Version 1.0

General Certificate of Education (A-level)
June 2011

Physics A PHYA2

(Specification 2450)

Unit 2: Mechanics, materials and waves

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner 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 examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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

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Instructions to Examiners

1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	*see specific mark scheme*	**5-6**
Modest - Adequate	*see specific mark scheme*	**3-4**
Poor - Limited	*see specific mark scheme*	**1-2**
The description and/or explanation expected in a good answer should include a coherent account of the following points: *see specific mark scheme*		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.

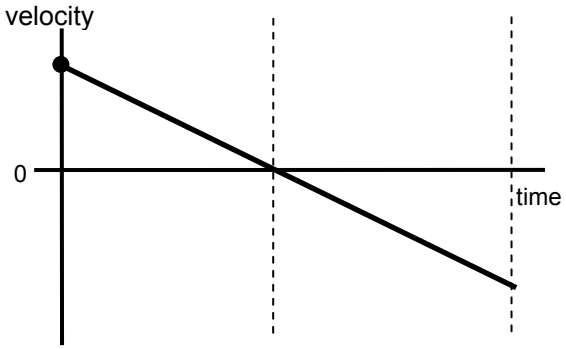
4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.

5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.

7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA2, Mechanics, Materials and Waves

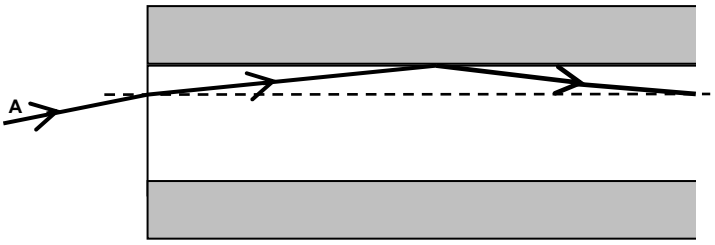
Question 1		
a i	gradient (allow 'slope'/'**steepness of the line**') ✓	**1**
a ii	 single straight line sloping down from X to t_2 ✓ passes through zero at t_1 ✓ increases to a maximum negative value at t_2 (ignore all lines beyond t_2) **or** allow line from zero at t_1 to a positive velocity at t_2 greater than the initial velocity ✓	**3**
b i	**ball** exerts **force on ground and** ground exerts force (on ball)/reaction ✓ and **these** forces are **equal** and **opposite** ✓	**2**
(b) ii	recognise that the downward force is the weight of the ball (accept gravity) ✓ recognition that the upward/reaction force (on the ball) is greater than the downward force on the ball ✓	**2**
	Total	**8**

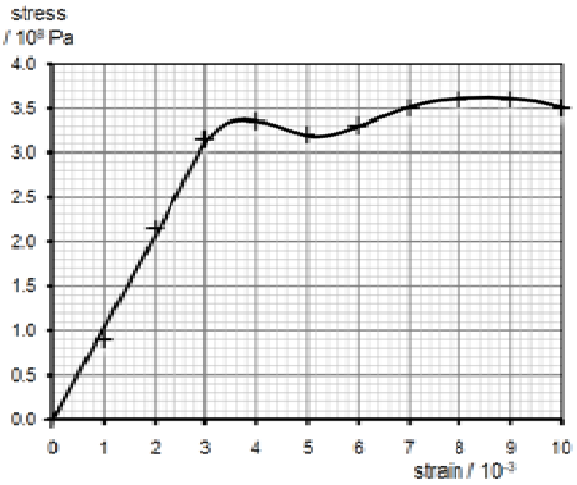
Question 2		
a	correct substitution in ($v^2 = u^2 + 2as$) **or** correct rearrangement $g = \frac{v^2}{2s}$ **or** $\frac{3.10^2}{2 \times 0.50}$ ✓ = 9.6 (9.61 m s^{-1}) ✓	**2**
b	$g = W/m$ **or** $W = mg$ (= ma) **and** weight is proportional to mass/doubling the mass doubles the weight/'masses cancel'/the factor of two cancels (so g remains the same) ✓	**1**
c	ball's acceleration will decrease/be less than cards **or** cards acceleration will be unaffected/nearly constant ✓ air resistance affects cards less **or** card is more streamlined **or** card does less work against air resistance ✓ **alternative** timing/(velocity/speed/acceleration) uncertain/(inaccurate /imprecise/less reliable) ✓ indication that full width of ball may not pass through gate/difficulty in determining 'length' of ball passing through gate ✓	**2**
	Total	**5**

