AQA

AS
Physics

PHYA2 – Mechanics, Materials and Waves
Mark scheme

2450
June 2016

Version: 1.0 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.

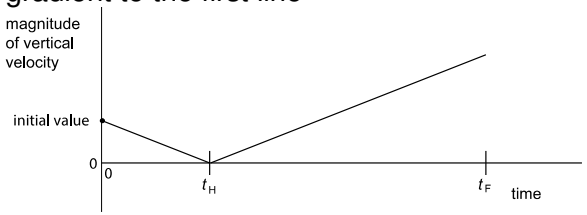
Further copies of this mark scheme are available from aqa.org.uk

Question	Answers	Additional Comments/Guidance	Mark	ID details
1(a)	a (resultant) force directed through the centre of mass of an object will not give it a moment/will not cause the object to rotate owtte or all the mass of the object appears to be concentrated at the centre of mass owtte or point at which all the (object's) weight acts ✓ owtte	We are not distinguishing between c of g and c of m. So allow point at which all the mass acts. If a balance idea is given the situation described must be achievable. Don't allow answers like: Where mass is most concentrated It has the same mass on both sides All forces act through this point	1	
1(b)	(moment of plank from the bank = $mg \times d$) = $32 \times 9.81 \times 2.0$ or $32 \times g \times 2.0$ ✓ this moment is balanced by $F \times 3.2$ giving $F = 200$ (N) ✓ (196 N)	Award 2 marks if 196 (N) is seen but 200 (N) only gains 1 mark with the second mark available if working is shown 9.8 m s^2 is ok for g.	2	
1(c)	(At the point of tipping) there is no (reaction) force from the bank ✓ (This point must be in words not implied from a calculation) Taking moments about the rock LHS = $1.2 \times 32 \times g = 38.4 \times g = 380$ (Nm) ✓ (377 N m) RHS = $0.80 \times 46 \times g = 36.8 \times g = 360$ (Nm) ✓ (361 N m) Or show a moment calculation that gives the maximum boy's weight that can be supported (471 N) Or show a moment calculation that gives the maximum distance the boy can be from the rock without tipping (0.83 m) Score any two of the above marks (Therefore) plank will not tilt ✓ (to score this mark the answer must be justified)	NB the first 3 marking points score a maximum of 2 marks. The last mark makes up the total to 3 marks Note it is the RHS mark that has the alternative approaches Condone missing 'g' provided it is cancelled/missed out in both moment calulations. The last mark can come from an ecf as long as the reason is clearly stated in terms of the answers given earlier.	3	

Total			6

Question	Answers	Additional Comments/Guidance	Mark	ID details
2(a)(i)	(using sin 25° = V_V/V $V = V_V$ / sin 25°) = 5.0 / sin 25° ✓ 11.8 (m s^{-1}) ✓ (working and answer is required)	Look out for cos 65° = sin 25° in first mark. Also calculating the horizontal component using cos 25° followed by Pythagoras is a valid approach. Working backwards is not acceptable.	2	
2(a)(ii)	(using tan 25° = V_V / V_H) $V_H = V_V$ / tan 25° ✓ = 5 / tan 25° = 11 (m s^{-1}) ✓ (10.7 m s^{-1}) Or (using cos 25° = V_H / V) $V_H = V$ cos 25° ✓ = 11.8 cos 25° = 11 (m s^{-1}) ✓ (10.7 m s^{-1}) Or (using $V_H^2 + V_V^2 = V^2$) $V_H^2 + 5^2 = 11.8^2$ ✓ (0r 12^2) V_H = 11 (m s^{-1}) ✓ (10.7 m s^{-1})	Note 1/cos 65° = sin 25° and tan 25° = 1/ tan 65° Rounding means answers between 10.7 and 11 m s^{-1} are acceptable.	2	
2(b)(i)	(using $v^2 = u^2 + 2as$ with up being positive $0 = 5.0^2 + 2 \times -9.81 \times s$) s = 1.3 (m) ✓ (1.27→1.28 m) or (loss of KE = gain of PE ½ ~~m~~ v^2 = ~~m~~ g h ½ 5.0^2 = 9.81 x h) h = 1.3 (m) ✓ (1.27→1.28 m) quoted to 2 sig figs ✓	for the sig fig mark the answer line takes priority. If a choice of sig figs given and not in answer line – no sig fig mark Sig fig mark stands alone provided some working is shown	2	
2(b)(ii)	(using $s = (u + v)t/2$) or horizontal distance = speed × time) s = 11 × 1.3 = 14 (m) ✓ (using 10.7 gives the same answer)	allow CE s = (aii) × 1.3 but working must be seen	1	
2(c)(i)	**A** marked at the point of landing or immediately before ✓	The **A** or its marked position must not be further to the left than the 'c' in the word 'scale'.	1	

