

# Markscheme

**May 2022**

**Physics**

**Standard level**

**Paper 2**

14 pages

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### 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	direction of motion is different / <b>OWTTE</b> ✓ $mv$ / magnitude of momentum is different «even though $v$ the same» ✓		2
1.	b	use of $ma=mg-T$ « $3.5 \times 2.4 = 3.5g - T$ » <b>OR</b> $T = 3.5(g-2.4)$ ✓ 26 «N» ✓	Accept 27 N from $g = 10 \text{ m s}^{-2}$	2

Question			Answers	Notes	Total
1.	c	i	proper use of kinematic equation ✓ $\sqrt{(2 \times 2.4 \times 0.95)} = 2.14 \text{ «m s}^{-1}\text{»}$ ✓	Must see either the substituted values <b>OR</b> a value for $v$ to at least three s.f. for <b>MP2.</b>	2
1.	c	ii	use of $\omega = \frac{v}{r}$ to give 84 «rad s <sup>-1</sup> » <b>OR</b> $\omega = 2.1 / 0.025$ to give 84 «rad s <sup>-1</sup> » ✓ quoted to 2sf only ✓.		2

Question		Answers	Notes	Total
1.	d	<p><b>ALTERNATIVE 1</b>                      «<math>v^2 = u^2 + 2as \Rightarrow 0 = 2.1^2 - 2a \times 0.35</math>» leading to <math>a = 6.3</math> «m s<sup>-2</sup>»  <b>OR</b>                      «<math>x = 1/2(u+v)t</math>» leading to <math>t = 0.33</math> « s » ✓</p> <p><math>F_{net} =</math> « <math>ma = 1.5 \times 6.3 =</math> » <math>9.45</math> «N» ✓                      Weight down ramp = <math>1.5 \times 9.8 \times \sin(30) = 7.4</math> «N» ✓                      friction force = net force – weight down ramp = <math>2.1</math> «N» ✓</p> <p><b>ALTERNATIVE 2</b>                      kinetic energy initial = work done to stop <math>0.5 \times 1.5 \times (2.1)^2 = F_{NET} \times 0.35</math> ✓  <math>F_{net} = 9.45</math> «N» ✓                      Weight down ramp = <math>1.5 \times 9.8 \times \sin(30) = 7.4</math> «N» ✓                      friction force = net force – weight down ramp = <math>2.1</math> «N» ✓</p>	<p>Accept <math>1.95</math> N from <math>g = 10</math> m s<sup>-2</sup>.                      Accept <math>2.42</math> N from <math>u = 2.14</math> ms<sup>-1</sup>.</p>	4
1.	e	<p>static coefficient of friction &gt; dynamic/kinetic coefficient of friction / <math>\mu_s &gt; \mu_k</math> ✓</p> <p>«therefore» force of dynamic/kinetic friction will be less than the force of static friction ✓</p> <p>there will be a net / unbalanced forward force once in motion «which results in acceleration»</p> <p><b>OR</b></p> <p>reference to net <math>F = ma</math> ✓</p>		3

Question		Answers	Notes	Total
2.	a	energy required for milk entering in 1 s = mass x specific heat x 73 ✓ 16 kW <b>OR</b> 16000 W ✓	<b>MP1</b> is for substitution into $mc\Delta T$ regardless of power of ten.  Allow any correct unit of power (such as $\text{Js}^{-1}$ <b>OR</b> $\text{kJ}\text{s}^{-1}$ ) if paired with an answer to the correct power of 10 for <b>MP2</b> .	2
2.	b	Underestimate / more energy or power required ✓  because energy transferred as heat / thermal energy is lost «to surroundings or electrical components» ✓	Do not allow general term “energy” or “power” for <b>MP2</b> .	2
2.	c	the temperature has increased so the internal energy / « average » KE «of the molecules» has increased <b>OR</b> temperature is proportional to average KE «of the molecules». ✓  «therefore» the «average» speed of the molecules or particles is higher <b>OR</b> more frequent collisions « between molecules » <b>OR</b> spacing between molecules has increased <b>OR</b> average force of collisions is higher <b>OR</b> intermolecular forces are less <b>OR</b> intermolecular bonds break and reform at a higher rate <b>OR</b> molecules are vibrating faster. ✓		2

Question			Answers	Notes	Total
2.	d	i	conduction/conducting/conductor «through metal» ✓		1
2	d	ii	use of $P = e\sigma AT^4$ where $T = 357 \text{ K}$ ✓ use of $A = 2\pi r l$ « = 0.236 m <sup>2</sup> » ✓ $P = 87$ «W» ✓	Allow 85 – 89 W for <b>MP3</b> . Allow <b>ECF</b> for <b>MP3</b> .	3
2	d	iii	convection «is likely to be a significant loss» ✓ «due to reduction in density of air near pipe surface» hot air rises «and is replaced by cooler air from elsewhere » <b>OR</b> «due to» conduction «of heat or thermal energy» from pipe to air ✓		2



