

# Markscheme

November 2016

Physics

Standard level

Paper 2

17 pages

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## General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through RM™ Assessor, by e-mail or telephone – if through RM™ Assessor or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through RM™ Assessor or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of RM™ Assessor, please contact [emarking@ibo.org](mailto:emarking@ibo.org).

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.
2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.
3. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**
4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate. Please do not allow these annotations to obscure the written material. Try to keep these to the margin of the scan as far as possible. (Ticks should however be at the point of award, cf 4.)
5. Personal codes/notations are unacceptable.
6. Where an answer to a part question is worth no marks but the candidate has attempted the part question, use the “ZERO” annotation to award zero marks. Where a candidate has not attempted the part question, use the “SEEN” annotation to show you have looked at the question. RM™ Assessor will apply “NR” once you click complete.
7. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp “SEEN” on any additional pages that contain work not related to the QIG you are currently marking, or are blank or where the candidate has crossed out his/her work.
8. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

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

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

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

Question		Answers	Notes	Total	
1.	a	<p>determines component correctly / <math>15 \sin 50</math> seen ✓</p> $s = \left\langle \frac{(15 \sin 50)^2}{2 \times 9.81} \right\rangle \Rightarrow 6.7 \text{ «m» } \checkmark$ <p>correct reasoning consistent with candidate data ✓</p>	<p>Allow method via <math>v = u + at</math>. Allow use of <math>g = 10 \text{ ms}^{-2}</math>, gives 6.6 m and 8.1 m.</p> <p>Allow <b>[2 max]</b> for use of <math>15 \cos 50</math>, gives 4.7 m and 6.2 m.</p> <p>Allow <b>[1 max]</b> (as MP2) if 13 m is obtained due to use of <math>15 \text{ ms}^{-1}</math> rather than <math>15 \sin</math> <b>or</b> <math>15 \cos 50</math>.</p> <p>If no unit given, assume metre.</p>	3	
	b	i	$F = \left\langle \frac{(0.058 \times 15)}{0.023} \right\rangle \Rightarrow 38 \text{ «N» OR } 37.8 \text{ «N» } \checkmark$	<p>Do not penalise sf here. Working not required.</p>	1
	b	ii	<p>force of ball on racket is equal to force of racket on ball <b>or</b> is 38 N ✓</p> <p>ball exerts force in opposite direction to force of racket on ball ✓</p>	<p>Do not accept "same force".</p> <p>Allow ECF from force value in bi</p> <p>Accept "opposite force" for "in opposite direction".</p> <p>Do not accept undefined references to "reaction" the direction of the forces must be clear.</p>	2

Question		Answers	Notes	Total	
2.	a	evidence that area under graph used <b>OR</b> use of mean velocity $\times$ time $\checkmark$  $\llcorner \frac{29.8 \times 2}{17.5} \llcorner = 3.41 \llcorner \text{ms}^{-1} \llcorner \checkmark$	Award <b>[2]</b> for a bald correct answer.   Award <b>[1]</b> for $1.70 \text{ms}^{-1}$ .	2	
	b	i	$\llcorner \text{deceleration} \llcorner = \frac{3.41}{14.0} \text{ OR } 0.243 \llcorner \text{ms}^{-2} \llcorner \checkmark$  $F = \llcorner 0.243 \times 20 = \llcorner 4.87 \llcorner \text{N} \llcorner \checkmark$	Award <b>[2]</b> for a bald correct answer. Award <b>[1 max]</b> for use of first 3.5 s. Allow ECF from 2(a). Ignore slight rounding errors	2
	b	ii	<b>ALTERNATIVE 1</b>  calculates KE using $\frac{1}{2}mv^2 \checkmark$  116 J $\checkmark$  <b>ALTERNATIVE 2</b>  calculates distance as 23.9 $\llcorner \text{m} \llcorner \checkmark$  $\llcorner 4.86 \times 23.90 \llcorner = 116 \text{J} \checkmark$	Allow ECF from (a).  Award <b>[2]</b> for a bald correct answer.  Allow ECF from (a).  Allow ECF from (a) and (b)(i) Award <b>[2]</b> for a bald correct answer. Award <b>[1 max]</b> for use of first 3.5 s Unit is required for MP2	2

