A-LEVEL
PHYSICS A

PHYA2 – mechanics, materials and waves
Mark scheme

2450
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COMPONENT NAME: Unit 2 – Mechanics, materials and waves

COMPONENT NUMBER: PHYA2

Question	Part	Sub Part	Marking Guidance	Mark		Comments
1	a		8300 x 9.81 OR = 81423 ✓ (8300 x 9.81 sin 25) = 3.4 x 10^4 (N) ✓ (34 411 N) ecf from first line unless g not used msin25 gets zero	2		Penalize use of g=10 here only (35 077 N) Allow 9.8 in any question **Correct answer only, gets both marks for all two mark questions**
1	b	i	($E_k = ½mv^2$) = ½ x 8300 x 56^2 ✓ = 1.3 x10^7 (J) ✓ (13 014 400) allow use of 8300 only	2		In general: Penalise transcription errors and rounding errors in answers

1	b	ii	*mgh* = KE (13 014 400) for *mgh* allow GPE or E_p OR 13 014 400 / 81 423 ✓ h = 160 (m) ✓ (159.8) ecf 1bi	2		Allow use of suvat approach
1	c	i	(work done) by friction \ drag \ air resistance \ resistive forces ✓ (Energy converted) to internal \ thermal energy ✓	2		Allow 'heat'
1	c	ii	0.87 x (8300 x 9.81 x 140 = 9 917 000) OR $v = \sqrt{\left[\frac{2 \times (9\,917\,000)}{8300}\right]}$ ✓ = 49 (= 48.88 ms^{-1}) ✓	2		87% of energy for 140m or 160m only for first mark. Use of 160 (52.26) and/or incorrect or no % (52.4) gets max 1 provided working is shown. **Do not credit suvat approaches here**.
			Total	10		

2	a	i	Use of $\left(s = \frac{1}{2}gt^2\right)$ OR $t^2 = 2s/g$ ✓ t = $\sqrt{\frac{2 \times 1.2}{9.81}}$ ✓ = 0.49 (0.4946 s) ✓ allow 0.5 do not allow 0.50	3		Some working required for full marks. Correct answer only gets 2

2	a	ii	*(s= vt)* = 8.5 x 0.4946 ✓ ecf ai = 4.2 m ✓ (4.20) ecf from ai	2		

2	b	i	$\left(s = \frac{1}{2}(u+v)\,t\right)$ $t = \frac{2s}{u(+v)}$ or correct sub into equation above ✓ $= \frac{2 \times 0.35}{8.5}$ = 8.2 x 10^{-2} (s) ✓ (0.0824) allow 0.08 but not 0.080 or 0.1	2		Allow alternative correct approaches

2	b ii		*a* = (*v*-*u*) / *t* OR correct substitution OR a= 103 ✓ (= -8.5) / 8.24 x 10^{-2} = 103.2) (*F = ma* =) 75 x (103.2) ✓ ecf from bi for incorrect acceleration due to arithmetic error only, not a physics error (e.g. do not allow a = 8.5. Use of g gets zero for the question. = 7700 N ✓ (7741) ecf (see above)	3		Or from loss of KE Some working required for full marks. Correct answer only gets 2

			Total	10		

3	a	i	$m = W/g$) (3.4 x 10^4 / 9.81 =) 3500 (3466 kg) ✓	1		Allow use of g=10
3	a	ii	(moment = 34 000 x 5.0) = 1.7 x 10^5 ✓ (Nm) **Nm** ✓ do not allow NM \ nM etc	2		allow in words
3	a	iii	170 000 = T x 12 OR T = 170 000 / 12 ✓ ecf aii = 1.4(167) x 10^4 ✓ (N)	2		
3	a	iv	(Component of T perpendicular to lever) = T cos 24 **OR** 14 167 x 0.9135 **OR** 12942 (N) ✓ ecf aiii allow 2.5cos24 x T (12942) x 2.5 = **F** x 8.0 **OR** F = ((12942) x 2.5) / 8.0 ✓ ecf for incorrect component of T or T on its own F = 4000 (N) ✓ (4044) ecf ecf for incorrect component of T or T on its own allow 4100 for use of 14 200 (4054)	3		Some working required for full marks. Correct answer only gets 2. Failure to find component of T is max 2 (4400 N)
			total	8		