Question		Answers	Notes	Total
3.	a	<p>movement of B means that path distance is different « between BM and AM »  <b>OR</b>                      movement of B creates a path difference «between BM and AM» ✓</p> <p>interference  <b>OR</b>                      superposition «of waves» ✓</p> <p>maximum when waves arrive in phase / path difference = <math>n \times \lambda</math>  <b>OR</b>                      minimum when waves arrive «<math>180^\circ</math> or <math>\pi</math> » out of phase / path difference = <math>(n + \frac{1}{2}) \times \lambda</math> ✓</p>		3
3.	b	<p>wavelength = 26 cm ✓</p> <p>peak to peak distance is the path difference which is one wavelength</p> <p><b>OR</b></p> <p>this is the distance B moves to be back in phase «with A» ✓</p>	Allow 25 – 27 cm for <b>MP1</b> .	2

Question		Answers	Notes	Total
3.	c	$\llcorner \frac{\lambda}{2} \llcorner = 13 \text{ cm } \checkmark$ $f = \llcorner \frac{c}{\lambda} = \frac{340}{0.13} \Rightarrow 2.6 \llcorner \text{kHz} \llcorner \checkmark$	<p><i>Allow ½ of wavelength from (b) or data from graph.</i></p>	2

Question		Answers	Notes	Total
4	a	<p><b>ALTERNATIVE 1</b></p> <p>attempt to use potential divider equation or similar method ✓</p> $\llcorner 6.0 \times \frac{40}{(40 + 60)} \gg = 2.4 \llcorner V \gg \checkmark$ <p><b>ALTERNATIVE 2</b></p> $\llcorner \text{current} = \frac{6}{60 + 40} \gg = 0.06 \llcorner A \gg \checkmark$ $40 \times 0.06 = 2.4 \llcorner V \gg \checkmark$		2

Question			Answers	Notes	Total
4.	b		<p><b>ALTERNATIVE 1</b></p> <p>pd across Q = 2.4 V so <math>I = 0.15</math> « A » ✓</p> <p>and pd across S is <math>6.0 - 2.4 = 3.6</math> « V » ✓</p> $R = \frac{V}{I} = \frac{3.6}{0.15} = 24$ «Ω» ✓ <p><b>ALTERNATIVE 2</b></p> <p>pd at PR junction = pd at QS junction ✓</p> <p>so <math>\frac{S}{Q} = \frac{R}{P}</math> <b>OR</b> <math>S = \frac{16 \times 60}{40}</math> ✓</p> <p>24 «Ω» ✓</p> <p><b>ALTERNATIVE 3</b></p> $I = \frac{40 \times 0.06}{16} = 0.15$ «A» ✓ $6.0 = (16+S)(0.15)$ <b>OR</b> $2.4 = (6)(\frac{16}{S+16})$ ✓ <p><math>R = 24</math> «Ω» ✓</p>	<p>Allow <b>ECF</b> for <b>MP3</b> from incorrect <b>MP1</b> or <b>MP2</b>.</p>	3
4.	c	i	<p>recognition that <math>4L</math> leads to <math>4R / \ll \frac{\rho 4L}{A} \gg = 4R</math> ✓</p> <p>«because the volume of S is constant new area is» <math>\frac{A}{4}</math> ✓</p> <p><math>16 \times 24 = 384</math> «Ω» ✓</p>		3

Question			Answers	Notes	Total
4.	c	ii	<p>«total» power has decreased ✓</p> <p>Because current in the branch has decreased «and <math>P=I^2R</math> »</p> <p><b>OR</b></p> <p>Because resistance has increased in branch «and <math>P = \frac{V^2}{R}</math> » ✓</p>	<p>Allow opposite argument as <b>ECF</b> from <b>(c)(i)</b> (if candidate deduces a lower resistance).</p> <p>Allow “power doesn’t change” if candidate has no change of resistance from <b>(b)</b> to <b>(c)(i)</b>.</p>	2

Question		Answers	Notes	Total
5.	a	<p>3 quarks / example with three quarks «eg up up down» ✓</p> <p>integer / zero / 1 / no fractional «electron» charge  <b>OR</b>                      held together by the strong force / gluons  <b>OR</b>                      half integer spin  <b>OR</b>                      baryon number = 1  <b>OR</b>                      colour neutral ✓</p>		2
5.	b	<p>A «Decay of the strange antiquark is a» weak «interaction» ✓</p> <p>B «Decay of the u to a gluon and eventually to d and anti-d is a» strong «interaction» ✓</p>		2
5.	c	<p>weak «interaction» ✓</p> <p>strangeness is not conserved and this is possible only in weak interactions  <b>OR</b>                      the weak interaction allows change of quark flavour  <b>OR</b>                      only the weak interaction has a boson / an exchange particle / a <math>W^+</math> to conserve the charge  <b>OR</b>                      neutrinos are only produced via the weak interaction ✓</p>		2