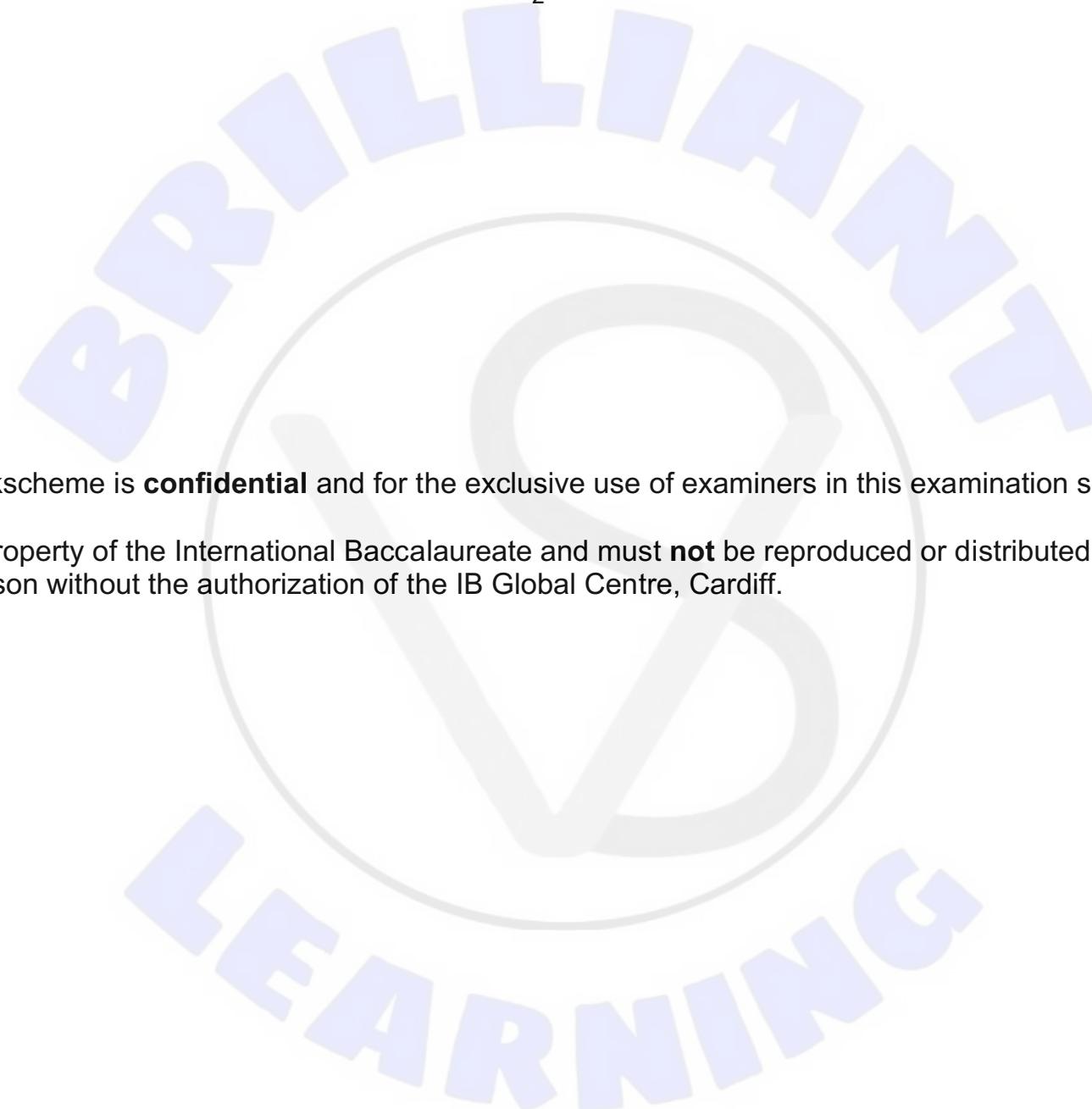
10	a	50 000 $\text{Nm}^{-2}$ or $\text{N/m}^2$ or $\text{Pa}$ or pascal(s)		2	A D
	b	<p>pressure is inversely proportional to area</p> <p><b>Contact with the ground</b> contact area between the prosthesis and the ground is as large as that of a natural foot</p> <p>pressure on the ground allows the elephant to walk without the artificial foot sinking into the ground</p> <p><b>Contact with the limb</b> area of contact between the prosthesis and the elephant's skin is maximized</p> <p>the elephant's skin feels less <u>pressure</u> making the limb comfortable</p>	<p>WTTE used correctly in either response box</p> <p>Accept "leg" for "foot"</p>	5	D
	c	<p><b>Any advantage, for example</b></p> <ul style="list-style-type: none"> <li>Allows movement</li> </ul> <p><b>Justification of advantage, for example</b></p> <ul style="list-style-type: none"> <li>Able to find food over a wider area</li> </ul> <p><b>Any disadvantage, for example</b></p> <ul style="list-style-type: none"> <li>Never as good as original limb</li> </ul> <p><b>Justification of disadvantage, for example</b></p> <ul style="list-style-type: none"> <li>Prosthetic limb/attachment might need maintenance, this would not be possible in its natural habitat</li> </ul> <p><b>Any additional advantage or disadvantage and justification, for example</b></p> <ul style="list-style-type: none"> <li>Male elephants fight and the prosthetic limb would not be sturdy enough</li> </ul> <p><b>A simple evaluative statement</b></p> <p><b>The evaluative statement is justified</b></p>		7 D	

# Markscheme

November 2018

Physics

On-screen examination



This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Horizontal wavy line that can be expanded
	Highlight tool that can be expanded to mark an area of a response

Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Text box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

## Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (or reverse argument) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (words to that effect) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add *ECF* (error carried forward) to the candidate response.

- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate's work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

Question	Answers	Notes	Total	Criterion
1	a speed of sound=330 ms <sup>-1</sup> <b>and</b> speed of light = 300 000 000 ms <sup>-1</sup>		1	A
	b time between lightning and thunder  use speed = distance / time to find distance  using speed of sound in air	Accept velocity, displacement  Can be implied, award separately	3	A
	c moving with constant / unchanging speed <b>or</b> it is not accelerating  <b>any additional point, for example</b> <ul style="list-style-type: none"><li>• moving towards <b>and</b> then away from student</li><li>• it passes at a distance of 1 km</li><li>• it passes overhead</li></ul>		2	A
	d values from graph  to give 12 (km hr <sup>-1</sup> )	Seen or implied  Ignore incorrect unit if present	2	A
2	a electrons are transferred from the small upward moving crystals to the water drops		1	A
	b R=500 000/20 000  R=25  correct unit Ω	Seen or implied	3	A
	c $\Delta Q = I \Delta t$  $\Delta Q = 0.6$ (C)	Seen or implied from $20\ 000 \times 30 \times 10^{-6}$  Award 1 mark for 600000 (°C)	2	A
	d metal is a better conductor / has a lower resistance than buildings  current/charge from lightning will flow through the conductor  current/charge passes to earth (without passing through building)		3	A

3	a	<p><b>All three correct</b></p> <p>Draggable:</p> <div style="border: 1px solid blue; padding: 5px; display: inline-block;"> <math>{}^0_{-1}\beta</math>  <math>{}^4_2\alpha</math> </div> <div style="margin-top: 10px;"> <math display="block">{}^{241}_{95}\text{Am} \rightarrow {}^{237}_{93}\text{Np} + {}^4_2\alpha</math> <math display="block">{}^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + {}^4_2\alpha</math> <math display="block">{}^{240}_{93}\text{Np} \rightarrow {}^{240}_{94}\text{Pu} + {}^0_{-1}\beta</math> </div>		1	A
	b	atomic number = 107 mass number = 270 bohrium <b>or</b> Bh	<i>Award all marks independently</i>	3	A
	c	high energy <b>or</b> high frequency <b>or</b> short wavelength electromagnetic waves <b>or</b> radiation <b>or</b> photon	<i>Do not accept particle</i>	2	A
	d	Carbon-14 after 10 000 years the change in abundance will be noticeable <b>or</b> the half-life is appropriate to the situation it exists in nature	WTTE	3	A

4	a	<p><b>Image Object</b></p> <table border="1"> <thead> <tr> <th>Independent variable</th><th>Dependent variable</th><th>Control variables</th></tr> </thead> <tbody> <tr> <td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input checked="" type="checkbox"/> Drop height</td></tr> <tr> <td><input checked="" type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/> Internal air pressure</td></tr> <tr> <td><input type="checkbox"/></td><td><input checked="" type="checkbox"/></td><td><input type="checkbox"/> Bounce height</td></tr> <tr> <td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input checked="" type="checkbox"/> Size of ball</td></tr> <tr> <td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input checked="" type="checkbox"/> Bouncing surface</td></tr> <tr> <td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input checked="" type="checkbox"/> Material of the ball</td></tr> </tbody> </table> <p><b>Text/MCQ/Mini-Cloze Object</b></p> <p><i>Independent:</i> only internal air pressure chosen</p> <p><i>Dependent:</i> only bounce height chosen</p> <p>Two control variables correct</p> <p>All control variables correct</p>	Independent variable	Dependent variable	Control variables	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> Drop height	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> Internal air pressure	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> Bounce height	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> Size of ball	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> Bouncing surface	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> Material of the ball		
Independent variable	Dependent variable	Control variables																							
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> Drop height																							
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> Internal air pressure																							
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> Bounce height																							
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> Size of ball																							
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> Bouncing surface																							
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> Material of the ball																							
	b	<p><b>Text/MCQ/Mini-Cloze Object</b></p> <p>Measurements each 10 kPa; 3 repetitions at each pressure ▾</p> <p><b>comment for reliability, for example [max 1]:</b></p> <ul style="list-style-type: none"> <li>• allows a mean to be calculated</li> <li>• reduces experimental uncertainty</li> </ul> <p>sufficient data <b>or</b> data across the full range</p>		<p>4</p> <p>B</p> <p>3</p> <p>B</p>																					

c	<p><b>Safety factor linked to the question is stated, for example [max 1]:</b></p> <ul style="list-style-type: none"> <li>use a safe method to drop from height</li> <li>avoid bouncing into the face</li> <li>avoid over pressurizing the ball</li> </ul> <p><b>Justification, for example [max 1]:</b></p> <ul style="list-style-type: none"> <li>to avoid falling injury</li> <li>to avoid injury</li> <li>the ball might explode</li> </ul>	<p>Consider both response boxes when awarding marks for this question part</p>	2	B
d	<p>83±0.5 kPa</p>	<p>Notes award 1 mark 12.5 PSI if unit is also present <i>Do not accept kpa for the unit mark</i></p>	2	D
e	line must go through all of the data points		1	C
f	0.63 – 0.65 (m)		1	C
g	<p>y intercept corresponds to bounce height approx. 0.40 m ball is deflated when its pressure is 0 kPa so in reality it will not bounce at all</p>		3	C
h	<p>if the relationship was proportional, the line would go through the origin of the graph the line does not go through the origin – it is not proportional</p>		2	C

5	a	<p><b>Identification of incorrect step in the method from this list <u>only</u> [max 2]</b></p> <ul style="list-style-type: none"> <li>• ruler not used correctly – eg at an angle, not placed on the floor</li> <li>• different ball used</li> <li>• bounce height measured incorrectly</li> <li>• ball is dropped at a different angle or height</li> </ul> <p><b>Effect of the error on the measurement [max 2]</b></p> <ul style="list-style-type: none"> <li>• the measurement of bounce height will be inconsistent</li> </ul> <p><b>Improvement linked with the step identified [max 2]</b></p> <ul style="list-style-type: none"> <li>• hold the ruler vertically</li> <li>• place the ruler on the floor</li> <li>• use the same ball for all repeats</li> </ul>	WTTE Consider all three responses for each step when awarding marks	6	C C														
	b	evidence of method of conversion to m  0.51(33)	No ECF from first marking point, ignore sig fig errors	2	C														
	c	<p><b>Table Object</b></p> <table border="1"> <thead> <tr> <th>Height +/-0.01m</th> <th>Bounce height +/-0.01m</th> </tr> </thead> <tbody> <tr> <td>1.0</td> <td>0.18</td> </tr> <tr> <td>1.4</td> <td>0.40</td> </tr> <tr> <td>1.8</td> <td>0.51</td> </tr> <tr> <td>2.2</td> <td>0.63</td> </tr> <tr> <td>3.0</td> <td>0.82</td> </tr> <tr> <td>3.4</td> <td>0.89</td> </tr> </tbody> </table> <p>both initial height <b>and</b> bounce height table headers correct  table headers include units that agree with the data <b>and</b> no units in the columns  correct values recorded  values recorded in order of increasing or decreasing initial height  values have been recorded to a consistent number of decimal places</p>	Height +/-0.01m	Bounce height +/-0.01m	1.0	0.18	1.4	0.40	1.8	0.51	2.2	0.63	3.0	0.82	3.4	0.89	Accept either vertical or horizontal tables  Data must be in consistent units	5	C
Height +/-0.01m	Bounce height +/-0.01m																		
1.0	0.18																		
1.4	0.40																		
1.8	0.51																		
2.2	0.63																		
3.0	0.82																		
3.4	0.89																		

	<b>d</b>	<p>data point plotted correctly (0.51, 1.8) <i>X axis: drop height/m and Y axis: bounce height/m</i></p>	<p><i>ECF part b</i> <i>Accept incorrect use of brackets, metres</i> <i>There must be a clear difference in the two types of height measured. Do not accept height alone</i></p>	<b>2</b>	C
--	----------	--	--	----------	---

6	a	<p><b>Dependent variable:</b> height of the bounce</p> <p><b>Control variables [max 2]:</b> accept any two reasonable, relevant control variables that would affect the outcome of the experiment</p>			Accept any specifically named bounce, (first bounce etc) and alternative, appropriate methods	3	B			
b			<b>1 mark</b>	<b>2 marks</b>	<b>3 marks</b>	<b>4 marks</b>	14	B		
		Hypothesis	RQ is suggested	Prediction linking IV and DV	Testable hypothesis linking IV and DV with incomplete scientific reasoning					
		Method / Equipment	Specific equipment for measuring the temperature of the ball	Specific equipment for measuring the temperature of the ball <b>and</b> precise measurement of dependent variable, eg video camera, stopwatch						
		Method / manipulation	Attempt at a method but detail is insufficient to follow	Method described and could easily be followed by another student	Complete method that would allow for precise data is described and could easily be followed					
		Data	Method implies a range of values	Method includes at least 5 values of DV or at least 3 trials/repeats	Method includes at least 5 values of DV and at least 3 trials/repeats	Method includes at least 5 values of DV with 3 trials/repeats and plans to calculate average				
		Safety	Reasonable safety consideration	Reasonable safety consideration with justification linked to a named hazard						

7	a	wind		1	A
	b	both global temperature <b>and</b> the amount of CO <sub>2</sub> increases  use of values from the graph for both temperature and CO <sub>2</sub>		2	D
	c	increased use of fossil fuels  because of industrialization	WTTE	2	D
	d	<b>Any two reasonable consequences of increasing temperature, for example [max 2]</b> <ul style="list-style-type: none"><li>• as the temperature rises, the polar ice sheets melt</li><li>• changing environmental conditions reduce plant growth</li></ul> <b>Any two correctly linked impacts, for example [max 2]</b> <ul style="list-style-type: none"><li>• rising ocean levels</li><li>• desertification</li></ul>		4	D
	e	<b>One type of technology, for example [max 1]</b> <ul style="list-style-type: none"><li>• wind power</li><li>• carbon capture</li><li>• electric vehicles</li></ul> <b>A strength of using this technology to reduce CO<sub>2</sub>, for example [max 1]</b> <ul style="list-style-type: none"><li>• no fossil fuels are burnt</li><li>• existing technology can be used</li><li>• converts wind energy to electrical energy</li><li>• CO<sub>2</sub> is stored underground</li><li>• electric vehicles do not produce CO<sub>2</sub></li></ul> <b>A limitation of using this technology, for example [max 1]</b> <ul style="list-style-type: none"><li>• visual impact, noisy</li><li>• unknown impact of long-term storage</li><li>• electric vehicles use new technology that is still being developed</li></ul> <b>An additional point, either a strength or limitation [max 1]</b>	Accept any reasonable specific technology	4	D

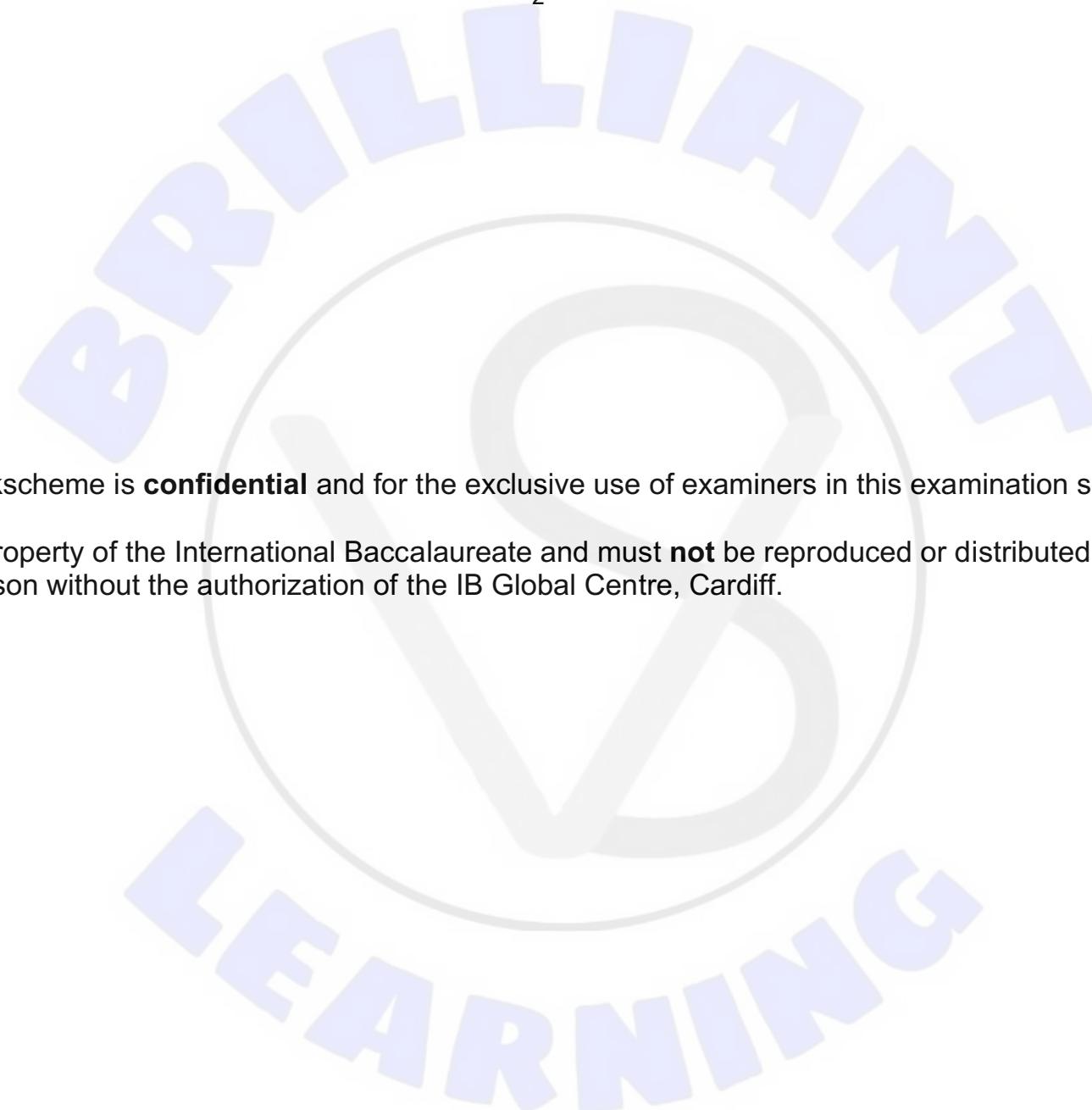
8		1	2	3	4	11
Health and well-being	A simple comment on a health or well-being impact for one of the methods	A health or well-being impact for both methods <b>or</b> a linked explanation for how one method impacts health	A health or well-being impact for <b>both</b> methods with a linked explanation for how the method impacts health for <b>either</b> method	A health or well-being impact for <b>both</b> methods with a linked explanation for how the method impacts health for <b>both</b> methods		
Economic or social impacts	A simple comment on an economic or social impact for <b>one</b> of the methods	An economic or social impact for <b>both</b> methods	An economic or social impact for <b>both</b> methods with a linked explanation for <b>either</b> method	An economic or social impact with a linked explanation for <b>both</b> methods		
Comparison	Comparison of health impacts for each method <b>or</b> Comparison of economic impacts for each method	Comparison of health impacts for each method <b>and</b> Comparison of economic impacts for each method				
Final recommendation	Recommendation of one method over another supported with justification (may be seen above)					

# Markscheme

May 2018

Physics

On-screen examination



This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

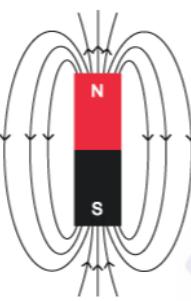
The following are the annotations available to use when marking responses.

Annotation	Explanation	Shortcut	Annotation	Explanation	Shortcut
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark	Alt+1		No benefit of the doubt	Alt+4
	Arithmetic error			No explanation given	
	Benefit of the doubt	Alt+3		Not good enough	
	Omission, incomplete	Alt+7		Not worthy of any marks	
	Contradiction	Alt+6		No working shown	
	Valid part (to be used when more than one element is required to gain the mark)			Test box used for additional marking comments	
	Error carried forward	Alt+8		Unclear	Alt+2
	Dynamic annotation, it can be expanded to surround work			Seen; must be stamped on all blank response areas	Alt+9
	Horizontal wavy line that can be expanded			Vertical wavy line that can be expanded	
	Highlight tool that can be expanded to mark an area of a response			Words to that effect	
	Not answered the question			Award 1, 2, 3, 4 marks. For use in holistically marked questions only.	

## Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (or reverse argument) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (words to that effect) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add *ECF* (error carried forward) to the candidate response.

- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate's work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

Question		Answers	Notes	Total	Criterion
1	a	B. 		1	A
	b	<b>Any two of the points below [max 2]</b> <ul style="list-style-type: none"> <li>• stronger magnet</li> <li>• faster movement of magnet</li> <li>• use a coil of wire with lower resistance</li> <li>• coils closer together</li> </ul>	<i>Do not accept increase the number of turns as this is given in the question</i>  <i>Accept area only if accompanied by discussion of flux density</i>	2	A
	c	current flows in the opposite direction		1	A
	d	evidence of use of transformer equation  correctly calculated value of 220 (V)	<i>Award 2 marks for correct answer only</i> <i>Award 2 marks for 0V only if there is justification using direct current</i>	2	A
	e	power in both coils calculated (60 W, 57 W)  efficiency correctly calculated as 95 % / 0.95	<i>Award 1 mark for correct answer with non-standard method</i>	2	A
	f	alternating current produces the change in magnetic field <b>or</b> direct current produces a change in the magnetic field only when it is switched on <b>or</b> off  (this) produces an alternating current of current in the secondary coil A <b>or</b> a direct current would only produce an output current when switched on or off	<i>Accept continuous output of current</i>	2	A

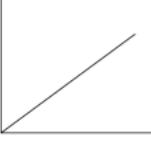
2	a	<table border="1"> <tr> <td>Velocity</td><td>Speed in a particular direction</td></tr> <tr> <td>Kinetic energy</td><td>Energy due to the motion of an object</td></tr> <tr> <td>Power</td><td>Energy transformed per unit time</td></tr> </table>	Velocity	Speed in a particular direction	Kinetic energy	Energy due to the motion of an object	Power	Energy transformed per unit time		3	A
Velocity	Speed in a particular direction										
Kinetic energy	Energy due to the motion of an object										
Power	Energy transformed per unit time										
b	gravitational potential	1	A								
c	evidence of use of correct formula  correct value of 26000 (J)  26 (kJ)	3	A								
d	friction	Do not accept air resistance alone	1								
e	<p>The diagram illustrates energy conversion from thermal energy to kinetic energy. A large blue arrow points from a curved surface at the top of a slope down to a horizontal surface. The initial form of energy at the top is labeled "Initial form of energy at the top of the slope". The energy is converted into "Kinetic energy (40 %)" and "Sound energy (10 %)". The remaining energy, "Thermal energy (50 %)", is shown at the bottom. A box labeled "Draggable:" is positioned next to the sound energy box.</p>	1	A								

<b>3</b>	<b>a</b>	convection	<b>1</b>	A
	<b>b</b>	cold air goes down <b>or</b> hot air goes up  hot air is less dense than cold air so it rises  cooling is more effective (than if it was placed at the bottom)	<i>Do not accept heat alone, must be hot air ORA</i>  <i>WTTE</i>	<b>3</b>  A
	<b>c</b>	high energy particles in the liquid escape the surface  leaving lower energy particles behind  link between kinetic energy and thermal energy <b>or</b> temperature	<i>Accept fast moving for high energy</i>	<b>3</b>  A
	<b>d</b>	silver <b>or</b> white <b>or</b> shiny <b>or</b> metallic <b>and</b> is best at reflecting sunlight  answer includes a correct reference to (infra-red) radiation / waves	<i>ORA Ignore references to other colours</i>  <i>Do not accept incorrectly named types of EM radiation</i>	<b>2</b>  A

4	a	How does the area of the hole affect the time it takes to fill a container?	WTTE Do <b>not</b> accept time to empty	1	B																												
	b	<p><b>Any simple prediction, for example</b> as the hole gets bigger the time to fill the container will reduce</p> <p><b>Explanation contains relevant scientific knowledge</b> (because) the larger the area of the hole the greater the amount of water flowing through it</p> <p><b>Any quantitative element agreeing with the prediction, for example</b> as the area doubles the flow rate doubles</p>	ORA for size and time  Accept equivalent <u>correct</u> relationships in terms of radius, diameter, circumference	3	B																												
	c	<table> <thead> <tr> <th>Independent Variable</th> <th>Dependent Variable</th> <th>Control Variable</th> <th></th> </tr> </thead> <tbody> <tr> <td colspan="4"><b>Text/MCQ/Mini-Cloze Object</b></td> </tr> <tr> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> <td>Type of liquid</td> </tr> <tr> <td><input checked="" type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td>Area of the out-flow tube</td> </tr> <tr> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> <td><input type="checkbox"/></td> <td>Time it takes for the second container to fill</td> </tr> <tr> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> <td>Volume of second container</td> </tr> <tr> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> <td>Viscosity</td> </tr> </tbody> </table> <p>Correct identification of area as IV only</p> <p>Correct identification of time as DV only</p> <p>Type of liquid <b>and</b> volume <b>and</b> viscosity as CV</p>	Independent Variable	Dependent Variable	Control Variable		<b>Text/MCQ/Mini-Cloze Object</b>				<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Type of liquid	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Area of the out-flow tube	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Time it takes for the second container to fill	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Volume of second container	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Viscosity		3	B
Independent Variable	Dependent Variable	Control Variable																															
<b>Text/MCQ/Mini-Cloze Object</b>																																	
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Type of liquid																														
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Area of the out-flow tube																														
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Time it takes for the second container to fill																														
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Volume of second container																														
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Viscosity																														
	d	<p><b>Any two suitable, for example [max 2]</b></p> <ul style="list-style-type: none"> <li>stopwatch/timer/chronometer</li> <li>device for measuring the size of the hole (ruler, calipers)</li> <li>measuring cylinder</li> </ul>		2	B																												

	e	measurements of <u>time</u> to fill a fixed volume <b>and</b> diameter/radius/area of hole  at least five increments  at least three repeated trials	No ECF	3	B
	f	title correctly linking IV and DV		1	C
	g	as area increases, the fill time decreases <b>or</b> as the inverse of area increases, the fill time increases  (fill time is) inversely proportional (to area) <b>or</b> proportional to the inverse of area <b>or</b> linear relationship that goes through zero	<i>First mark is implicit in second marking point, award 2 marks</i>	2	C
	h	calculation using data from the graph  constant correctly calculated = 15 ( $\text{scm}^2$ )	Seen or implied  unit not required	2	C
	i	evidence of using $a = k/t$  answer correctly calculated 0.17 ( $\text{cm}^2$ )	ECF from part (h)  <i>Accept answers in the range 0.16-0.18 Do <b>not</b> accept answers given as a fraction</i>	2	C

5		1	2	3	4	13	B
Variables (V)	Time implied as dependent variable	Independent variable <b>and</b> dependent variable of time to fill container stated	Independent, dependent variable of time to fill container <b>and</b> one control variable stated <b>and</b> justified	Independent, dependent variable of time to fill container <b>and</b> two control variables are stated <b>and</b> justified			
Equipment (E)	Some equipment is listed	Equipment to give a range of IV is listed	Named equipment for measuring volume and time				
Method (M)	Attempt at a method linked to volume and time	The method is described <b>and</b> could be followed by another student	Complete method is described, fully explained <b>and</b> could easily be followed by another student				
Data (D)	Reference to different increments <b>or</b> trials	At least five increments <b>or</b> three trials	At least five increments <b>and</b> three trials				

6	a	<p><u>12.8</u> (s)</p> <p>s</p>	<p>Needs to be stated to this precision</p> <p>Award this mark separately</p> <p>Accept second(s) do <b>not</b> accept sec(s)</p>	2	C D												
	b	<table border="1"> <thead> <tr> <th>Height of water / cm</th> <th>Time taken to empty the tube / s</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>6.4</td> </tr> <tr> <td>4</td> <td>9.0</td> </tr> <tr> <td>6</td> <td>11.1</td> </tr> <tr> <td>8</td> <td>12.8</td> </tr> <tr> <td>10</td> <td>14.3</td> </tr> </tbody> </table> <p>both labels correct: Time (to fill the container) <b>and</b> height (of liquid)      both units included in labels <b>and</b> not next to data values      all times and corresponding heights correctly recorded      data organized in ascending or descending order</p>	Height of water / cm	Time taken to empty the tube / s	2	6.4	4	9.0	6	11.1	8	12.8	10	14.3	<p>Ignore incorrect use of brackets around unit</p> <p>ECF from part (a)</p>	4	C
Height of water / cm	Time taken to empty the tube / s																
2	6.4																
4	9.0																
6	11.1																
8	12.8																
10	14.3																
	c	<p>A. </p>		1	C												

d	<p>for the results to be proportional the line must go through (0,0)  the line crosses the y axis at 5.0 so not proportional  <b>or</b>  for the results to be proportional the line must be straight  a curve would fit the data better so cannot be proportional  <b>or</b>  if the quantities are proportional then doubling the height will double the time  data used to demonstrate that this trend is not seen</p>	<i>Accept values in the range <math>5.0 \pm 0.5</math></i>	2	C
e	<p>student D had the most valid method  because the range of data most clearly shows the correct relationship  the range of data of the other students is not wide enough to show the correct relationship  <b>or</b>  the range of data of the other students shows an incorrect linear relationship across the range selected</p>	<i>WTTE</i>	3	C
f	<p><b>Any relevant alternative independent variable, for example</b></p> <ul style="list-style-type: none"> <li>• liquid with a different viscosity</li> <li>• pressure</li> <li>• liquid with a different density</li> <li>• type of liquid</li> </ul>	<i>Do not accept size of hole, volume of container, gravitational field strength</i>	1	C
g	<p>Any simple prediction linked to relevant IV  Prediction links IV from part (f) to time taken to empty tube  Attempts to link to scientific knowledge</p>		3	C

7	a	<p>increased (between 1975 to 2005)</p> <p>it was below world average before 1998 <b>or</b> it was above world average after 1998</p>	<i>Accept in the range 1997-1999</i>	2	D
	b	<p><b>Accept any reasonable answer, for example</b></p> <ul style="list-style-type: none"> <li>• increased industrialization</li> <li>• more people having domestic electricity</li> <li>• more electrical energy used in the home</li> <li>• increased use of technology</li> </ul>	<i>Do not accept more people as the data refers to power consumption per person</i>	1	D
	c	<p>first mark for data points (<math>1.27 \pm 0.01</math>, <math>3150 \pm 50</math>)</p> <p>correct use of data to calculate <math>3.94 \times 10^{12}</math> (kWh)</p>	<i>Accept any value in range <math>3.9-4.1 \times 10^{12}</math></i>	2	D
	d	<p><b>Accept any reasonable answer linked to the environment, for example [max 3]</b></p> <ul style="list-style-type: none"> <li>• named pollutant gases <b>or</b> CO<sub>2</sub></li> <li>• smoke or particulate pollution</li> <li>• coal mining and destruction of habitat</li> <li>• contribution to climate change <b>or</b> rising sea levels <b>or</b> greenhouse effect</li> <li>• acid rain</li> </ul>	<i>Do not accept “pollution”, “waste”, “burning fossil fuels” without further detail</i> <i>Accept more than one response in a single box</i>	3	D
	e	<p><b>Gravitational potential – kinetic energy – electrical energy</b></p> <p>three correct forms selected</p> <p>all in correct sequence</p>		2	D

8		1	2	3	4			
		Impacts on the river (I)	A positive <b>or</b> negative impact on the river	A positive <b>or</b> negative impact on the river supported with information	A positive <b>and</b> negative impact on the river supported with information	A positive <b>and</b> negative impact on the river supported with information and linked to science		
		Wider landscape (W)	A positive <b>or</b> negative impact on the natural landscape	A positive <b>or</b> negative impact on the natural landscape supported with information	A positive <b>and</b> negative impact on the natural landscape supported with information	A positive <b>and</b> negative impact on the natural landscape supported with information and linked to science		
		Global perspective related to CO <sub>2</sub> (G)	An attempt to identify an impact on a global scale	An impact on a global scale supported with information	An impact on a global scale supported with information and linked to science			
		Concluding appraisal (C)	A concluding statement	A concluding appraisal including positive and negative arguments	A concluding appraisal evaluating all arguments			

14

D

# Markscheme

November 2019

Physics

On-screen examination

13 pages

This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

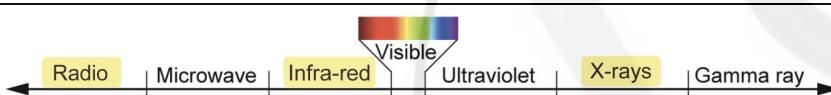
It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Horizontal wavy line that can be expanded
	Highlight tool that can be expanded to mark an area of a response

Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Text box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

Question	Answers			Notes	Total	Criterion	Level
1	a	Symbol	Quantity	Unit		Ai	1-2
		$p$	momentum	$\text{Ns}$ or $\text{kg m s}^{-1}$			
		$m$	mass	Kg			
		$v$	velocity	$\text{m s}^{-1}$			
		two correct all correct			2		
	b	the train has a greater mass <b>or</b> the train is heavier			1	Ai	1-2
	c	the ball has forward momentum  a force is required to change (an object's) momentum  as no force is available to change the momentum (the ball keeps moving)  <b>or</b>  (initially) the ball is moving forward <b>and</b> with the train (at $5 \text{ ms}^{-1}$ )  (Newton's first law states that) an object's velocity will stay the same unless a force acts on it <b>or</b> any correct reference to inertia  there is no net force acting so the velocity will not change			WTTE	Aii	5-6
	d	Friction (creates a force that prevents the bag from moving)			1		

<b>2</b>	<b>a</b>	P = IV or I = P/V or 1100/220 5 A <b>or</b> amp(s) <b>or</b> ampere(s)	Award 2 marks for answer with no calculation Award this unit mark independently	<b>3</b>	Ai Aii Diii	3-4 3-4 5-6
	<b>b</b>	(electrons carry negative charge so) dust becomes negatively charged reference to attraction between opposite charges	WTTE	<b>2</b>	Aiii	5-6 5-6
	<b>c</b>	dust particles interfere with this field making it weaker <b>or</b> addition of negative charges to the positive plate reduces / neutralizes the overall (positive) charge  (so) force of attraction is weaker	WTTE	<b>2</b>	Aii	3-4 3-4
<b>3</b>	<b>a</b>	 Responses must be in the correct location either above or below the line		<b>1</b>	Ai	1-2
	<b>b</b>	<b>Any reasonable suggestion, for example [max 1]</b> <ul style="list-style-type: none"> <li>infrared does not pass through fur</li> <li>infrared could adversely affect health</li> <li>infrared could cause a heating effect</li> <li>infrared has higher energy than radio waves</li> </ul>	ORA	<b>1</b>	Aiii	3-4
	<b>c</b>	$v = f \lambda$ or $134000 \times 2238$ $299892000 \text{ (ms}^{-1}\text{)}$  $2.99892 \times 10^8 \text{ or } 3(0.0) \times 10^8 \text{ (ms}^{-1}\text{)}$	Award 2 marks for $29989200$ with no calculation shown Award 1 mark for $3(0.0) \times 10^8$ with no calculation Ignore incorrect units	<b>3</b>	Aii Diii	3-4 3-4 3-4
	<b>d</b>	induction requires no internal power source  alternative power source would lose power over time (requiring a replacement RFID or battery) <b>or</b>		<b>2</b>	Aiii	3-4 3-4

		an internal power source would be too large <b>e</b> (AC in the scanner coil produces an) <u>alternating</u> magnetic field / flux the magnetic field passes through the cat to the RFID changing field in the RFID generates an emf in the RFID	WTTE		<b>3</b>	Aii	5-6 5-6 7-8
--	--	--	------	--	----------	-----	-------------------

<b>4</b>	<b>a</b>	how does the <u>angle</u> between 2 (plane) mirrors affect the number of images?	<i>WTTE Accept responses phrased as questions only</i>	1	Bi	1-2																										
	<b>b</b>	<p><b>Table Object</b></p> <table border="1"> <thead> <tr> <th></th> <th>Independent variable</th> <th>Dependent variable</th> <th>Control variable</th> </tr> </thead> <tbody> <tr> <td>The object used</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>The position of the object</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>The number of images observed</td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td>The size of the mirrors used</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>The angle between the mirrors</td> <td><input checked="" type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td>The shape of the mirrors used</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> </tbody> </table> <p>IV – the angle between the mirrors only  DV – the number of images observed only  CV – the position of the object <b>and</b> the object used <b>and</b> the size of the mirrors used <b>and</b> the shape of the mirrors used <b>only</b></p>		Independent variable	Dependent variable	Control variable	The object used	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	The position of the object	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	The number of images observed	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	The size of the mirrors used	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	The angle between the mirrors	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The shape of the mirrors used	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	3	Biii
	Independent variable	Dependent variable	Control variable																													
The object used	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																													
The position of the object	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																													
The number of images observed	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>																													
The size of the mirrors used	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																													
The angle between the mirrors	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																													
The shape of the mirrors used	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																													
<b>c</b>	protractor		1	Biv	3-4																											
<b>d</b>	$92 \pm 2 (\circ)$		1	Cii	1-2																											
<b>e</b>	as angle increases number of images decreases conditions of inverse proportion clearly stated or implied in calculation $N = k/\text{Angle}$ <b>or</b> if angle is doubled, the number of images is not halved data from the graph correctly used to show that relationship is not inversely proportional	<i>Award separately and ignore any further incorrect comment linked to inversely proportional relationship</i>  <i>Award three marks if the first marking point is implied in the last marking point</i>	3	Ciii	1-2 7-8 7-8																											
<b>f</b>	<b>Any reasonable explanatory points, for example [max 2]</b>	<i>Accept discrete variable</i>	2	Ci	5-6 7-8																											
<b>g</b>	(the second student because) there are more data points <b>or</b> (the second student because) data are taken at regular intervals increased number of measurements over the range shows the pattern more clearly	<i>WTTE</i>	2	Civ	3-4 3-4																											

<b>5</b>	a	<p>distance noted as being 220m evidence of use of speed equation (distance/time) rounded correctly to 2sf <math>280 \text{ m s}^{-1}</math></p>	<p><i>Award third marking point if an incorrect value is rounded correctly to 2sf</i></p>	3	Cii Diii	5-6 3-4 7-8
	b	<p>increase the number of time measurements at this distance (because this will) improve reliability by minimising the effect of random errors in timing increase the overall time for the sound to travel by increasing the distance to the wall (because) small timing errors (due to human reactions) become less significant if the overall time is longer</p>	<p><i>WTTE</i> <i>Do not award marks if additional equipment is used</i></p>	4	Cv	5-6 7-8 5-6 7-8
	c	<p><math>2.65 \pm 0.03</math> <b>and</b> <math>0.90 \pm 0.03</math> <math>(2.65 - 0.90 = ) 1.75 \pm 0.06 \text{ (s)}</math></p>	<p><i>Award 2 marks for the correct value</i></p>	2	Cii	3-4 3-4
	d	<p><b>Column Headers:</b> Distance (travelled) <b>and</b> time results in order <b>Units in column heading only:</b> m <b>and</b> s data rounded to 2 dp and recorded correctly including their value from part c</p>	<p><i>Accept tables presented in rows</i> <i>ecf from part (c)</i></p>	4	Ci	1-2 5-6 3-4 5-6

	e	correct gradient of LOBF speed = 330 to 355 ( $\text{m s}^{-1}$ )	<i>seen or implied</i> <i>Ignore rounding</i>	2	Cii	5-6 5-6
	f	identification of data point at 400m or 1s  time is too low – should be greater to follow the trend and be closer to the LOBF	<i>WTTE</i>	2	Cii	1-2 3-4
	g	sound faster at higher temp  temp linked to kinetic energy <b>or</b> speed of particles  time between collisions is reduced <b>or</b> faster rate of energy transfer		3	Cii	1-2 7-8 7-8

6	a		1	2	3	4	14	Biv	4x1-2 4x3-4 4x5-6 2x7-8
			Variables	independent variable of mass <b>and</b> dependent variable of time period of oscillation stated	independent, dependent variable <b>and</b> one control variable stated <b>and</b> justified	independent, dependent variable <b>and</b> two control variables are stated <b>and</b> justified			
			Hypothesis	attempt at a hypothesis linked to either mass <b>or</b> time period	testable hypothesis linking mass <b>and</b> time period	hypothesis links IV and DV, is testable and with an attempted explanation referencing relevant scientific knowledge			
			Method	attempt at a method linked to mass and time	attempt at method, insufficient detail and not likely to give relevant data	method described, could be followed, will produce relevant data			
			Data collection	reference to different increments <b>or</b> trials	at least five different masses on the spring <b>or</b> three trials	at least five different masses on the spring <b>and</b> three trials			

6	b	<p><b>Any relevant IV, for example [max 1]</b></p> <ul style="list-style-type: none"> <li>• different spring (constant or length)</li> <li>• different number of springs</li> <li>• different initial displacement</li> </ul> <p>DV identified or implied as time period</p> <p>research question is consistent with variables identified</p> <p>mass identified as control variable</p> <p>1 other control variable identified</p>	<p>Award RQ mark separately – ignore CON in marking points 2-4</p> <p><i>Do not allow repetition of mass on spring from part (a)</i></p> <p><i>Do not allow CON to other variables here</i></p>	5	Biii	3-4
					Biii	3-4
					Biii	3-4
					Biii	3-4
					Biii	3-4

<b>7</b>	<b>a</b>	$v^2 = u^2 + 2as \text{ or } u^2/2a = s$ $400/(2^2) = s$ $s = 100$ m	Accept use of $s = ut + 1/2at^2$  <i>Award the unit mark separately</i>	<b>4</b>	<b>Aii</b>	3-4 5-6 5-6 5-6
	<b>b</b>	 Using a cell phone <input type="checkbox"/> driver factor  Heavy rain <input type="checkbox"/> environmental factor  Worn out tyre tread <input type="checkbox"/> car factor   Faulty brakes <input type="checkbox"/> car factor  Drinking alcohol <input type="checkbox"/> driver factor <b>2 correct 1 mark</b> <b>all correct 2 marks</b>		<b>2</b>	<b>Di</b>	1-2 1-2

	c	<p><b>Alcohol:</b> increases time taken (for the brain) to respond <b>or</b> delayed reactions  so stopping distance <b>or</b> thinking distance increases</p> <p><b>Poor road surface:</b> <u>friction</u> is lower on a poor road surface  so stopping distance <b>or</b> braking distance increases</p>	WTTE	4	Dii	3-4 3-4 3-4 3-4
--	---	--	------	---	-----	--------------------------

8			1	2	3	4			
		<b>Driverless technology</b>	an incomplete statement about a feature of DT	a statement of one feature of DT related to safety	description of one feature of DT or statements about two features of DT related to safety	description of more than one feature related to safety			
		<b>Society</b>	an incomplete statement of societal implications	one advantage <b>or</b> one disadvantage about society	one advantage <b>and</b> one disadvantage about society clearly stated	more than one advantage <b>and</b> more than one disadvantage about society clearly stated		<b>14</b>	Dii
		<b>Economic</b>	an incomplete statement about economic implications	one advantage <b>or</b> one disadvantage about economic implications	one advantage <b>and</b> one disadvantage about economic implications	more than one advantage <b>and</b> more than one disadvantage about economic implications			
		<b>Concluding appraisal</b>	a brief concluding appraisal	a concluding appraisal linking all arguments					

4x1-2  
4x3-4  
3x5-6  
3x7-8

# Markscheme

May 2019

Physics

On-screen examination

13 pages

This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

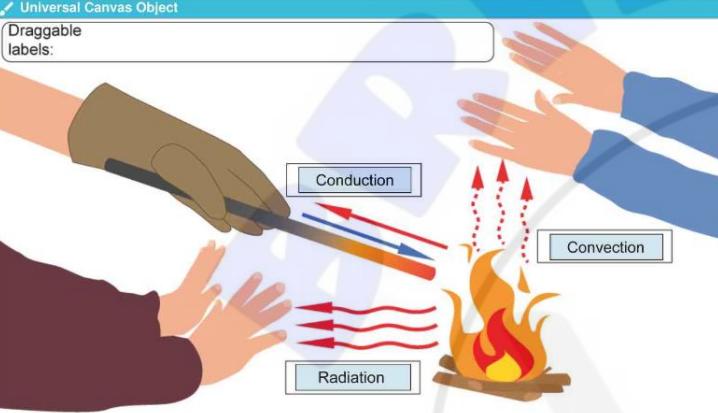
The following are the annotations available to use when marking responses.

