

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS B (ADVANCING PHYSICS) G492 MS

Unit G492: Understanding Processes and Experimentation and Data Handling

Specimen Mark Scheme

The maximum mark for this paper is 100.

Section A				
Question Number	Answer	Max Mark		
1 (a)	B✓	[1]		
(b)	A✓	[1]		
2	B✓	[1]		
3 (a)	20 ✓ (m s ⁻¹)	[1]		
(b)	0.5 ✓ (s)	[1]		
(c)	$(20 \times 0.5) + (\frac{1}{2} \times 20 \times 3.5) \checkmark m = 45 \text{ (m)} \checkmark e$	[0]		
	$45 \text{ m} \neq 2$	[2]		
4 (a)	energy (= $6.6 \times 10^{-4} \times 3.2 \times 10^{14}$) = $2.1 \times 10^{16} \checkmark$ (J)	F41		
(b)	$(1.0 \times 10^{-7})/(2.1 \times 10^{-19})$, (-1.0×10^{11}) , (-2.0×10^{11}) , $(-2.0 \times 10^{-7})/(2.1 \times 10^{-19})$, (-1.0×10^{11}) , (-2.0×10^{-19}) ,	[[]		
(0)	$(1.0 \times 10)/(2.1 \times 10) = 4.8 \times 10 = 400 \text{ ect}$ from (a)	[2]		
5	Either s = $\frac{1}{2}$ at ² \Rightarrow t ² = (2 x 0.15)/9.8 \Rightarrow t = 0.18 s \sqrt{m}			
	Or directly using t = 0.2 s to find s = 0.196 m \checkmark method \checkmark evaluation			
	allow g = 10 N kg ⁻¹ , giving t =0.17 s or s = 200 mm			
	then explaining why he can't catch the note \checkmark	[3]		
6(a)	$F = 10\ 000\ x\ 3.1\ \checkmark\ = 31\ 000\ \checkmark\ (N)$	[2]		
(b)	weight = 75 000 – 31 000 = 44 000 (N) ✓	[1]		
(c)	$g = 44\ 000\ /\ 10\ 000 = 4.4\ \checkmark\ (N\ kg^{-1})\ ecf\ from\ (b)$			
	no ecf if g = 9.8 N kg ⁻¹ assumed in (b)	[1]		
7	test proposed e.g. calculate $k = y/x^2$ to see if constant, \checkmark			
	carried out on all data \checkmark conclusion based on test: not constant			
	(values 0.099,0.076,0.056) <u>because</u> variation too great/value of k gets progressively smaller, so not random variation \checkmark			
	test can be implicit in working	[3]		
	Section A total	[20]		
8(a)	$v^2 = 2gh$ approach $v^2 = 2 \times 9.8 \times 169 \checkmark v = 58 \checkmark (m s^{-1})$	[2]		
(b)	$v = 100/2.12 = 47 \text{m s}^{-1} \checkmark$			
	$47 \text{m s}^{-1} = 47 \times 60 \times 60 / 1000 \text{ km h}^{-1} = 170 \text{ km h}^{-1} (> 160 \text{ km h}^{-1}) \checkmark$	[2]		
(c)(i)	weight = 72 x 9.8 = 710 N ✓ (accept 2 or 3 S.F.)			