2(c)(ii)	**B** marked at the maximum height of the path ✓	The B must lie vertically between the 'r' and 'a' in the word 'resistance above figure 2.	1	

2(d)	straight line from point given down to point t_H on the axis ✓ straight line starting where first line stops (t_H) but with opposite gradient to the first line ✓  	(A measure of accuracy for the second mark) The second line must end (t_F) between the height of the vertical axis and half this height. Obviously straight lines drawn by hand are acceptable.	2	

Total			11

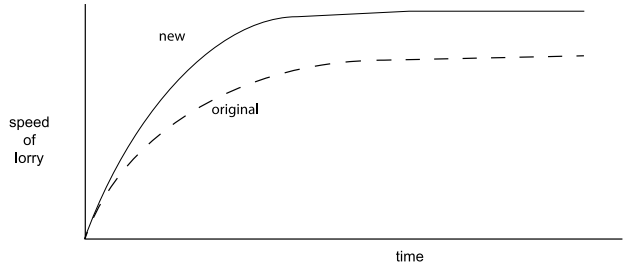
Question	Answers	Additional Comments/Guidance	Mark	ID details
3(a)	(using $F = ma$) a (= F/m) = 1400 / (any mass/masses taken from the table) ✓(any arrangement gains mark) = (1400/(2600 + 2900 + 1300) = 0.206 m s^{-2}) = 0.21 (m s^{-2}) ✓	Allow any single or combination of masses from the table for first mark. 0.21 m s^{-2} on its own gains 2 marks but 0.2 m s^{-2} on its own gains 1 mark 1 sig fig is not acceptable	2	
3(b)(i)	they have the same line of action they have the same magnitude (not size) the forces are of the same kind ✓ any one statement	The statement must be of a general nature. The statement 'equal magnitude + opposite direction does not make the similarity clear and so gains zero marks. If forces act against each other or cancel or act on the same body this mark is lost.	1	
3(b)(ii)	they are in opposite directions they act on different bodies ✓ any one statement	The statement must be of a general nature. If forces act against each other or cancel or act on the same body this mark is lost.	1	
3(c)	they do not have the same magnitude/size the forces are of different types they do not act on different bodies drag is greater than the weight there is a resultant force (as deceleration occurs) ✓ any one statement	Statements can be written negatively	1	
3(d)	actual deceleration (= F/m) = 670 / 890 = 0.75 (m s^{-2}) ✓ (0.753 m s^{-2}) minimum required deceleration = $\Delta v / \Delta t$ = (5.5 – 3.0) / 3.5 = 0.71 (m s^{-2}) ✓ (0.714 m s^{-2}) therefore (compared to 0.75 m s^{-2}) there is sufficient deceleration, yes ✓ Or actual deceleration	ignore any interchange between acceleration and deceleration	3	

	(= F/m) = 670 / 890 = 0.75 (m s^{-2}) ✓ (0.753 m s^{-2}) maximum required time = $\Delta t = \Delta v/a$ = (5.5 – 3.0) / 0.753 = 3.3 s (3.32 s) ✓ therefore (compared to 3.5 s) there is sufficient time, yes ✓ Or actual deceleration (= F/m) = 670 / 890 = 0.75 (m s^{-2}) ✓ (0.753 m s^{-2}) (using $v = u + at$) v = 5.5 – 0.753 x 3.5 = 2.8 (m s^{-1}) ✓ which is a safe landing speed ✓ Or (using $Ft = \Delta mv$) 670 × 3.5 = 890 × Δv ✓ Δv =2.7 landing speed = 5.5 – 2.7 = 2.8 (m s^{-1}) ✓ which is a safe landing speed ✓	3rd mark is dependent on having a valid attempt at the calculation. 3rd mark can be given for wrong answer if it follows from an arithmetic error.		
Total			8	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4(a)	energy cannot be created or destroyed ✓ it can only be transferred/changed/converted from one form to another ✓	'Transformed' can be taken to mean transferred from one form to another.	2	
4(b)(i)	(using $E_k = ½ mv^2$) $2.2 = ½ \times 0.40 \times v^2$ v = 3.3 (ms^{-1}) ✓	Ignore errors in 3 sig fig. Answer only can gain mark.	1	
4(b)(ii)	(using work done = $F \times s$) 2.2 = F × 1.2 ✓ (F = 1.83 N) or (using $a = (v^2 – u^2) / 2 s$) a = ($0^2 – 3.32^2$) /2 x 1.2 = (-) 4.59 (m s^{-1})	A substitution of numbers are necessary for the mark	1	