Question		Answers	Notes	Total	
3.	a	mention of atoms/molecules/particles ✓  sum/total of kinetic energy and «mutual/intermolecular» potential energy ✓	Do not allow “kinetic energy and potential energy” bald.  Do not allow “sum of average ke and pe” unless clearly referring to total ensemble.	2	
	b	i	«intermolecular» potential energy/PE of an ideal gas is zero/negligible	1	
	b	ii	<p><b>THIS IS FOR USE WITH AN ENGLISH SCRIPT ONLY</b></p> use of $T = \frac{PV}{nR}$ <b>or</b> $T = \frac{1.4 \times 21}{0.46 \times 8.31}$ ✓  7.7 K ✓	Award mark for correct re-arrangement as shown here not for quotation of Data Booklet version.  Award [2] for a bald correct answer in K. Award [2 max] if correct 7.7 K seen followed by -265°C and mark BOD. However, if only -265°C seen, award [1 max].  Do not penalise use of “°K”	2
	b	ii	<p><b>THIS IS FOR USE WITH A SPANISH SCRIPT ONLY</b></p> $T = \frac{PV}{nR}$ ✓  $T = \frac{1.4 \times 2.1 \times 10^{-6}}{0.46 \times 8.31}$ ✓  $T = 7.7 \times 10^{-6} \text{ K}$ ✓	Award mark for correct re-arrangement as shown here not for quotation of Data Booklet version.  Uses correct unit conversion for volume  Award [2] for a bald correct answer in K. Finds solution. Allow an ECF from MP2 if unit not converted, ie candidate uses 21 m3 and obtains 7.7 K Do not penalise use of “°K”	2 max

Question			Answers	Notes	Total
	<b>b</b>	<b>iii</b>	models used to predict/hypothesize ✓ explain ✓ simulate ✓ simplify/approximate ✓	<i>Allow similar responses which have equivalent meanings. Response needs to identify <b>one</b> reason.</i>	<b>1 max</b>



Question		Answers	Notes	Total
4.	a	charge: -1 «e» <b>or</b> negative <b>or</b> $K^-$ ✓	Negative signs required.	1
	b	<p>correct symbols for both missing quarks ✓</p> <p>exchange particle and electron labelled W <b>or</b> <math>W^-</math> and e <b>or</b> <math>e^-</math> ✓</p>	Do not allow $W^+$ or $e^+$ or $\beta^+$ Allow $\beta$ or $\beta^-$	2

Question	Answers	Notes	Total
c	decay products include an electron that has mass <b>OR</b> products have energy that has a mass equivalent <b>OR</b> mass/mass defect/binding energy converted to mass/energy of decay products ✓  «so» mass C-14 > mass N-14 <b>OR</b> mass of $n$ > mass of $p$ <b>OR</b> mass of $d$ > mass of $u$ ✓	Accept reference to "lighter" and "heavier" in mass. Do not accept implied comparison, eg "C-14 has greater mass". Comparison must be explicit as stated in scheme.	2

Question			Answers	Notes	Total
5.	a	i	minima = destructive interference ✓  at minima waves meet $180^\circ$ <b>or</b> $\pi$ out of phase ✓	Allow "crest meets trough", but not "waves cancel". Allow "destructive superposition" but not bald "superposition".  Allow similar argument in terms of effective path difference of $\frac{\lambda}{2}$ .  Allow "antiphase", allow "completely out of phase" Do not allow "out of phase" without angle.  Do not allow $\frac{n\lambda}{2}$ unless qualified to odd integers  but accept $(n + \frac{1}{2})\lambda$	2
	a	ii	$\lambda = \frac{sd}{D}$ <b>or</b> $\lambda = \frac{12 \times 2 \times 7.2}{54} =$ <b>or</b> $\lambda = \frac{12 \times 7.2}{54} =$ seen ✓  $\lambda = \left\langle \frac{12 \times 2 \times 7.2}{54} \right\rangle = 3.2$ «cm» ✓	Award [2] for a bald correct answer.  Award [1 max] for 1.6 «cm»  Award [2 max] to a trigonometric solution in which candidate works out individual path lengths and equates to $\frac{\lambda}{2}$ .	2