	Accept use of $g = 10 \text{ N kg}^{-1}$ to give 720 N	[1]		
(ii)	Scale drawing: 15° right-angled triangle with opposite side shown as			
	including ecf to give 180 N +10 N \checkmark			
	or 710 sin 15° \checkmark = 180N \checkmark ecf from (c)(i)	[2]		
<i></i>	balanced forces idea (resultant force = zero) \checkmark	[-]		
(111)	argued in terms of forces	[1]		
	Total	[8]		
9 (a)(i)	Any three points from:			
	symmetrical about central max			
	central maximum is brightest			
	Intensity decreases with 'order'			
	maxima are equally spaced	101		
		[3]		

Question NumberAnswerMax Mark(ii)A: constructive interference/waves add/waves superimpose IN PHASE / path difference is a whole number of λ /AW AND B: destructive interference/waves cancel/ waves in ANTIPHASE (out of phase)/ pd is an odd number of half wavelengths \checkmark [1](ib)(i)1 / 80 000 or (1 x 10 ³)/80 \checkmark (= 1.25 x 10 ⁵ m)[1](ii)tan $\theta = 0.06 / 1.2 \Rightarrow 0 = 2.86^{\circ} / method < valuationAW e.g. Pythagoras and then find sin 0 from the triangle for \checkmark \checkmarkallow tan 0 = sin 0 if reason given e.g. angles small\lambda = 1.25 \times 10^5 x sin 2.9^{\circ} \checkmark = 6.3 \times 10^7 m \checkmark [deduce 2nd mark ifno unit](allow use of 3° giving 6.5 \times 10^{-7})[4](c)sensible change \checkmark justified \checkmarke.g. more lines mm-1 \checkmark larger spacing between maxima to measure \checkmarkor move screen further \checkmark smaller % error in distances \checkmarkmeasure to higher order \checkmark smaller % error in distances \checkmark[2][2]10N/kg x kg/m3 x m2 = N m-1 \checkmark (beware fudge)J = N m so J m2 = N m m2 = N m-1 \checkmark or reverse working from N=J/mStages must be shown clearly(b)(i)[2](iii)2 \lor 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J m^2) \sim 4100ecf from (b)(i)[2](iiii)4090 \times 12 \checkmark = 49\ 000 \approx 50\ kW \lor (W) (ecf from (b)(ii))49\ 0000 \times 500 \checkmark = 24\ 500\ 000 = 24.5\ MW \checkmark ecf(iv)[4]11(a)increases and decreases \checkmark (can be stated or implied)Between 0% and 16% \checkmarkOrne of: cyclic/repeating / equally spaced / no sign of dying out \checkmarkQWC: spelling, punctuation & grammar\checkmark(b)(i)[4](b)(i)x: resultant phasor amplitude = 4 \checkmarky: resultant phasor amplitude = 4 \checkmarky: resultant phasor amplitude = 4 \checkmarky: resultant phasor amplitu$	Section B		
(ii) A: constructive interference/waves add/waves superimpose IN PHASE / path difference is a whole number of λ /AW AND B: destructive interference/waves cancel/ waves in ANTIPHASE (out of phase)/ pd is an odd number of half wavelengths \checkmark [1] (b)(i) 1/80 000 or (1 × 10 ³)/80 \checkmark (=1.25 × 10 ⁵ m) [1] (ii) tan $\theta = 0.06 / 1.2 \Rightarrow \theta = 2.86^{\circ} \sqrt{method \checkmark evaluation}$ AW e.g. Pythagoras and then find sin θ from the triangle for \checkmark allow tan $\theta = \sin \theta$ if reason given e.g. angles small $\lambda = 1.25 \times 10^{\circ} \times sin 2.9^{\circ} \checkmark = 6.3 \times 10^{-7} \text{ m} \checkmark$ [deduce 2nd mark if no unit] (allow use of 3° giving 6.5×10^{-7}) [4] (c) sensible change \checkmark justified \checkmark e.g. more lines mm ⁻¹ \checkmark larger spacing between maxima to measure \checkmark or move screen further \checkmark smaller % error in distances \checkmark [2] (a) N/kg x kg/m ³ x m ² = N m ⁻¹ \checkmark (beware fudge) (a) J = N m so J m ² = N m ⁻¹ \checkmark or reverse working from N=J/m Stages must be shown clearly [2] (b)(i) 0.9 m \checkmark [1] (ii) $\frac{1}{2} \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J m^2) \sim 4100$ (iii) $\frac{4090 \times 12 \checkmark = 49000 \approx 50 \text{ kW} \checkmark (W)$ (cef from (b)(ii) 49000 $\times 500 \checkmark = 24 500000 = 24.5 \text{ MW} \checkmark$ ecf [4] (iv) lots of damage/erosion / for conversion to electrical power \checkmark [1] 11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark W: resultant phasor amplitude = 4 \checkmark W: resultant pha	Question Number	Answer	Max Mark
B: destructive interference/waves cancel/ waves in ANTIPHASE (out of phase)/ pd is an odd number of half wavelengths \checkmark [1] (b)(i) 1/80 000 or (1 x 10 ³)/80 \checkmark (= 1.25 x 10 ⁵ m) [1] (ii) tan θ = 0.06 / 1.2 \Rightarrow θ = 2.86 ° \checkmark method \checkmark evaluation AW e.g. Pythagoras and then find sin 0 from the triangle for \checkmark allow tan θ = sin θ if reason given e.g. angles small $\lambda = 1.25 \times 10^{-5} x \sin 2.9^{\circ} \checkmark = 6.3 \times 10^{-7} \text{ m} \checkmark$ [deduce 2nd mark if no unit] (allow use of 3° giving 6.5×10^{-7}) [4] (c) sensible change \checkmark justified \checkmark e.g. more lines mm ⁻¹ \checkmark larger spacing between maxima to measure \checkmark or move screen further \checkmark smaller % error in distances \checkmark measure to higher order \checkmark smaller % error in distances \checkmark [2] 10 N/kg x kg/m ³ x m ² = N m ⁻¹ \checkmark (beware fudge) (a) J = N m so J m ² = N m m ⁻¹ \checkmark or reverse working from N=J/m Stages must be shown clearly [1] (b)(i) 0.9 m \checkmark [1] (ii) $\frac{1}{2} \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J m^2) \sim 4100$ [1] (iii) $4090 \times 12 \checkmark = 490000 \approx 50 \text{ kW} \checkmark (W)$ (cef from (b)(ii)) [2] (iv) lots of damage/erosion / for conversion to electrical power \checkmark [1] 11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar/ [4] (b)(i) x : resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = (4 + 4) ² = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]	(ii)	A: constructive interference/waves add/waves superimpose IN PHASE / path difference is a whole number of λ /AW AND	
(b)(i) 1 / 80 000 or $(1 \times 10^{-3})/80 \checkmark (= 1.25 \times 10^{-5} m)$ [1] (ii) tan $\theta = 0.06 / 1.2 \Rightarrow \theta = 2.86 \degree \checkmark method \checkmark evaluation AW e.g. Pythagoras and then find sin \theta from the triangle for \checkmark \checkmark allow tan \theta = \sin \theta if reason given e.g. angles small \lambda = 1.25 \times 10^{-5} \times \sin 2.9^{\circ} \checkmark = 6.3 \times 10^{-7} m \checkmark [deduce 2nd mark if no unit] (allow use of 3° giving 6.5 \times 10^{-7}) [4](c) sensible change \checkmark justified \checkmark e.g. more lines mm-1 \checkmark larger spacing between maxima to measure \checkmark or move screen further \checkmark smaller % error in distances\checkmark measure to higher order \checkmark smaller % error in distances\checkmark [2]10 N/kg x kg/m3 x m2 = N m-1 \checkmark (beware fudge) J = N m so J m2 = N m-1 \checkmark or reverse working from N=J/m Stages must be shown clearly [2](b)(i) 0.9 m \checkmark [1](ii) \frac{1}{2} \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J m2) \sim 4100 [1](iii) 4090 \times 12 \checkmark = 49000 \approx 50 kW \checkmark (W) (ecf from (b)(i)) [2](iii) 4090 \times 12 \checkmark = 49000 \approx 50 kW \checkmark (W) (ecf from (b)(i)) [2]11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar/ [4](b)(i) x: resultant phasor amplitude = (4 + 4)^4 = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]$		B: destructive interference/waves cancel/ waves in ANTIPHASE (out of phase)/ pd is an odd number of half wavelengths \checkmark	[1]