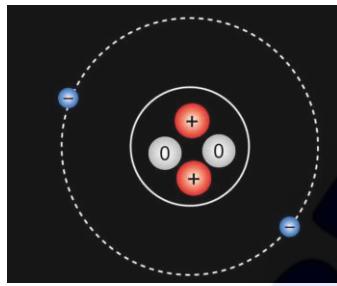
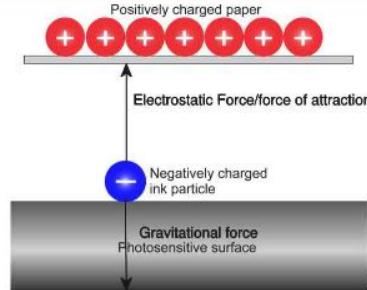
Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Horizontal wavy line that can be expanded
	Highlight tool that can be expanded to mark an area of a response

Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Test box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

## Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (*or reverse argument*) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (*or words to that effect*) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add ECF (error carried forward) to the candidate response.
- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate’s work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

Question	Answers	Notes	Total	Criterion
1 a	<p>Universal Canvas Object Draggable labels:</p>  <p>All correct</p>		1	A
b	<p>Celsius/<math>^{\circ}</math>C or Kelvin/K Joules/J or kilojoules/kJ</p>		2	A
c	<p><b>Feature of Dewar flask and named type of heat transfer [2 max] correctly linked scientific explanation [2 max]</b></p> <ul style="list-style-type: none"> <li>silvered surface reflects (infra red) <u>radiation</u></li> <li>so the sun's rays are reflected away from the ice</li> <li>vacuum prevents <u>conduction</u></li> <li>because conduction needs a medium and there is no medium for heat / (thermal) energy to transfer (from the surroundings) to the ice</li> <li>insulated support prevents <u>conduction</u></li> <li>heat / (thermal) energy cannot transfer through insulating materials and (so) cannot transfer (from the surroundings) to the ice</li> </ul>	<p>Do <b>not</b> accept reference to the stopper <i>Accept references to moving particles</i></p>	4	A

2	a	 <p>All correct</p>	Accept overlapping protons and neutrons	1	A
	b	Electrostatic force		1	A
	c	Positives and negative charges <u>attract</u> <b>or</b> there is an <u>attractive</u> force  (So) the ink sticks <b>or</b> is attracted to the paper to create the copy	<i>Ignore references to magnetism</i>	2	A
	d	 <p>single arrow pointing up at 90° to the photosensitive surface single arrow pointing down at 90° to the photosensitive surface labels: electrostatic (<u>force</u>) <b>or</b> gravitational force</p>	<i>Ignore relative size of arrows</i>  <i>Arrows must touch or be very close to touching the surface of the particle (judge by eye)</i>	3	A
	e	Force <b>or</b> attraction increases as the distance between charges <b>or</b> the oppositely charged surfaces decreases  Distance needs to be small so the electric force can be greater than any opposing <b>or</b> downward force or weight  Ink will then stick to the paper	<i>Additional arrows are CON</i>  <i>Award separately</i>  <i>Accept weight or gravity</i>	3	A

3	a	<p>Draggable:</p> <p>Two correct – one mark</p> <p>All three correct – two marks</p>		2	A
	b	<p>Distance <b>or</b> mass</p>		1	A
	c	<p>One arrow pointing towards the Sun</p> <p>Both arrows point in the direction of the Sun</p> <p>Arrow at A shorter than arrow at B</p>	<p>Judge by eye</p>	3	A
	d	<p>evidence of use of the correct equation</p> <p>562 000 000 (kg) <b>or</b> <math>5.62 \times 10^8</math> (kg)</p>	<p>Seen or implied</p> <p>Award two marks for the correct answer.</p>	2	A
	e	<p>Selection of correct equation</p> <p>56 200 000 (N) <b>or</b> <math>5.62 \times 10^7</math> (N)</p>	<p>Seen or implied</p> <p>ECF from part d</p>	2	A

4	a	100 $\text{kmh}^{-1}$	Accept $\text{km/h}$ . Do <b>not</b> accept $\text{kmh}^{-1}$ or unit written out as words	2	C
	b	Only weight identified as the IV  Only air speed identified as the DV  Only CSA <b>and</b> shape identified as the CV		3	B
	c	As the weight increases, the air speed needed increases  Reference to air speed <sup>2</sup>  <b>Correct scientific information, for example [1 max]:</b> <ul style="list-style-type: none"> <li>reference to Newton's first law</li> <li>description of forces in equilibrium (weight and drag)</li> </ul>	Accept reference to gravitational force, do <b>not</b> accept gravity	3	B
	d	All balls have the same CSA  Balls with weight 1.20 N and 0.40 N are chosen  Only 5 balls chosen	No ECF from part b  Award the third mark only if the first two marks are awarded	3	B
	e	<b>Any two points from the following list [2 max]:</b> <ul style="list-style-type: none"> <li>greatest possible range</li> <li>this will generate sufficient data</li> <li>control variables held constant</li> </ul>		2	B
	f	Number of trials between 3 and 5  <b>Any reasonable justification, for example [1 max]:</b> <ul style="list-style-type: none"> <li>it is difficult to spot outliers for fewer than three trials</li> <li>you can be sure you have reliable data</li> <li>you can calculate the mean/average</li> </ul>	Do <b>not</b> accept references to accuracy	2	B

<b>5</b>	<b>a</b>	How does the CSA affect the air speed needed for it to float?	<i>WTTE</i>	<b>1</b>	B
	<b>b</b>	38 cm <sup>2</sup>		<b>1</b>	D
	<b>c</b>	<b>Column title:</b> CSA <b>and</b> unit  <b>Column title:</b> speed <b>and</b> unit  Units in column header only  All data recorded <b>and</b> arranged in order	<i>Accept area for CSA</i>  <i>Accept table arranged in columns or rows</i>  <i>Accept ecf from part b</i>  <i>Accept either ascending or descending</i>	<b>4</b>	C
	<b>d</b>	Graph C  Allows for a straight line to be drawn  Arranges IV and DV so that relationship can be determined		<b>3</b>	C
	<b>e</b>	(If hypothesis supported) a graph of $1/v^2 \sim$ CSA would be a straight line (going through the origin)  Graph C shows this trend  (Therefore) the hypothesis is supported  <b>or</b>  (If hypothesis supported) two sets of data would show same constant  Data used to demonstrate this  (Therefore) the hypothesis is supported	<i>Award one mark only if candidate has stated there is an (inverse) relationship</i>  <i>Do not award the third mark unless either of the first two marks are awarded</i>  <i>Seen or implied</i>  <i>Do not award the third mark unless either of the first two marks are awarded</i>	<b>3</b>	C
	<b>f</b>	Repeats measurements <b>or</b> increases the number of trials  Reduces the effect of (random) errors <b>or</b> increases reliability		<b>2</b>	C

6	a	Scatter / line graph  Graph of weight against volume (of boat) below the water  x-axis: weight of boat <b>and</b> y-axis: volume of boat below the water	<i>Accept displaced.</i>	3	C
	b	<u>Straight</u> line through the points  Line goes through the origin		2	C
	c	<b>Any reasonable improvement, for example: [2 max]</b> <ul style="list-style-type: none"><li>• greater range</li><li>• more trials</li><li>• regular increment</li></ul> <b>Correctly linked effect, for example: [2 max]</b> <ul style="list-style-type: none"><li>• gives more evidence for a proportional relationship over a greater range</li><li>• reduces experimental uncertainty</li><li>• better evidence for an observed trend</li></ul>		4	C

		1 mark	2 marks	3 marks	
d	1. RQ  (Research question)	Research question links IV and DV	Research question links IV and DV and refers to a control variable		11      B
	2.E  (Equipment)	Specific equipment for measuring mass of boat/cup eg top pan balance	Specific equipment for measuring mass of boat/cup eg top pan balance, <b>and</b> equipment to monitor at least one control variable		
	3. V  (IV and DV)	IV identified as mass of salt (weight or density accepted) <b>or</b> DV identified as mass (weight) of boat/cup	IV identified as mass of salt (weight or density accepted) <b>and</b> DV identified as mass (weight) of boat/cup		
	4. M  (Method)	Attempt at a method but detail is insufficient to follow	Method described and could easily be followed by another student including reference to control of the control of displacement (eg measured line on the boat/cup)		
	5. D  (Data)	Method implies a range of values of the IV (eg. mass of salt added)	Method implies a range of values of the IV (eg. mass of salt added) with at least 3 trials/repeats	Method implies a range of values of the IV (eg. mass of salt added) with 3 trials/repeats <b>and</b> plans to calculate average (mean)	

7	a	Long enough half-life to record images  Short enough to prevent long term exposure		2	D	
	b	<b>Any two reasonable advantages, for example [2 max]:</b> <ul style="list-style-type: none"> <li>gamma rays are not blocked by bone or skin</li> <li>they do not damage cells (by ionisation)</li> <li>they can be detected by a gamma camera</li> </ul>	<i>Do not accept references to half-life.</i>	2	D	
c	1 mark	2 marks	3 marks	4 marks	9	D
	1. A  <b>(Advantages)</b>	A statement of an advantage  A statement of two or more advantages <b>or</b> A statement of one advantages with an explanation	A statement of two or more advantages with at least one explained	A statement of two or more advantages with at least one explained <b>and</b> linked to the specific country		
	2. D  <b>(Disadvantages)</b>	A statement of a disadvantage  A statement of two or more disadvantages <b>or</b> A statement of one disadvantage with an explanation	A statement of two or more disadvantages with at least one explained	A statement of two or more disadvantages with at least one explained <b>and</b> linked to the specific country		
3. C  <b>(Conclusion)</b>		A simple conclusion				

8		1 mark	2 marks	3 marks	4 marks	11	D
		1. Ad/Dis <b>(Advantages and disadvantages)</b>	States either an advantage <b>or</b> disadvantage	An advantage <b>and</b> disadvantage	An advantage <b>and</b> disadvantage <b>one</b> of which is supported with scientific understanding		
		2. P <b>(Political implications)</b>	General reference to a factor relating to government or public affairs	Specific reference to a factor relating to government or public affairs with an example (eg public safety)	More than one specific reference to a governmental responsibility each with an example		
		3. E <b>(Environmental implications)</b>	General reference to an environmental implication	A specific environmental implication with an example			
		4. A <b>(Appraisal)</b>	A simple conclusion	A concluding appraisal with reference to issues raised			

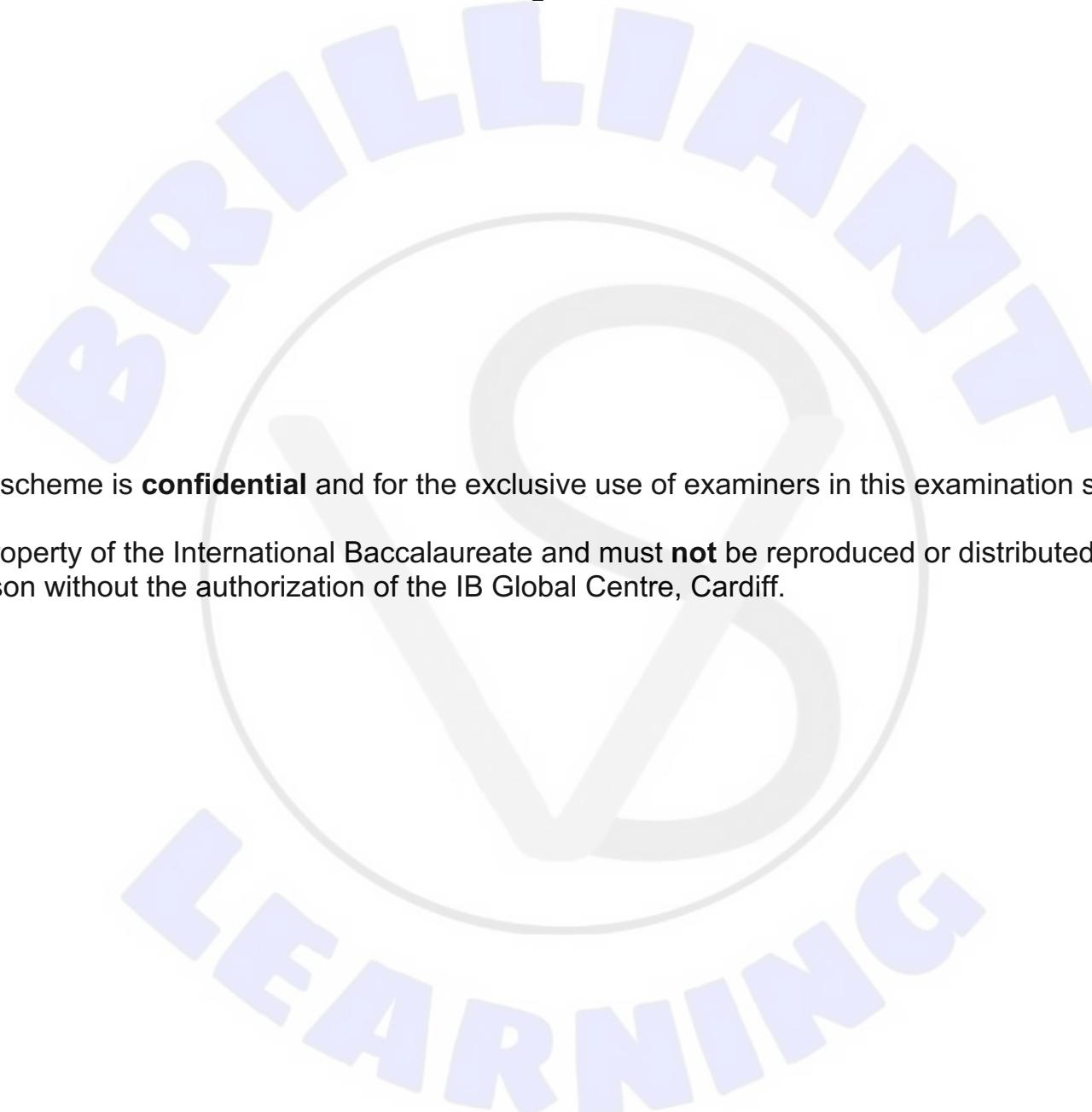
# Markscheme

November 2020

Physics

On-screen examination

12 pages



This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

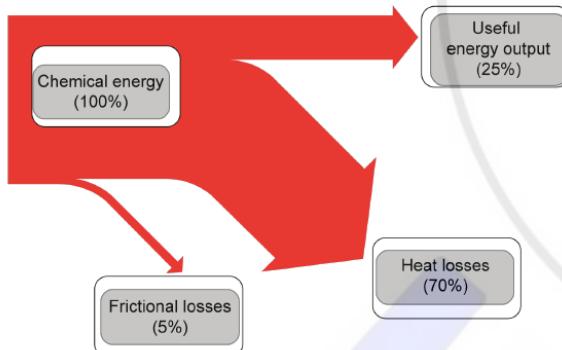
Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Horizontal wavy line that can be expanded
	Highlight tool that can be expanded to mark an area of a response

Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Test box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

### Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (or reverse argument) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (words to that effect) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add *ECF* (error carried forward) to the candidate response.

- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate's work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

Question		Answers	Notes	Total	Crit
1	a	C		1	A
	b	hollow fibres help to trap air air is a poor conductor / good insulator <b>or</b> heat cannot be lost through convection	WTTE	2	A
	c	white fur <b>and</b> reduces (heat lost through infra-red) radiation large <u>surface area</u> <b>and</b> increases (heat lost through) conduction <b>or</b> convection <b>or</b> radiation		2	A
	d	Heat is required for evaporation or evaporation removes heat high energy particles (in the liquid) escape the surface leaving lower <u>energy</u> particles behind	Accept fast moving for high energy	3	A
2	a	 <p>two correct all correct</p>		2	A

	b	gain in height = 1440(m)  gain in energy = mgh  $(= 880 \times 10 \times 1440) = 12\ 672\ 000\ (\text{J})\ \text{or}\ 12.672\ (\text{MJ})$  <b>J or MJ or joule or mega joule</b>	<i>Seen or implied, ECF</i>  <i>Accept any correctly rounded value</i>  <i>Accept Nm</i> <i>Do not accept j, unit must match number given</i>	4	A  D												
	c	power = energy / time taken  <b>16117 or 0.016117 or 16.117</b>  <b>W / Js<sup>-1</sup> or MW or kW</b>	<i>Seen or implied</i>  <i>Accept correctly rounded values to 2 or 3 sig figs</i>  <i>Unit to be consistent with value in second marking point. Do not accept MJ s<sup>-1</sup> or kJ s<sup>-1</sup></i>	3	A												
3	a	<table border="1"><thead><tr><th colspan="2">Table Object</th></tr><tr><th>Object</th><th>Emits or reflects light</th></tr></thead><tbody><tr><td>Star</td><td>Emits</td></tr><tr><td>Moon</td><td>Reflects</td></tr><tr><td>Planet</td><td>Reflects</td></tr><tr><td>Satellite</td><td>Reflects</td></tr></tbody></table> three correct – one mark  all four correct - two marks	Table Object		Object	Emits or reflects light	Star	Emits	Moon	Reflects	Planet	Reflects	Satellite	Reflects		2	A
Table Object																	
Object	Emits or reflects light																
Star	Emits																
Moon	Reflects																
Planet	Reflects																
Satellite	Reflects																
b	orbital period of 1 day / 24 hours	WTTE	1	A													
c	weather forecasting <b>or</b> communications <b>or</b> television relay <b>or</b> navigation <b>or</b> GPS	WTTE  <i>Accept military intelligence</i> <i>Do not accept reference to mobile phone use as this is given in the question</i>	1	A													
d	conversion of km to m  0.24  s	<i>Seen or implied</i>  <i>Award two marks max for 0.12s</i>	3	A													

	e	in the past galaxies would be closer together which is evidence for the big bang model <b>or</b> a description of the big bang model	WTTE	2	A																												
4	a	How does the current flowing through the coil affect the strength of the electromagnet / magnetic field?	WTTE	1	B																												
	b	<p><b>Table Object</b></p> <table border="1"> <thead> <tr> <th>Quantity</th> <th>Independent</th> <th>Dependent</th> <th>Control</th> </tr> </thead> <tbody> <tr> <td>Current</td> <td><input checked="" type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td>Diameter of the iron rod</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>Number of turns</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>Total length taken up by the turns</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>Total weight of paper clips supported by the electromagnet</td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td>Size of the paper clips</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> </tbody> </table> <p><b>Independent:</b> only current chosen</p> <p><b>Dependent:</b> only total weight of paperclips chosen</p> <p><b>Control variables:</b> two control variables correct</p> <p>all control variables correct</p>	Quantity	Independent	Dependent	Control	Current	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Diameter of the iron rod	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Number of turns	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Total length taken up by the turns	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Total weight of paper clips supported by the electromagnet	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Size of the paper clips	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>		4	B
Quantity	Independent	Dependent	Control																														
Current	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																														
Diameter of the iron rod	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																														
Number of turns	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																														
Total length taken up by the turns	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																														
Total weight of paper clips supported by the electromagnet	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>																														
Size of the paper clips	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																														
	c	<p><b>If:</b> the current increases</p> <p><b>Then:</b> the weight of the papers clips supported will increase <b>or</b> the strength of the electromagnet will increase</p> <p><b>Because:</b> the electromagnetic field is stronger</p>	<p><i>Do not award the second mark and third marks unless the first is given</i></p>	3	B																												
	d	<p>D to measure size of the current</p> <p><b>or</b></p> <p>B to weigh (the total mass of) the paper clips</p>		2	B																												
	e	B greatest range		2	B																												

5	a	<p><b>Table Object</b></p> <table border="1"> <thead> <tr> <th>Length of coil/ cm</th><th>Number of paperclips picked up</th></tr> </thead> <tbody> <tr><td>1.0</td><td>6</td></tr> <tr><td>2.0</td><td>3</td></tr> <tr><td>3.0</td><td>2</td></tr> <tr><td>4.0</td><td>1</td></tr> <tr><td>5.0</td><td>1</td></tr> <tr><td>6.0</td><td>1</td></tr> </tbody> </table> <p><b>Raw data table</b> header and units data recorded correctly data recorded in ascending <b>or</b> descending numerical order</p>	Length of coil/ cm	Number of paperclips picked up	1.0	6	2.0	3	3.0	2	4.0	1	5.0	1	6.0	1	<p>Accept weight of paperclips / g, turns <math>\text{cm}^{-1}</math></p> <p>Ignore additional information or processed</p>	3	C
Length of coil/ cm	Number of paperclips picked up																		
1.0	6																		
2.0	3																		
3.0	2																		
4.0	1																		
5.0	1																		
6.0	1																		
b	<p><b>Table Object</b></p> <table border="1"> <thead> <tr> <th>Turns per centimetre/ <math>\text{cm}^{-1}</math></th> <th>Weight of paperclips picked up/N</th> </tr> </thead> <tbody> <tr><td>6.0</td><td>1.2</td></tr> <tr><td>3.0</td><td>0.6</td></tr> <tr><td>2.0</td><td>0.4</td></tr> <tr><td>1.5</td><td>0.2</td></tr> <tr><td>1.2</td><td>0.2</td></tr> <tr><td>1.0</td><td>0.2</td></tr> </tbody> </table> <p><b>Processed data table</b> Terms per centimetre (no units needed) <b>and</b> weight / N correct number of turns per centimetre recorded for all data correct total weight of paper clips recorded for all data complete set of data <b>and</b> all data recorded to 1 dp</p>	Turns per centimetre/ $\text{cm}^{-1}$	Weight of paperclips picked up/N	6.0	1.2	3.0	0.6	2.0	0.4	1.5	0.2	1.2	0.2	1.0	0.2	<p>unit needed for weight</p> <p><i>Do not accept spacing</i></p>	4	C	
Turns per centimetre/ $\text{cm}^{-1}$	Weight of paperclips picked up/N																		
6.0	1.2																		
3.0	0.6																		
2.0	0.4																		
1.5	0.2																		
1.2	0.2																		
1.0	0.2																		
	c	this would lead to more accurate data (because) small pins produce a more precise measure of weight supported		2	C														
	d	Graph has straight line (which goes) through the origin (indicating that) the relationship is proportional		4	C														

		<p><b>Any reasonable further point, for example [max 1]</b></p> <ul style="list-style-type: none"> <li>• (if) current is a control variable</li> <li>• equation suggests that relationship between magnetic force and turns per centimetre is directly proportional</li> <li>• each increase of 1 turn <math>\text{cm}^{-1}</math> allows an additional 0.25(N) to be supported</li> </ul>																										
	e	<p><b>shape:</b> (the line of would be straight and so) no change</p> <p><b>gradient:</b> would be different (as it represents a different quantity)</p>	Accept gradient would be constant	2 C																								
6	a	<table border="1"> <thead> <tr> <th></th> <th>Diameter / mm</th> <th><math>\frac{1}{\text{diameter}} / \text{mm}^{-1}</math></th> <th>Height of water / mm</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>0.8</td> <td>1.25</td> <td>37.0</td> </tr> <tr> <td>B</td> <td>1.6</td> <td>0.63</td> <td>19.0</td> </tr> <tr> <td>C</td> <td>2.5</td> <td>0.40</td> <td>12.0</td> </tr> <tr> <td>D</td> <td>3.2</td> <td>0.31</td> <td>9.0</td> </tr> <tr> <td>E</td> <td>4.0</td> <td>0.25</td> <td>7.0</td> </tr> </tbody> </table> <p>Height = <math>12 \pm 0.5</math> <b>and</b> diameter = <math>2.5 \pm 0.5</math></p> <p>0.4 accept value in range 0.3-0.5</p>		Diameter / mm	$\frac{1}{\text{diameter}} / \text{mm}^{-1}$	Height of water / mm	A	0.8	1.25	37.0	B	1.6	0.63	19.0	C	2.5	0.40	12.0	D	3.2	0.31	9.0	E	4.0	0.25	7.0	<p>Ignore sig fig errors</p> <p>ECF</p>	2 C
	Diameter / mm	$\frac{1}{\text{diameter}} / \text{mm}^{-1}$	Height of water / mm																									
A	0.8	1.25	37.0																									
B	1.6	0.63	19.0																									
C	2.5	0.40	12.0																									
D	3.2	0.31	9.0																									
E	4.0	0.25	7.0																									
	b	<p>point plotted</p> <p>line of best fit added</p> <p>x- axis: inverse / 1 / diameter <b>and</b> y-axis: height (of liquid)</p> <p><b>Units:</b> <math>\text{mm}^{-1}</math> <b>and</b> mm</p>	<p>ECF from part a</p> <p>Approximately equal distribution of points above and below the line</p> <p>Do not award a mark for diameter alone</p>	4 C																								
	c	<p>two points from line of best fit <math>\Delta y \geq 20</math></p> <p>evidence of gradient calculation</p> <p>final value = <math>30 \pm 5</math></p>	Ignore any unit if present	3 C																								

	<b>d</b>	height is inversely proportional to diameter  (so) for a tree of this height, the diameter of the capillary tubes (inside the tree) would have to be extremely small (for capillary action alone)		<b>2</b>	<b>A</b>																													
<b>7</b>		<table border="1"> <thead> <tr> <th></th><th><b>1</b></th><th><b>2</b></th><th><b>3</b></th><th><b>4</b></th></tr> </thead> <tbody> <tr> <td><b>Research question (RQ)</b></td><td>simple research question</td><td></td><td></td><td></td></tr> <tr> <td><b>Variables (V)</b></td><td>some variables implied</td><td>IV <b>or</b> DV <b>and</b> one CV identified</td><td>IV <b>and</b> DV <b>and</b> one CV identified</td><td></td></tr> <tr> <td><b>Equipment (E)</b></td><td>equipment suggested but not relevant</td><td>equipment to measure IV <b>or</b> DV</td><td>equipment to measure IV <b>and</b> DV</td><td></td></tr> <tr> <td><b>Method (M)</b></td><td>attempt at method, insufficient detail and not likely to give relevant data</td><td>method described, could be followed, will produce relevant data</td><td></td><td></td></tr> <tr> <td><b>Data (D)</b></td><td>refer to different increments or trials</td><td>at least five increments <b>or</b> three trials</td><td>at least five increments <b>and</b> three trials</td><td>at least five increments, three trials and plans to calculate mean</td></tr> </tbody> </table>		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>Research question (RQ)</b>	simple research question				<b>Variables (V)</b>	some variables implied	IV <b>or</b> DV <b>and</b> one CV identified	IV <b>and</b> DV <b>and</b> one CV identified		<b>Equipment (E)</b>	equipment suggested but not relevant	equipment to measure IV <b>or</b> DV	equipment to measure IV <b>and</b> DV		<b>Method (M)</b>	attempt at method, insufficient detail and not likely to give relevant data	method described, could be followed, will produce relevant data			<b>Data (D)</b>	refer to different increments or trials	at least five increments <b>or</b> three trials	at least five increments <b>and</b> three trials	at least five increments, three trials and plans to calculate mean	<b>13</b>	<b>B</b>
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>																														
<b>Research question (RQ)</b>	simple research question																																	
<b>Variables (V)</b>	some variables implied	IV <b>or</b> DV <b>and</b> one CV identified	IV <b>and</b> DV <b>and</b> one CV identified																															
<b>Equipment (E)</b>	equipment suggested but not relevant	equipment to measure IV <b>or</b> DV	equipment to measure IV <b>and</b> DV																															
<b>Method (M)</b>	attempt at method, insufficient detail and not likely to give relevant data	method described, could be followed, will produce relevant data																																
<b>Data (D)</b>	refer to different increments or trials	at least five increments <b>or</b> three trials	at least five increments <b>and</b> three trials	at least five increments, three trials and plans to calculate mean																														
<b>8</b>	<b>a</b>	iron		<b>1</b>	<b>A</b>																													
	<b>b</b>	<p><b>Key:</b></p> <table style="margin-left: 20px;"> <tr> <td><span style="background-color: blue; width: 15px; height: 15px; display: inline-block;"></span></td> <td>Levitation</td> </tr> <tr> <td><span style="background-color: green; width: 15px; height: 15px; display: inline-block;"></span></td> <td>Guidance</td> </tr> <tr> <td><span style="background-color: red; width: 15px; height: 15px; display: inline-block;"></span></td> <td>Propulsion</td> </tr> </table> <p>one correct</p> <p>all three correct</p>	<span style="background-color: blue; width: 15px; height: 15px; display: inline-block;"></span>	Levitation	<span style="background-color: green; width: 15px; height: 15px; display: inline-block;"></span>	Guidance	<span style="background-color: red; width: 15px; height: 15px; display: inline-block;"></span>	Propulsion	<b>2</b>	<b>D</b>																								
<span style="background-color: blue; width: 15px; height: 15px; display: inline-block;"></span>	Levitation																																	
<span style="background-color: green; width: 15px; height: 15px; display: inline-block;"></span>	Guidance																																	
<span style="background-color: red; width: 15px; height: 15px; display: inline-block;"></span>	Propulsion																																	
	<b>c</b>	<p><b>Accept any two reasonable points, for example [max 2]</b></p> <ul style="list-style-type: none"> <li>• less noise</li> <li>• less energy wasted</li> <li>• less wear and tear / maintenance for train or track</li> </ul>		<b>2</b>	<b>D</b>																													

