Version 1.0

General Certificate of Education (A-level)
January 2013

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 students' 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 students' 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.

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Question				Mark & Comments	
1	a		$(Ep = mg\Delta h)$ = 65 × 9.81× 54 ✓ = 3.44×10^4 = 3.4×10^4 (J) ✓ (34433)	2	max 1 if g =10 used (35100 J) Correct answer gains both marks
1	b		$v = \sqrt{\frac{2Ep}{m}}$ OR $v = \sqrt{\frac{2\times34433}{65}}$ ✓ = 33 (32.55 ms^{-1}) ✓ ecf 1(a) OR correct use of $v^2 = 2\,g\,s$	2	allow 32 (32.3) for the use of 34000 allow 32.6 don't penalise g=10 (32.863)
1	c		$(s = 1/2\ gt^2$ or other kinematics equation) $t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2\times54}{9.81}}$ ✓ = 3.318 = 3.3 (s) ✓ ecf from 1(b) if speed used	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.
1	d		(all G)PE (lost) is transferred to KE no (GP)E transferred to 'heat' / 'thermal' / internal energy **OR** ✓ (therefore) $mg\Delta h = \frac{1}{2}mv^2$ ✓ mass cancels ✓	3	Must imply that <u>all</u> 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
			total	9	

2	a		$(s = \frac{1}{2}(u + v)t)$ $u = \frac{2s}{t}$ - *v* **OR** substitution in above equation **OR** $u = \frac{2\times1.5}{0.43}$ - 5.0 ✓ = 6.9767 – 5.0 ✓ = 2.0 ✓ (1.98 ms^{-1})	3	Correct answer with no working gets 2 out of three. Full credit for use of *g*sin25 = acceleration down slope. This yields answer 3.22 ms^{-1} Allow 1sf answer (2).
2	b	i	(*F* = 75 × 9.81 ×) <u>sin25</u> (^{o})✓ = 310 (311, 310.94) (N) ✓	2	use of g = 10 not penalised here 'sin25' on its own Use of g=10 yields 317 Allow cos65
2	b	ii	$W = Fs$ = 311× 2.0 = 620 (622 J) ✓ ecf (2bi) × 2.0	1	
2	c		Idea that GPE is ultimately transferred to: internal (energy) /'heat'/ 'thermal' (energy in the surroundings) ✓ Correct reference to a named resistive force: friction / drag / air resistance ✓ <u>All</u> GPE becomes 'heat', etc **OR** no (overall) increase in KE **OR** reference to <u>work done</u> against or by a resistive force ✓	3	Allow transfer of GPE to KE and then to 'thermal' etc Do not allow reference to 'sound' on its own Don't accept implication that a resistive force is a form of energy Do not allow references to loss of body heat. Allow: '(GPE) not converted to KE'
			total	**9**	

3	a		(sum of) clockwise moment(s) = (sum of) anticlockwise moment(s) ✓ **sum of** clockwise moment **s** = **sum of** anticlockwise moment **s** (about any given point) ✓ (for a system in) equilibrium ✓ allow 'balanced'	3	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
3	b	i	35 × 110 (×10^{-3}) ✓ (= 3.85) = 3.9 (or 3.8) ✓ (3.9) **Nm** / allow (3850, 3900) **Nmm** ✓ don't allow nm, NM	3	allow 4 or 3.90 but not 4.0 unit must match answer
3	b	ii	3.85 = T × 25 (×10^{-3}) ✓ ecf from (bi) T = 3.85 / 25 (×10^{-3}) = 0.150 (×10^{3}) ✓ ecf = 150 (154 N) ✓	3	Correct answer with no working gets 2 out of three. Allow 156 (160) N from rounding error
3	c		($P = Fv$, $F = P/v$) = 2.8(×10^{3}) / 15 ✓ = 190 (186.7 N) ✓	2	
			total	11	