	(F = ma) = 0.4 x 4.59 ✓ = (1.84 N)			
4(b)(iii)	(work done in moving 0.2 m) =1.8 × 0.2 (J) ✓ (= 0.36 J) (allow ecf (bii) × 0.2) total work done = 2.2 + 0.36 = 2.6 ✓ (same answer is achieved if F = 2N) J or joule ✓		3	
4(b)(iv)	(use of energy = ½ F x) 2.6 = ½ F_{max} 0.2 F_{max} = 26 N ✓ (allow ecf 10 × (biii))	Allow mark for answer only even for ecf.	1	
Total			8	

Question	Answers	Additional Comments/Guidance	Mark	ID details
5	The mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC).			
	Descriptor (references to parts 1 to 9 are given in the final row of the table)	A part is only credited if the writing makes the physics content unambiguous.	**Mark**	
	High Level – Good to Excellent The relationship between the acceleration and the gradient of the graph or how it changes should be given including the reason why the initial acceleration would remain the same. Also a reference to terminal velocity should be made and an explanation of why the terminal speed is greater. *The information presented as a whole should be well organised using appropriate specialist vocabulary. There should only be one or two spelling or grammatical errors for this mark.*	6 marks = 6 points given from the descriptor list but at least one must come from each Group. 5 marks = 5 points given from the descriptor list but at least one must come from each Group.	5 - 6	
	Intermediate Level – Modest to Adequate The relationship between the acceleration and the gradient of the graph or how it changes should be given. Also something should be said about the initial acceleration being the same and/or the terminal velocity being larger. With this restriction marks can come from any marking point that is clearly given. *The grammar and spelling may have a few shortcomings but the ideas must be clear.*	4 marks = 4 points from the descriptor list but at least one must come from two Groups. 3 marks = 3 points from the descriptor list but at least one must come from two Groups.	3 - 4	
	Low Level – Poor to Limited Any two valid statements that cover any of the parts given below. *There may be many grammatical and spelling errors and the information may be poorly organised.*	2 marks = any 2 points from the descriptor list with no restriction on which Group they come from 1 mark = any point from the descriptor list	1 - 2	
	The description expected in a competent answer should include: **First Group:**			

	1. the acceleration is the gradient of the graph (or the link between acceleration and gradient is clearly made) 2. the acceleration is greatest initially/(continuously) decreases 3. a constant final velocity/terminal velocity is shown by the graph becoming <u>horizontal/flat</u>. **Second Group:** 4. initial acceleration or the initial gradient is the same or only <u>slightly</u> greater (as initially the mass is the same) 5. $a = F/m$ (in words or symbols) **Third Group:** 6. at the end/eventually/at terminal velocity <u>resistance force = drive force</u> 7. resistance force is now less at the same speed (because mass is less) 8. speed will be higher or graph has higher line (this may come from the Figure 7) 9. in the middle of the graph the acceleration will be greater.			
Total			6	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr><td>6(a)</td><td>A wave transfers energy <u>from one point to another</u> ✓
without transferring material/(causing permanent displacement of the medium) ✓ owtte</td><td></td><td>2</td><td></td></tr>
<tr><td>6(b)(i)</td><td>0.6 (mm) or 0.60 (mm) ✓</td><td></td><td>1</td><td></td></tr>
<tr><td>6(b)(ii)</td><td>0.080 (m) ✓</td><td>Allow 1 sig fig</td><td>1</td><td></td></tr>
<tr><td>6(b)(iii)</td><td>$f = 1/T = 1/0.044 = 23$ (Hz) ✓ (22.7 Hz)</td><td></td><td>1</td><td></td></tr>
<tr><td>6(b)(iv)</td><td>$v = f\lambda = 22.7 \times 0.080 = 1.8$ (m s^{-1}) ✓ (1.82 m s^{-1})</td><td>allow CE v = (biii) × (bii) but working must be shown
1 sig fig not acceptable</td><td>1</td><td></td></tr>
<tr><td>6(c)</td><td><table><tr><th>s und waves are transverse</th><th>sound waves are longitudinal</th><th>sound waves can interfere</th><th>sound waves can be polarised</th></tr><tr><td></td><td>√</td><td>√</td><td></td></tr></table></td><td></td><td>1</td><td></td></tr>
<tr><td>6(d)</td><td>the wavelength would be smaller
smaller spread in main peak or more peaks (between A and B)
the central peak is higher (owtte)
as the energy is concentrated over a smaller area (owtte)
reference to (sin $\theta_{min} = \lambda/d$)
✓✓✓ any 3 lines max 3</td><td>Note that the marks here are for use of knowledge rather than performing calculations.

