

**General Certificate of Education (A-level)  
January 2013**

**Physics A**

**PHYA2**

**(Specification 2450)**

**Unit 2: Mechanics, materials and waves**

**Final**

***Mark Scheme***

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Question		Mark & Comments
1	a	$(Ep = mg\Delta h)$ $= 65 \times 9.81 \times 54 \checkmark$ $= 3.44 \times 10^4 = 3.4 \times 10^4 \text{ (J)} \checkmark \text{ (34433)}$
1	b	$v = \sqrt{\frac{2Ep}{m}}$ OR $v = \sqrt{\frac{2 \times 34433}{65}} \checkmark = 33 \text{ (32.55 ms}^{-1}\text{)} \checkmark$ ecf 1(a)  OR correct use of $v^2 = 2gs$
1	c	$(s = 1/2 gt^2 \text{ or other kinematics equation})$ $t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2 \times 54}{9.81}} \checkmark = 3.318 = 3.3 \text{ (s)} \checkmark$  ecf from 1(b) if speed used
1	d	(all G)PE (lost) is transferred to KE no (GP)E transferred to 'heat' / 'thermal' / internal energy <b>OR</b> $\checkmark$ (therefore) $mg\Delta h = \frac{1}{2}mv^2 \checkmark$ mass cancels $\checkmark$
total		9

2 max 1 if g =10 used (35100 J)  
Correct answer gains both marks

2 allow 32 (32.3) for the use of 34000  
allow 32.6  
don't penalise g=10 (32.863)

2 With use of g= 9.8 or 9.81or 10 and/or various suvat equations, expect range 3.2 to 3.4 s.  
No penalty for using g= 10 here.

3 Must imply that all GPE is transferred to KE. E.g. accept 'loss of GPE is gain in KE' but not: 'loses GPE and gains KE.'  
  
Accept 'm's crossed out

2	a	$(s = \frac{1}{2}(u + v)t)$ $u = \frac{2s}{t} - v \text{ OR substitution in above equation OR } u = \frac{2 \times 1.5}{0.43} - 5.0 \checkmark$ $= 6.9767 - 5.0 \checkmark = 2.0 \checkmark (1.98 \text{ ms}^{-1})$	3	<p>Correct answer with no working gets 2 out of three.</p> <p>Full credit for use of <math>g \sin 25 =</math> acceleration down slope. This yields answer <math>3.22 \text{ ms}^{-1}</math></p> <p>Allow 1sf answer (2).</p>	
2	b	i	$(F = 75 \times 9.81 \times) \sin 25 (^{\circ}) \checkmark$ $= 310 (311, 310.94) \text{ (N)} \checkmark$	2	<p>use of <math>g = 10</math> not penalised here</p> <p>'sin25' on its own</p> <p>Use of <math>g=10</math> yields 317</p> <p>Allow cos65</p>
2	b	ii	$W = Fs$ $= 311 \times 2.0 = 620 (622 \text{ J}) \checkmark \text{ ecf } (2\text{bi}) \times 2.0$	1	
2	c		<p>Idea that GPE is ultimately transferred to: internal (energy) / 'heat' / 'thermal' (energy in the surroundings) <math>\checkmark</math></p> <p>Correct reference to a named resistive force: friction / drag / air resistance <math>\checkmark</math></p> <p><u>All</u> GPE becomes 'heat', etc <b>OR</b> no (overall) increase in KE <b>OR</b> reference to <u>work done</u> against or by a resistive force <math>\checkmark</math></p>	3	<p>Allow transfer of GPE to KE and then to 'thermal' etc</p> <p>Do not allow reference to 'sound' on its own</p> <p>Don't accept implication that a resistive force is a form of energy</p> <p>Do not allow references to loss of body heat.</p> <p>Allow: '(GPE) not converted to KE'</p>
			total	<b>9</b>	

3	a	<p>(sum of ) clockwise moment(s) = (sum of ) anticlockwise moment(s) ✓  <u>sum of</u> clockwise moment <u>s</u> = <u>sum of</u> anticlockwise moment <u>s</u> (about any given point) ✓                      (for a system in) equilibrium ✓ allow 'balanced'</p>	3	<p>third mark depends upon the first                      Don't allow references to 'forces' being balanced.                      Don't allow 'stationary'.                      Allow 'total', etc instead of sum                      Ignore definitions of moment</p>	
3	b	i	<p><math>35 \times 110 (\times 10^{-3}) \checkmark</math>  <math>(= 3.85) = 3.9 ( \text{ or } 3.8) \checkmark</math>  <math>(3.9) \text{ Nm} / \text{ allow } (3850, 3900) \text{ Nmm} \checkmark</math> don't allow nm, NM</p>	3	<p>allow 4 or 3.90 but not 4.0                      unit must match answer</p>
3	b	ii	<p><math>3.85 = T \times 25 (\times 10^{-3}) \checkmark</math> ecf from (bi)  <math>T = 3.85 / 25 (\times 10^{-3}) = 0.150 (\times 10^3) \checkmark</math> ecf  <math>= 150 (154 \text{ N}) \checkmark</math></p>	3	<p>Correct answer with no working gets 2 out of three.                      Allow 156 (160) N from rounding error</p>
3	c		<p><math>(P = Fv , F = P/v )</math>  <math>= 2.8(\times 10^3) / 15 \checkmark</math>  <math>= 190 (186.7 \text{ N}) \checkmark</math></p>	2	
			total	11	

