Version 1.0

General Certificate of Education (A-level)
January 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.

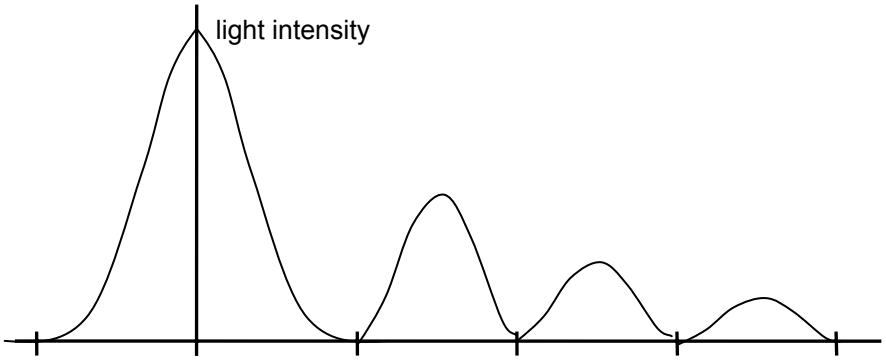
6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. 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.

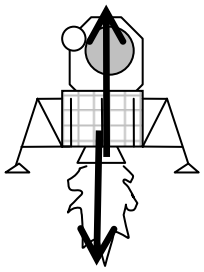
GCE Physics, Specification A, PHYA2, Mechanics, Materials and Waves

Question 1			
(a)	(i)	$F \propto \Delta L$ ✓ up to limit of proportionality ✓ accept 'elastic limit' F = kΔL with terms defined gets first mark	**2**
(a)	(ii)	straight line ✓ through origin ✓	**2**
(a)	(iii)	working shown and $F \geq 200$ N ✓ (500/0.385) = **1290** ± 20 ✓ **N m^{-1} or** N/m kg s^{-2} ✓	**3**
(b)	(i)	($\Delta W = F\Delta s$) so area (beneath line from origin to ΔL) represents (work done or) energy (to compress/extend) ✓ **work done** (on or by the spring) linked to energy stored ✓ (area of triangle) = $\frac{1}{2} b \times h$ (therefore $E = \frac{1}{2} F\Delta L$) ✓	**3**
(b)	(ii)	F = **360** (N) used ✓ $P = \frac{\frac{1}{2} \times (360) \times 0.28}{1.5} = \frac{50.4}{1.5}$ ✓ = **34** (33.6) (W) ✓ ecf from wrong force	**3**
		Total	**13**

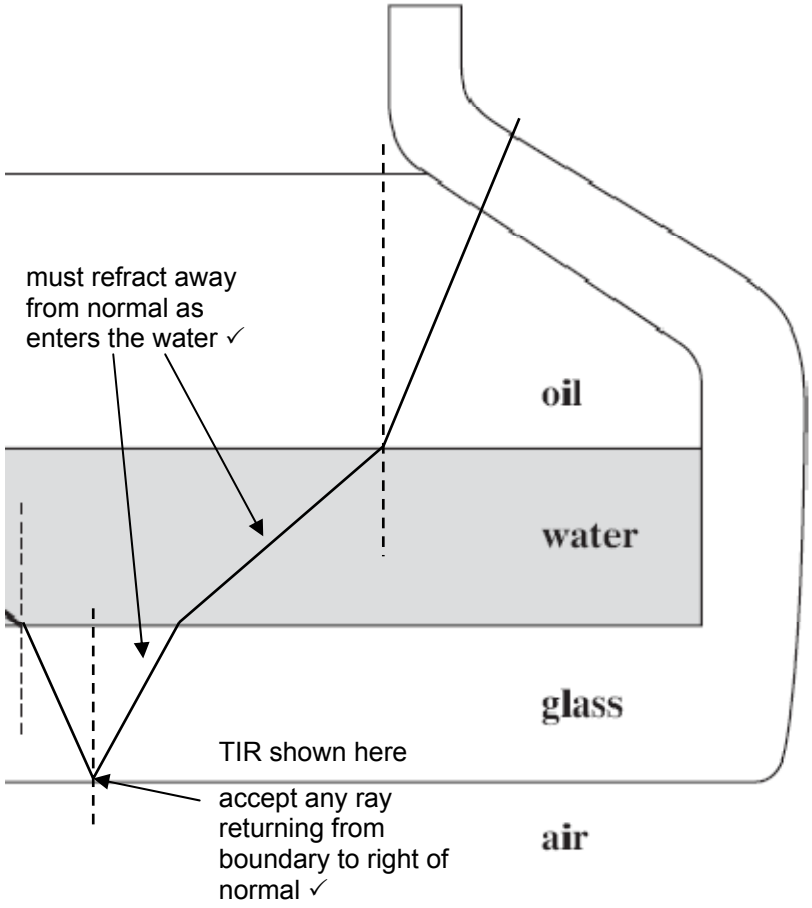
Question 2			
(a)	(i)	$t = \sqrt{\frac{2s}{g}}$ (evidence for correct rearrangement or substitution) ✓ $= \sqrt{\frac{2 \times 67}{9.81}}$ (correct substitution leading to answer) ✓ (= **3.7** (3.696) (s))	**2**
(a)	(ii)	$\left(v = \frac{s}{t} = \frac{150}{3.696}\right)$ = **41** (m s^{-1}) ✓ 2 sf ✓	**2**
(a)	(iii)	(v = (u +) gt =) 9.81 × 3.696 ✓ = **36** ✓ (m s^{-1})	**2**
(a)	(iv)	$v = \sqrt{40.586^2 + 36.257^2}$ (or correct scale drawing) ✓ = 54 (m s^{-1}) ✓ ecf from (ii) (iii) [for scale drawing allow range 53 → 56] tan$\theta = \frac{36.257}{40.586}$ ✓ or correct alternative (angle from horizontal =) **42** (°) or correct alternative angle **and clear indication of direction** ✓ [for scale drawing allow range 40 → 44 ✓ for scale drawing: quality of construction ✓]	**4**
(b)	(i)	(= mgh = 22 × 9.81 × 67) = 14000 (14460) (J) ✓	**1**
(b)	(ii)	(G)PE → KE ✓ (KE to) internal/thermal/'heat' (energy) ✓	**2**
		Total	**13**