Question	Answers	Notes	Total
<p><b>b</b></p>	<p><b>ALTERNATIVE 1</b></p> <p>the component of the polarized signal in the direction of the receiving antenna ✓</p> <p>is a maximum «when both are parallel» ✓</p> <p><b>ALTERNATIVE 2</b></p> <p>receiving antenna must be parallel to plane of polarisation ✓ for power/intensity to be maximum ✓</p> <p><b>ALTERNATIVE 3</b></p> <p>refers to Malus' law <b>or</b> <math>I = I_0 \cos^2 \theta</math> ✓</p> <p>explains that <math>I</math> is max when <math>\theta = 0</math> ✓</p> <p><b>ALTERNATIVE 4</b></p> <p>an electric current is established in the receiving antenna which is proportional to the electric field ✓</p> <p>maximum current in receiving antenna requires maximum field «and so must be parallel» ✓</p>	<p><i>Do not accept "receiving antenna must be parallel to transmitting antenna"</i></p>	<p><b>2</b></p>

Question			Answers	Notes	Total
	<b>c</b>	<b>i</b>	$I_0 = \frac{I}{\cos^2 \theta} \text{ or } \frac{12}{\cos^2 30} \text{ seen } \checkmark$ $1.6 \times 10^{-5} \text{ «W» } \checkmark$	<p>Award <b>[2]</b> for bald correct answer.</p> <p>Award <b>[1 max]</b> for MP1 if <math>9 \times 10^{-6} \text{ W}</math> is the final answer (<math>I</math> and <math>I_0</math> reversed).</p> <p>Award <b>[1 max]</b> if cos not squared (<math>14 \mu\text{W}</math>).</p> <p>Units not required but if absent assume W.</p>	<b>2</b>
	<b>c</b>	<b>ii</b>	$1.9 \times 10^{-4} \text{ «s» } \checkmark$		<b>1</b>

<b>6.</b>	<b>a</b>	<b>i</b>	«gravitational» force per unit mass on a «small or test» mass $\checkmark$		<b>1</b>
	<b>a</b>	<b>ii</b>	$\text{N kg}^{-1} \checkmark$	<p>Award mark if <math>\text{N kg}^{-1}</math> is seen, treating any further work as neutral.</p> <p>Do not accept bald <math>\text{m s}^{-2}</math></p>	<b>1</b>

Question		Answers	Notes	Total
	<b>b</b> <b>i</b>	<p>clear evidence that <math>v</math> in <math>v^2 = \frac{4\pi^2 R^2}{T^2}</math> is equated to orbital speed <math>\sqrt{\frac{GM}{R}}</math></p> <p><b>OR</b></p> <p>clear evidence that centripetal force is equated to gravitational force</p> <p><b>OR</b></p> <p>clear evidence that <math>a</math> in <math>a = \frac{v^2}{R}</math> etc is equated to <math>g</math> in <math>g = \frac{GM}{R^2}</math> with consistent use of symbols ✓</p> <p>substitutes and re-arranges to obtain result ✓</p> $\left\langle T = \sqrt{\frac{4\pi^2 R}{\left(\frac{GM}{R^2}\right)}} = \sqrt{\frac{4\pi^2 R^3}{GM}} \right\rangle$	<p>Minimum is a statement that <math>\sqrt{\frac{GM}{R}}</math> is the orbital speed which is then used in <math>v = \frac{2\pi R}{T}</math></p> <p>Minimum is <math>F_c = F_g</math> ignore any signs.</p> <p>Minimum is <math>g = a</math>.</p> <p>Allow any legitimate method not identified here. Do not allow spurious methods involving equations of shm etc</p>	<b>2</b>

