A-LEVEL
Physics

PHYA2 – Mechanics, Materials and Waves
Mark scheme

2450
June 2015

Version: 1 Final

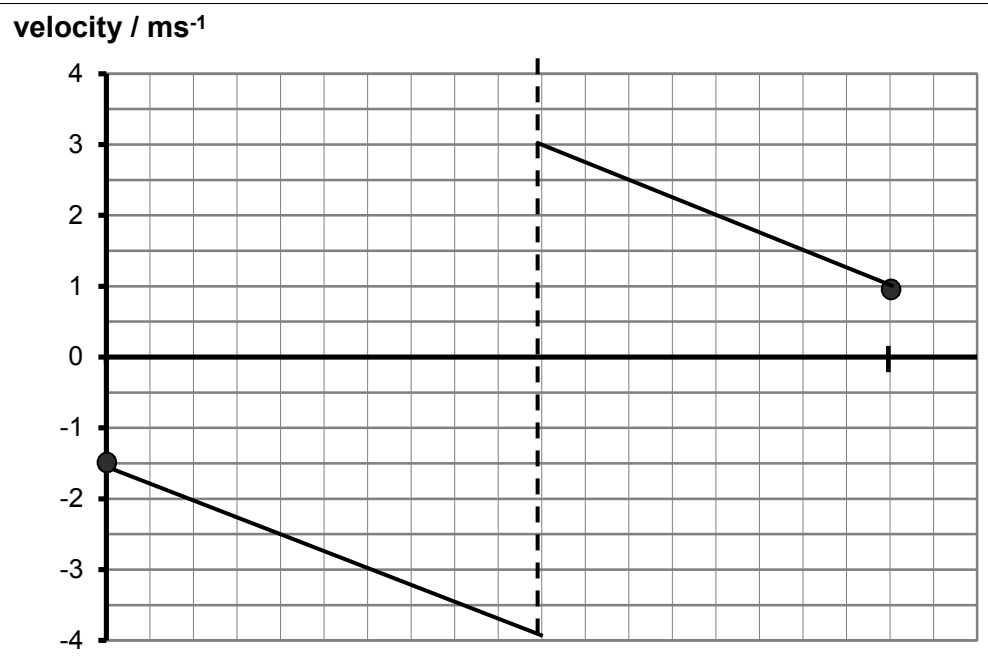
Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this 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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<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr><td>1a</td><td>Velocity and speed correct ✓
Distance and displacement correct ✓
<table><tr><td></td><td>velocity</td><td>speed</td><td>distance</td><td>displacement</td></tr><tr><td>vector</td><td>✓</td><td></td><td></td><td>✓</td></tr><tr><td>scalar</td><td></td><td>✓</td><td>✓</td><td></td></tr></table></td><td></td><td>2</td><td></td></tr>
<tr><td>1bi</td><td>$v^2 = u^2 + 2as$
$v = \sqrt{u^2 + 2as}$ ✓ $v = \sqrt{1.5^2 + 2 \times 9.81 \times 0.65}$ ✓
= (-)3.9 (m s^{-1}) ✓two or more sig fig needed (- 3.87337 m s^{-1})</td><td>1st mark for equation rearranged to make v the subject (note sq' root may be implied by a later calculation) penalise the use of g = 10 m s^2 only on this question
2nd mark for substituting numbers into any valid equation
3rd mark for answer
Alt' approach is gainKE=lossPE
Missing out u gives zero marks
Answer only gains one mark
[Note it is possible to achieve the correct answer by a wrong calculation]</td><td>3</td><td></td></tr>
</table>

1bii	 first line descends from X to the dotted line at t_A or up to one division sooner ✓ (allow line to curve) first line is straight and descends from X to v = -4 (m s^{-1}) ✓(allow tolerance one division) second line has same gradient as the first , straight and descends to v = 1(m s^{-1}) ✓ (tolerance ½ division) A steep line may join the two straight lines but its width must be less than 2 divisions		3	

1c	$s = ut + 1/2at^2$ $t = \sqrt{\frac{2s}{a}}$ OR correct substitution seen into either equation $t = \sqrt{\frac{2\times1.2}{9.81}}$ ✓ = 0.49 (s) ✓ (0.4946 s) $v = s/t$ = 5.0 / 0.49 = 10 (m s^{-1}) ✓ (10.2 m s^{-1}) (allow CE from their time)	working must be shown for the first mark but not the subsequent marks. [Note it is possible to achieve the correct answer by a wrong calculation]	3	