4	a		$(W = mg)$ = 4.8 × 35 × 9.81✓ =1600 (1648 N) ✓	2	Allow g=10 : 1680 (1700 N) g = 9.8 → 1646 N max 1 for doubling or halving. Max 1 for use of grammes
4	b		(stress = tension / area) = (0.5 ×) 1.5×10^{6} / 6.2×10^{-4} OR = 1.5×10^{6} / (2 ×) 6.2×10^{-4} ✓ = 1.2×10^{9} (1.21 GPa) ✓	2	For first mark, forgive absence of or incorrect doubling/ halving. Forgive incorrect prefix if correct answer seen.
4	c	i	(weight = stress × area) = 400×(10^{6}) × 6.2×10^{-4} (= 248 000 N) ✓ (× 2 =) 5.0×10^{5} (496 000 N) ✓	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 ÷ 400k Pa which gives correct answer but scores zero.
4	c	ii	$\Delta L = \frac{F\ L}{A\ E}$ **OR** correct substitution into a correct equation (forgive incorrect doubling or halving for this mark only) ✓ = $\frac{(\text{Ans } 4\text{ci}/\mathbf{2})\times 35}{6.2\times10^{-4}\times 2.1\times 10^{11}}$ **OR** $\frac{\text{Ans } 4\text{ci} \times 35}{\mathbf{2}\times 6.2\times10^{-4}\times 2.1\times 10^{11}}$ ✓ ecf from 4ci (= $\frac{(4.96\times10^{5}/2)\times 35}{6.2\times10^{-4}\times 2.1\times 10^{11}}$ =) 6.7×10^{-2} (6.667×10^{-2} m) ✓ ecf from 4ci	3	OR alternative method: strain = stress/ *E* then Δ*L* = *L* x 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)×10^{6} ✓ (Nm^{-1})	2	Allow halving extension for force on one cable Correct answer gains both marks
4	c	iv	($E = \frac{1}{2}F\Delta L$ or $E = \frac{1}{2}k\Delta L^2$) = ½ × 496 000 × 6.667×10^{-2} OR $½ \times 7.4(4) \times 10^{6} \times (6.667 \times 10^{-2})^2$ ✓ 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		$(n =) \frac{\sin 14.1}{\sin 9.54}$ **OR** 0.2436 / 0.1657 working must be seen **AND** (= 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^o to 85^o to normal or labelled e.g. θ and θ, etc
5	b	ii	(90 – 9.54 =) 80.46 or 80.5 ✓ (^{o}) (allow 80^o)	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		• protect the <u>core</u> (from scratches, stretching or breakage) • prevent 'crossover' of signal / ensure security of data / prevent loss of information/data/signal • increase the critical angle / reduce pulse broadening/(modal)dispersion / rays with a small angle of incidence will be refracted out of the core • increase rate of data transfer max two correct (from separate bullet points) ✓✓	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		**Good / Excellent** **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. Mentions: • (1) waves (meet when) travelling in <u>opposite</u> directions / cross/ wave meets a reflected wave / etc • (2) same wavelength (or frequency) • (3) node – point of minimum or no disturbance • (4) antinode – point of maximum disturbance / maximum displacement/amplitude occurs • (5) node - two waves (always) cancel/ destructive interference / 180^{o} phase difference (between displacements of the two waves at the node) • (6) antinode – reinforcement / constructive interference occurs / (displacements) in phase • (7) mention of <u>superposition</u> of the two waves 5 marks: points (1) **AND** (2) with three points from (3), (4), (5), (6) or (7) for 6 marks: points (1) to (6) must be seen	5/6	can say disturbance, amplitude or displacement labelled diagram can provide supporting evidence but labels: 'node' / 'antinode' by themselves cannot replace points 3 and 4
	3/4		**Modest** **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 any 3 of the 7 points. 4 marks: (1) **OR** (2) **AND** three others.	3/4	

	1/2		**Limited** **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. One relevant point **OR** a relevant, labelled diagram 2 marks: two points OR one point and a relevant labelled diagram	1/2	
			total	6	

7	a		same wavelength/ frequency ✓ constant phase relationship ✓ allow 'constant phase difference' but not 'in phase'	2	
7	b	i	($\lambda = \frac{c}{f}$) $3.00\times10^{8} = 9.4\times (10^{9})\ \lambda$ OR $= \frac{3.00\times10^{8}}{9.4\times(10^{9})}$ ✓ $= 3.2\times10^{-2}$ $(3.19\times10^{-2}$ m) ✓	2	Use of speed of sound gets zero Allow 0.03
7	b	ii	3.2×10^{-2} ✓ (m) ecf from bi	1	Don't allow '1 wavelength', 1λ, etc Do not accept: zero, 2π, 360°
7	c		maximum (at position shown) ✓ constructive interference / reinforcement ✓ **ecf for 'minimum' or for reference to wrong maximum** (the waves meet) 'in step' / peak meets peak / trough meets trough / path difference is (n)λ / in phase ✓	3	allow constructive superposition. 'Addition' is not enough
7	d		$s = \frac{\lambda D}{w}$ $= \frac{0.0319\times0.42}{0.11}$ ✓ ecf 7bi = 0.12 (0.1218 m) ✓ = **any <u>2sf</u>** 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 **any** 2 sf number

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