Question 3		
a i	$\left(\alpha = \frac{v-u}{t}\right) = \frac{58}{3.5}$ ✓ = 17 (m s^{-2}) ✓	**2**
a ii	(*F* = *ma*) = 5800 × 16.57 ecf (a)(i) ✓ = 96000 ✓ allow 98600 or 99000 for use of 17 **N** ✓	**3**
a iii	$\left(s = \frac{1}{2}(u+v)t\right) = \frac{1}{2}$ × 58 × 3.5 ✓ = 100 (101.50, 102, accept 101 m) ✓ **or** use of $v^2 = u^2 + 2as$ (= 101 m. 98.9 for use of 17) **or** $s = ut + \frac{1}{2}at^2$ (= 101.7, use of 17 gives 104) (ecf from (a)(i))	**2**
a iv	(*W* = *Fs*) (a)(ii) × (a)(iii) **or** use of $\frac{1}{2}mv^2$ ✓ (= 13.6 to 14.7) $\left(P = \frac{Fs}{t}\right) = \frac{96106 \times 101.5}{3.5}$ ✓ = 2.8 M (W) ecf (a)(ii), (a)(iii) **or** use of $P = \frac{Fv}{2}$ their answer × 5 ✓ = 14,000,000 = 14 M (W)	**3**
b	$\frac{1}{2}(m)v^2 = (m)g(\Delta)h$ **or** (loss of) KE = (gain in) PE ✓ allow their work done from (iv) used as KE $h = \frac{1}{2}\frac{v^2}{g}$ **or** $h = \frac{1}{2} \times \frac{58^2}{9.81}$ ✓ accept use of kinematics equation = 170 ✓	**3**
	Total	**13**

Question 4		
a i	(one) **force** × distance between the **forces** ✓ (one) **force** × **perpendicular** distance between the **lines of action** **or** (one) **force** × **perpendicular** distance between the (two) **forces** ✓	**2**
a ii	(810 × 7.3 =) 5900 ✓ (5913) (or alternative correct method) **Nm** ✓	**2**
b	*P* = *Fv* = (2 ×) 810 × 0.91 ✓ (1620 × 0.91) = 1500 ✓ (1474 W) **any number to 2 sf** ✓	**3**

c	to enable comparison between steam and horses **or** mill owners/engineers etc needed to know which steam engine would be suitable **or** would easily be able to compare the cost/time saved **or** good marketing ploy for steam engines **or** easily understood (by industrialists or the public) **or** other suitable valid reason ✓	**1**
	Total	**8**

Question 5		
a	decrease ✓ constant ✓ decrease ✓	**3**
b	 straight ray (ignore arrow) reflecting to the right ✓ reflected angle = incident angle ✓ (accept correct angle labels if reflected angle is outside tolerance)	**2**
c i	($n = \frac{c}{c_s}$) use of 3 ($\times 10^8$) ✓ = $\frac{300\ (\times 10^8)}{2.04\ (\times 10^8)}$ = 1.47 ✓ (1.4706) (must see 3 sf or more)	**2**
c ii	$\sin\theta_c = \frac{1.45}{1.47(06)}$ or correct substitution in un-rearranged formula ✓ θ_c = 80.4 ✓ (80.401) (80.3 to 80.54) (≈ 80°) must see 3 sf or more	**2**
d	angle of refraction = 180 – 90 – 80.4 = 9.6° ✓ $\sin\theta$ = 147(06) sin 9.6 ✓ = 0.25 ecf from first mark θ = 14 (= 14.194°) ✓ ecf from first mark range **13 to 15°** due to use of rounded values	**3**
e	(reduced amplitude) due to absorption/energy loss (within the fibre)/ attenuation/scattering (by the medium)/loss from fibre ✓ (pulse broadening caused by) multi-path (modal) dispersion/different rays/ modes propagating at different angles/non axial rays take longer time to travel same distance along fibre as axial rays ✓	**2**
	Total	**14**

