AQA

AS
Physics

PHYA2 – Mechanics, Materials and Waves
Mark scheme

2450
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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Question	Answers	Additional Comments/Guidance	Mark	ID details
1 (a) (i)	$t = \sqrt{\frac{2s}{g}}$ (evidence for correct rearrangement or substitution) ✓ $(= \sqrt{\frac{2 \times 57}{9.81}})$ answer given to 3 or more sf = 3.41 (s) or substitution $\sqrt{\frac{2 \times 57}{9.81}}$ shown to give 3.4 (s) ✓		2	
1 (a) (ii)	$\left(v = \frac{s}{t} = \frac{130}{3.41}\right)$ = **38** (m s^{-1}) ✓ 2 sf ✓		2	
1 (a) (iii)	(Use equation $v = u + at$) = 0 + 9.81 × 3.41 ✓ = **33** (m s^{-1}) ✓ (33.45 ms^{-1})	Alternative equations of motion may be used. If t = 3.4 s is used the answer becomes **34** m s^{-1}	2	
1 (a)(iv)	$v = \sqrt{(38^2 + 33^2)}$ (or correct scale drawing) ✓ = 50 or 51 (m s^{-1}) ✓ (allow CE from (ii) and (iii)) [for scale drawing allow range 47 → 53] tan θ = $\frac{33}{38}$ ✓ (or θ indicated correctly on a scale drawing) angle θ measured from the horizontal = 41 ° ✓ [for scale drawing allow range 39 → 43]	The angle relative position can be taken from a sketch diagram but the resultant velocity must point in the correct direction (right and down) to allow this.	4	
1 (b) (i)	(= mgh = 19 × 9.81 × 57) = 1.1 × 10^4 (J) ✓ (10.6 kJ)		1	
1 (b) (ii)	(G)PE → KE ✓ (KE to) internal/thermal/'heat' (energy) ✓		2	

Total			**13**

Question	Answers	Additional Comments/Guidance	Mark	ID details
2 (a)	(sum of) clockwise moment**s** =(sum of) anticlockwise moment**s** ✓ about a point (for a system) in equilibrium ✓ accept *balanced* not *stationary*		2	
2 (b)	(825 × 0.39) = 320 (Nm) ✓ (321.75 N) (anticlockwise) **Nm** ✓ or newton metre(s) accept Newton metre(s) (not J, nm or nM, Nms, etc)		2	
2 (c)	F_A × 1.4 ✓ = 825 × 0.39 + 1200 × 0.50 or (b) + 1200 × 0.50 ✓ (= 922) First two marks can come from a single rearranged equation F_A (= 922 / 1.4) = 660 N ✓ (658 N) 2 sf only ✓ standalone mark		4	
2 (d)	(825 +1200 – 660) = 1400 N ✓ (1365 N) allow CE from (c)		1	
2 (e)	$\left(F = \frac{P}{v}\right) = \frac{9.5\,(\times 10^3)}{32}$ ✓ must be arranged in this form = 300 (N) ✓ (297 N)		2	