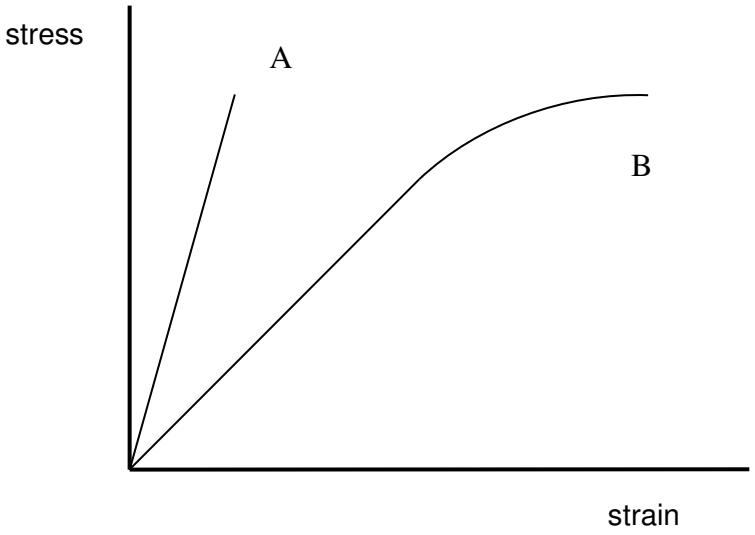
4	a 5/6	Good/excellent	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following 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 **5** of the following: • Diagram (not necessarily labelled) showing a workable arrangement of suitable apparatus • measure diameter of wires • use a micrometer (for the diameter)* • apply range of loads or masses • measure original length • measure or calculate extension • (metre) rule (or equivalent) for the original length or extended length or extension* • Calculation of the weight of the mass \ use 'weights' in newtons And **2** of the following: • Measure diameter in several places • At least 7 different loads* • Repeat measurements for the same wire (or measure whilst unloading)	5/6		

			• Use of a travelling microscope or Searle's apparatus \ pointer touching scale \ set square (for parallax reduction) \ Vernier scale (not Vernier calipers) * • Monitor diameter change during experiment *These points may appear in a clear diagram			
	3/4	Moderate	**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 **4** points in total from the following 2 lists: • Diagram (not necessarily labelled) showing a workable arrangement of suitable apparatus • measure diameter of wires (must be stated) • use a micrometer (for the diameter)* • apply range of loads or masses • measure original length • measure or calculate extension • (metre) rule (or equivalent) for the original length or extended length or extension* • Calculation of the weight of the mass \ use 'weights' in newtons Accuracy • Measure diameter in several places • At least 7 different loads* • Repeat measurements for the same wire (or measure whilst unloading) • Use of a travelling microscope or Searle's apparatus \ pointer	3/4		

			touching scale \ set square(for parallax reduction) \ Vernier scale (not Vernier calipers)* • Monitor diameter change during experiment *These points may appear in a clear and suitably labelled diagram A **four mark answer** will have good QWC **OR** will exceed the specification above and will have at least one of the 5 points from the Accuracy list.			
	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. **Two** valid points from the list For two marks, at least **3** points are required	1/2		
			Marking points: • Diagram (not necessarily labelled) showing a workable arrangement of suitable apparatus • measure <u>diameter</u> of wires • use a micrometer (for the diameter)* • apply range of loads or masses • measure original length • measure or calculate extension		**6 marks**	

			• (metre) rule (or equivalent) for the original length or extended length or extension* • Calculation of the weight of the mass \ use 'weights' in newtons • Measure diameter in several places • At least 7 different loads* • Repeat measurements for the same wire (or measure whilst unloading) • Use of a travelling microscope or Searle's apparatus \ pointer touching scale \ set square(for parallax reduction) \ Vernier scale (not Vernier calipers) * • Monitor diameter change during experiment			