		<ul style="list-style-type: none"> <li>• speed can be higher than conventional trains</li> <li>• less affected by weather</li> </ul>																															
d		<p>increase in number of passengers will increase weight <b>or</b> there will be an increased load this will decrease the distance between the magnets (hence) the size of the repelling force will increase</p>		3 D																													
9		<table border="1"> <thead> <tr> <th></th><th>1</th><th>2</th><th>3</th><th>4</th></tr> </thead> <tbody> <tr> <td>Economic advantages and disadvantages compared to driving</td><td>an economic advantage <b>or</b> disadvantage is implied</td><td>an economic advantage <b>or</b> disadvantage is compared to driving</td><td>an economic advantage <b>and</b> disadvantage are compared to driving</td><td>an economic advantage <b>and</b> disadvantage <b>and</b> an additional advantage or disadvantage are compared to driving</td></tr> <tr> <td>Environmental advantages and disadvantages</td><td>an environmental advantage <b>or</b> disadvantage is implied</td><td>an environmental advantage <b>or</b> disadvantage is compared to driving</td><td>an environmental advantage <b>and</b> disadvantage are compared to driving</td><td>an environmental advantage <b>and</b> disadvantage <b>and</b> an additional advantage or disadvantage are compared to driving</td></tr> <tr> <td>Comfort</td><td>a comfort advantage <b>or</b> disadvantage is implied</td><td>a comfort advantage <b>or</b> disadvantage is compared to driving</td><td>a comfort advantage <b>and</b> disadvantage are compared to driving</td><td></td></tr> <tr> <td>Safety</td><td>a simple statement about safety</td><td>a comparative statement about safety using data from the table</td><td></td><td></td></tr> <tr> <td>Concluding appraisal</td><td>a concluding statement</td><td>a concluding appraisal</td><td></td><td></td></tr> </tbody> </table>		1	2	3	4	Economic advantages and disadvantages compared to driving	an economic advantage <b>or</b> disadvantage is implied	an economic advantage <b>or</b> disadvantage is compared to driving	an economic advantage <b>and</b> disadvantage are compared to driving	an economic advantage <b>and</b> disadvantage <b>and</b> an additional advantage or disadvantage are compared to driving	Environmental advantages and disadvantages	an environmental advantage <b>or</b> disadvantage is implied	an environmental advantage <b>or</b> disadvantage is compared to driving	an environmental advantage <b>and</b> disadvantage are compared to driving	an environmental advantage <b>and</b> disadvantage <b>and</b> an additional advantage or disadvantage are compared to driving	Comfort	a comfort advantage <b>or</b> disadvantage is implied	a comfort advantage <b>or</b> disadvantage is compared to driving	a comfort advantage <b>and</b> disadvantage are compared to driving		Safety	a simple statement about safety	a comparative statement about safety using data from the table			Concluding appraisal	a concluding statement	a concluding appraisal			15 D
	1	2	3	4																													
Economic advantages and disadvantages compared to driving	an economic advantage <b>or</b> disadvantage is implied	an economic advantage <b>or</b> disadvantage is compared to driving	an economic advantage <b>and</b> disadvantage are compared to driving	an economic advantage <b>and</b> disadvantage <b>and</b> an additional advantage or disadvantage are compared to driving																													
Environmental advantages and disadvantages	an environmental advantage <b>or</b> disadvantage is implied	an environmental advantage <b>or</b> disadvantage is compared to driving	an environmental advantage <b>and</b> disadvantage are compared to driving	an environmental advantage <b>and</b> disadvantage <b>and</b> an additional advantage or disadvantage are compared to driving																													
Comfort	a comfort advantage <b>or</b> disadvantage is implied	a comfort advantage <b>or</b> disadvantage is compared to driving	a comfort advantage <b>and</b> disadvantage are compared to driving																														
Safety	a simple statement about safety	a comparative statement about safety using data from the table																															
Concluding appraisal	a concluding statement	a concluding appraisal																															

# Markscheme

November 2021

Physics

On-screen examination

14 pages

This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Horizontal wavy line that can be expanded
	Highlight tool that can be expanded to mark an area of a response

Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Test box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

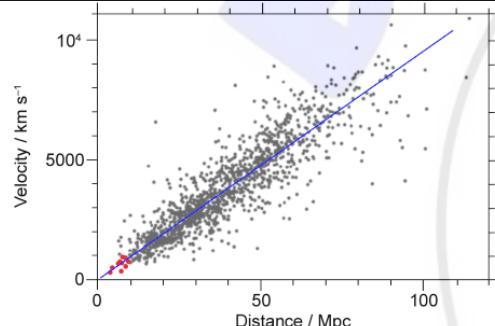
## Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation **ORA** (*or reverse argument*) in the Notes column. Candidates should not be rewarded for reverse arguments unless **ORA** is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation **WTTE** (*or words to that effect*) in the Notes column.

- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add ECF (error carried forward) to the candidate response.
- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate's work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

Question		Answers			Notes		Total	Crit								
1	a	Liquid ▾	Gas ▾	Solid ▾			1	A								
	b	<p>Table Object</p> <table border="1"> <thead> <tr> <th>Change of state</th> <th>Initial State</th> <th>Final State</th> </tr> </thead> <tbody> <tr> <td>Condensation</td> <td>Gas ▾</td> <td>Liquid ▾</td> </tr> <tr> <td>Vaporization</td> <td>Liquid ▾</td> <td>Gas ▾</td> </tr> </tbody> </table>	Change of state	Initial State	Final State	Condensation	Gas ▾	Liquid ▾	Vaporization	Liquid ▾	Gas ▾	All correct				1
Change of state	Initial State	Final State														
Condensation	Gas ▾	Liquid ▾														
Vaporization	Liquid ▾	Gas ▾														
c	<p>the particles have greater (kinetic) energy  <i>or</i>          particles move faster</p> <p>the number of collisions per second is increased  <i>or</i>          particles collide with greater force</p> <p>(resulting in) greater pressure</p>		WTTE		3	A										
d	<p>air particles are moving (but are too small to be seen)</p> <p>(that) collide with (larger) smoke particles (that can be seen)</p>		WTTE		2	A										

2	a	<table border="1"><tr><td><math>E</math></td><td>=</td><td><math>m</math></td><td><math>(c)^2</math></td></tr><tr><td>joule</td><td></td><td>kilogram</td><td>metre per second</td></tr></table>	$E$	=	$m$	$(c)^2$	joule		kilogram	metre per second		1	A
$E$	=	$m$	$(c)^2$										
joule		kilogram	metre per second										
b	Gravitational potential 80 J	<i>Award independently</i>	2	A									
c	$KE = \frac{1}{2}mv^2$  correct answer: 7.26636...  stated to 2 sig figs: 7.3 ( $ms^{-1}$ )	<i>Seen or implied</i>  <i>Award 3 marks for correct final answer</i>	3	D									
d	substitution into $E=mc^2$  $1.6398 \times 10^{-13}$ (J)	<i>Ignore incorrect substitution of one mass only (<math>9.11 \times 10^{-31}</math>) for first mark</i>  <i>Award 1 mark for <math>8.199 \times 10^{-14}</math> (J)</i>	2	A									

3	a	Light is an example of a transverse electromagnetic wave.		1	A
	b	B the wavelength is stretched by the source moving away <b>or</b> the wavelength is increased as the source moves away	WTTE Do <b>not</b> award second mark if incorrect wave is selected Accept correct reference to frequency	2	A
	c	wavelength emitted from stars has increased (so) the stars appear more red (if they are moving away)		2	A
	d	 line passes through the origin line passes approximately through the centre of the data points	judge by eye	2	C
	e	As the distance (away from the Earth) increases, the velocity increases (there is a) proportional (relationship)		2	A
	f	suggests that there is an origin <b>or</b> everything was in the same place before (as) objects are moving away from each other <b>or</b> the universe is expanding		2	A
	g	the estimate is based on more data <b>or</b> the data we have is more reliable	WTTE	1	A

4	a	<p> Table Object</p> <table border="1"> <thead> <tr> <th>Voltage/V</th><th>Current/A</th></tr> </thead> <tbody> <tr> <td>1.0</td><td>0.20</td></tr> <tr> <td>2.0</td><td>0.41</td></tr> <tr> <td>3.0</td><td>0.60</td></tr> <tr> <td>4.2</td><td>0.81</td></tr> <tr> <td>5.1</td><td>1.01</td></tr> </tbody> </table> <p>column headings voltage <b>and</b> current  units of V <b>and</b> A in headers only  all data complete and arranged in order of voltage <b>or</b> current  all current readings rounded to 2d.p.  correct conversion of 601 (mA) to 0.60(1) (A)  <u>0.41</u> (A)</p>	Voltage/V	Current/A	1.0	0.20	2.0	0.41	3.0	0.60	4.2	0.81	5.1	1.01	<p><i>Accept data arranged in rows or columns</i></p> <p><i>Accept ascending or descending</i></p> <p><i>Ignore 601 mA for this marking point</i></p> <p><i>Value must be quoted to 2 dp</i></p>	6	C
Voltage/V	Current/A																
1.0	0.20																
2.0	0.41																
3.0	0.60																
4.2	0.81																
5.1	1.01																

<b>b</b>	doubling of voltage (approximately) doubles current <b>or</b> doubling of voltage does not exactly double current  calculation of constant of proportionality, for at least two values <b>or</b> calculation of predicted current when voltage is doubled  (so therefore) hypothesis is supported (within range of experimental precision) <b>or</b> hypothesis is rejected with correct reference to calculation	<i>Do not award third mark unless first or second mark is awarded.</i>	<b>3</b>	C
<b>c</b>	graph is not straight <b>or</b> gradient is not constant  (so) it is a non-ohmic conductor	<i>Do not award second mark unless first is awarded</i>	<b>2</b>	C
<b>d</b>	easier to evaluate the visual representation of the relationship presented in a graph	WTTE	<b>1</b>	C
<b>e</b>	5.0 ( $\Omega$ )  15 ( $\Omega$ )  $\Omega$ <b>or</b> ohm(s)	<i>Unit must be visible in one answer</i>	<b>3</b>	C D
<b>f</b>	<input type="button" value="C"/>		<b>1</b>	B

<b>5</b>	<b>a</b>	$\frac{\rho}{A}$		<b>1</b>	C
	<b>b</b>	evidence of gradient calculation  answer in the range 0.043 to 0.047  $\Omega \text{ m}^{-1}$	<i>Award 2 marks for correct value alone</i>  <i>Award unit mark separately. Accept <math>\Omega/\text{m}</math>. Do not accept caret for exponent</i>	<b>3</b>	C
	<b>c</b>	length of zero should have a resistance of zero  (and) graph doesn't intercept origin		<b>2</b>	C
	<b>d</b>	all values shifted by the same amount  because the errors cancel out in gradient calculation  (so therefore) statement is invalid	<i>award one mark for saying gradient calculation is not accurate because data are not accurate</i>	<b>3</b>	C
	<b>e</b>	<b>Accept any reasonable response, for example [max 1]</b> <ul style="list-style-type: none"><li>• zero error</li><li>• calibration error</li><li>• additional resistance from other components in the circuit</li></ul>		<b>1</b>	C
	<b>f</b>	if the area of the wire increases, the resistance would decrease  relationship is inversely proportional  <u>electrons</u> are moving  fewer pathways if the area is smaller	ORA  ORA, WTTE	<b>4</b>	B

6	a	two bulbs in series  ammeter connected to measure current through bulbs  correct circuit with no additional components in series with the bulbs	<i>Ignore switch or voltmeter added in parallel</i>	3	B
b		<b>1 mark</b>	<b>2 marks</b>	<b>3 marks</b>	15
		Research question links IV and DV			
		Hypothesis  A simple prediction that is incomplete or incorrect	Predicts that the current will decrease as the number of bulbs in series increases	Predicts that the current will decrease as the number of bulbs in series increases because resistance increases	
		IV and DV  Independent variable identified number of bulbs <b>or</b> dependent variable identified as current	Independent variable identified as number of bulbs <b>and</b> dependent variable identified as current		
		CV  supply voltage is the same	supply voltage is the same as increased supply voltage would increase the current flow		
		Data  Method implies a range of values	Method includes at least 5 values of IV		
		Method  Attempt at a method but detail is insufficient to follow	Method described and could easily be followed by another student		
c		<b>Accept any reasonable additional IV, for example [max 1]</b> <ul style="list-style-type: none"><li>• bulbs in parallel</li><li>• material of wires</li><li>• colour / type of light bulb</li><li>• different supply voltage</li></ul>	<i>Do not accept length of wire, cross-sectional area of wire, resistors</i>	1	C
		any reasonable research question linked to IV in part c and current		1	B

7	<b>a</b>	<b>Wood burning biomass</b>	<b>Geothermal power</b>	<b>Tidal power</b>		<b>3</b>	<b>D</b>								
		<b>Disadvantage</b> Needs a large amount of space for fuel production. There is also a time delay between planning the power plant and production beginning.	<b>Disadvantage</b> Needs to be built in geologically suitable areas and the start-up costs are high.	<b>Disadvantage</b> Needs to be built in coastal areas on land and may disrupt the ecosystem.											
		one disadvantage correct	two disadvantages correct	all disadvantages correct											
	<b>b</b>	Chemical potential → Thermal → Kinetic → Electrical	correct energy forms selected in the correct order	<i>Ignore order for this first mark</i>		<b>2</b>	<b>D</b>								
	<b>c</b>	<table border="1"> <thead> <tr> <th></th> <th><b>1 mark</b></th> <th><b>2 marks</b></th> </tr> </thead> <tbody> <tr> <td><b>Advantages</b></td><td>A statement of an advantage implicitly linked to a country</td><td>A statement of an advantage implicitly linked to a country with explanation</td></tr> <tr> <td><b>Disadvantages</b></td><td>A statement of a disadvantage implicitly linked to a country</td><td>A statement of two or more disadvantages implicitly linked to a country with explanation for each</td></tr> </tbody> </table>		<b>1 mark</b>	<b>2 marks</b>	<b>Advantages</b>	A statement of an advantage implicitly linked to a country	A statement of an advantage implicitly linked to a country with explanation	<b>Disadvantages</b>	A statement of a disadvantage implicitly linked to a country	A statement of two or more disadvantages implicitly linked to a country with explanation for each			<b>4</b>	<b>D</b>
	<b>1 mark</b>	<b>2 marks</b>													
<b>Advantages</b>	A statement of an advantage implicitly linked to a country	A statement of an advantage implicitly linked to a country with explanation													
<b>Disadvantages</b>	A statement of a disadvantage implicitly linked to a country	A statement of two or more disadvantages implicitly linked to a country with explanation for each													

<b>8</b>	<b>a</b>	Nuclear power plant uranium <b>or</b> nuclear fuel is a finite resource				<b>WTTE</b>	<b>2</b>	<b>D</b>
	<b>b</b>		<b>1 mark</b>	<b>2 marks</b>	<b>3 marks</b>	<b>4 marks</b>		
	<b>Advantages of their method over oil</b>	A statement of an advantage	A statement of two advantages <b>or</b> A statement of an advantage with justification	A statement of two advantages, one of which with justification			<b>12</b>	<b>D</b>
	<b>Political implications</b>	A statement of a political implication	A statement of a political implication with further explanation <b>or</b> Statement of two political implications	Statement of two political implications both with further explanation				
	<b>Economic implications</b>	General reference to an economic implication for their option	An economic implication supported with general reference to data for their option	An economic implication supported with specific data quoted for their option compared with both of the other options	A comparative reference to two economic implications supported with data including evidence of data processing			
	<b>Appraisal</b>	A simple conclusion	A concluding appraisal with reference to issues raised					

# Markscheme

May 2021

Physics

On-screen examination

15 pages

This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Horizontal wavy line that can be expanded
	Highlight tool that can be expanded to mark an area of a response

Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Text box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

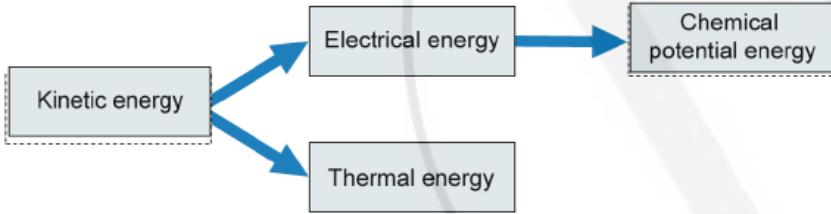
### Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation **ORA** (or reverse argument) in the Notes column. Candidates should not be rewarded for reverse arguments unless **ORA** is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation **WTTE** (words to that effect) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add **ECF** (error carried forward) to the candidate response.

- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate's work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

Question	Answers	Notes	Total	Criterion
1	a  Radio waves travel at the same speed as light waves in a vacuum.  Radio waves have a longer wavelength than light waves.		2	A
	b Diffraction		1	A
	c Evidence of conversion of km to m  Correct answer (0.00002)  Expressed in standard form $2 \times 10^{-5}$ (s)	<i>Seen or implied</i>  <i>Award if an incorrect answer is expressed in standard form.</i>  <i>Award 3 marks if <math>2 \times 10^{-5}</math> alone is seen</i>	3	A
	d <b>Accept any reasonable suggestion [max 2]</b> <ul style="list-style-type: none"> <li>• Able to communicate while moving (e.g. boats)</li> <li>• Communication over larger distances <b>or</b> with other countries <b>or</b> to previously inaccessible locations</li> <li>• High speed communication is possible</li> <li>• No failures of wired connections <b>or</b> saves material <b>or</b> money required for wired connections</li> <li>• Led to the development of (named) new technology</li> </ul>	<i>Do not accept messages can be sent without the need for wires</i>  <i>Each named piece of technology can be awarded 1 mark</i>	2	D

2	a	29 is the <input type="text"/> number of protons <input type="button" value="▼"/> in the nucleus 63 is the <input type="text"/> total number of protons and neutrons <input type="button" value="▼"/> in the nucleus		2	A
	b	<input type="text"/> C <input type="button" value="▼"/> Correct image selected Beta (particles) are electrons <b>or</b> beta (particles) are negatively charged (so they are) deviated toward the positive plate in an electric field	<i>Only consider the justification if C is selected</i>	3	A
	c	Evidence of use of half-life <b>or</b> beginning mass of the sample is 100 g, half of it is 50 g $60 \pm 2$ (h)	<i>Award 2 marks for correct answer with no working shown</i>	2	A
	d	Half-life (time period) is suitable to allow treatment <b>or</b> short enough to limit the long-term effects Beta or gamma radiation can kill cancer cells <b>or</b> tumours	<i>Ignore references to penetrating power</i>	2	A

3	a	Use of KE equation  468750(J)	<i>Seen or implied</i>  Accept any correctly rounded answer to two or more sig figs for 2 marks  Accept answers correctly stated in kJ	2	A
	b	Use of $v^2 = u^2 + 2as$  (-) 10.4166...  Rounded correctly to (-)10.4  $m\ s^{-2}$ or $m/s^2$	Accept loss in KE = work done by force  Award three marks if only 10.4 is seen  Award this unit mark separately. Superscripts must be used correctly. Do not accept $^2$ .	4	A
	c	Heat energy cannot be used (by the car) <b>or</b> cannot perform work	WTTE. Do not accept wasted / lost energy as this is given in the question	1	A
	d	  All correct for one mark		1	A
	e	<b>Accept any point from the list, [max 1]</b> <ul style="list-style-type: none"> <li>• energy (stored in the battery) can be transformed into kinetic energy</li> <li>• energy (stored in the battery) can be transformed into electrical energy to drive the car</li> </ul>	Do not accept the car's battery is recharged WTTE	1	A
	f	Burning fuel produces carbon dioxide/ CO <sub>2</sub>  Link to climate change <b>or</b> greenhouse effect	Do not accept unnamed greenhouse gas emissions or pollution  WTTE	2	D

4	a	How does the distance a ball roll affect the time taken?	WTTE	1	B																						
	b	<table border="1"> <thead> <tr> <th></th> <th>Independent variable</th> <th>Dependent variable</th> <th>Control variable</th> </tr> </thead> <tbody> <tr> <td>Mass of the ball</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>Time taken</td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td>Size of the ball</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>Distance travelled by the ball</td> <td><input checked="" type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td>Angle of the slope</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input checked="" type="checkbox"/></td> </tr> </tbody> </table> <p>IV – distance only DV – time only CV – mass, size, angle of slope only</p>		Independent variable	Dependent variable	Control variable	Mass of the ball	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Time taken	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Size of the ball	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Distance travelled by the ball	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Angle of the slope	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	3
	Independent variable	Dependent variable	Control variable																								
Mass of the ball	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																								
Time taken	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>																								
Size of the ball	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																								
Distance travelled by the ball	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																								
Angle of the slope	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>																								
c	<p>weight of the ball <b>or</b> gravitational force <b>or</b> gravity</p> <p>Use of Newton's Second Law or <math>F = ma</math> or Newton's First Law to correctly link force and acceleration</p>	No need to explain why the force is constant (and link this to the constant acceleration) for the second marking point	2	B																							
d	<p>B</p> <p><b>Any two from [max 2]</b></p> <ul style="list-style-type: none"> <li>• graph goes through the origin, or when <math>s = 0</math> then <math>t^2 = 0</math></li> <li>• relationship is proportional</li> <li>• gradient = <math>\frac{1}{2} a</math></li> </ul>	Only consider the justification if graph B is selected	3	B																							
e	<p>Unit = <math>s^2</math></p> <p>4.7961 <b>or</b> 4.8 <b>or</b> 4.796 <b>or</b> 5</p> <p>4.80</p>	<p>Do not accept <math>s^2</math>. Accept unit and value in table or response box.</p> <p>Seen or implied. Accept 4.79 for 1 mark for correct calculated value incorrectly rounded</p> <p>Award two marks for correctly rounded value to 2 dp only</p>	3	C																							

f	<p><b>Accept any reasonable response, for example [max 1]</b></p> <ul style="list-style-type: none"> <li>• not using common units</li> <li>• measurements with a device like this relies on another person having the same tool to compare with</li> <li>• all water clocks are different</li> <li>• comment relating to difficulty in getting the regular flow of water required <b>or</b> difficulty of construction</li> </ul>	<p><b>WTTE</b></p> <p><i>Do not accept that the water clock is not an accurate/reliable instrument for measuring time without further details</i></p>	1	C
g	Stopwatch <b>or</b> stopclock <b>or</b> chronometer <b>or</b> timer		1	C
h	<p>Any reasonable single IV selected</p> <p><b>Any two reasonable CV, for example [max 2]</b></p> <ul style="list-style-type: none"> <li>• mass of the ball</li> <li>• surface of the ramp</li> <li>• size of the ball</li> <li>• distance</li> <li>• angle of slope</li> </ul> <p>Any reasonable RQ linking IV and DV</p>	<p><i>Do not accept distance or non-specific "type" of ball for IV</i></p> <p><i>Do not accept temperature, gravity, pressure, same measuring equipment or IV given above for CV</i></p>	4	C