4	a	$(W = mg)$ $= 4.8 \times 35 \times 9.81 \checkmark$ $= 1600 (1648 \text{ N}) \checkmark$	2	Allow $g=10 : 1680 (1700 \text{ N})$ $g = 9.8 \rightarrow 1646 \text{ N}$ max 1 for doubling or halving. Max 1 for use of grammes
4	b	$(\text{stress} = \text{tension} / \text{area})$ $= (0.5 \times) 1.5 \times 10^6 / 6.2 \times 10^{-4} \text{ OR } = 1.5 \times 10^6 / (2 \times) 6.2 \times 10^{-4} \checkmark$ $= 1.2 \times 10^9 (1.21 \text{ GPa}) \checkmark$	2	For first mark, forgive absence of or incorrect doubling/ halving. Forgive incorrect prefix if correct answer seen.
4	c i	$(\text{weight} = \text{stress} \times \text{area})$ $= 400 \times (10^6) \times 6.2 \times 10^{-4} (= 248\,000 \text{ N}) \checkmark$ $(\times 2 =) 5.0 \times 10^5 (496\,000 \text{ N}) \checkmark$	2	max 1 mark for incorrect power of ten in first marking point max 1 mark for doubling or halving both stress and area Forgive incorrect prefix if correct answer seen. Look out for $YM \div 400\text{k Pa}$ which gives correct answer but scores zero.
4	c ii	$\Delta L = \frac{FL}{AE} \text{ OR correct substitution into a correct equation (forgive incorrect doubling or halving for this mark only) } \checkmark$ $= \frac{(\text{Ans } 4\text{ci}/2) \times 35}{6.2 \times 10^{-4} \times 2.1 \times 10^{11}} \text{ OR } \frac{\text{Ans } 4\text{ci} \times 35}{2 \times 6.2 \times 10^{-4} \times 2.1 \times 10^{11}} \checkmark \text{ ecf from } 4\text{ci}$ $( = \frac{(4.96 \times 10^5 / 2) \times 35}{6.2 \times 10^{-4} \times 2.1 \times 10^{11}} = ) 6.7 \times 10^{-2} (6.667 \times 10^{-2} \text{ m}) \checkmark \text{ ecf from } 4\text{ci}$	3	OR alternative method: strain = stress/ $E$ then $\Delta L = L \times \text{strain}$ If answer to 4ci is used, it must be halved, unless area is doubled, for this mark  Any incorrect doubling or halving is max 1 mark. Allow 0.07

4	c	iii $( k = \frac{F}{\Delta L} )$ $= \frac{2 \times 248\,000}{6.667 \times 10^{-2}}$ OR correct substitution into $F=k\Delta L$ ✓ ecf ci and cii ( answer 4c(i) ÷ answer 4c(ii) ) $= 7.4(4) \times 10^6$ ✓ (Nm <sup>-1</sup> )	2	Allow halving extension for force on one cable  Correct answer gains both marks
4	c	iv $( E = \frac{1}{2}F\Delta L \text{ or } E = \frac{1}{2}k\Delta L^2 )$ $= \frac{1}{2} \times 496\,000 \times 6.667 \times 10^{-2}$ OR $\frac{1}{2} \times 7.4(4) \times 10^6 \times (6.667 \times 10^{-2})^2$ ✓ ecf ci, cii, ciii $= 1.6(5) \times 10^4$ (J) ✓	2	Correct answer gains both marks  Forgive incorrect prefix if correct answer seen. Doubling the force gets zero.
total			13	