(ii) $\tan \theta = 0.06 / 1.2 \Rightarrow \theta = 2.86 \circ \sqrt{method \sqrt{evaluation}}$ AW e.g. Pythagoras and then find sin θ from the triangle for $\checkmark \checkmark$ allow tan $\theta = \sin \theta$ if reason given e.g. angles small $\lambda = 1.25 \times 10^{5} \times \sin 2.9^{\circ} \checkmark = 6.3 \times 10^{7} \text{ m} \checkmark [deduce 2nd mark if no unit]}$ (allow use of 3° giving 6.5×10^{7}) [4] (c) sensible change \checkmark justified \checkmark e.g. more lines mm ⁻¹ \checkmark larger spacing between maxima to measure \checkmark or move screen further \checkmark smaller % error in distances \checkmark measure to higher order \checkmark smaller % error in distances \checkmark [2] 10 N/kg x kg/m ³ x m ² = N m ⁻¹ \checkmark (beware fudge) (a) J = N m so J m ² = N m m ² = N m ⁻¹ \checkmark or reverse working from N=J/m Stages must be shown clearly (b)(i) 0.9 m \checkmark (ii) $\frac{1}{2} \times 9.8 \times 1030 \times (0.9)^{2} \checkmark = 4090 \checkmark (J m^{-2}) \sim 4100$ (iii) $\frac{1}{4} 0900 \times 12 \checkmark = 49 000 \approx 50 \text{ kW} \checkmark (W)$ (ecf from (b)(i)) 4090 x 12 $\checkmark = 49 000 \approx 50 \text{ kW} \checkmark (W)$ (ecf from (b)(ii)) (iv) lots of damage/erosion / for conversion to electrical power \checkmark (11) 11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark WC: spelling, punctuation & grammar \checkmark (b)(i) x: resultant phasor amplitude = (4 + 4) ^{3/2} = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]	(b)(i)	$1 / 80\ 000$ or $(1 \times 10^{-3})/80 \checkmark$ (= 1.25 x 10 ⁻⁵ m)	[1]
AW e.g. Pythagoras and then find sin 0 from the triangle for $\checkmark \checkmark$ allow tan $0 = \sin 0$ if reason given e.g. angles small $\lambda = 1.25 \times 10^{5} \times \sin 2.9^{\circ} \checkmark = 6.3 \times 10^{7} \text{ m} \checkmark [deduce 2nd mark ifno unit](allow use of 3° giving 6.5 \times 10^{-7})[4](c)sensible change \checkmark justified \checkmarke.g. more lines mm-1 \checkmark larger spacing between maxima to measure \checkmarkor move screen further \checkmark smaller % error in distances \checkmarkmeasure to higher order \checkmark smaller % error in distances \checkmarkmeasure to higher order \checkmark smaller % error in distances \checkmark[2]10N/kg x kg/m3 x m2 = N m-1 \checkmark (beware fudge)3 = N m so J m2 = N m m-1 \checkmark or reverse working from N=J/mStages must be shown clearly[2](b)(i)0.9 m \checkmark(1)[1](ii)2 \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J m^{-2}) \sim 4100a 000 x 500 \checkmark = 24500 000 = 24.5 \text{ MW }\checkmark ecf(1)[4](iii)increases and decreases \checkmark (can be stated or implied)Between 0% and 16\%One of: cyclic/repeating / equally spaced / no sign of dying out \checkmarkQWC: spelling, punctuation & grammar \checkmark(2)[4](b)(i)x: resultant phasor amplitude = 4 \checkmarky: resultant phasor amplitude = 4 \landy: resultant phasor amplitude = 2.6 to 3.0)for missing scale factor (x=2, y = 1.4) 2 marks max[3]$	(ii)	tan θ = 0.06 / 1.2 \Rightarrow θ = 2.86 ° \checkmark method \checkmark evaluation	