Total			**11**

Question	Answers	Additional Comments/Guidance	Mark	ID details
3 (a)	Kinetic energy		1	
3 (b) (i)	B: drag / air resistance ✓ C: weight ✓	'gravity' can be included alongside weight but not alone.	2	
3 (b) (ii)	**closed** triangle (of vectors) ✓ so forces are in **equilibrium** / **resultant force is zero** / **forces balance** (so moving at constant velocity) ✓		2	
3 (c)	$W = 11000 \times \sin 62°$ ✓ = 9700 (N) ✓ (9712 N)		2	
Total			**7**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4 (a)	$(W = mg)$ = 4.7 × 45 × 9.81✓ =2100 ✓ (2075 N)		2	
4 (b)	(stress = force / area) = 1.3 × 10^6 / 6.0×10^{-4} ✓ = 2.2 ×10^9 (Pa) ✓ (2.167 × 10^9 N)	Power of 10 error in final answer loses one mark	2	
4 (c) (i)	(weight = stress × area) (= 300 x 10^6 x 6.0 x 10^4) = 1.8 x 10^5 ✓		1	
4 (c) (ii)	$\Delta L = \frac{F\ L}{A\ E}$ **OR** $\Delta L = L$ × strain **and** $strain = \frac{stress}{E}$ ✓ $\Delta L = \frac{1.8 \times 10^5 \times 45}{6.0 \times 10^{-4} \times 2.1 \times 10^{11}}$ ✓ allow CE from (c)(i) = 6.4 × 10^{-2} (m) ✓ (6.429 × 10^{-2} m)	ΔL = (c)(i) × 3.6 × 10^{-7}	3	
4 (c) (iii)	($k = \frac{F}{\Delta L}$) = $\frac{1.8 \times 10^5}{6.4 \times 10^{-2}}$ ✓ (k does not need to be the subject for this mark) = 2.8 × 10^6 (N m^{-1}) ✓ (2.813 × 10^6 N m^{-1})	Correct answer gains both marks Allow CE = c(i) / c(ii)	2	
4 (c) (iv)	(Using $E = \frac{1}{2} F \Delta L$) = ½ 1.8 × 10^5 × 6.4 × 10^{-2} ✓	Correct answer gains both marks CE = ½ × c(i) × c(ii)	2	

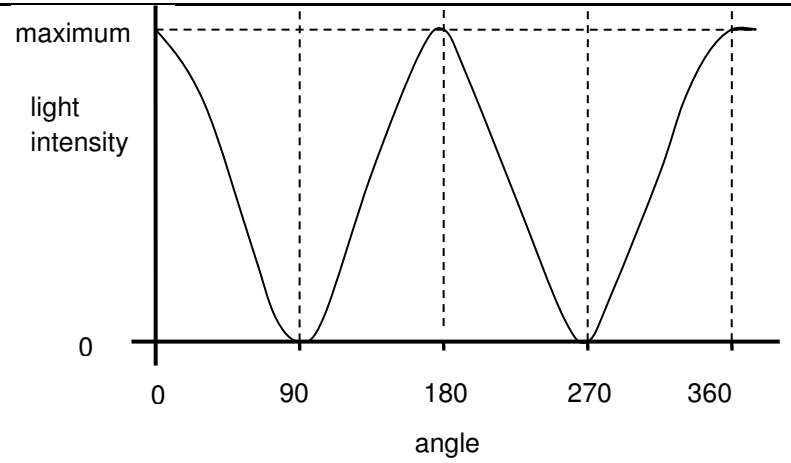
	= 5.8 x 10^3 (J) ✓ (5834 J) ✓ (Using $E = \frac{1}{2}k\Delta L^2$) = ½ × 2.8 × 10^6 × $(6.4 \times 10^{-2})^2$ ✓ = 5.7 × 10^3 (J) ✓ Allow CE from (c)(i), c(ii) and c(iii)	Or CE = ½ × c(iii) × c(ii)^2		
Total			**12**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
5	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of the three levels according to the following criteria. **High Level (good to excellent) 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. Refers to waves of same frequency travelling in opposite directions. Uses the terms Node or Antinode and explains these in terms of destructive or constructive superposition or interference. Additionally some numerical values are included such as the wavelength, number of nodes or number of antinodes **Intermediate Level (modest to adequate) 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. Refers to waves of same frequency travelling in opposite directions. (accept 'waves reflect/ rebound back or from clamp') Uses the terms interference or superposition and makes reference to nodes or antinodes. Some additional point may be given such as explaining the formation of a node or	Part 1 same frequency opposite direction Part 2 Refers to Superposition or interference Refers to Node or Antinode with destructive or constructive numbers λ = 0.6 m or 5 nodes or 4 antinodes adjacent antinodes out of phase Provided the organisation and language is appropriate to the level the following indicates the level of detail expected for various scores. 6 marks any 6 points 5 marks any points 5 using both parts 4 marks any points 4 using both parts 3 marks any points 3 using both parts 2 marks any 2 points 1 marks any 1 points	6	

	referring to the phase or giving some numerical value if one of the introductory points is missing. **Low Level (poor to limited) 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may only be partly appropriate. One correct key feature **or** one relevant remark regarding formation given. **The explanation expected in a competent answer should include a coherent account of most of the following points concerning the physical principles involved and their consequences in this case.** • 5 nodes where there is no movement/zero amplitude • 4 antinodes where amplitude is maximum • wavelength 0.60 m • adjacent antinodes are out of phase • between node and antinode, amplitude of oscillation increases • waves reflect off the clamp (and the rod) • waves travelling in opposite directions superpose/add/interfere • wave have same wavelength and frequency (similar amplitude) • always cancellation at nodes/always constructive superposition at antinodes • (energy is not transferred along string)			