Question		Answers	Notes	Total
	<b>b</b> <b>ii</b>	<p>« <math>T = 365 \times 24 \times 60 \times 60 = 3.15 \times 10^7 \text{ s}</math> »</p> $M = \left\langle \frac{4\pi^2 R^3}{GT^2} \right\rangle = \frac{4 \times 3.14^2 \times (1.5 \times 10^{11})^3}{6.67 \times 10^{-11} \times (3.15 \times 10^7)^2} \checkmark$ <p><math>2 \times 10^{30}</math> «kg» ✓</p>	<p>Allow use of <math>3.16 \times 10^7 \text{ s}</math> for year length (quoted elsewhere in paper).</p> <p>Condone error in power of ten in MP1.</p> <p>Award <b>[1 max]</b> if incorrect time used (24 h is sometimes seen, leading to <math>2.66 \times 10^{35} \text{ kg}</math>).</p> <p>Units are not required, but if not given assume kg and mark POT accordingly if power wrong.</p> <p>Award <b>[2]</b> for a bald correct answer.</p> <p>No sf penalty here.</p>	<b>2</b>

Question			Answers	Notes	Total
7.	a	i	$R_T$ decreases with increasing $I$ <b>OR</b> $R_T$ and $I$ are negatively correlated ✓	Must see reference to direction of change of current in first alternative.  Do not allow "inverse proportionality".  May be worth noting any marks on graph relating to 7bii.	1
	a	ii	at 0.4 A: $V_R > V_T$ <b>or</b> $V_R = 5.6$ V and $V_T = 5.3$ V ✓  so $R_R > R_T$ because $V = IR / V \propto R$ «and $I$ same for both» ✓	Award <b>[0]</b> for a bald correct answer without deduction or with incorrect reasoning. Ignore any references to graph gradients.  Both elements must be present for MP2 to be awarded.	2
	b	i	decreases <b>OR</b> becomes zero at X ✓		1
	b	ii	realization that $V$ is the same for R and T <b>OR</b> identifies that currents are 0.14 A and 0.06 A ✓  $V = 2$ V OR 2.0 V ✓	Award <b>[0]</b> if pds 2.8 V and 3.7 V or 1.4 V and 2.6 V are used in any way. Otherwise award <b>[1 max]</b> for a bald correct answer. Explanation expected.	2



Question		Answers	Notes	Total
8.	a	$\llcorner 55.5 \times 14.6 \times 0.59 \gg = 4.78 \times 10^8 \text{ W} \checkmark$	<i>A unit is required for this mark. Allow use of <math>\text{J s}^{-1}</math>. No sf penalty.</i>	1
	b	$\llcorner 14.6 \times 2.75 \times 3.16 \times 10^7 = \gg 1.27 \times 10^9 \llcorner \text{kg} \gg \checkmark$	<i>If no unit assume kg.</i>	1
	c	CO <sub>2</sub> linked to greenhouse gas OR greenhouse effect $\checkmark$  leading to $\llcorner$ enhanced $\gg$ global warming <b>OR</b> climate change <b>OR</b> other reasonable climatic effect $\checkmark$		2
	d	internal energy of steam/particles OR KE of steam/particles $\checkmark$  $\llcorner$ transfers to $\gg$ KE of turbine $\checkmark$  $\llcorner$ transfers to $\gg$ KE of generator <b>or</b> dynamo $\llcorner$ producing electrical energy $\gg$ $\checkmark$	<i>Do not award mark for first and last energies as they are given in the question. Do not allow "gas" for "steam".  Do not accept reference to moving OR turning generator.</i>	2 max