4	b	i	brittle ✓ allow misspellings allow: britle, brittleness,	1		

4	b	ii	 For stress- strain: Straight line labelled 'A' with greater gradient than other line and starting close to origin✓ allow small curve in correct direction at end of line. Line labelled 'B' with significant curve and decreasing gradient which may then undulate ✓ (**forgive one label to be missing**)	3		Allow full credit if strain plotted against stress correctly Allow reasonable free hand straight line. Tolerance for curve of A: no more than 10% of the total change in strain for their line.

			Both of the above AND axes labelled, y, 'stress' or symbol or F/A, and x, 'strain or symbol or deltaL / L' ✓ (disallow if incorrect units are included but forgive 'PA' etc) (Assume stress-strain if no labels are give – max 2) For strain – stress: Straight line labelled 'A' with lesser gradient than other line ✓ allow small curve in correct direction at end of line. Line labelled 'B' with significant curve and increasing gradient which may then undulate ✓ (allow one label to be missing) Both of the above AND axes labelled, x, 'stress' or symbol or F/A , and y, 'strain or symbol or deltaL / L' ✓ (disallow if incorrect units are included)			Line B must have a curved portion of 20% or more. It must have an initial straight section A correct force-extension graph gets max 2
4	c	i	(strain = $\Delta L / L$) strain = 0.24/100 (= 0.0024) OR correct calculation of extension (0.0036) ✓ (stress = E x strain) stress = 2.80 (x 10^{11}) x 0.0024 ✓ **ecf from first mark** = 6.7 x10^{8} (Pa) ✓ ecf from first mark	3		Some working required for full marks. Correct answer only gets 2
4	c	ii	($A = \pi(D/2)^2$)	3		Some working required for full

			$\pi(1.4\ (x10^{-3})\ /2)^2$ OR $= 1.539 \times 10^{-6}\ (m^2)$ ✓ ignore incorrect powers of ten $F = E \times A \times \Delta L / L$ **OR** $= 280\ (x10^9) \times 1.539\ (x\ 10^{-6})\ 0.0024$ ecf 4ci (incorrect extension or strain) **OR** A x their stress from 4ci ✓ ecf 4ci for strain and ecf for incorrect area in 4cii but do not accept use of diameter or radius as the area = 1 000 ✓ (1034.46 N)			marks. Correct answer only gets 2 Use of diameter or radius for area gets zero for the question

			total		16	

5	a	i	sin 60 = 1.47sin θ **OR** sin θ = sin 60 / 1.47 ✓ ($\sin^{-1}$ 0.5891) = 36 (°) ✓ (36.0955°) (allow 36.2)	2		Allow 36.0

5	a	ii	$\sin \theta_c = 1.33/1.47$ OR $\sin \theta_c = 0.9(048)$ ✓ ($\sin^{-1}$ 0.9048) = 65 (°) ✓ (64.79)	2		Allow 64 for use of 0.9 and 66 for use of 0.91

5	a	iii	Answer consistent with previous answers, e.g. If aii >ai: Ray refracts at the boundary AND goes to the right of the normal ✓ Angle of refraction > angle of incidence ✓ **this mark depends on the first** If aii < ai: TIR ✓ Angle of reflection = angle of incidence ✓ Ignore the path of the ray beyond water/glass boundary	2		Approx. equal angles (continuation of the line must touch 'Figure 4' label)

5	b		For Reason or Explanation: The angle of refraction should be > angle of incidence when entering the water ✓ water has a lower refractive index than glass \ light is faster in water than in glass ✓ TIR could not happen \ there is no critical angle, when ray travels from	4		Allow 'ray doesn't bend towards normal' (at glass/water) Allow optical

			water to oil✓ TIR only occurs when ray travels from higher to lower refractive index \ water has a lower refractive index than oil ✓			density Boundary in question must be clearly implied
			total		10	