Question 3		
(a)	3 subsidiary maxima in correct positions ✓ intensity decreasing ✓  	**2**
(b)	a single wavelength ✓ constant phase relationship/difference ✓	**2**
(c)	maxima further apart/central maximum wider/subsidiary maximum wider/maxima are wider ✓	**1**
(d)	wider/increased separation ✓ lower intensity ✓	**2**
(e)	distinct fringes shown with subsidiary maxima ✓ indication that colours are present within each subsidiary maxima ✓ blue/violet on the inner edge **or** red outer for at least one subsidiary maximum ✓ (middle of) central maximum white ✓	**3**
	Total	**10**

Question 4		
	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. Mentions **waves** travelling in **opposite directions or** waves of **same frequency** (and amplitude) **and** superpose **or** interfere **or** add together. **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. Mentions **waves** travelling in **opposite directions** (accept 'waves reflect/ rebound back or from clamp') **or superposition/addition/interference of waves or** waves of same frequency/wavelength. **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 the following points concerning the physical principles involved and their consequences in this case.** ● 4 nodes where there is no movement/zero amplitude ● 3 antinodes where amplitude is maximum ● wavelength 0.80 m ● end antinodes in phase/middle and ends in antiphase ● 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	**max 6**
	Total	**6**

Question 5		
(a) (i)	$\left(a = \frac{F}{m}\right) = \frac{(-)30(000)}{15100}$ ✓ = (–) 2.0 (= 1.99 m s^{-2}) ✓	**2**
(a) (ii)	($v = u + at$) $t = \frac{v-u}{a}$ or substitution ✓ = $\left(\frac{150-2040}{-1.99}\right)$ = 950 (s) ✓ ecf from (i)	**2**
(b) (i)	 opposing vertical arrows of roughly equal length **or** labelled weight/mg/gravity/W **and** thrust/reaction/R/F/TF/engine force/rocket force/motor force/motive force/driving force ✓ correctly labelled + arrows vertical + not more than 2 mm apart + roughly central + weight arrow originates within rectangular section and thrust originates within rectangular section or on jet outlet ✓	**2**
(b) (ii)	new mass = 15100 × 0.47 = 7097 (kg) ✓ ($F = mg$ = 7097 × 16(1)) = 11000 (= 11426 N) ✓	**2**
(c)	($v^2 = u^2 + 2as$ $v = \sqrt{0.80^2 + 2 \times 1.61 \times 1.2}$) correct u, a and s clearly identified ✓ = 2.1 (= 2.122 m s^{-1}) ✓	**2**
	Total	**10**

Question 6		
(a) (i)	straight best fit line from 0 → (at least) extension of 4.0 × 10^{-3} m ✓ smooth curve near points after 5.0 × 10^{-3} m ✓	**2**
(a) (ii)	$\left(k = \frac{\Delta F}{\Delta l} = \frac{2.55(\times 10^5)}{5.0\ (\times 10^{-3})}\right)$ their $\frac{\Delta F}{\Delta l}$ (ignore powers of ten) ✓ = 5.1 × 10^7 **and** x axis interval ≥ 3.0 ✓ (5.06 to 5.14 × 10^7 N m^{-1}) ecf from graph allow error in calculation ± 2%	**2**
(b)	load = 2.8 × 10^5 or $\left(stress = \frac{F}{A}\right) = \frac{2.8\ (\times 10^5)}{2.5 \times 10^{-3}}$ ✓ 2.8 only = 1.1 × 10^8 (Pa) 110 (MPa) ✓ (1.12 × 10^8) (M)Pa, pascals, N m^{-2} ✓	**3**
(c)	$\left(\Delta l = \frac{F}{k}\right) = \frac{150000}{5.1 \times 10^7}$ ✓ (= 2.94 × 10^{-3} m for 10 m) gives 0.29(4) (m) ✓ ecf or reads a reasonable extension for 150 kN from the graph ✓ and multiples by 100 (= 0.29) (ecf) ✓	**2**
	Total	**9**

Question 7		
(a)	$\sin\theta = \frac{1.47 \sin 44}{1.33}$ or 1.33 $\sin\theta$ = 1.47 sin44 or $\sin^{-1}$ 0.768 ✓ θ = 50.15, 50.2, 50.35 (°) ✓ answer seen to > 2 sf	**2**
(b)	refracts towards normal ✓ 44° shown ✓	**2**
(c)	(TIR) only when ray travels from higher *n* to lower *n* **or** (water to glass) is lower *n* to higher *n* ✓ do not allow 'density', allow 'optical density', n or refractive index only	**1**
(d)	$\sin\theta_c = \frac{1}{1.47}$ or 1.47 $\sin\theta_c$ = (1 ×) sin90 ✓ θ_c = 42.86 (= 43.0(°)) ✓	**2**
(e)		**2**
	Total	**9**