5	a	(If) The surface area increases <b>and</b> (then) the time taken to fall will increase  (because) air resistance will increase  (because) the parachute will have more collisions with air particles	WTTE Accept correct responses appearing in any box	3	B																													
	b	<table border="1"> <thead> <tr> <th></th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> </tr> </thead> <tbody> <tr> <td>V (Variables)</td> <td>time implied as dependent variable</td> <td>independent variable of surface area <b>and</b> dependent variable of time stated</td> <td>independent variable of surface area <b>and</b> dependent variable of time stated <b>and</b> two control variables stated</td> <td>independent variable of surface area and dependent variable of time stated <b>and</b> two control variables stated <b>and</b> with correct justification</td> </tr> <tr> <td>E (Equipment)</td> <td>equipment to measure time <b>or</b> length</td> <td>equipment to measure time <b>and</b> length</td> <td></td> <td></td> </tr> <tr> <td>M (Method)</td> <td>attempt at a method linked to surface area <b>or</b> time</td> <td>method is described with measurements of surface area <b>and</b> time but not detailed enough to be followed by another student</td> <td>complete method is described with measurements of surface area and time <b>and</b> could easily be followed by another student</td> <td></td> </tr> <tr> <td>D (Data)</td> <td>at least five increments <b>or</b> three trials</td> <td>at least five increments <b>and</b> three trials</td> <td>at least five increments <b>and</b> three trials <b>and</b> plans to calculate an average</td> <td></td> </tr> <tr> <td>S (Safety)</td> <td>mentions a relevant precaution for example when working at height, use of scissors for cutting materials or to make sure the drop area is clear</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>		1	2	3	4	V (Variables)	time implied as dependent variable	independent variable of surface area <b>and</b> dependent variable of time stated	independent variable of surface area <b>and</b> dependent variable of time stated <b>and</b> two control variables stated	independent variable of surface area and dependent variable of time stated <b>and</b> two control variables stated <b>and</b> with correct justification	E (Equipment)	equipment to measure time <b>or</b> length	equipment to measure time <b>and</b> length			M (Method)	attempt at a method linked to surface area <b>or</b> time	method is described with measurements of surface area <b>and</b> time but not detailed enough to be followed by another student	complete method is described with measurements of surface area and time <b>and</b> could easily be followed by another student		D (Data)	at least five increments <b>or</b> three trials	at least five increments <b>and</b> three trials	at least five increments <b>and</b> three trials <b>and</b> plans to calculate an average		S (Safety)	mentions a relevant precaution for example when working at height, use of scissors for cutting materials or to make sure the drop area is clear				13	B
	1	2	3	4																														
V (Variables)	time implied as dependent variable	independent variable of surface area <b>and</b> dependent variable of time stated	independent variable of surface area <b>and</b> dependent variable of time stated <b>and</b> two control variables stated	independent variable of surface area and dependent variable of time stated <b>and</b> two control variables stated <b>and</b> with correct justification																														
E (Equipment)	equipment to measure time <b>or</b> length	equipment to measure time <b>and</b> length																																
M (Method)	attempt at a method linked to surface area <b>or</b> time	method is described with measurements of surface area <b>and</b> time but not detailed enough to be followed by another student	complete method is described with measurements of surface area and time <b>and</b> could easily be followed by another student																															
D (Data)	at least five increments <b>or</b> three trials	at least five increments <b>and</b> three trials	at least five increments <b>and</b> three trials <b>and</b> plans to calculate an average																															
S (Safety)	mentions a relevant precaution for example when working at height, use of scissors for cutting materials or to make sure the drop area is clear																																	

6	a	<p>Correct reading from scale <math>42.8 \pm 0.1</math></p> <p><math>d_i = 12.8 \pm 0.1</math></p> <p>cm</p>	<p>Allow ECF if calculation <math>d_i = (\text{reading} - 30)</math> is evident</p> <p>Unit mark can be awarded independently if seen anywhere in the answer</p> <p>Award 3 marks for <math>12.8 \text{ cm}</math> with no working shown</p>	3	C											
	b	<p> Table Object</p> <table border="1"> <thead> <tr> <th>Distance from candle to lens / cm</th> <th>Distance from lens to screen / cm</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>90.1</td> </tr> <tr> <td>20</td> <td>16.4</td> </tr> <tr> <td>30</td> <td>12.8</td> </tr> <tr> <td>40</td> <td>11.6</td> </tr> <tr> <td>50</td> <td>11.1</td> </tr> </tbody> </table> <p>Column headings (using symbols or words) and units in header only</p> <p>All data in order and complete</p> <p><math>d_o</math> to one decimal place <b>or</b> nearest cm</p> <p>All <math>d_i</math> data expressed to consistent number of decimal places</p>	Distance from candle to lens / cm	Distance from lens to screen / cm	10	90.1	20	16.4	30	12.8	40	11.6	50	11.1	<p>Accept non-subscripts for <math>d_o</math> and <math>d_i</math></p> <p>Accept data in rows or columns</p> <p>ECF from part a</p>	4
Distance from candle to lens / cm	Distance from lens to screen / cm															
10	90.1															
20	16.4															
30	12.8															
40	11.6															
50	11.1															
c	<p><math>m</math></p> <p>5.87</p> <p>0.170</p>		3	C												
d	0.187		1	C												
e	<p>C</p> <p><b>A correct justification, for example [max 1]</b></p> <ul style="list-style-type: none"> <li>the equation shows that a straight line or linear relationship is expected</li> <li>the best fit line should not include the anomalous data point</li> <li>reference to numbers of data points above and below the best fit line</li> </ul>	<p>Correct graph must be selected to award the justification mark</p>	2	C												

	f	<p>Y intercept stated as <math>5.8 \pm 0.1</math></p> <p><math>f = 0.172 \pm 0.003 \text{ (m)}</math></p>	<p><i>ECF if wrong graph selected in e</i></p> <ul style="list-style-type: none"><li>- graph A - accept <math>4.7 \pm 0.1</math></li><li>- graph B – accept <math>5.5 \pm 0.1</math></li><li>- graph D – accept <math>4.5 \pm 0.1</math></li></ul> <p>Award the second point for evidence of a calculation involving 1/intercept</p>	2	C
--	---	---	--	---	---

7	a	A Forces are unbalanced <b>or</b> net force is not zero	WTTE	2	A														
	b	<table border="1"> <thead> <tr> <th></th><th>1</th><th>2</th><th>3</th></tr> </thead> <tbody> <tr> <td>Ad (Advantages)</td><td>a statement of an advantage</td><td>a statement of two or more advantages <b>or</b> a statement of one advantage with an explanation</td><td>a statement of two or more advantages with at least one explained</td></tr> <tr> <td>Dis (Disadvantages)</td><td>a statement of a disadvantage</td><td>a statement of two or more disadvantages <b>or</b> a statement of one disadvantage with an explanation</td><td>a statement of two or more disadvantages with at least one explained</td></tr> <tr> <td>Con (Conclusion)</td><td>a simple conclusion</td><td></td><td></td></tr> </tbody> </table>		1	2	3	Ad (Advantages)	a statement of an advantage	a statement of two or more advantages <b>or</b> a statement of one advantage with an explanation	a statement of two or more advantages with at least one explained	Dis (Disadvantages)	a statement of a disadvantage	a statement of two or more disadvantages <b>or</b> a statement of one disadvantage with an explanation	a statement of two or more disadvantages with at least one explained	Con (Conclusion)	a simple conclusion			7
	1	2	3																
Ad (Advantages)	a statement of an advantage	a statement of two or more advantages <b>or</b> a statement of one advantage with an explanation	a statement of two or more advantages with at least one explained																
Dis (Disadvantages)	a statement of a disadvantage	a statement of two or more disadvantages <b>or</b> a statement of one disadvantage with an explanation	a statement of two or more disadvantages with at least one explained																
Con (Conclusion)	a simple conclusion																		

8		1	2	3	4		
	<b>Env (Environmental)</b>	a statement of one use of drones in environmental monitoring	a statement of one use of drones in environmental monitoring <b>and</b> how this use relates to science <b>or</b> at least two statements of the use of drones in environmental monitoring	a statement of at least two uses of drones in environmental monitoring <b>and</b> a statement of how <b>one</b> use is a benefit to science	a statement of at least two uses of drones in environmental monitoring <b>and</b> a statement of how these uses are a benefit to science		
	<b>Soc (Social implications)</b>	a positive <b>or</b> a negative social implication for an individual	a positive <b>and</b> a negative social implication for an individual	a positive <b>and</b> a negative social implication for an individual with <b>one</b> supported by further justification	a positive <b>and</b> a negative social implication for an individual with <b>both</b> supported by further justification	14	D
	<b>Pol (Political implications)</b>	a positive <b>or</b> a negative political or security implication for a location	a positive <b>and</b> a negative political or security implication for a location	a positive <b>and</b> a negative political or security implication for a location with <b>one</b> supported by further justification	a positive <b>and</b> a negative political or security implication for a location with <b>both</b> supported by further justification		
	<b>Con (Concluding appraisal)</b>	a concluding opinion is given	a concluding appraisal linking to previous arguments				

# Markscheme

November 2022

Physics

On-screen examination

15 pages

This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Horizontal wavy line that can be expanded
	Highlight tool that can be expanded to mark an area of a response

Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Text box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

### Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses. Do not deduct marks for spelling errors.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (or reverse argument) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.

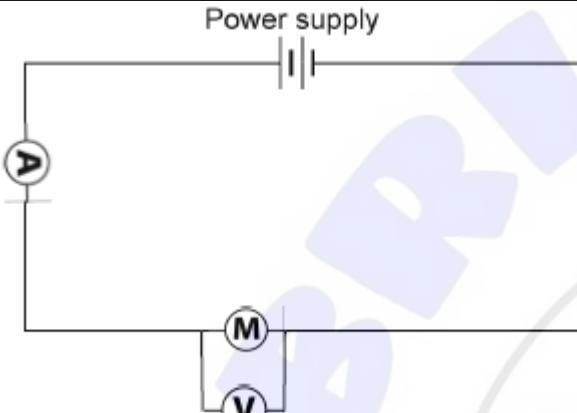
- 15 If the candidate's response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (*or words to that effect*) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add ECF (error carried forward) to the candidate response.
- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate's work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

Question	Answers	Notes	Total	Crit.
1    a	<p>Both of these forms of uranium have <input type="text"/> of 92.</p> <p>Uranium-236 has one more <input type="text"/> than uranium-235.</p> <p>These two different forms of uranium are known as <input type="text"/>.</p>		3	A
b	$^{92}_{36}\text{Kr}$		1	A
c	$18.5 \pm 0.5$ min(utes)		2	A
d	evidence of energy requirement / energy per g  (conversion of MJ into J to give mass of) 1.536... (g) <b>or</b> 1.54	<i>Award 2 marks for correct answer with no working shown</i>	2	A
e	<b>Any reasonable suggestion, for example [max 1]</b> <ul style="list-style-type: none"> <li>• different skills</li> <li>• complementary skills</li> <li>• science is a creative endeavour</li> </ul>		1	D

2	a	<table border="1"> <thead> <tr> <th>Heat energy added</th><th>Heat energy removed</th></tr> </thead> <tbody> <tr> <td>Boiling</td><td>Freezing</td></tr> <tr> <td>Melting</td><td>Condensing</td></tr> </tbody> </table> <p>One correct term in blue All terms in blue correct</p>	Heat energy added	Heat energy removed	Boiling	Freezing	Melting	Condensing		2	A
Heat energy added	Heat energy removed										
Boiling	Freezing										
Melting	Condensing										
<p><b>Accept any reasonable similarity:</b></p> <ul style="list-style-type: none"> <li>• both are types of vaporization</li> <li>• change of state is liquid to gas in both</li> </ul> <p><b>Accept any reasonable difference, for example [max 1]:</b></p> <ul style="list-style-type: none"> <li>• boiling only happens at the boiling point <b>and</b> evaporation can happen at any temperature</li> <li>• boiling happens at constant temperature <b>and</b> evaporation leads to cooling of the liquid</li> <li>• evaporation happens at the surface <b>and</b> boiling does not</li> <li>• evaporation is a slow process <b>and</b> boiling is a fast process</li> <li>• boiling creates bubbles (of vapour) <b>and</b> evaporation does not produce bubbles</li> </ul>											
c		cooking oil ethanol		2	A						
d		20.8± 0.1		1	A						
e		Cooking oil did not evaporate <b>and</b> a large amount of ethanol evaporates  correct link to amount of energy required for evaporation (so student B is correct)		2	A						

3	a	<b>Accept two valid differences, for example [max 2]</b> <ul style="list-style-type: none"><li>• stars emit light</li><li>• moons reflect light</li><li>• stars are gaseous</li><li>• moons orbit planets</li><li>• stars do not orbit planets</li><li>• moons are solid</li></ul>	Accept “satellite”	2	A
	b	He saw the moons were orbiting Jupiter (not Earth)  If the geocentric model was true, the moons would have been orbiting Earth	WTTE	2	A
	c	<b>Accept any reasonable suggestion, for example [max 1]</b> <ul style="list-style-type: none"><li>• Water could indicate presence of life</li><li>• Europa could be used as a future settlement</li></ul>		1	D
	d	<b>Accept any two properties from the list [max 2]</b> <ul style="list-style-type: none"><li>• All travel at the same speed</li><li>• All transverse waves</li><li>• Can all travel through a vacuum</li><li>• All have waves properties (reflection/refraction etc.)</li></ul>		2	A

4	a	heat <b>or</b> sound		1	B
	b	RQ linked to useful energy, total energy, work done or efficiency  RQ correctly linking the amount of work done or mass or height lifted by a motor and its efficiency (DV)		2	B
	c	Lift the mass to different heights  Use data to calculate work done or change of gravitational potential energy for each height		2	B

d	 <p>Power supply</p> <p>Motor <b>and</b> Ammeter <b>and</b> voltmeter only</p> <p>Ammeter connected in series</p> <p>Voltmeter connected in parallel across motor</p>	<i>Ignore any switch if present</i>	3	B
e	<p>identification of time</p> <p><math>\text{power} * \text{time} = \text{work or energy}</math></p>	WTTE	2	B

5		1	2	3	4		
V (Variables)	time implied as dependent variable	independent variable of voltage <b>and</b> dependent variable of time stated	independent variable of voltage <b>and</b> dependent variable of time stated <b>and</b> two control variables stated <b>or</b> one control variable with correct justification	independent variable of voltage <b>and</b> dependent variable of time stated <b>and</b> two control variables stated <b>and</b> with correct justification			
M (Method)	attempt at a method linked voltage <b>or</b> time	method is described with measurements of voltage <b>and</b> time but not detailed enough to be followed by another student	complete method is described with measurements of voltage and time <b>and</b> could easily be followed by another student	complete method is described with measurements of voltage and time <b>and</b> could easily be followed by another student <b>and</b> with details of m and $\Delta H$ as CV		14	B
D (Data)	at least five increments <b>or</b> three trials	at least five increments <b>and</b> three trials	at least five increments <b>and</b> three trials <b>and</b> plans to calculate an average				
P (processing)	plans to calculate Useful energy <b>or</b> total energy	plans to calculate Useful energy <b>and</b> total energy	plans to calculate Useful energy <b>and</b> total energy <b>and</b> Efficiency				

6	a	<p>correct statement <b>or</b> reference to <math>\Delta E_p = mg\Delta h</math>  final answer 0.465975 (J)</p>	<p><i>Award 2 marks for any correctly rounded value to 2 or more sf. Award 1 mark for 46(.6 J) no conversion to m</i></p>	2	C																	
	b	<p>Mass is IV so voltage should be CV</p> <p><b>Justification:</b>  Any changes in efficiency must be related to changes in IV only  <b>or</b>  Increasing the voltage would increase the power</p>	WTTE	2	C																	
	c	<p>Table Object</p> <table border="1"> <thead> <tr> <th>Mass/g</th> <th>Current/A</th> <th>Time/s</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>0.12</td> <td>4.32</td> </tr> <tr> <td>20</td> <td>0.14</td> <td>4.68</td> </tr> <tr> <td>30</td> <td>0.15</td> <td>4.74</td> </tr> <tr> <td>40</td> <td>0.17</td> <td>5.16</td> </tr> <tr> <td>50</td> <td>0.18</td> <td>5.21</td> </tr> </tbody> </table> <p>complete data in increasing or decreasing values of mass  column headers correct  units appearing only in column headers</p>	Mass/g	Current/A	Time/s	10	0.12	4.32	20	0.14	4.68	30	0.15	4.74	40	0.17	5.16	50	0.18	5.21		3
Mass/g	Current/A	Time/s																				
10	0.12	4.32																				
20	0.14	4.68																				
30	0.15	4.74																				
40	0.17	5.16																				
50	0.18	5.21																				
d	<p>use of correct formula to calculate total energy (<math>E = V \cdot I \cdot t</math>)  correct total energy = 1.8756(J)  correct calculation of efficiency = <math>24.844 = 25 (\%)</math></p>	<i>ecf from part (a) and mp2</i>	3	C																		

7	a	<p>Graph D</p> <p>LOBF intersects the most points <b>or</b> correct reference to the number of data points above and below the LOBF <b>or</b> correct reference to the outlier</p>	<p><b>WTTE</b></p> <p><i>Correct graph has to be selected to award justification mark</i></p>	2	C
	b	<p><math>5.1 \pm 0.1</math> (m)</p> <p><math>82 \pm 2</math> (degrees)</p>		2	C
	c	<p>Maximum height reached decreases when the angle is increased</p> <p>But not in inverse proportion</p> <p>doubling of IV does not halve DV</p> <p><b>or</b></p> <p>inverse proportion would not show an intercept</p>		3	C
	d	<p>(Height)</p> <p>Due to the motion of the ball, the height of the ball would be hard to measure</p>	<p><i>No mark for height but this should be selected for the mp</i></p> <p><b>WTTE</b></p>	1	C
	e	<p>Repeated trials</p> <p><b>or</b></p> <p>Any correct suggestion relating to a more accurate height measurement being taken</p>		1	C
	f	<p>Decreased</p> <p>Gain in GPE is less</p> <p>Energy is converted to heat <b>or</b> kinetic energy is wasted</p> <p><b>or</b></p> <p>Total force acting against the ball is greater</p> <p>(so) deceleration of the ball is increased</p>		3	B

	<b>g</b>	Correct statement relating to streamlining due to shape <b>or</b> small size <b>or</b> comment relating to inertia/mass of metal ball  Air resistance caused by collisions of air particles with the surface of the ball		<b>2</b>	C
	<b>h</b>	<b>Any relevant DV, for example [max 1]</b> <ul style="list-style-type: none"><li>• Time of flight</li><li>• horizontal range</li></ul> <b>Any 2 control variables consistent with launch angle as IV and DV chosen [max 2]</b>	<b>WTTE</b>	<b>3</b>	C

<b>8</b>	<b>a</b>	Use of $s=d/t$ or Total distance of 0.16(m)  Distance to kidney stone = 0.08(m)  Correct conversion to cm			<b>3</b>	<b>A</b>
	<b>b</b>	<i>ecf from an incorrect distance of 0.16</i>				
	<b>Waves</b>	<b>1</b> description of reflection, absorption or transmission in non-technical terms for one technique	<b>2</b> identification of one wave phenomenon for one technique	<b>3</b> identification of one wave phenomenon for both techniques	<b>4</b> identification of one wave phenomenon for both techniques and how image is produced	<b>16</b>
	<b>Health</b>	health impact for one technique	health impact for both techniques	health impact for both techniques with <b>one</b> supported by further justification	health impact for both techniques with <b>both</b> supported by further justification	
	<b>Economic</b>	an economic implication	a positive <b>or</b> a negative economic implication for the government	a positive <b>and</b> a negative economic implication for the government	a positive <b>and</b> a negative economic implication for the government with <b>one</b> supported by further justification	
	<b>Ethics</b>	a comment	a comment supported with further justification			
	<b>Conclusion</b>	a concluding opinion is given	a concluding appraisal linking to previous arguments			

	c	<p><b>Accept any reasonable points, for example [max 4]</b></p> <ul style="list-style-type: none"><li>• Evidence of a large number of terminations taking place</li><li>• Terminations should not take place based on sex alone</li><li>• Stable family structures less likely</li><li>• Work force supply issues</li><li>• Future fall in birth rate <b>or</b> population pyramid issues</li><li>• Difficult for males to find female partners</li><li>• Lack of diversity in society</li></ul> <p><b>Accept any reasonable suggestion, for example [max 1]</b></p> <ul style="list-style-type: none"><li>• Introduce legislation preventing sex being identified before birth</li><li>• Run an education campaign</li></ul>	5	D
--	---	---	---	---

# Markscheme

May 2022

Physics

On-screen examination

19 pages

This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Horizontal wavy line that can be expanded
	Highlight tool that can be expanded to mark an area of a response

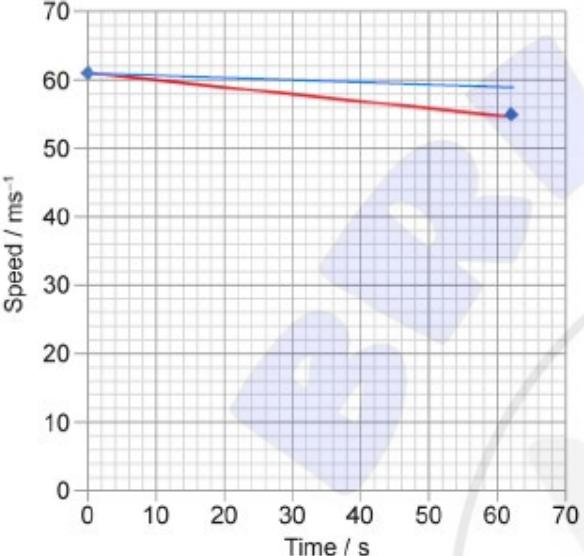
Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Text box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

## Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses. Do not deduct marks for spelling errors.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (*or reverse argument*) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (*or words to that effect*) in the Notes column.

- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add ECF (error carried forward) to the candidate response.
- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate's work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

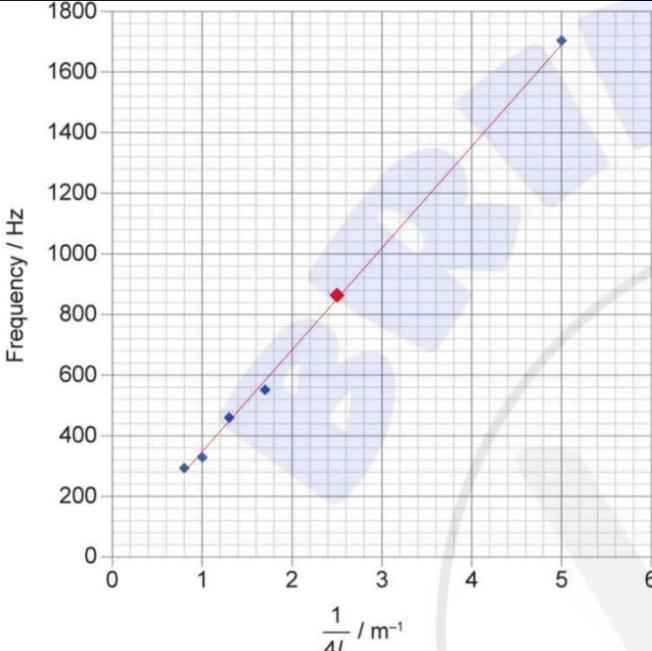
Question	Answers	Notes	Total	Crit
1 a	newtons		1	A
1 b	<p>Normal force Drag force Weight</p> <p>Magnetic force Drag force Weight</p> <p>or</p> <p>2 correct All correct</p>	Accept magnetic force or normal force for vertical component	2	A
1 c	Less than The drag force <b>or</b> air resistance is reduced The forces are balanced <b>or</b> resultant force is zero (at constant speed)	WTTE WTTE	3	A
1 d	Evidence of speed x time <b>or</b> area calculation Use of 2 data points from graph to calculate area of trapezium <b>or</b> average speed 3600 or 3596 (m)	Seen or implied (eg 61x62) Accept answers in the range 3534 to 3627(m) for 3 marks. Rounding not required	3	A

e	 <p>y intercept is the same Always above original line</p>	<p>Candidate's line has no end markers Allow approximately the same starting point, ignore end point <b>Do not accept positive gradient (showing acceleration)</b></p>	2	A
---	---	--	---	---

<b>2</b>	<b>a</b>	Power <b>and</b> equal to	<i>Both required</i>	<b>1</b>	A
	<b>b</b>	Evidence of use of transformer equation <b>or</b> power in = power out  12 000 (V)	<i>Seen or implied</i>  <i>Award 2 marks for correct answer</i>  <i>Accept 651V for 2 marks if the number of turns from the diagram is used to calculate the primary voltage</i>	<b>2</b>	A
	<b>c</b>	Use of $P=IV$  Power supplied (98% efficiency) 14112 (W)	<i>Seen or implied</i>  <i>Accept correct answer rounded to 2sf or more in W or kW for 2 marks</i>	<b>2</b>	A
	<b>d</b>	<b>Accept any points from the list [max 2]</b> <ul style="list-style-type: none"> <li>• By increasing the voltage, the current is reduced</li> <li>• Energy is wasted as heat in the wires</li> <li>• (Increasing voltage or decreasing current) reduces energy wasted (as heat)</li> <li>• R is fixed value (property of wire)</li> <li>• more energy or power is supplied to the destination</li> </ul>	ORA	<b>2</b>	A

3	a	<table border="1"> <tr><td>Radiation</td><td>Transfer of heat by electromagnetic radiation</td></tr> <tr><td>Conduction</td><td>Transfer of heat by direct contact</td></tr> <tr><td>Convection</td><td>Transfer of heat by moving fluids</td></tr> </table> <p>All correct</p>	Radiation	Transfer of heat by electromagnetic radiation	Conduction	Transfer of heat by direct contact	Convection	Transfer of heat by moving fluids		1	A
Radiation	Transfer of heat by electromagnetic radiation										
Conduction	Transfer of heat by direct contact										
Convection	Transfer of heat by moving fluids										
b	D			1	A						
c	Condensation		Accept "it condenses"	1	A						
d	Condensation occurs on cold surfaces <i>or</i> Salt water is only cold at the top of the cup			1	A						
e	<p><b>Any two points from the list, [max 2]</b></p> <ul style="list-style-type: none"> <li>• salt water is more dense (than pure water)</li> <li>• melted cold water remains near surface</li> <li>• convection of salt water does not occur <b>or</b> less convection in saltwater than in pure water</li> </ul> <p><b>Conclusion:</b> (so) heat is transferred less quickly (in the salt water)</p>		<p>WTTE for all points</p> <p>WTTE</p> <p><i>Do not award the final mark unless the first and second marks are awarded</i></p>	3	A						
f	<p><b>First marking point:</b> Melted cold water would be distributed <i>or</i> Stirring would increase (heat transfer by) convection</p> <p><b>Second marking point:</b> Melting time for the ice in salt water would decrease <i>or</i> Melt time would be the same for both ice cubes <i>or</i> Melt time would be less for both cubes</p>		<p>WTTE</p> <p>WTTE</p>	2	B						

4	a	How does the length of a tube affect the <u>frequency</u> of the sound produced?	WTTE	1	B
	b	At least three of one material only, no other material included  At least three of one diameter only  5 lengths of 2.5 cm diameter wood only	Award third mark only if first 2 marks awarded	3	B
	c	IV is length <b>or</b> wood is the only material with five different lengths  Material <b>and</b> diameter should be controlled	Accept description of length as IV  WTTE	2	B
	d	Two data points taken from the graph  Correct calculation using pair of points <b>or</b> double IV and halve DV <b>or</b> comparing products of x and y values   So hypothesis supported	Award 1 mark only if the candidate identifies the fact that as length increases, frequency decreases but performs no calculation or processing to confirm if this is inverse proportionality  WTTE  Do not award the third mark unless marking points one and two are awarded	3	C
	e	4L value = 0.4 <b>and</b> 1/4L value 2.5	Values must be to 1 d.p.	1	C

<b>f</b>  <p>Frequency / Hz</p> <p><math>\frac{1}{4L} / \text{m}^{-1}</math></p> <p>Data point plotted correctly (2.5, 860)</p> <p>Line of best fit has roughly equal distribution of data points above and below line (judge by eye)</p>	<p>Award the mark if the point is plotted within the correct square i.e. <math>(2.5 \pm 0.1, 860 \pm 20)</math></p>	<b>2</b> <b>C</b>
<b>g</b> <p>Image Object</p> <p><math>\frac{1}{v}</math>      <math>v</math>      <math>\frac{1}{4L}</math>      <math>\frac{v}{4L}</math></p> <p>Text/MCQ/Mini-Cloze Object</p> <p><input type="radio"/> <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/></p>		<b>1</b> <b>C</b>

	<b>h</b>	Calculation seen and points separated by more than 1000Hz in y  Correct value $343 \pm 10$  $\text{m s}^{-1}$	<i>Consistent with their LOBF in part g</i>  <i>Accept m/s or Hz m</i> <i>Award unit mark separately</i>	3	C
--	----------	---	---	---	---

5	a	W=mg 3 (N)	Seen or implied	2	C												
	b	<b>Accept any two variables from the list, [max 2]</b> <ul style="list-style-type: none"> <li>Length of wire</li> <li>Thickness <b>or</b> diameter</li> <li>Material <b>or</b> type of wire <b>or</b> density of wire</li> <li>Force of the pluck <b>or</b> strum of the string</li> </ul>	WTTE	2	C												
	c	<p>Table Object</p> <table border="1"> <thead> <tr> <th>tension (N)</th> <th>frequency (Hz)</th> </tr> </thead> <tbody> <tr> <td>4.9</td> <td>180</td> </tr> <tr> <td>14.7</td> <td>280</td> </tr> <tr> <td>24.5</td> <td>460</td> </tr> <tr> <td>39.3</td> <td>509</td> </tr> <tr> <td>49.0</td> <td>588</td> </tr> </tbody> </table> <p>Column headers: Tension and Frequency      Units for both quantities in headers only      39.28 correctly rounded to 39.3 (N) to give consistent dps      Results in order</p>	tension (N)	frequency (Hz)	4.9	180	14.7	280	24.5	460	39.3	509	49.0	588	<p>Accept tables arranged in columns or rows</p> <p>Accept results in ascending or descending order</p>	4	C
tension (N)	frequency (Hz)																
4.9	180																
14.7	280																
24.5	460																
39.3	509																
49.0	588																
	d	<p><b>Accept any relevant suggestion for example, [max 1]</b> <ul style="list-style-type: none"> <li>increased range of data</li> <li>repeat measurements</li> <li>values of the IV in between the values already used</li> <li>regular intervals of the IV</li> </ul> <b>Accept any correctly linked justification for example, [max 1]</b> <ul style="list-style-type: none"> <li>pattern in data will be more clearly visible</li> <li>reduce the effect of random errors on the line of best fit</li> <li>line of best fit would be more accurate/reliable</li> </ul> </p>		2	C												

<p><b>e</b></p> <p><b>Accept any reasonable IV, for example [max 1]</b></p> <ul style="list-style-type: none"> <li>• length</li> <li>• thickness <b>or</b> diameter</li> <li>• material</li> <li>• temperature</li> </ul> <p><b>Accept any two reasonable CV, for example [max 2]</b></p> <ul style="list-style-type: none"> <li>• length</li> <li>• thickness or diameter</li> <li>• material</li> <li>• temperature</li> <li>• tension</li> </ul>	<p><b>Award 0 marks for this question if tension is selected as IV</b></p> <p><b>Do not award CV mark if it is the same as the IV</b></p>	<p><b>3</b></p> <p><b>B</b></p>
<p><b>f</b></p> <p><b>If, then:</b> linking their IV with frequency</p> <p><b>Because:</b> Attempt at explanation linked to their IV and frequency</p>	<p><b>Does not have to be correct for the first marking point</b></p> <p><b>Award 0 marks if the hypothesis relates tension and frequency</b></p>	<p><b>2</b></p> <p><b>B</b></p>

6	a	<p><b>Accept any reasonable suggestion, for example [ max 1]</b></p> <ul style="list-style-type: none"><li>• increased reliability</li><li>• reference to background noise</li><li>• to identify anomalies</li></ul>	<p><b>Do not accept “to take an average”,</b> <b>Do not accept “to improve accuracy/validity” without clarification</b></p> <p>WTTE</p>	1	C
	b	113 113	<p><b>Do not accept answers with additional decimal places e.g. 113.3</b></p>	2	C
	c	105 (dB)		1	C

6	d					
		1	2	3	4	
13	B	<b>Variables</b>	sound intensity level as dependent variable <b>or</b> number of layers/thickness of cardboard as independent variable	sound intensity level as dependent variable <b>and</b> number of layers/thickness of cardboard as independent variable	IV and DV correct <b>and</b> one control variable stated <b>and</b> justified <b>or</b> IV and DV correct <b>and</b> two control variables stated	independent, dependent variable <b>and</b> two control variables are stated <b>and</b> justified
		<b>Hypothesis</b>	attempt at a hypothesis linked to either sound intensity level <b>or</b> number of layers/thickness of cardboard	testable hypothesis linking sound intensity level <b>and</b> number of layers/thickness of cardboard	hypothesis links sound intensity level <b>and</b> number of layers/thickness of cardboard, is testable and with an attempted explanation referencing relevant scientific knowledge	
		<b>Method</b>	attempt at a method linked to <b>either</b> sound intensity level <b>or</b> number of layers/thickness of cardboard	attempt at method linked to sound intensity level <b>and</b> number of layers/thickness of cardboard but insufficient detail to be followed by another student and not likely to give relevant data	method linked to sound intensity level <b>and</b> number of layers/thickness of cardboard described <b>and</b> could easily be followed by another student and will produce relevant data	
		<b>Data collection</b>	reference to different increments <b>or</b> trials	at least five different numbers of cardboard layers/thicknesses <b>or</b> three trials	at least five different numbers of cardboard layers/thicknesses <b>and</b> three trials	

7	a	Mars seems to go backwards <b>or</b> changes direction  If Earth was the centre, Mars would orbit in a circular path/ellipse around Earth <b>or</b> Mars would seem to follow a straight-path or an arc <b>or</b> reference to changing distance between Earth and Mars	WTTE  WTTE	2	D
	b	Calculation of time in s: $4 \times 10^{11} / 3 \times 10^8 = 1330$ (s) <b>or</b> use of ratio to give 1330(s), 1333(s), 1333.3(s)  Conversion and rounding 22 (minutes)	Accept any correct value of time in s rounded or unrounded for first mark  Award two marks for correct answer alone		A D
	c	<b>Accept any two points from the list [max 2]</b> <ul style="list-style-type: none"> <li>• the launch date is calculated to give the shortest journey time</li> <li>• the launch date gives the shortest distance to travel</li> <li>• in order to minimise fuel</li> <li>• in order to minimise communication time</li> <li>• the launch date is calculated to reach a specific landing spot on Mars</li> </ul>	WTTE for all	2	D

8		1	2	3	4		
	<b>Technical (planning the journey)</b>	One technical challenge is stated	One technical challenge is stated with a partial explanation <b>or</b> Two technical challenges stated	Two technical challenges stated with a scientific explanation for at least one	Two technical challenges stated with a scientific explanation for both		
	<b>Economic advantages and disadvantages (for the government of a country)</b>	One economic advantage <b>or</b> disadvantage is stated	One economic advantage <b>and</b> disadvantage is stated <b>or</b> Two advantages or disadvantages are stated	One economic advantage <b>and</b> one disadvantage are stated with further discussion for one	One economic advantage <b>and</b> one disadvantage are stated with further discussion for both		
	<b>Political implications</b>	One political implication is stated	One political implication is stated with further discussion <b>or</b> two political implications are stated	Two political implications are stated and further discussion for one			
	<b>Concluding appraisal</b>	A simple conclusion	A concluding appraisal with reference to issues raised				

9	<p><b>Effect of low temperature, for example [max 1]</b></p> <ul style="list-style-type: none"><li>• too cold for humans to live</li><li>• too cold for humans to grow food</li></ul> <p><b>Correctly linked suggestion to overcome the effect of low temp [max 1]</b></p> <ul style="list-style-type: none"><li>• reference to minimising heat transfer through insulation of housing/clothing</li></ul> <p><b>Effect of radiation, for example [max 1]</b></p> <ul style="list-style-type: none"><li>• (exposure to) too much radiation is harmful to health <b>or</b> can cause cancer</li></ul> <p><b>Correctly linked suggestion to overcome effect of UV radiation [max 1]</b></p> <ul style="list-style-type: none"><li>• reference to a method of absorbing or reflecting the radiation</li></ul> <p><b>Effect of low gravity, for example [max 1]</b></p> <ul style="list-style-type: none"><li>• reference to health problems caused by low gravity eg poor circulation, muscle wasting, bone density</li><li>• difficulties in moving around compared to Earth</li></ul> <p><b>Correctly linked suggestion to overcome effect of low gravity [max 1]</b></p> <ul style="list-style-type: none"><li>• need to exercise to build muscle mass or maintain bone density</li><li>• wear a weighted suit</li></ul>	<p><i>Do not accept constant heating without mention of insulation as a solution</i></p> <p><i>Accept responses suggesting the use of rotation to simulate gravity if this is clearly expressed.</i></p>	6	D
---	---	--	---	---

# Markscheme

November 2023

Physics

On-screen examination

13 pages

This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Horizontal wavy line that can be expanded
	Highlight tool that can be expanded to mark an area of a response

Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Test box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

## Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses. Do not deduct marks for spelling errors.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (*or reverse argument*) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (*or words to that effect*) in the Notes column.

- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add ECF (error carried forward) to the candidate response.
- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate's work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

Question		Answers	Notes	Tot	Crit
1	a	 <p>Two planets in correct location All three planets in correct location</p>	<p>Planets added by candidates are Venus, Earth and Jupiter</p>	2	A
	b	<p><b>Accept any object from the list, [max 1]</b></p> <ul style="list-style-type: none"> <li>• Comets</li> <li>• Asteroids</li> <li>• Minor Planets / Dwarf planets</li> <li>• Moons</li> </ul>	<p><b>Do not accept objects made by humans eg rockets, satellites</b></p>	1	A
	c	<p><b>Accept any two points, for example [max 2]</b></p> <ul style="list-style-type: none"> <li>• a star is luminous</li> <li>• a star undergoes nuclear fusion in the core</li> <li>• a star is more massive</li> <li>• a star has a greater temperature</li> </ul>	<p><b>WTTE</b> <b>Do not accept the sun is star.</b> <b>Comparison can be implied</b></p>	2	A
	d	<p><b>Accept any three points, [max 3]</b></p> <ul style="list-style-type: none"> <li>• Galaxies moving apart (with greater speed) imply the universe is expanding</li> <li>• The universe was once in a hot, dense state</li> <li>• The universe is finite in age or the age of the universe is 13.7 billion years</li> <li>• The universe was smaller in the past</li> </ul>	<p><b>WTTE</b></p>	3	A
	e	<p><b>Accept any reasonable disadvantage, for example [max 1]</b></p> <ul style="list-style-type: none"> <li>• conversions are more difficult</li> <li>• people could be unfamiliar with non-SI units</li> <li>• inconsistency with other areas of physics</li> </ul> <p><b>Accept any reasonable advantage, for example: [max 1]</b></p> <ul style="list-style-type: none"> <li>• Simplifies use of very large numbers</li> <li>• less need for scientific notation</li> </ul>		2	D

2	a	Protons = 6 Neutrons = 8		2	A
	b	Beta  Electron / Beta <u>particle</u> <b>or</b> anti neutrino		2	A
	c	5500±100 (years) )		1	A
	d	13 000±500 (years)		1	A
	e	At 40 000 the remaining number of C-14 atoms would be very small or close to zero <b>or</b> the graph only shows C-14 data for 40 000 years  (So after 65 million years) the remaining C-14 would be too small a sample to detect <b>or</b> measure reliably <b>or</b> (So after 65 million years) C-14 dating is not appropriate or cannot be used in this way		2	A

3	a	<p>Electrical energy 100 W</p> <p>Light</p> <p>95</p> <p>Thermal energy 5 W</p>		2	A
b		<p>Draggable items:</p> <p>Correct arrangement of ammeter (series with LED)</p> <p>Voltmeter in parallel with the LED</p>		2	A
c		<p>Use of <math>P = VI</math></p> <p>0.05 (W)</p>	<p>Seen or implied, award two marks for correct answer</p>	2	A
d		<p>Efficiency of filament bulb is 5 %</p> <p>Efficiency for LED is <math>0.02 / 0.05 = 40 \%</math></p> <p>Efficiency for an LED is higher than a filament bulb</p>	<p>Only award the 3<sup>rd</sup> marking point if marking points 1 and 2 are awarded</p>	3	A

4	a	Accept any RQ with height of drop linked to height of the first bounce	WTTE	1	B
	b	IV – drop height only  DV – height of the first bounce only  All controls – kind of ball, surface and temperature only		3	B
	c	0.31 <b>or</b> 31 m <b>or</b> cm	Award unit mark independently	2	C
	d	Gravitational potential energy mentioned  Energy transformed into heat <b>or</b> sound <b>or</b> wasted on impact  (so) height of first bounce is lower	<i>Do not accept deformation of the ball on impact</i>	3	B
	e	0.25(66666)  0.26 correctly stated to 2 decimal places	Award 2 marks if only 0.26 is seen	2	C
	f	Height of bounce is difficult to measure accurately  Effect of random errors is minimized <b>or</b> allows for the calculation of an average	WTTE  <i>Do not accept references to accuracy for the second marking point</i>	2	C
	g	<b>(Graph B selected)</b>  <b>Accept any two points from the list [max 2]</b> <ul style="list-style-type: none"><li>• Data points cover more than half of the area</li><li>• Allows the curve of the graph to be seen clearly</li><li>• Allows a correct trendline to be fitted</li><li>• The straight trend line has a non-zero intercept (which is illogical)</li></ul>	No mark for graph selection although graph B must be selected to be awarded the marking points	2	C
	h	As drop height increases, the bounce height increases  Curved trendline <b>or</b> trendline is not straight <b>or</b> Doubling the drop height does not double the bounce height <b>or</b> As the drop height increases, the height of the bounce does not increase proportionally  so the prediction is incorrect	Award first mark separately, third point can only be awarded if the first two are also seen	3	C

5	a	<p><b>Accept any reasonable suggestion, for example [max 1]</b></p> <ul style="list-style-type: none"> <li>Simple equipment can be used to measure height (but not speed)</li> <li>Speed is changing</li> <li>Measuring height gives less random error than measuring speed</li> </ul>	<i>Do not accept measuring speed is more difficult than measuring height</i>	1	B																	
	b	No height of bounce <b>or</b> the ball would not bounce <b>or</b> no speed of rebound	WTTE	1	A																	
	c	<p>Table Object</p> <table border="1"> <thead> <tr> <th>Drop height (<math>h_1</math>) / m</th> <th>Average height of first bounce(<math>h_2</math>) / m</th> <th>Coefficient of restitution (<math>e</math>)</th> </tr> </thead> <tbody> <tr> <td>0.50</td> <td>0.34</td> <td>0.82</td> </tr> <tr> <td>1.00</td> <td>0.65</td> <td>0.81</td> </tr> <tr> <td>1.50</td> <td>0.94</td> <td>0.79</td> </tr> <tr> <td>2.00</td> <td>1.21</td> <td>0.78</td> </tr> <tr> <td>2.50</td> <td>1.44</td> <td>0.76</td> </tr> </tbody> </table> <p>Results in order Units added for drop height column header only Drop heights converted to unit consistent with header Evidence of <math>e</math> value calculated correctly (0.77781...) <math>e</math> correctly rounded to 2 or 3 sig figs 0.78 or 0.778 Rounded to consistent DPs for drop height and two DP for <math>e</math> column</p>	Drop height ( $h_1$ ) / m	Average height of first bounce( $h_2$ ) / m	Coefficient of restitution ( $e$ )	0.50	0.34	0.82	1.00	0.65	0.81	1.50	0.94	0.79	2.00	1.21	0.78	2.50	1.44	0.76	<i>Accept cm or m</i> <i>Seen or implied</i> <i>Do not accept addition of 0 to achieve consistent DP</i>	6
Drop height ( $h_1$ ) / m	Average height of first bounce( $h_2$ ) / m	Coefficient of restitution ( $e$ )																				
0.50	0.34	0.82																				
1.00	0.65	0.81																				
1.50	0.94	0.79																				
2.00	1.21	0.78																				
2.50	1.44	0.76																				
d	<p><math>e</math> values change or are not constant <math>e</math> values decrease with height (so) hypothesis is incorrect</p>	<i>Accept <math>e</math> depends on height</i> <i>First marking point is implied by the second</i> <i>Do not award the third mark unless the first two marking points are awarded</i>	3	C																		
e	<p><math>KE = \frac{1}{2} mv^2</math> Coefficient of restitution is the ratio between speeds whereas KE is related to speed squared 0.5 speed means 25 % kinetic energy remains <b>or</b> 75 % is wasted</p>	<i>Seen or implied</i>	3	C																		

6	a	1	2	3	4		
		<b>Variables</b> Height implied as only dependent variable <b>or</b> thickness implied as only independent variable	IV of thickness <b>and</b> DV of height stated	IV, DV <b>and</b> one CV stated	IV, DV <b>and</b> one CV stated <b>and</b> justified	14	B
		<b>Hypothesis</b> Attempt at a hypothesis linked to either thickness or height	Hypothesis links to thickness and height of first bounce	Hypothesis links to thickness and height of first bounce with attempted explanation not linked to science	Hypothesis links to thickness and height of first bounce with explanation linked to energy transformations, dissipation of energy or forces		
		<b>Equipment</b> Equipment to measure height					
		<b>Data</b> Reference to different thickness <b>or</b> trials	At least five different thicknesses <b>or</b> three trials	At least five different thicknesses <b>and</b> three trials			
		<b>Method</b> Method is described, could be followed, will produce relevant data	Method is described, could be followed, will produce relevant data with consideration of how to minimize errors				
	<b>b</b>	<b>Research question:</b> Any relevant research question  <b>IV: Accept any reasonable IV, for example [max 1]</b> <ul style="list-style-type: none"><li>• Surface</li><li>• material of ball</li><li>• pressure of ball</li><li>• temperature of ball</li></ul> <b>Control variables: accept any two reasonable CV, for example [max 2]</b> <ul style="list-style-type: none"><li>• drop height</li><li>• temperature of ball</li><li>• surface</li></ul>				4	C
		<i>Do not accept drop height or thickness of sponge layer for IV</i>					

7	a	Heat is transferred to surroundings, insulation is poor (in actively heated houses) <b>or</b> Good insulation minimizes heat losses (in passively heated houses)  (so) less additional heat is needed to maintain comfortable temp (as less is lost in passively heated houses)	ORA	2	D
	b	Conduction is heat transfer through solids  Air or air gaps are a poor <u>conductor</u> <b>or</b> a good <u>insulator</u>		2	D
	c	Air (particles) will move from areas of higher pressure to areas of lower pressure  If there is a leak or a gap, the air will escape <b>or</b> (so) higher pressure inside the house wall causes air to move from inside to outside the house  Enabling the location of the leak to be found		3	D
	d	$15\pm1\%$		1	C
	e	Reduced fossil fuels needed to meet energy requirements  Hence less pollution from burning fuels to generate energy <b>or</b> lower impact on climate change		2	D

8		1	2	3	4	13	D
Socio-eco (Individuals)	a positive <b>or</b> a negative social or economic implication	A positive <b>and</b> a negative social or economic implication	a positive <b>and</b> a negative social or economic implication with <b>one</b> supported by further justification	a positive <b>and</b> a negative social or economic implication with <b>both</b> supported by further justification			
Eco (government)	a positive <b>or</b> a negative economic implication for a government	a positive <b>or</b> a negative economic implication for a government supported by further justification <b>or</b> more than one positive or negative implication for a government	a positive <b>and</b> a negative economic implication for a government with <b>one</b> supported by further justification				
Eco (business)	a positive <b>or</b> a negative economic implication for business	a positive <b>and</b> a negative economic implication for business	a positive <b>and</b> a negative economic implication for business with <b>one</b> supported by further justification	a positive <b>and</b> a negative economic implication for business with <b>both</b> supported by further justification			
Con (Concluding appraisal)	a concluding opinion is given	a concluding appraisal linking to previous arguments					

# Markscheme

May 2023

Physics

On-screen examination

15 pages

This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

The following are the annotations available to use when marking responses.

Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Underline tool that can be expanded
	Highlight tool that can be expanded to mark an area of a response

Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Text box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

## Markscheme instructions

- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses. Do not deduct marks for spelling errors.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA (or reverse argument)* in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE (or words to that effect)* in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add ECF (error carried forward) to the candidate response.
- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate’s work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

Question	Answers	Notes	Total	Crit									
1 a	Use of speed = distance/time  4(kmh <sup>-1</sup> )	Seen or implied	2	A									
b	<input checked="" type="radio"/> C. energy transformed = power × time		1	A									
c	<table border="1"> <tr> <td>Horse</td> <td>Mass of horse/kg</td> <td>Weight/N</td> </tr> <tr> <td>A</td> <td>350</td> <td>3500</td> </tr> <tr> <td>B</td> <td>510</td> <td>5100</td> </tr> </table>	Horse	Mass of horse/kg	Weight/N	A	350	3500	B	510	5100		2	A
Horse	Mass of horse/kg	Weight/N											
A	350	3500											
B	510	5100											
d	<table border="1"> <tr> <td>Chemical potential energy</td> <td>→ Kinetic energy</td> <td>→ Gravitational potential energy</td> </tr> </table>	Chemical potential energy	→ Kinetic energy	→ Gravitational potential energy		1	A						
Chemical potential energy	→ Kinetic energy	→ Gravitational potential energy											
e	Calculate work done 61200 (J)  Calculate power 11127  11.127 (kW)	<i>ECF if (incorrect work done)/5.5</i> <i>ECF if W to kW is done correctly</i> <i>Award 3 marks for 11.127 expressed to 2 or more sig figs ECF</i>	3	A									
f	I=P/V  I= 6.48695.. or 6.5 (A)	<i>Seen or implied</i> <i>Accept answer stated to 2 or more sig figs</i>	2	A									

<b>2</b>	<b>a</b>	D. Dispersion		<b>1</b>	<b>A</b>
	<b>b</b>	Red light has the longest wavelength <b>or</b> the lowest frequency Red is <u>refracted</u> the least (of the colours) Red light is the fastest (in the prism) <b>or</b> Red light has the lowest refractive index <b>or</b> Red light is slowed down the least (by the glass)		<b>3</b>	<b>A</b>
	<b>c</b>	IR has longer wavelength <b>or</b> IR has lower frequency <b>or</b> IR is detectable as heat	<i>WTTE</i>	<b>1</b>	<b>A</b>
	<b>d</b>	$f = \frac{v}{\lambda}$ seen or implied 4(.00) $\times 10^{14}$ (Hz)	<i>Award 1 mark for <math>4 \times 10^5</math> (no conversion to m)</i>	<b>2</b>	<b>A</b>

3	a	Atomic number= 6  Mass number=14		2	A
	b	<p><b>Accept any similarity from the list [max 1]</b></p> <ul style="list-style-type: none"> <li>• same number of protons</li> <li>• same charge on the nucleus</li> </ul> <p><b>Accept any difference from the list [max 1]</b></p> <ul style="list-style-type: none"> <li>• different number of neutrons</li> <li>• different number of nucleons</li> <li>• C-14 nucleus is unstable but C-12 nucleus is stable</li> </ul>	<p><i>Do not accept same atomic number or both are carbon nuclei</i></p> <p><i>Do not accept different mass number</i></p>	2	A
	c	<p>Universal Canvas Object</p> <p>Draggable items:</p> <ul style="list-style-type: none"> <li>Cosmic ray</li> <li>Ultrasound wave</li> </ul> <p>Key:</p> <ul style="list-style-type: none"> <li>Gamma ray</li> <li>X-ray</li> <li>Produced from the nucleus of an atom</li> <li>Produced from inner orbit of electrons</li> </ul>	<p><i>Award 1 mark if gamma ray and x-ray are selected but are in the wrong location</i></p>	2	A
	d	$^{238}_{92}\text{U} \rightarrow ^{232}_{90}\text{Th} + ^4_2\alpha$ $^{232}_{90}\text{Th} \rightarrow ^{234}_{91}\text{Pa} + ^0_{-1}\beta$		2	A
	e	A <u>neutron</u> is absorbed by the <u>nucleus</u> of uranium-238	WTTE	1	A

<b>4</b>	<b>a</b>	A RQ linking mass <b>or</b> force <b>or</b> weight <b>or</b> pressure <b>and</b> volume		<b>1</b>	<b>B</b>
	<b>b</b>	Mass as only IV  Volume of air as only DV		<b>2</b>	<b>B</b>
	<b>c</b>	Increase		<b>1</b>	<b>B</b>
	<b>d</b>	Correct use of ( $m \times g$ )  Increase in pressure = $1.51898 \times 10^5$ or 151899 (Pa or $Nm^{-2}$ )  Total pressure = $2.5 \times 10^5$ (Pa or $Nm^{-2}$ ) or 251899 (Pa or $Nm^{-2}$ )	<i>Seen or implied</i>  <i>Correct to at least 2 sig figs, no ECF</i>  <i>Award 3 marks for correct total pressure value stated to at least 2 sig figs</i>	<b>3</b>	<b>C</b>
	<b>e</b>	As the pressure increases, the volume decreases  <b>Second mark, accept any further description [max 1]</b> <ul style="list-style-type: none"><li>• in an inverse relationship</li><li>• pressure is proportional to 1/volume</li><li>• pressure is inversely proportional to volume</li><li>• when pressure doubles, volume halves</li></ul>		<b>2</b>	<b>C</b>
	<b>f</b>	<b>Reference to the graph, for example [max 1]</b> <ul style="list-style-type: none"><li>• the line is horizontal <b>or</b> flat <b>or</b> the same value (of 11000) is found for every pressure</li><li>• There is a slight slope to the line</li><li>• The value at 300kPa is not constant</li></ul> <b>Justification [max 1]</b> <ul style="list-style-type: none"><li>• (so) the graph supports Boyle's Law (within experimental error)</li><li>• (so) the graph does not support Boyle's Law</li></ul>	<i>Reference to the graph must be made for the first marking point</i>  <i>Do not award the second marking point without the first marking point being awarded</i>	<b>2</b>	<b>C</b>
	<b>g</b>	Answer in range 145-155  $cm^3$	<i>Award unit mark independently</i>	<b>2</b>	<b>C</b>

5	a	<p>As temperature increases, the kinetic energy <b>or</b> speed increases</p> <p>The number of collisions between the gas particles and the wall of the balloon increases <b>or</b></p> <p>The force of the collisions between the gas particles and the wall of the balloon increases <b>or</b></p> <p>The kinetic energy of the particles is transferred to elastic potential energy</p> <p>So the balloon expands because the balloon is elastic <b>or</b></p> <p>The balloon expands because its wall is pushed out by the pressure of the gas</p>	WTTE	3	B
---	---	--	------	---	---

b		1	2	3	4	
	RQ	an RQ correctly linking temperature and volume or circumference				
	V (Variables)	temperature as independent variable <b>or</b> circumference implied as dependent variable	independent variable of temperature <b>and</b> dependent variable of circumference stated	independent variable of temperature <b>and</b> dependent variable of circumference stated <b>and</b> one control variable stated		
	E (Equip)	equipment to measure temperature <b>or</b> circumference	equipment to measure temperature <b>and</b> circumference			
	M (Method)	attempt at a method linked to circumference <b>or</b> temperature	method is described with measurements of circumference <b>and</b> temperature but not detailed enough to be followed by another student	complete method is realistic and described with measurements of circumference <b>and</b> temperature <b>and</b> could easily be followed by another student		
	D (Data)	a reference to different temperatures	at least five increments of temperature	at least five increments of temperature <b>and</b> repeated measurements of circumference	at least five increments of temperature <b>and</b> repeated measurements of circumference <b>and</b> plans to calculate average	
	S (Safety)	mentions a relevant safety precaution for example: working at elevated temperature or making sure the balloon is not inflated too much at the start				

14 B

6	a	<p>Acceleration is due to an unbalanced force <b>or</b> Newton's second law says the greater the force, the greater the acceleration <b>or</b> <math>F=ma</math></p> <p>Expulsion of gas and thrust are paired forces <b>or</b> Forces are an action-reaction pair of forces</p> <p>(this is an example of) Newton's third law</p>		3	C													
	b	An RQ correctly linking circumference <b>or</b> volume with distance travelled		1	B													
	c	38.2 <b>and</b> cm		Unit <b>and</b> value required for the point. Accept 0.382 m.	1	C												
	d	<p><input type="button" value="Table Object"/></p> <table border="1"> <thead> <tr> <th>Circumference / cm</th> <th>Distance travelled / m</th> </tr> </thead> <tbody> <tr> <td>35.8</td> <td>1.07</td> </tr> <tr> <td>38.2</td> <td>1.30</td> </tr> <tr> <td>41.0</td> <td>1.97</td> </tr> <tr> <td>50.3</td> <td>3.10</td> </tr> <tr> <td>54.9</td> <td>3.99</td> </tr> <tr> <td>58.2</td> <td>5.06</td> </tr> </tbody> </table> <p>Table with circumference and distance travelled <b>and</b> units in headers only Data in ascending or descending order Data to consistent dp Numbers correctly converted to consistent units</p>		Circumference / cm	Distance travelled / m	35.8	1.07	38.2	1.30	41.0	1.97	50.3	3.10	54.9	3.99	58.2	5.06	Accept this value if seen in the table in part d, even if missing from this question part  Accept data arranged in either vertical columns or horizontal rows  Accept either metres or centimetres for each column
Circumference / cm	Distance travelled / m																	
35.8	1.07																	
38.2	1.30																	
41.0	1.97																	
50.3	3.10																	
54.9	3.99																	
58.2	5.06																	

	e	<p>The graphs show that as the circumference increases, the distance travelled will increase          (but) the graph shows that there is a proportional relationship between distance travelled and circumference cubed  <b>or</b>          (but) the graph shows that there is not a proportional relationship between distance travelled and circumference</p> <p>(so) the hypothesis is not valid  <b>or</b>          The hypothesis is only partially valid</p>	<p><i>Only award the 3<sup>rd</sup> marking point if the first 2 points have been awarded</i></p>	3	C
	f	<p><b>Accept any three reasonable variables, for example [max 3]</b></p> <ul style="list-style-type: none"> <li>• gas inside</li> <li>• temperature</li> <li>• shape of balloon</li> <li>• pressure</li> <li>• length of straw attached to balloon</li> <li>• angle of line</li> <li>• elasticity of balloon</li> <li>• circumference or volume</li> </ul>		3	C
	g	<p><b>Accept any reasonable hypothesis correctly linked to the IV given above and distance travelled</b></p> <p>If (the IV) increases then distance travelled will increase or decrease</p> <p>Attempt at explanation using scientific reasoning</p>		2	C

7	a	<p>Accept period in the range 1.6-1.8</p> <p>Accept frequency in the range 0.56-0.63</p> <p>Hz or <math>s^{-1}</math></p>	<p><i>Seen or implied</i></p> <p><i>Must be expressed as 2 sig figs</i></p> <p><i>Award the unit mark independently</i></p> <p><i>Accept unit written in words and ignore incorrect use of capitals or lowercase</i></p>	3	c
	b	C			1 A
	c	<p>Pedro's voice is converted into an electrical signal by the microphone in his mobile phone.</p> <p>The phone then converts that electrical signal into a radio wave.</p> <p>The radio wave signal is transmitted from the mobile phone to tower A.</p> <p>Tower A receives the signal, then sends the signal out through a connection using wires or fibre-optic cables to Tower B, where the signal is converted again.</p> <p>Natasha's phone receives the radio wave signal and converts it back into a sound wave that she can hear.</p> <p>All correct</p>		1 D	

d		1	2	3	4		
	<b>Advantages and disadvantages</b> (location-tracking tech)	a statement of one advantage <b>or</b> disadvantage for an individual	a statement of one advantage <b>and</b> one disadvantage for an individual <b>or</b> a statement of one advantage for an individual <b>or</b> disadvantage for an individual with support	a statement of more than one advantage for an individual <b>and</b> more than one disadvantage for an individual	a statement of at least two advantages for an individual with support for one <b>and</b> at least two disadvantages for an individual with support for one		
	<b>Economic</b> (Economic benefits)	an economic benefit for a company	more than one economic benefit for a company <b>or</b> one benefit with support	more than one economic benefit for a company with support for at least two			
	<b>Security</b> (Security implications)	a positive <b>or</b> a negative security implication for a country	a positive <b>and</b> a negative security implication for a country	a positive <b>and</b> a negative security implication for a country with support for <b>one</b>	a positive <b>and</b> a negative security implication for a country with support for <b>both</b>		
	<b>Con</b> (Concluding appraisal)	a concluding opinion is given	a concluding appraisal linking to previous arguments				

8		1	2	3	8	D
	<b>Benefits of controlling</b>	a statement of a benefit	a statement of two or more benefits <b>or</b> a statement of one benefit with an explanation	a statement of two or more benefits with at least one explained		
	<b>Limitations of controlling</b>	a statement of a limitation	a statement of two or more limitations <b>or</b> a statement of one limitation with an explanation	a statement of two or more limitations with at least one explained		
	<b>Con (Conclusion)</b>	a simple conclusion	a conclusion with a detailed appraisal of the issues raised			

## E-assessment May 2023

### Physics

#### Criteria B

##### **5b)**

The students are interested in how the temperature of the balloon affects its circumference. Design an experiment that the students could use to carry out this investigation. They are provided with standard laboratory equipment, including an oven to change the temperature. In your plan, you must include:

- a research question
- the independent, dependent and one control variable
- a list of the equipment they will need
- a detailed method for collecting data
- an explanation of how the students will collect sufficient data
- details of how they will make sure that the method is safe.

##### **Answer 5b**

**RQ:** How does the temperature of a balloon affect its circumference?

**Independent Variable:**

Temperature of the balloon

**Dependent Variable:**

Circumference of the balloon

**Control Variable:** (any one)

Type and size of the balloon  
pressure inside the balloon  
duration of heating  
room temperature

**Equipment:**

- Balloons (identical in size and material)
- Oven
- Thermometer
- Measuring tape
- Stopwatch
- Heat-resistant gloves
- Safety goggles

**Method for Collecting Data:**

**Preparation:**

- Ensure all balloons are identical in size and material.
- Set up the oven and preheat it to the desired temperature (e.g., 30°C).
- Measure the initial circumference of each balloon using a measuring tape.

**Experimental Procedure:**

- Put on safety goggles and heat-resistant gloves to ensure safety during the experiment.

- Place the first balloon inside the oven and expose it to the predetermined temperature for a specific duration (e.g., 5 minutes).
- Carefully remove the balloon from the oven and measure its circumference immediately.

**Data Collection:**

- Record the initial and final circumferences of the balloon after each temperature exposure.
- Repeat the experiment with different temperatures (e.g., 40°C, 50°C, 60°C, 70°C) for consistency.
- Conduct three trials for each temperature to ensure the reliability of the data.
- Record the circumference for each trial at different temperatures and take the average.

**Safety Measures:**

- Wear safety goggles to protect eyes from potential bursts or leaks.
- Use heat-resistant gloves when handling the balloons to avoid burns.

## Criteria D

**7d)** Discuss and evaluate the implications of mobile phone technology being used to track the locations and movements of individuals. In your answer, you should discuss:

- the advantages and disadvantages of location-tracking technology for an individual
- the economic benefits of location-tracking technology for a company
- the positive and negative security implications of location-tracking technology for a country
- an overall appraisal in which you evaluate the points discussed.

### **Answer 7d**

#### **Advantages and Disadvantages of Location-Tracking Technology for Individuals:**

##### **Advantages:**

- **Convenience:** Location tracking can enhance convenience by providing personalized services, such as location-based recommendations, traffic updates, and proximity-based reminders.
- **Emergency Services:** In emergency situations, tracking can be vital for services to locate individuals quickly, potentially saving lives.
- **Family and Social Connection:** Tracking allows families and friends to stay connected and aware of each other's whereabouts, providing a sense of security.

##### **Disadvantages:**

- **Privacy Concerns:** Constant tracking raises significant privacy concerns, as individuals may feel their every move is being monitored.
- **Abuse and Stalking:** Malicious actors could exploit location data for stalking or other harmful activities.
- **Data Security Risks:** Storing location data poses risks of unauthorized access and potential misuse, leading to identity theft or other cybercrimes.

#### **Economic Benefits of Location-Tracking Technology for Companies:**

##### **Benefits:**

- **Targeted Marketing:** Companies can use location data to deliver personalized and targeted advertisements, increasing the effectiveness of marketing efforts.
- **Operational Efficiency:** Location tracking enhances supply chain management, fleet optimization, and overall operational efficiency for businesses.
- **Customer Insights:** Analyzing location data helps companies understand customer behavior, leading to better product and service development.

#### **Positive and Negative Security Implications for a Country:**

##### **Positive Implications:**

- **Law Enforcement:** Location tracking can aid law enforcement in solving crimes and locating missing persons.

- **National Security:** Governments can use location data for monitoring and responding to security threats, especially in times of crisis.

#### **Negative Implications:**

- **Surveillance Concerns:** Mass surveillance using location data raises concerns about civil liberties and the potential for abuse by authoritarian regimes.
- **Data Breaches:** Large-scale collection and storage of location data increase the risk of data breaches, with potentially severe consequences for national security.

#### **Overall Appraisal:**

The use of mobile phone technology for location tracking presents a complex landscape with both benefits and risks. Striking a balance between individual privacy and societal interests is crucial. While the technology offers convenience, economic benefits, and security advantages, it also poses serious threats to privacy, personal security, and civil liberties. A comprehensive regulatory framework is necessary to address these concerns, ensuring that individuals have control over their data while allowing responsible use for societal benefits. Companies and governments must prioritize data security and ethical considerations to build trust and mitigate the potential negative consequences of widespread location tracking.

#### **Examiner Report (7d)**

Some students who put the time and effort into their responses were able to produce some excellent work, which showed a deep level of insight into the issues and had exceptional breadth and depth, covering all of the aspects required.

Weaker students showed more disorganization and a general lack of support for the points made in their answers. Discussing the advantages and disadvantages of location-tracking mobile phones concerning the individual was probably the best-answered part. Many discussed safety and security issues along with navigation and convenience for advantages. Quite a few students discussed privacy breaches and data security as disadvantages.

The economic benefits for the company were sometimes confused. Those who achieved well in this area discussed targeted marketing, location-based services with Apps, and even a few noted improvements in tracking shipment logistics.

For the security of a country, unfortunately, several students discussed this from the perspective of an individual and did not get any marks for this part. Some statements were too broad, and it was difficult to tell whether it was connected to the security of a country.

**8) The ability of modern mobile phones to access the internet has influenced the way that people communicate. On the internet, people tend to communicate with other people that have the same ideas as they do, which can reinforce opinions that may not be logical or scientifically accurate.**

Some people think that this kind of communication has led to an increase in the number of people believing in conspiracy theories. One such idea is the flat-Earth theory.

Some people have suggested that any scientific information that is shared through the internet should be checked for accuracy. Information that is incorrect or misleading should be removed.

Discuss and evaluate the benefits and limitations of controlling scientific information that is shared through the internet.

## **Answer 8**

### **Benefits of Controlling Scientific Information on the Internet:**

- **Accurate Information Dissemination:** Implementing controls ensures that accurate and reliable scientific information is shared, reducing the spread of misinformation and promoting a more informed public.
- **Prevention of Harmful Beliefs:** Controlling information helps prevent the dissemination of pseudoscientific ideas and conspiracy theories, such as the flat-Earth theory, which can have real-world consequences, especially in areas like public health and safety.
- **Maintaining Public Trust:** Ensuring the accuracy of scientific information builds and maintains public trust in online sources. This is crucial for individuals seeking reliable information for personal decision-making or educational purposes.
- **Enhancing Educational Value:** A controlled environment promotes educational value by providing users with trustworthy resources. This is particularly important for students and researchers who rely on the internet for academic purposes.

### **Limitations of Controlling Scientific Information on the Internet:**

- **Censorship Concerns:** The line between controlling misinformation and censoring divergent opinions can be blurry. Excessive control may infringe on freedom of expression and impede the open exchange of ideas.
- **Dynamic Nature of Science:** Science is an evolving field, and what may be considered accurate today might be revised in the future. Overly strict controls may hinder the dissemination of new, groundbreaking research and ideas.
- **Implementation Challenges:** Implementing effective controls is a challenging task, given the vastness of the internet. Determining what information is accurate and who gets to make such decisions raises practical and ethical challenges.
- **Diverse Perspectives:** Controlling information may lead to the suppression of diverse perspectives, hindering the free exchange of ideas and potentially stifling innovation and progress.

## **Conclusion**

Controlling scientific information on the internet is a nuanced and challenging task that requires a delicate balance between promoting accurate information and respecting freedom of expression. While there are clear benefits in preventing the spread of misinformation and protecting the public from harm, there are also significant limitations related to potential censorship, the dynamic nature of scientific knowledge, and the need to embrace diverse perspectives.

Efforts should focus on promoting digital literacy and critical thinking skills to empower individuals to evaluate the information they encounter. Rather than strict control, fostering a culture of open dialogue, transparency, and collaborative fact-checking can be more effective in combating misinformation while preserving the principles of free speech and the dynamic

nature of scientific inquiry. It's essential to strike a balance that protects the public interest without stifling the exchange of ideas that drive scientific progress and innovation.

### **Examiner report**

Some students produced excellent responses to this question, while others, unfortunately, did not answer the question stated in the prompt. Some students answered the question from the perspective of the advantages and disadvantages of sharing scientific information on the internet and did not address the key aspect of the benefits and limitations of controlling this scientific information.

The stronger responses referenced some interesting discussion points such as the dangers of misinformation vs. the problems of limiting free speech. Also, the question of who would decide what was correct or accurate, was raised repeatedly in student responses and this showed a good level of insight into the issues. Some students included an interesting discussion but did not end the response with a concluding statement.

### **Guidance**

Students should be advised to identify the main words in a question before tackling it in order not to go off-topic. Practice criterion D style assessments should have a specific context that the students have to respond to, as student responses are often too open-ended to show any engagement with the topic of debate.

One of the key areas that students struggle with on the 'discuss and evaluate' questions is the ability to come up with good arguments to support their answers. They should practise writing well-developed paragraphs that contain a main point with support and examples, connecting back to the issue being discussed. They should also practise writing concluding appraisals that encapsulate the points raised in their arguments.

# Markscheme

May 2024

Physics

On-screen examination

21 pages

This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

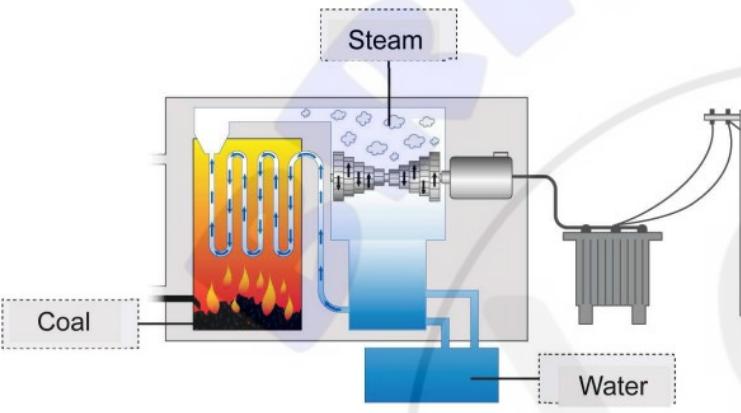
The following are the annotations available to use when marking responses.