Total			**6**

Question	Answers	Additional Comments/Guidance	Mark	ID details
6 (a) (i)	n_{glass} = sin 58° / sin 32° ✓ = 1.6 ✓		2	
6 (a) (ii)	sin θ_c = 1 / 1.6 ✓ Allow CE from (a)(i) θ_c = 39 ° ✓ (38.7°)		2	
6 (b)	TIR from the upper side of the prism **and** correct angle ✓ refraction out of the long edge of the prism away from the normal ✓		2	
Total			**6**	

Question	Answers	Additional Comments/Guidance	Mark	ID detail
7 (a)	**maximum displacement** from equilibrium/mean position/mid-point/etc ✓		1	
7 (b)	transverse wave: oscillation (of medium) is perpendicular to wave travel or transverse can be polarised or **all** longitudinal require a medium ✓		Max 1	
7 (c) (i)	vertical line on B ± 5° ✓		1	
7 (c) (ii)	 max 0, 180, 360 + min 90, 270 ✓ **and** line reaches same minimum and maximum every time and reasonable shape, i.e. not triangular with sharp corners✓	The diagram shows how close the sinusoidal graph can appear to be triangular and still get the shape mark. If the peaks or troughs are any sharper than this the mark will be lost.	2	

Question	Answers	Additional Comments/Guidance	Mark	ID details
7 (d)	appropriate use ✓ reason for Polaroid filter being used ✓ **Eg** (the example must be one where a polaroid is used not simply an example of a wave that is polarised when generated) **Polaroid** glasses/**sun**glasses/ windscreens — to reduce glare camera — reduce glare/enhance image (in a) microscope — to identify minerals/rocks polarimeter — to analyse chemicals/ concentration or type of sugar stress analysis — reveals areas of high/low stress/ other relevant detail LCD displays — very low power/other relevant detail 3D glasses — enhance viewing experience, etc		2	
Total			**7**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
8 (a)	single frequency (or wavelength or <u>photon</u> energy) ✓	not single colour accept '<u>very</u> narrow band of frequencies' Any incorrect addition to the answer loses the mark e.g. same phase.	1	
8 (b)	subsidiary maxima (centre of) peaks closer to the centre ✓ one whole subsidiary maxima seen on either side **AND** central maximum twice width of subsidiaries **AND** symmetrical ✓	For second mark: One square tolerance horizontally. Two squares tolerance vertically Central max higher than subsidiaries	2	
8 (c)	ONE FROM: • don't shine towards a person • avoid (accidental) reflections • wear **<u>laser</u>** safety goggles • 'laser on' warning light outside room • Stand behind laser • other sensible suggestion ✓ eye / skin damage could occur ✓	allow green goggles for red laser, 'high intensity goggles', etc. not 'goggles', 'safety goggles', 'sunglasses	2	

Question	Answers	Additional Comments/Guidance	Mark	ID details
8 (d)	3 from 4 ✓✓✓ • central white (fringe) • each/every/all subsidiary maxima are composed of a spectrum (clearly stated or implied) • each/every/all subsidiary maxima are composed of a spectrum (clearly stated or implied) **AND** (subsidiary maxima) have violet (allow blue) nearest central maximum **OR** red furthest from center • Maxima are wider / dark fringes are smaller (or not present)	allow 'white in middle' For second mark do not allow 'there are colours' or 'there is a spectrum' on their own Allow 'rainbow pattern' instead of spectrum but not 'a rainbow' If they get the first, the second and third are easier to award Allow full credit for annotated sketch An incorrect statement may be ignored for 1 or 2 marks but it will prevent full marks being given.	3	
Total			**8**	