6	a		One of: (spectral) analysis of light from stars (analyse) composition of stars Chemical analysis Measuring red shift \ rotation of stars ✓ Insufficient answers: 'observe spectra', 'spectroscopy', 'view absorption \emission spectrum', 'compare spectra', 'look at light from stars'.	1		Allow : measuring wavelength or frequency from a <u>named source</u> of light. Allow any other legitimate application that specifies the source of light. E.g. absorbtion\emission spectra in stars, 'observe spectra of materials'
6	b	i	first order beam first order spectrum first order image ✓	1		Allow 'n=1' , '1' 'one', 1st
6	b	ii	The light at A will appear white (and at B there will be a spectrum) OR greater intensity at A ✓	1		
6	c		(d = 1/ (lines per mm x 10^3) = 6.757 x 10^{-7} (m) OR 6.757 x 10^{-4} (mm) ✓	3		Some working required for full marks. Correct

			($n\lambda = d \sin\theta$) = 6.757 x 10^{-7} x sin 51.0 ✓ ecf **only** for : • incorrect power of ten in otherwise correct calculation of d • use of d =1480, 1.48, 14.8 (etc) • from incorrect order in 6bii = 5.25 x 10^{-7} (m) ✓ ecf **only** for : • incorrect power of ten in otherwise correct d • from incorrect order in 6bii			answer only gets 2 Power of 10 error in d gets max 2. For use of d in mm, answer = 5.25 x 10^{-4} gets max 2 n =2 gets max 2 unless ecf from 6bii use of d=1480 yields wavelength of 1150m

6	d		n = d (sin90) / λ OR n = 6.757 x 10^{-7} / 5.25 x 10^{-7} ✓ ecf both numbers from 6c = 1.29 so <u>no more</u> beams observed ✓ or answer consistent with their working **OR** 2 = d (sinΘ) / λ OR sinΘ = 2 x 5.25 x 10^{-7} / 6.757 x 10^{-7} ✓ ecf both numbers from 6c sinΘ = 1.55 (so not possible to calculate angle) so <u>no more</u> beams ✓	2		Accept 1.28, 1.3 Second line gets both marks Conclusion consistent with working

			OR $\sin^{-1}$(2 x (their λ / their d)) ✓ (not possible to calculate) so no more beams ✓ ecf			

			total		8	
7	a		number of (complete) waves (passing a point) in 1 second OR number of waves / time (for the waves to pass a point) OR (complete number of) oscillations \ vibrations per second OR 1/T with T defined as time for 1 (complete) oscillation ✓	1		Allow: Cycles Allow: unit time
7	b		For two marks: Oscillation of particles \ medium \ material etc, but not oscillation of wave is parallel to \ in same direction as the direction wave (travels) ✓✓ For one mark: Particles\material\medium move(s) \ disturbance \ displacement Parallel to \ in same direction as the direction wave travels OR (oscillations) parallel to direction of wave travel ✓ The one mark answer with: Mention of compressions and rarefactions	2		Allow Vibration Allow direction of energy transfer \ wave propagation

			OR (Longitudinal waves) cannot be polarised Gets **two** marks ✓			

7	c		(f = 1540 / 0.50 x10^{-3}) = 3 100 000 (Hz) ✓ (3 080 000) **2sf** ✓	2		

7	d		No more than two points from either list (max 3): <u>Description</u> • Mention of nodes <u>and</u> antinodes • Particles not moving at a node • Maximum displacement at antinode • Particles either side of node in antiphase / between two nodes in phase • Variation of amplitude between nodes <u>Explanation</u> • A stationary wave (forms) • two waves are of <u>equal frequency</u> or wavelength (and amplitude in the same medium) • reflected and transmitted waves \ waves travelling in opposite directions, pass through each other • superpose / interfere occurs • constructive interference at antinodes • destructive interference at nodes	3		Allow 'standing wave'

			✓✓✓			

			total		8	
			Total on paper		70	