Question 6		
a	 suitable scale on both axes (eg not going up in 3s) **and** > ½ space used ✓ ≥ 8 points correct (within half a small square) ✓ line is straight up to at least stress = 2.5×10^8 **and** curve is smooth beyond straight section ✓	**3**
b	understanding that E = gradient (= $\Delta y/\Delta x$) ✓ allow y/x if line passes through origin = 1.05×10^{11} (Pa) (allow 0.90 to 1.1) **ecf** from their line in (a) if answer outside this range **and** uses a y value ≥ 2.0 ✓ when values used from table; ● two marks can be scored only if candidates line passes through them ● one mark only can be scored if these points are not on their line	**2**

c	correct rearrangement of symbols or numbers ignoring incorrect powers of ten, eg $A = \frac{FL}{E\Delta L}$ ✓ correct substitution in any correct form of the equation, eg = $\frac{10(000)\times 3.0}{1.90\ (\times 10^{11})\times 1.0\ (\times 10^{-3})}$ ✓ allow incorrect powers of ten for this mark = 1.6×10^{-4} ✓ (1.5789) (m^2)	**3**
	Total	**8**

Question 7		
a	**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 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. The candidate provides a comprehensive and coherent description which includes; fringe spacing/separation *w* **and** distance *D* measured with one **instrument named**, uses $\lambda = \frac{ws}{D}$ to obtain value for λ, measures distance between several maxima and includes a valid point about safety. **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. The candidate provides an adequate explanation that lacks some of the essential points. The candidate is expected to include; *w* **or** 'fringes' measured **or** uses $\lambda = \frac{ws}{D}$ to obtain value for λ. They include one accuracy point **or** a valid point about safety. **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. The candidate provides a limited explanation with no more than one or two valid points. **Incorrect, inappropriate of no response: 0 marks** No answer or answer refers to unrelated, incorrect or inappropriate physics.	**max 6**

	The explanation expected in a competent answer should include a coherent selection of the following points. **Measurements** • suitable measuring instrument for *w* • suitable measuring instrument for *D* **Finding the wavelength** • uses $\lambda = \frac{ws}{D}$ to obtain value for λ • explains graphical approach **Accuracy** • several fringe spaces measured • centres of fringes used • five or more fringes/four fringe spaces measured • large value of *D* • *D* greater than or equal to 2 m • dark room • repeat measurements • **vernier** calliper for *w* (not 'calliper', not micrometer) • graphical method varying *D* and measuring *w* • other valid accuracy point **Safety** • avoid shining laser at (or near) a person • **laser** safety goggles • avoid reflections • warning sign or light	
b	(light from both sources has) constant phase **relationship**/**difference** ✓✓ 'in phase' or 'same wavelength' or 'same frequency' is **one mark**	**2**
c	single slit **then** double slits to the right ✓ single slit and double slits **labelled** ✓	**2**

<table>
<tr><td>d</td><td>
<table>
<tr><th>if candidate refers to white light Young's fringes with white light;</th><th>or
if candidate refers to the laser;</th></tr>
<tr><td>contain (different) colours or central white fringe</td><td>monochromatic/one colour</td></tr>
<tr><td>less intense</td><td>more intense</td></tr>
<tr><td>maxima wider/minima narrower or max or min closer together for white light compared to a red laser</td><td>maxima narrower/minima wider or max or min further apart for a red laser</td></tr>
<tr><td>fringes/lines/bands etc compared to 'dots'</td><td>'dots' for laser compared to 'bands' etc</td></tr>
</table>
from each row, one only max 2 ✓
</td><td>2</td></tr>
<tr><td>e</td><td>cancellation/waves cancel/destructive interference/destructive superposition ✓

(light from one slit meets light from the other) in antiphase (180 out of phase) or a path difference of ((n+) ½)λ ✓</td><td>2</td></tr>
<tr><td></td><td>Total</td><td>14</td></tr>
</table>

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