5	a		$(n = \frac{\sin 14.1}{\sin 9.54})$ <b>OR</b> 0.2436 / 0.1657      working must be seen <b>AND</b> (= 1.4699) = 1.47      ✓ given correctly to 3 or more significant figures	1	0.24/0.17 = 1.41 is not acceptable Watch for: 14.1 / 9.54 = 1.478
5	b	i	ray goes along the boundary ✓  (partial) reflection shown ✓ (allow dotted or solid line. This mark can be awarded if TIR is shown)	2	Deviation by no more than 1mm by the end of the diagram.  Tolerance: 70° to 85° to normal or labelled e.g. $\theta$ and $\theta$ , etc
5	b	ii	$(90 - 9.54 = )$ 80.46 or 80.5 ✓ (°) ( allow 80°)	1	Don't allow 81 degrees
5	b	iii	$(n = n_c \sin \theta)$ $= 1.47 \sin 80.46^\circ$ ✓ ecf bii $= 1.45$ ✓ (1.4496)	2	allow 80 or 81 degrees here  Correct answer gains both marks
5	c		<ul style="list-style-type: none"> <li>• protect the <u>core</u> (from scratches, stretching or breakage)</li> <li>• prevent 'crossover' of signal / ensure security of data / prevent loss of information/data/signal</li> <li>• increase the critical angle / reduce pulse broadening/(modal)dispersion / rays with a small angle of incidence will be refracted out of the core</li> <li>• increase rate of data transfer</li> </ul> <p style="text-align: right;">max two correct (from separate bullet points) ✓✓</p>	2	comment on 'quality' of signal' is not sufficient don't allow 'leakage' on its own. Don't allow 'loss of light' Allow 'leakage of signal', etc
			total	8	



6	5/6	<p><b>Good / Excellent</b></p> <p><b>The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.</b></p> <p>The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.</p> <p><b>High Level (Good to excellent): 5 or 6 marks</b></p> <p>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.</p> <p>Mentions:</p> <ul style="list-style-type: none"> <li>• (1) waves (meet when) travelling in <u>opposite</u> directions / cross/ wave meets a reflected wave / etc</li> <li>• (2) same wavelength (or frequency)</li> <li>• (3) node – point of minimum or no disturbance</li> <li>• (4) antinode – point of maximum disturbance / maximum displacement/amplitude occurs</li> <li>• (5) node - two waves (always) cancel/ destructive interference / 180° phase difference (between displacements of the two waves at the node)</li> <li>• (6) antinode – reinforcement / constructive interference occurs / (displacements) in phase</li> <li>• (7) mention of <u>superposition</u> of the two waves</li> </ul> <p>5 marks: points (1) <b>AND</b> (2) with three points from (3), (4), (5), (6) or (7)</p> <p>for 6 marks: points (1) to (6) must be seen</p>	5/6	<p>can say disturbance, amplitude or displacement</p> <p>labelled diagram can provide supporting evidence but labels: 'node' / 'antinode' by themselves cannot replace points 3 and 4</p>
	3/4	<p><b>Modest</b></p> <p><b>Intermediate Level (Modest to adequate): 3 or 4 marks</b></p> <p>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.</p> <p>Mentions any 3 of the 7 points.</p> <p>4 marks: (1) <b>OR</b> (2) <b>AND</b> three others.</p>	3/4	

	1/2	<p><b>Limited</b>  <b>Low Level (Poor to limited): 1 or 2 marks</b>                  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.                  One relevant point  <b>OR</b> a relevant, labelled diagram</p> <p>2 marks: two points OR one point and a relevant labelled diagram</p>	1/2	
		total	6	

7	a	same wavelength/ frequency ✓ constant phase relationship ✓ allow 'constant phase difference' but not 'in phase'	2	
7	b	i $(\lambda = \frac{c}{f})$ $3.00 \times 10^8 = 9.4 \times (10^9) \lambda$ OR $= \frac{3.00 \times 10^8}{9.4 \times (10^9)}$ ✓ $= 3.2 \times 10^{-2}$ (3.19 × 10 <sup>-2</sup> m) ✓	2	Use of speed of sound gets zero  Allow 0.03
7	b	ii $3.2 \times 10^{-2}$ ✓ (m) ecf from bi	1	Don't allow '1 wavelength', $1\lambda$ , etc Do not accept: zero, $2\pi$ , $360^\circ$
7	c	maximum (at position shown) ✓ constructive interference / reinforcement ✓ <b>ecf for 'minimum' or for reference to wrong maximum</b> (the waves meet) 'in step' / peak meets peak / trough meets trough / path difference is $(n)\lambda$ / in phase ✓	3	allow constructive superposition. 'Addition' is not enough
7	d	$s = \frac{\lambda D}{w}$ $= \frac{0.0319 \times 0.42}{0.11}$ ✓ ecf 7bi $= 0.12$ (0.1218 m) ✓  $=$ <b>any 2sf</b> number ✓	3	Don't allow use of Fig 5 as a scale diagram.  Do not penalise s and w symbols wrong way round in working if answer is correct.  Correct answer gains first two marks.  Independent sf mark for <b>any 2 sf</b> number

7	e	<p>a maximum ✓</p> <p>(<math>f \times 2</math> results in) <math>\lambda/2</math> ✓</p> <p>path difference is an even number of multiples of the new wavelength (<math>2n \lambda_{new}</math>) ✓</p> <p>allow 'path difference is <math>n\lambda</math>' / any even number of multiples of the new <math>\lambda</math> quoted e.g. 'path difference is now <math>2\lambda</math>'</p>	3	Candidates stating 'minimum' can get second mark only
		total	14	