Total			11

Question	Answers	Additional Comments/Guidance	Mark	ID details
2a	(moment =) Force x perpendicular distance ✓ Between line of action (of force) and pivot/point ✓	both marks need to be clear – avoid bod If the force is named specifically (eg weight) mark the work but give a maximum of 1 mark. Ignore extra material such as law of moments.	2	
2bi	moment = 250 x 0.048 = 12 ✓ (allow 12000 for this mark) **N m** ✓ (stand alone mark if no number is present but only for N mm, N cm and N m)	only allow answers in other units if consistent eg 1200 N cm no working shown can gain full marks if answer and unit are consistent newton should be upper case if a symbol and metre should be in lower case (but only penalise if it is very obviously wrong)	2	
2bii	Y x 0.027 = 12 OR Y = 12/0.027 ✓ (allow use of 12 and 27 for this mark) = 440 (N) ✓ (444.4 N) CE from 2bi	Y = 2b(i)/0.027 treat power of 10 error as an AE note 450 N is wrong 1 sig fig is not acceptable	2	
2biii	*(k = F/ΔL)* = 444.4 / 0.015 ✓ CE from 2b(ii) = 3.0×10^4 (Nm^{-1}) ✓ (29630 Nm^{-1})	k = 2b(ii)/0.015 treat power of 10 error as an AE using 440 gives 2.9×10^4 (Nm^{-1}) 1 sig fig is not acceptable	2	
2biv	W (= ½ F ΔL) = ½ x 444.4 x 0.015 Or W (= ½ k ΔL^2) = ½ × 29630 × 0.015^2 ✓ (give this mark for seeing the digits only ie ignore powers of 10 and allow CE from b(ii) or b(iii) as appropriate = 3.3 (J) ✓ (3.333 J)	W = ½ × b(ii) × 0.015 W = ½ × b(iii) × 0.015^2 treat power of 10 error as an AE If either equation misses out the ½ no marks. Common CE is to use F = 250 N which can be used giving W = 1.9 J	2	
Total			10	

Question	Answers	Additional Comments/Guidance	Mark	ID details
3ai	($a = (v-u) / t$) = 27.8 (-0) / 4.6 = 6.04 ✓ = 6.0 (ms^{-1}) ✓	no need to see working for the mark 2 sig fig mark stands alone	2	
3aii	($F = ma$) = (360 + 82) x 6.0(4) ✓ (allow CE from 3ai) = 2700 (N) ✓ (2670 N or 2652 N)	$F = 442 \times$ a(i) 1 mark may be gained if mass of rider is ignored giving answer 2200N from 2175N	2	
3b	(forward force would have to) increase ✓ air resistance/drag increases (with speed) ✓ driving/forward force must be greater than resistive/drag force✓ (So that) resultant/net force stayed the same / otherwise the resultant/net force would decrease ✓	no mark for wind resistance	4max3	
3c	horizontal force arrows on both wheels towards the right starting where tyre meets road or on the axle labelled driving force or equivalent ✓ A horizontal arrow to the left starting anywhere on the vehicle labelled drag/air resistance ✓	ignore the actual lengths of any arrows ignore any arrows simply labelled 'friction' no mark for wind resistance, resistance or friction force the base of an arrow is where the force is applied	2	
3d	($F = P/v$) = 22 000/ 55✓ Condone 22/55 for this mark = 400 ✓ (N)		2	
Total			11	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4a	breaking stress ✓ stiffness constant, *k* tensile strain tensile stress Young modulus ✓		1	
4bi	Elastic limit✓	only one attempt at the answer is allowed	1	
4bii	($E = 300 \times 10^6 / 4 \times 10^{-2} = 7.5 \times 10^9$) 7.5 (Pa) ✓ allow 7.4 to 7.6 (Pa) $\times 10^9$ ✓	first mark is for most significant digits ignoring the power of 10. Eg 7500 gains mark	2	
4c	straight line beginning on existing line at a strain of 0.10 and hitting the strain axis at a lower non-zero value ✓ line that ends on the x -axis with strain between 0.045 and 0.055✓(only allow if first mark is given)	ie accuracy required ± one division	2	
4d	8.99×10^{-3} (m^3)✓ condone 1 sig fig	allow 9.00×10^{-3}	1	
4e	$0.9872 \times 8.99 \times 10^{-3}$ or $= 8.8749 \times 10^{-3}$ (m^3) ✓ allow CE from 4d ($m = \rho V$)= $2700 \times 8.8749 \times 10^{-3}$ = 24 (kg) ✓ (23.962 kg) allow CE from first part ,e.g. if 1.28% was used gives 0.311 kg	$V = 0.9872 \times$ (d) $m = 2.665 \times$ (d) 1.28% of vol = 1.15×10^{-4} m^3	2	
Total			9	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr><td>5a</td><td>
<table>
<tr><td></td><td>wavelength</td><td>frequency</td><td>speed</td></tr>
<tr><td>increases</td><td></td><td></td><td></td></tr>
<tr><td>stays the same</td><td></td><td>✓</td><td></td></tr>
<tr><td>decreases</td><td>✓</td><td></td><td>✓</td></tr>
</table>
middle column correct ✓
first and third column correct ✓</td><td></td><td>2</td><td></td></tr>
<tr><td>5bi</td><td>($n_1 \sin\theta_2 = n_2 \sin\theta_2$)
(1.09)sin 65.0 = (1.00)sinθ_2 ✓ (giving θ_2 =81°)