allow tan $\theta = \sin \theta$ if reason given e.g. angles small $\lambda = 1.25 \times 10^{-5} x \sin 2.9^{\circ} \checkmark = 6.3 \times 10^{-7} \underline{m} \checkmark [deduce 2nd mark if no unit] (allow use of 3° giving 6.5 \times 10^{-7}) [4](c) sensible change \checkmark justified \checkmarke.g. more lines mm-1 \checkmark larger spacing between maxima to measure \checkmark or move screen further \checkmark smaller % error in distances\checkmarkmeasure to higher order \checkmark smaller % error in distances\checkmarkmeasure to higher order \checkmark smaller % error in distances\checkmark [2]10 N/kg x kg/m3 x m2 = N m-1 \checkmark (beware fudge)(a) J = N m so J m-2 = N m m-2 \checkmark N m-1 \checkmark or reverse working from N=J/mStages must be shown clearly [1](b)(i) 0.9 m \checkmark [1](ii) \frac{1}{2} x 9.8 x 1030 x (0.9)^2 \checkmark = 4090 \checkmark (J m^2) \sim 4100(iii) 4090 x 12 \checkmark = 49 000 \approx 50 kW \checkmark (W) (ecf from (b)(ii))49 000 x 500 \checkmark = 24 500 000 = 24.5 MW \checkmark ecf [4](iv) lots of damage/erosion / for conversion to electrical power \checkmark [1]11(a) increases and decreases \checkmark (can be stated or implied)Between 0% and 16%\checkmark(b)(i) x: resultant phasor amplitude = 4 \checkmarky: resultant phasor amplitude = (4 + 4)15 = 2.8 \checkmark method\checkmark evaluation(scale drawing tolerance 2.6 to 3.0)for missing scale factor (x=2, y = 1.4) 2 marks max [3]$		AW e.g. Pythagoras and then find sin θ from the triangle for $\checkmark\checkmark$	
$\begin{array}{c c} \lambda = 1.25 \times 10^{-5} \times \sin 2.9^{\circ} \checkmark = 6.3 \times 10^{-7} \ \underline{m} \checkmark [deduce 2nd mark if no unit]} (allow use of 3^{\circ} giving 6.5 \times 10^{-7}) [4] \\ & \text{sensible change } justified \checkmark \\ & \text{e.g. more lines mm}^{-1} \checkmark larger spacing between maxima to measure } \checkmark \\ & \text{or move screen further } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ smaller \% \ error in distances \checkmark \\ & \text{measure to higher order } \checkmark \ measure function \\ & \text{Stages must be shown clearly} \\ & \text{(b)(i)} \qquad 0.9 \ measure \ 12 \ error \ error \ 100 \ error \ from (b)(ii) \\ & \text{measure to hamage/errosion / for conversion to electrical power } \checkmark \\ & \text{(increases and decreases } \checkmark \ (can be stated or implied) \\ & \text{Between 0\% and 16\%} \\ & \text{One of: cyclic/repeating / equally spaced / no sign of dying out } \land \\ & \text{(b)(i)} \qquad x: resultant phasor amplitude = 4 \ y \\ y: resultant phasor amplitude = 4 \ y \\ y: resultant phasor amplitude = 4 \ y \\ y: resultant phasor amplitude = 4 \ y \\ y: resultant phasor amplitude = ($		allow tan θ = sin θ if reason given e.g. angles small	
(c) sensible change \checkmark justified \checkmark e.g. more lines mm ⁻¹ \checkmark larger spacing between maxima to measure \checkmark or move screen further \checkmark smaller % error in distances \checkmark measure to higher order \checkmark smaller % error in distances \checkmark [2] Total [11] 10 N/kg x kg/m ³ x m ² = N m ⁻¹ \checkmark (beware fudge) (a) J = N m so J m ² = N m m ² = N m ⁻¹ \checkmark or reverse working from N=J/m Stages must be shown clearly (b)(i) 0.9 m \checkmark [1] (ii) $\frac{1}{2} \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J m2) \sim 4100$ (iii) $4090 \times 12 \checkmark = 49\ 000 \approx 50\ kW \checkmark (W)$ (ecf from (b)(ii)) 49\ 000 x 500 \checkmark = 24\ 500\ 000 = 24.5\ MW \checkmark ecf [4] (iv) lots of damage/erosion / for conversion to electrical power \checkmark [1] 11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar \checkmark [4] (b)(i) x: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = 4 \checkmark j: resultant phasor amplitude = 4 \checkmark (b)(i) x: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = 4 \checkmark (b)(i) (i) (i) (j) (j) (j) (j) (j) (j) (j) (j) (j) (j		$\lambda = 1.25 \times 10^{-5} \times \sin 2.9^{\circ} \checkmark = 6.3 \times 10^{-7} \text{ m} \checkmark \text{ [deduce 2nd mark if}$	
(c) sensible change \checkmark justified \checkmark e.g. more lines mm ¹ \checkmark larger spacing between maxima to measure \checkmark or move screen further \checkmark smaller % error in distances \checkmark measure to higher order \checkmark smaller % error in distances \checkmark [2] Total [11] 10 N/kg x kg/m ³ x m ² = N m ¹ \checkmark (beware fudge) (a) J = N m so J m ² = N m ¹ \checkmark (beware fudge) J = N m so J m ² = N m ¹ \checkmark or reverse working from N=J/m Stages must be shown clearly (b)(i) 0.9 m \checkmark (1] (ii) $\frac{1}{2} \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J m2) \sim 4100$ (iii) $4090 \times 12 \checkmark = 49000 \approx 50 \text{ kW} \checkmark (W)$ (ecf from (b)(ii)) 49000 x 500 $\checkmark = 24500000 = 24.5 \text{ MW} \checkmark \text{ ecf}$ [4] (iv) lots of damage/erosion / for conversion to electrical power \checkmark (11) 11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar \checkmark (4) x: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = (4 + 4) ^{3/2} = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]		no unit] (allow use of 2° giving 6.5 × 10 ⁻⁷)	F 4 1
(c)sensible triangle $\sqrt{100}$ sensible triangle $\sqrt{100}$ sensible triangle $\sqrt{100}$ sensible $\sqrt{100}$ e.g. more lines mm ⁻¹ \checkmark larger spacing between maxima to measure $\sqrt{100}$ or move screen further $\sqrt{100}$ smaller $\%$ error in distances $\sqrt{100}$ [2]Total10N/kg x kg/m ³ x m ² = N m ⁻¹ \checkmark (beware fudge)(a)J = N m so J m ² = N m ⁻¹ \checkmark (beware fudge)(a)J = N m so J m ² = N m ⁻¹ \checkmark (beware fudge)(a)J = N m so J m ² = N m ⁻¹ \checkmark (or reverse working from N=J/mStages must be shown clearly[2](b)(i)0.9 m \checkmark (ii)½ x 9.8 x 1030 x (0.9) ² \checkmark = 4090 \checkmark (J m ⁻²) \sim 4100erf from (b)(i)(iii)4090 \approx 50 kW \checkmark (W) (ecf from (b)(ii))49 000 x 500 \checkmark = 24 500 000 = 24.5 MW \checkmark ecf(iv)lots of damage/erosion / for conversion to electrical power \checkmark IIITotal11(a)increases and decreases \checkmark (can be stated or implied)Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar \checkmark (4)x: resultant phasor amplitude = 4 \checkmark y: resultant		(allow use of 5 giving 0.5 x 10)	[4]
Instrume of the second problem of the second prob	(C)	e a more lines mm ⁻¹ \checkmark larger spacing between maxima to measure \checkmark	
measure to higher order \checkmark smaller % error in distances \checkmark [2]Image: constraint of the state of the sta		or move screen further \checkmark smaller % error in distances \checkmark	
Image: constraint of the sector of the se		measure to higher order ✓ smaller % error in distances√	