Annotation	Explanation
	Correct point, place at the point in the response where it is clear that the candidate deserves the mark. For use in analytically marked questions only.
	Omission, incomplete
CON	Contradiction
	Valid part (to be used when more than one element is required to gain the mark)
	Error carried forward
	Dynamic annotation, it can be expanded to surround work
	Underline tool that can be expanded
	Highlight tool that can be expanded to mark an area of a response

Annotation	Explanation
	Not good enough
	The candidate has given a response but it is not worthy of any marks
	Text box used for additional marking comments
	Seen; must be stamped on all blank response areas and on duplicate pages of concatenated responses
	Vertical wavy line that can be expanded
	Words to that effect
	Award 1, 2, 3, 4 marks. For use in holistically marked questions only

## Markscheme instructions

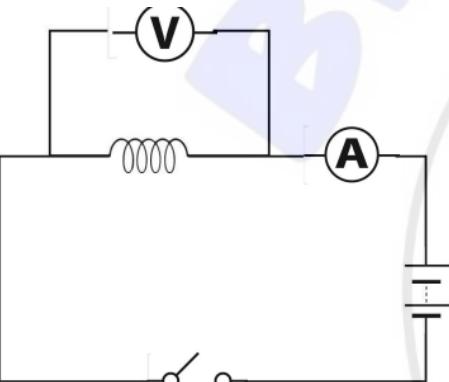
- 1 Mark positively. Give candidates credit for what they have achieved and what is correct. Do not deduct marks for incorrect responses. Do not deduct marks for spelling errors.
- 2 Follow the markscheme provided and award only whole marks.
- 3 Each marking point appears on a separate line.
- 4 The maximum mark for each subpart is indicated in the “Total” column.
- 5 Where a mark is awarded a tick should be placed in the text at the precise point where it is clear the candidate deserves the mark.
- 6 Each marking point in a question part should be awarded separately unless there is an instruction to the contrary in the Notes column.
- 7 A question subpart may have more marking points than the total allows. This will be indicated by the word “**max**” in the Answer column. Further guidance may be given in the Notes column.
- 8 Additional instructions on how to interpret the markscheme are in bold italic text in the Answer column.
- 9 Alternative wording may be indicated in the Answer column by a slash (/). Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 10 Alternative answers are indicated in the Answer column by “**or**”. Either alternative is equally acceptable but the candidate cannot be rewarded for both as they are associated with the same marking point.
- 11 If two related points are required to award a mark, this is indicated by “**and**” in the answer column.
- 12 Words in brackets ( ) in the Answer column are not necessary to gain the mark.
- 13 Words that are underlined are essential for the mark.
- 14 In some questions a reverse argument is also acceptable. This is indicated by the abbreviation *ORA* (*or reverse argument*) in the Notes column. Candidates should not be rewarded for reverse arguments unless *ORA* is given in the Notes column.
- 15 If the candidate’s response has the same meaning or is clearly equivalent to the expected answer the mark should be awarded. In some questions this is emphasized by the abbreviation *WTTE* (*or words to that effect*) in the Notes column.
- 16 When incorrect answers are used correctly in subsequent question parts the follow through rule applies. Award the mark and add ECF (error carried forward) to the candidate response.
- 17 The order of marking points does not have to be the same as in the Answer column unless stated otherwise.
- 18 Marks should not be awarded where there is a contradiction in an answer. Add CON to the candidate response at the point where the contradiction is made.
- 19 Do not penalize candidates for errors in units or significant figures unless there is specific guidance in the Notes column.
- 20 Questions with higher mark allocations will generally be assessed using a level response method using task specific clarifications developed with reference to the criteria level descriptors. A candidate’s work should be reviewed to determine holistically the mark for each row of the holistic grid and a mark awarded for each row.

Question	Answers	Notes	Total
1 a	 <p>All correct</p>		1 A
b	Molecules move faster	Accept move more, or vibrate more	1 A
c	<b>Accept any two points from the list [max 2]</b> <ul style="list-style-type: none"> <li>• speed of movement of particles does not increase</li> <li>• energy is being used to break bonds</li> <li>• energy is used to separate molecules/particles</li> <li>• potential energy of particles is increased</li> </ul>		2 A
d	$1.125 \times 10^{13} \text{ (J)}$ Rounded correctly to $1.1 \times 10^{13} \text{ (J)}$	Accept $11 \times 10^{12}$ or $11\text{TJ}$ <i>Award 2 marks for a correct answer rounded to 2 sf</i>	2 A
e	Recognition/application of efficiency formula $7476 \text{ MW}$ or $7.476 \times 10^9 \text{ W}$	<i>Seen/implied</i> <i>Award 2 marks to correct answers given with units of kW, W or MW to 2 or more significant figures.</i>	2 A

	<b>f</b>	Heat energy absorbed and re-emitted by greenhouse gases ▾	1	A
	<b>g</b>	<p><b>Relevant concept from thermal physics identified [max 1]</b></p> <ul style="list-style-type: none"> <li>• melting of ice</li> <li>• convection currents</li> <li>• evaporation</li> <li>• kinetic energy of molecules in atmosphere</li> </ul> <p><b>Link between increased temperature/heat and its influence on the process in marking point 1, for example [max 1]</b></p> <ul style="list-style-type: none"> <li>• increased heat in the atmosphere increases the rate of evaporation of water</li> </ul> <p><b>Connection to weather, for example [max 1]</b></p> <ul style="list-style-type: none"> <li>• movement of air masses across globe</li> <li>• more energy in storms</li> <li>• more water/precipitation to fall from atmosphere</li> <li>• flooding</li> <li>• drought</li> <li>• rising sea levels</li> </ul>	3	A

2	a	Protons = 92  Neutrons = 143		2	A
	b	<b>Any correct statements from the list [maximum two]</b> <ul style="list-style-type: none"> <li>• Protons <b>or</b> neutrons <b>or</b> protons and neutrons are divided (between the daughter nuclei)</li> <li>• The total number of protons in the daughter nuclei is the same as in U-235</li> <li>• Two free neutrons are released</li> <li>• Total number of neutrons and protons is the same after the reaction as before</li> </ul>		2	A
	c	One reaction causes another reaction to occur  The released neutrons cause other reactions	WTTE	2	A
	d	More reactions mean more energy is released <b>or</b> each reaction in a chain reaction releases energy <b>or</b> too much energy is released  Results in an atomic explosion <b>or</b> a nuclear melt down  Emission of radioactive material into the surrounding environment <b>or</b> Nuclear fallout <b>or</b> harmful effects of radiation on living things <b>or</b> effects of fire/explosion on the surrounding environment	Accept reference to heat in place of energy	3	A
	e	1400-1600 million years or 1.4 - 1.6 billion years		1	C
	f	<b>Comment about the risk of radioactive material [max 1]</b> <ul style="list-style-type: none"> <li>• radiation is harmful to human health/living things/cells</li> <li>• radiation causes environmental damage/problems to agriculture</li> </ul> <b>Comment about storage concerns [max 1]</b> <ul style="list-style-type: none"> <li>• needs to be stored safely for a long time</li> <li>• needs to be stored securely for a long time</li> <li>• stays radioactive for a long time</li> </ul>		2	D

3	a	How does the length of the wire affect the resistance of the wire?		1	B																																																							
	b	<p><b>If, Then:</b> hypothesis links length and resistance  <b>or</b>            hypothesis links length and brightness of the bulb</p> <p><b>Correctly linked explanatory points, for example [max 2]</b></p> <ul style="list-style-type: none"> <li>• current is a flow of electrons</li> <li>• electrons have to travel a further distance with more obstacles in the way</li> <li>• electrons collide with more ions as they pass through a longer wire</li> <li>• as <math>R=\rho L/A</math>, resistance is directly proportional to length</li> </ul>	<i>Does not have to be correct for mp 1</i>	3	B																																																							
	c	<p><b>Table Object</b></p> <table border="1"> <thead> <tr> <th></th> <th>Length / cm</th> <th>Material</th> <th>Cross-sectional area / mm<sup>2</sup></th> </tr> </thead> <tbody> <tr> <td><input checked="" type="checkbox"/></td> <td>40</td> <td>Silver</td> <td>2.5</td> </tr> <tr> <td><input checked="" type="checkbox"/></td> <td>60</td> <td>Silver</td> <td>2.5</td> </tr> <tr> <td><input checked="" type="checkbox"/></td> <td>80</td> <td>Silver</td> <td>2.5</td> </tr> <tr> <td><input type="checkbox"/></td> <td>100</td> <td>Copper</td> <td>1.0</td> </tr> <tr> <td><input type="checkbox"/></td> <td>100</td> <td>Silver</td> <td>1.5</td> </tr> <tr> <td><input type="checkbox"/></td> <td>100</td> <td>Copper</td> <td>2.0</td> </tr> <tr> <td><input type="checkbox"/></td> <td>100</td> <td>Aluminium</td> <td>2.5</td> </tr> <tr> <td><input type="checkbox"/></td> <td>100</td> <td>Copper</td> <td>2.5</td> </tr> <tr> <td><input type="checkbox"/></td> <td>100</td> <td>Gold</td> <td>2.5</td> </tr> <tr> <td><input type="checkbox"/></td> <td>100</td> <td>Nichrome</td> <td>2.5</td> </tr> <tr> <td><input checked="" type="checkbox"/></td> <td>100</td> <td>Silver</td> <td>2.5</td> </tr> <tr> <td><input type="checkbox"/></td> <td>100</td> <td>Copper</td> <td>3.0</td> </tr> <tr> <td><input checked="" type="checkbox"/></td> <td>120</td> <td>Silver</td> <td>2.5</td> </tr> </tbody> </table> <p>At least three of one material only, and no other material included</p> <p>At least three of one cross-sectional area only</p> <p>5 different lengths of 2.5 mm<sup>2</sup> cross-sectional area silver only</p>		Length / cm	Material	Cross-sectional area / mm <sup>2</sup>	<input checked="" type="checkbox"/>	40	Silver	2.5	<input checked="" type="checkbox"/>	60	Silver	2.5	<input checked="" type="checkbox"/>	80	Silver	2.5	<input type="checkbox"/>	100	Copper	1.0	<input type="checkbox"/>	100	Silver	1.5	<input type="checkbox"/>	100	Copper	2.0	<input type="checkbox"/>	100	Aluminium	2.5	<input type="checkbox"/>	100	Copper	2.5	<input type="checkbox"/>	100	Gold	2.5	<input type="checkbox"/>	100	Nichrome	2.5	<input checked="" type="checkbox"/>	100	Silver	2.5	<input type="checkbox"/>	100	Copper	3.0	<input checked="" type="checkbox"/>	120	Silver	2.5		3
	Length / cm	Material	Cross-sectional area / mm <sup>2</sup>																																																									
<input checked="" type="checkbox"/>	40	Silver	2.5																																																									
<input checked="" type="checkbox"/>	60	Silver	2.5																																																									
<input checked="" type="checkbox"/>	80	Silver	2.5																																																									
<input type="checkbox"/>	100	Copper	1.0																																																									
<input type="checkbox"/>	100	Silver	1.5																																																									
<input type="checkbox"/>	100	Copper	2.0																																																									
<input type="checkbox"/>	100	Aluminium	2.5																																																									
<input type="checkbox"/>	100	Copper	2.5																																																									
<input type="checkbox"/>	100	Gold	2.5																																																									
<input type="checkbox"/>	100	Nichrome	2.5																																																									
<input checked="" type="checkbox"/>	100	Silver	2.5																																																									
<input type="checkbox"/>	100	Copper	3.0																																																									
<input checked="" type="checkbox"/>	120	Silver	2.5																																																									

<b>d</b>	<p>Independent variable is length <b>or</b> the only variable that should change is length  <b>or</b>          Silver is the only material with five different lengths  <b>or</b>          Five data points are required for sufficient data            Material <b>and</b> cross-sectional area should be controlled</p>	WTTE		<b>2</b>	<b>B</b>
<b>e</b>	 <p>All correct</p>		<p>Switch and ammeter acceptable in either position</p>	<b>1</b>	<b>B</b>
<b>f</b>	<p>Evidence of using <math>R = V/I</math>            Correct answer: 6.25 or 6.3 (<math>\Omega</math>)</p>	<p>Seen or implied            Award 2 marks for a correct result</p>		<b>2</b>	<b>C</b>
<b>g</b>	<p>Data point plotted correctly (100, 6.3)            Line of best fit has data points above and below line and correctly models the data</p>		<p>On 100 on the x axis and between 6.2 and 6.4    <i>Proportional relationship, judge by eye, intercept at (0,0) not required to be seen</i></p>	<b>2</b>	<b>C</b>

	<p><b>h</b></p> <p><b>A suggestion of a reasonable source of error, for example [max 1]</b></p> <ul style="list-style-type: none"><li>• wires may heat up which changes the resistance/resistivity of wire.</li><li>• voltage and current readings may fluctuate</li><li>• voltmeter or ammeter may be inaccurate</li><li>• measurement of length was inaccurate</li><li>• clipping on probes/leads of voltmeter and ammeter may not be at exact length</li><li>• diameter of wire may not be consistent throughout wire length</li></ul> <p><b>A correctly linked comment about the effect on resistance [max 1]</b></p> <ul style="list-style-type: none"><li>• resistance will increase (at increased temperature)</li><li>• calculated values of resistance will be inaccurate</li><li>• resistance will not be calculated for correct length</li><li>• calculated resistance will not be reliable</li></ul>	<p><i>Do not accept increase the number of trials</i></p> <p><i>Award second point for a comment correctly linked to MP1</i></p>	<p>2</p>	<p>C</p>
--	--	--	----------	----------

4	a	(The law of conservation of) <u>energy</u>		1	A
	b	Magnetic force drawn horizontally to the right (any length)  Normal force vertically up and weight force vertically down  Normal force and weight force are equal in magnitude <b>and</b> no additional forces added either horizontally or vertically	<i>Arrows must align with the center of the ball to be accepted</i>  <i>Arrows can be directed into the ball or away from the ball</i>  <i>Only award MP3 if MP2 has been awarded</i>	3	A
	c	Magnetic force increases as the ball approaches the magnet <b>or</b> magnetic field is stronger closer to the magnet  Acceleration increases		2	C
	d	A		1	A
	e	A reference to magnetic energy being released <b>or</b> changes in the magnetic field cause additional kinetic energy		1	C

4	f			11	B
---	---	--	--	----	---

	1 mark	2 marks	3 marks	4 marks	Notes
1.V	Identifies height as IV <b>or</b> maximum height as DV	Identifies initial height as IV <b>and</b> maximum height as DV	Identifies initial height as IV <b>and</b> maximum height as DV <b>and</b> one appropriate CV		<p><i>Only requirement is to state using the terminology of IV, DV and CV. No need to explain further.</i></p> <p><b>Accept</b> <math>h_1</math> and <math>h_2</math> in place of initial height and maximum height for IV and DV, maximum can be implied for the DV</p> <p><b>Accept</b> for CV – strength of magnet, angle of incline of plane, material/mass/size of balls</p> <p><b>Do not accept</b> “keeping equipment the same”, “type of balls”, “magnet”, “temperature”, “pressure”, “acceleration due to gravity” as a CV.</p>
2.H	Attempt at a hypothesis linked to height	Testable hypothesis linked to initial height <b>and</b> maximum height	Testable hypothesis linked to initial height <b>and</b> maximum height with an attempted explanation	Testable hypothesis linked to initial height <b>and</b> maximum height and with an explanation linking to the conservation of energy or conversion of kinetic energy or (gravitational) potential energy	<p><b>Accept</b> a scientific explanation that correctly uses conservation of momentum to explain the hypothesis</p> <p>The hypothesis does not need to be correct to receive credit but full credit can only be awarded to logical answers based on scientific reasoning</p>
3.M	Attempt at a method linked to the collision between the balls	Method to change initial height and measure final height is outlined but is not detailed enough to be followed by another student	Complete method is described with measurements of initial height and maximum height, detailed enough to be followed by another student		<p>A method that does not include how to vary the IV is incomplete.</p> <p>Details on the number of trials and number of increments is not needed to award full credit</p>

4.S	Mentions a relevant precaution linked to a specific hazard			<p><b>Do not accept:</b> general considerations not linked to the specific investigation, e.g. wear a mask, tie hair back</p> <p><b>Do not accept:</b> handle magnets carefully as this is not linked to a hazard, wear gloves unless this is linked to prevention of trapping fingers etc</p> <p><b>Accept:</b> taking care not to trap fingers between the colliding balls/magnets</p> <p>Precautions regarding heavy balls rolling off the table onto feet/other objects</p>
-----	--	--	--	---

4	g	<p>Column headers for initial height and maximum exiting height including units</p> <p>Values for five increments of initial height shown</p> <p>Spaces for at least three trials of maximum height</p> <p>Column for average or mean maximum height</p> <table border="1"> <thead> <tr> <th>Initial Height of Ball / cm</th><th>Trial One Max Height / cm</th><th>Trial Two Max Height / cm</th><th>Trial Three Max Height / cm</th><th>Average Max Height of exiting ball / cm</th></tr> </thead> <tbody> <tr><td>5</td><td></td><td></td><td></td><td></td></tr> <tr><td>10</td><td></td><td></td><td></td><td></td></tr> <tr><td>15</td><td></td><td></td><td></td><td></td></tr> <tr><td>20</td><td></td><td></td><td></td><td></td></tr> <tr><td>25</td><td></td><td></td><td></td><td></td></tr> </tbody> </table>	Initial Height of Ball / cm	Trial One Max Height / cm	Trial Two Max Height / cm	Trial Three Max Height / cm	Average Max Height of exiting ball / cm	5					10					15					20					25					<p><i>Award marks for arrangement in columns or rows</i></p> <p><i>Values should be realistic, do not award MP2 if units in the column are repeated</i></p>	4	C
Initial Height of Ball / cm	Trial One Max Height / cm	Trial Two Max Height / cm	Trial Three Max Height / cm	Average Max Height of exiting ball / cm																															
5																																			
10																																			
15																																			
20																																			
25																																			

5	a	1.87 (s)		1	c
	b	$s = \frac{1}{2}at^2$ seen or implied 0.11(07266436) $m\ s^{-2}$ or $m/s^2$ <i>or</i> 11(.07266436) $cm\ s^{-2}$ or $cm/s^2$		3	c d
	c	Mass	<i>Do not accept weight</i>	1	c
	d	<input type="button" value="D"/>		1	b
	e	<b>Accept any 2 statements from the list [max 2]</b> <ul style="list-style-type: none"> <li>• The line of best fit does not go through the origin</li> <li>• The line of best fit intercepts the x axis at 4A or there is no force when the current is 4A</li> <li>• The line of best fit intercepts the y axis at -2.7mN</li> <li>• Force is negative and positive</li> </ul> <i>or</i> candidate uses 2 specific data points (to show that) doubling the current does not double the force <i>or</i> candidate uses 2 specific data points (to show that) F divided by I is not constant		2	c

	<b>f</b>	The rod will not move <b>or</b> The rod will not accelerate  (because) there is no (net) force <b>or</b> (because) the force is not strong enough (to overcome friction)		2	<b>c</b>
	<b>g</b>	2.6 - 2.8 (mN)	<i>Accept a negative value for friction</i>	1	<b>c</b>

6	<p><b>a</b> (White light is) made up of different frequencies  <b>or</b>          (White light is) made up of different wavelengths          (different frequencies/wavelengths) <u>refract</u> by different amounts  <b>or</b>          (different frequencies/wavelengths) have different <u>refractive indices</u>  <b>or</b>          (white light is) <u>dispersed</u></p>		2	D
<b>b</b>	 <p>All labels in correct location</p>		1	D
	<p><b>c</b> 3</p>		1	D
	<p><b>d</b> Galaxies moving away  <b>or</b>          A reference to red shift  <b>or</b>          Increased wavelength/decreased frequency of light emitted from galaxies</p>	<i>Accept reference to stars instead of galaxies</i>	1	D

	e	A reference to the atmosphere or air on Earth <b>or</b> In space the telescope is in vacuum  <b><i>A specific effect caused by the atmosphere, for example [max 1]</i></b> <ul style="list-style-type: none"><li>• scattering</li><li>• refraction</li><li>• light pollution</li><li>• weather conditions</li><li>• absorption</li></ul>	<i>Do not accept references to being closer to space</i>	2	D
--	---	--	--	---	---

7	a	13	D
---	---	----	---

<b>The scientific challenges of launching a telescope into space</b>			
<b>Mark</b>	<b>Descriptor</b>	<b>Notes</b>	
1	A statement	<p><b>The main themes to explore are:</b></p> <ol style="list-style-type: none"> <li>1. Requires great technological innovations, extensive testing to ensure it can work remotely</li> <li>2. Issues due to location / distance from Earth, including communication issues and the danger of impact with other objects in space</li> <li>3. Thermal issues</li> <li>4. Deployment issues, including coordinating the launching process and navigating to the required location</li> </ol>	
2	A statement with further support <i>or</i> Two statements	<p><b>Examples of statements</b></p> <ul style="list-style-type: none"> <li>• repair of space telescopes is challenging</li> <li>• a large diameter mirror requires advanced scientific innovation</li> <li>• harsh conditions in space. Nothing to protect the telescope from extreme high and low temperatures</li> <li>• once in deep space, the telescope must operate autonomously for long periods</li> <li>• the launching process is complex and requires precise calculations and coordination</li> </ul>	
3	Two statements with further support for one	<p><b>Examples of scientific support</b></p> <ul style="list-style-type: none"> <li>• the JWST's remote location at L2 (from video) could not be physically repaired (maintenance)</li> <li>• folding and unfolding mechanisms for 18 hexagonal mirrors would need to be created to fit into the rocket. (OR reference to precision alignment of mirror segments)</li> <li>• metal parts of the telescope can fuse together due to temperatures causing cracks and damage to the telescope</li> <li>• during testing, simulated conditions must include complexities such as vacuums, intense vibrations, extremely loud sounds, dense dust, extreme temperatures</li> <li>• autonomous communication links with earth are difficult to establish since ... the position of the satellite relative to the earth will be changing ... obstacles may block communication lines, time lags of signals due to long distances.</li> </ul>	
4	Two statements with further support for both		

The social or cultural implications of observations made with telescopes		
Mark	Descriptor	Notes
1	A statement	<p><b>The main themes to explore are</b></p> <ul style="list-style-type: none"> <li>1. Expanding human knowledge</li> <li>2. Religion / philosophical</li> <li>3. Artistic / literary creativity</li> <li>4. Collaboration internationally</li> </ul> <p><b>Examples of social or cultural implications</b></p> <ul style="list-style-type: none"> <li>• it can expand our understanding of the universe</li> <li>• it can improve international collaboration</li> <li>• images observed will contribute to humanity's collective cultural heritage...</li> <li>• artists can draw inspiration from these images to create pieces that depict the mystery and beauty of the universe</li> <li>• observations may go against or support certain religious beliefs or conspiracy theories.</li> <li>• it can stimulate interest in science amongst a new generation of young people</li> </ul>
2	A statement with further support <i>or</i> Two statements	
3	Two statements with further support for one	<p><b>Examples of support</b></p> <ul style="list-style-type: none"> <li>• by observing the formation of stars and galaxies in closer detail (with infrared sensors), we will be able expand our knowledge of cosmic evolution</li> <li>• space telescopes can involve collaboration between countries (as with the JWST), which would lead to greater unity amongst nations</li> <li>• deep space images have been incorporated in artwork displayed in museums, clothing designs and tattoos</li> <li>• images from space telescopes can be used in church or religious groups to portray the wonders of God or support beliefs that there is extra – terrestrial life</li> </ul>

The economic implications of spending government funds on a space telescope		
Mark	Descriptor	Notes
1	A statement	<p><b>The main themes to explore are</b></p> <ol style="list-style-type: none"> <li>1. High costs / budget</li> <li>2. Economic growth due to tech advancement, industry innovation, or scientific discoveries</li> </ol> <p><b>Examples of economic implication</b></p> <ul style="list-style-type: none"> <li>• a large government investment for a space telescope</li> <li>• the development of a space telescope would lead to new tech or industrial innovations helping society</li> </ul>
2	A statement with further support <i>or</i> Two statements	
3	Two statements with further support for one	<p><b>Examples of support (do not need to be linked to the JWST directly)</b></p> <ul style="list-style-type: none"> <li>• space telescopes require nations to budget carefully. These funds could be used for other services such as healthcare and education</li> <li>• advancement in materials, optics, and other engineering solutions (such as folding mirrors) could lead to other innovations and applications enhancing the economy</li> <li>• the budget of the JWST does not seem high when it is placed alongside the annual budget of the US military (750 billion) and this money was spent over the many years of the project</li> <li>• countries that develop space telescopes can attract the best and brightest scientists to work for them, some of these scientists will relocate from overseas</li> </ul>
4	Two statements with further support for both	

<b>A concluding appraisal giving your opinion on the impact of the JWST</b>		
<b>Mark</b>	<b>Descriptor</b>	<b>Notes</b>
1	A simple conclusion	<p><b>Characteristics of a simple conclusion</b></p> <ul style="list-style-type: none"> <li>the candidate writes a statement saying they are in support/against JWST in simple terms without an attempt to balance the positive and negative aspects which are evident</li> </ul>
2	A concluding appraisal with reference to issues raised	<p><b>Characteristics of an appraisal</b></p> <ul style="list-style-type: none"> <li>the candidate recognises the fact that there are positive and negative aspects to the impact of the JWST but makes a case for why they are in support/against the development by weighing up both sides</li> </ul>

7	b	<p><b>Accept any two reasonable benefits, for example [max 2]</b></p> <ul style="list-style-type: none"> <li>planetary data that was not available previously</li> <li>picks up wavelengths specific to biomolecules</li> </ul> <p><b>Accept any two reasonable limitations, for example [max 2]</b></p> <ul style="list-style-type: none"> <li>technique is limited in scope – can only be used for planets around small number of stars</li> <li>no direct evidence of existence of alien life</li> <li>cannot be sure if molecules were formed biologically or geologically</li> </ul> <p>A simple conclusion</p> <p>Conclusion is linked to benefits and limitations</p>	WTTE	6	D
---	---	--	------	---	---