No bod if writing does not make <u>in</u>crease or <u>de</u>crease clearly distinct.

Marking should be lenient.</td><td>3</td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td>10</td><td></td></tr>
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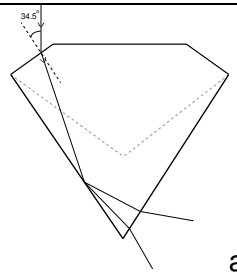
Question	Answers	Additional Comments/Guidance	Mark	ID details
7(a)	Answer D ✓ (violet)		1	
7(b)	(light from each slit) superpose light from adjacent slits have a path difference of one wavelength (at this angle all) the waves are in phase constructive interference/peaks coincide/(positively)reinforce any 3 points ✓✓✓ max 3	Ignore reference to nodes or antinodes If general statements are made only give marks for parts related to 'Bright line' or 'First order' which appears in the question.	3	
7(c)(i)	use of $\sin\theta = \lambda/d = 5.3 \times 10^{-7} / 1.8 \times 10^{-6}$ ✓ (= 0.294) $\theta = 17^{o}$ ✓ (17.1^{o})	Answer alone scores both marks	2	
7(c)(ii)	(use of $n = d \sin\theta/\lambda$) $n_{max} = (d \sin 90^{o}/\lambda) = d/\lambda$ = ✓ $= 1.8 \times 10^{-6} / 5.3 \times 10^{-7} = 3.4$ ✓ max order = 3 ✓	Showing that n=4 is not possible is not answering the question but the first mark (equation mark) can be gained this way Max order is an independent mark from reducing a calculated value for n to the next lowest integer.	3	
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
8(a)(i)	$\sin C = 1/n = 1/2.42$ ✓ (= 0.413) $C = 24.4^o$ ✓ (allow 2 or more sig figs)	Answer only gains both marks	2	
8(a)(ii)	$\sin\theta_{dia} = \sin\theta_{air} / n = \sin 50.2 / 2.42$ ✓ (= 0.317) $\theta_{dia} = 18.5^o$ ✓ (allow 2 or more sig figs)	Answer only gains both marks Answer can be 18^o or 19^o depending on rounding	2	
8(a)(iii)	TIR shown at bottom left surface ✓ (If the reflected ray were extended it would pass through the writing below the diagram between the 'i' in 'it' and the full stop at the end of 'diamond'.) ray leaves bottom right surface either with an increased emergent angle or straight though if hitting normally ✓ (The second mark is consequential on gaining the first mark)	 acceptable emergent rays	2	
8(a)(iv)	it has smaller critical angle / critical angle is 22^o allowing more/same number/greater chance/increased probability of TIR's occurring greater/same sparkle ✓✓ max 2	'reflect more' is insufficient for a mark	2	
8(b)(i)	$c_{core} = c_{air} / n = 3.00 \times 10^8 / 1.55 = 1.9 \times 10^8$ (ms^{-1}) ✓ (1.94×10^8 ms^{-1})	1 sig fig is not acceptable if no other answer is given	1	
8(b)(ii)	($n = c_{air} / c_{core} = f\lambda_{air} / f\lambda_{core} = \lambda_{air} / \lambda_{core}$) $\lambda_{core} = \lambda_{air} / n$ or $1300 \times (10^{-9}) / 1.55$ ✓ $= 8.4 \times 10^{-7}$ (m) ✓ (8.39×10^{-7} m or 839 nm)	The first mark is for the equation or substitution ignoring powers of 10 errors 1st mark can be gained from calculating the frequency ($f = 3.0 \times 10^8 / 1300 \times 10^{-9} = 2.3 \times 10^{14}$ (Hz) which then can be used to find the the wavelength Using this method the answer can range between $8.4 \times 10^{-7} \rightarrow 8.7 \times 10^{-7}$ (m) and	2	

		consider ecf's from 8(b)(i)		
8(b)(iii)	protects the core (from scratches etc) prevents crosstalk/stops signal crossing from one fibre to another/increases critical angle/reduces pulse broadening/reduces smearing/prevents multipath dispersion allows fibre to be supported/touched (without losing light) ✓ any one point	Preventing signal loss is not enough for the mark.	1	
Total			12	