α = 9(°) ✓ (8.93°)</td><td>no internal CE
Allow 9.0°</td><td>2</td><td></td></tr>
<tr><td>5bii</td><td>1.09sin65 = 1.70sinx
or sinx = 0.58
or x = 35.5 (°) ✓ (allow 35° or 36°)

90 - 35.5 = 54.5(°) ✓ (allow 54° or 55°)
CE for 90° - their value</td><td>[Beware an answer close to the correct value can come from n = 1 / sinC]</td><td>2</td><td></td></tr>
<tr><td>5ci</td><td><u>total</u> internal reflection</td><td>TIR does not gain the mark</td><td>1</td><td></td></tr>
</table>

5cii	diagram showing core/cladding and light ray TIR at interface at least once with another TIR shown on the diagram or suggested in their explanation✓ light fibre consists of core and cladding with lower refractive index/<u>optical</u> density✓ light (incident) at angle greater than the critical angle (results in TIR)✓	labelling is not required and reflections do not have to be accurate provided they are shown on the correct side of the normal	3	

Total			10

Question	Answers	Additional Comments/Guidance	Mark	ID details
6	**The student's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The student's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. *Answers may cover some of the following points:* • *(1) A wave and its reflection/waves travelling in opposite directions meet/interact/overlap/cross/pass through etc* • *(2) same wavelength (or frequency)* • *(3) node – point of minimum or no disturbance* • *(4) antinode – is a point of maximum amplitude* • *(5) node - two waves (always) cancel/ destructive interference / 180^{o} phase difference /in antiphase [out of phase is not enough](of the two waves at the node)*[not peak meets trough] • *(6) antinode – reinforcement / constructive interference occurs / (displacements) in phase* • *(7) mention of <u>superposition</u> [not superimpose]of the two waves* • *(8) energy is not transferred (along in a standing wave)* **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	Point (1) must be stated together ie it should not be necessary to search the whole script to find the two parts namely the directions of the waves and their meeting. Points (3) and (4) may come from a diagram but only if the node and antinode is written in full and the y-axis is labelled amplitude or displacement. If any point made appears to be contradicted elsewhere the point is lost – no bod's	6	

	correctly. The form and style of writing is appropriate to answer the question. *6 marks: points (1) **AND** (2) **with** 4 other points which must include point (4) or the passage must indicate that the wave is oscillating at an antinode* *5 marks: points (1) **AND** (2) **with** any three other points* **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. *4 marks: (1) **OR** (2) **AND** any three other points* *3 marks: any three points* **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 be only partly appropriate. *2 marks: any two points* *1 marks: any point or a reference is made to both nodes and antinodes*	Although point (1) may not be given as a mark the script can be searched to see if its meaning has been conveyed as a whole before restricting the mark and not allowing 5 or 6 marks.		

Total			6

Question	Answers	Additional Comments/Guidance	Mark	ID details
7a	Uniform width peaks ✓ (accurate to within ± one division) A collection of peaks of constant amplitude or amplitude decreasing away from central peak ✓	Peaks need to be rounded ie not triangular The minima do not need to be exactly zero. Pattern must look symmetrical by eye Condone errors towards the edge of the pattern Double width centre peak total mark = 0	2	
7bi	Constant/fixed/same phase relationship/difference (and same frequency/wavelength) ✓	In phase is not enough for the mark	1	
7bii	Single slit acts as a point/single source diffracting/spreading light to <u>both slits</u> ✓ OR The path lengths between the single slit and the double slits are constant/the same/fixed ✓		1	
7biii	<u>Superposition</u> of waves from two slits ✓ Diffraction (patterns) from both slits overlap (and interfere constructively) ✓(this mark may come from a diagram) Constructive interference / reinforcement (at bright fringe) peaks meet peaks / troughs meet troughs ✓(any reference to antinode will lose this mark) Waves from each slit meet in phase OR path difference = $n\lambda$ ✓	phrase 'constructive superposition' = 2 marks	4max3	

7ci	$D = \frac{w\,s}{\lambda}$ = $\frac{0.004 \times 5.0\ 10^{-5}}{405 \times 10^{-9}}$ ✓ **do not penalise any incorrect powers of ten for this mark** = 0.5 (m) ✓ (0.4938 m)	Numbers can be substituted into the equation using any form Note 0.50 m is wrong because of a rounding error. Full marks available for answer only	2	
7cii	fringes further apart or fringe/pattern has a greater width/is wider ✓	Ignore any incorrect reasoning Changes to green is not enough for mark	1	

7ciii	Increase *D* ✓ Measure across more than 2 maxima ✓ Added detail which includes ✓ Explaining that when *D* is increased then *w* increases Or repeat the reading with a changed distance *D* or using different numbers of fringes or measuring across different pairs of (adjacent) fringes. Or Explaining how either of the first two points improves/reduces the percentage error.	Several/few implies more than two. No mark for darkened room	3	

Total			13