Total[11]10N/kg x kg/m³ x m² = N m¹ ✓ (beware fudge) J = N m so J m² = N m m² = N m¹ ✓ or reverse working from N=J/m Stages must be shown clearly[2](b)(i) $0.9 \text{ m} \checkmark$ [1](ii) $1/2 x 9.8 x 1030 x (0.9)^2 \checkmark = 4090 \checkmark (J m²) ~ 4100$ $4090 x 12 \checkmark = 49 000 ≈ 50 kW ✓ (W) (ecf from (b)(ii))49 000 x 500 \checkmark = 24 500 000 = 24.5 MW \checkmark ecf[4](iv)lots of damage/erosion / for conversion to electrical power ✓[1]11(a)increases and decreases ✓ (can be stated or implied)Between 0% and 16% ✓QWC: spelling, punctuation & grammar ✓QWC: spelling, punctuation & grammar ✓(j'' resultant phasor amplitude = 4 ✓y: resultant phasor amplitude = (4 + 4)½ = 2.8 ✓ method✓ evaluation(scale drawing tolerance 2.6 to 3.0)for missing scale factor (x=2, y = 1.4) 2 marks max[3]$			[2]
10N/kg x kg/m³ x m² = N m⁻¹ ✓ (beware fudge) J = N m so J m² = N m m² = N m⁻¹ ✓ or reverse working from N=J/m Stages must be shown clearly[2](b)(i) $0.9 \text{ m} \checkmark$ [1](ii) $1/2 \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J m²) ~ 4100$ ecf from (b)(i)[2](iii) $4090 \times 12 \checkmark = 49\ 000 \approx 50\ kW \checkmark (W)$ (ecf from (b)(ii)) $49\ 000 \times 500 \checkmark = 24\ 500\ 000 = 24.5\ MW \checkmark ecf$ [4](iv)lots of damage/erosion / for conversion to electrical power ✓[1]11(a)increases and decreases ✓ (can be stated or implied) Between 0% and 16% ✓ One of: cyclic/repeating / equally spaced / no sign of dying out ✓ QWC: spelling, punctuation & grammar√ y: resultant phasor amplitude = 4 ✓ y: resultant phasor amplitude = 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max[3]		Total	[11]
(a) $J = N m \text{ so } J m^2 = N m m^2 = N m^{-1} \checkmark \text{ or reverse working from N=J/m}$ Stages must be shown clearly [2] (b)(i) $0.9 \text{ m } \checkmark$ [1] (ii) $\sqrt{2} \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J m^2) \sim 4100$ ecf from (b)(i) [2] (iii) $4090 \times 12 \checkmark = 49\ 000 \approx 50\ \text{kW } \checkmark (W)\ (\text{ecf from (b)(ii)})$ $49\ 000 \times 500 \checkmark = 24\ 500\ 000 = 24.5\ \text{MW } \checkmark \text{ ecf}$ [4] (iv) lots of damage/erosion / for conversion to electrical power \checkmark [1] 11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark $QWC:$ spelling, punctuation & grammar \checkmark [4] (b)(i) $x:$ resultant phasor amplitude = $4 \checkmark$ $y:$ resultant phasor amplitude = $(4 + 4)^{\frac{1}{2}} = 2.8 \checkmark$ method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]	10	N/kg x kg/m ³ x m ² = N m ⁻¹ \checkmark (beware fudge)	
Stages must be shown clearly[2](b)(i) $0.9 \text{ m }\checkmark$ [1](ii) $1/2 \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J \text{ m}^{-2}) \sim 4100$ [1](iii) $1/2 \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J \text{ m}^{-2}) \sim 4100$ [2](iii) $4090 \times 12 \checkmark = 49000 \approx 50 \text{ kW }\checkmark (W)$ (ecf from (b)(ii))[2](iii) $40900 \times 500 \checkmark = 24500000 = 24.5 \text{ MW }\checkmark \text{ ecf}$ [4](iv)lots of damage/erosion / for conversion to electrical power \checkmark [1]11(a)increases and decreases \checkmark (can be stated or implied)Etween 0% and 16% \checkmark Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark [4](b)(i) $x:$ resultant phasor amplitude = $4 \checkmark$ y: resultant phasor amplitude = $(4 + 4)^{\frac{1}{2}} = 2.8 \checkmark$ method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0)[3]	(a)	J = N m so J m ⁻² = N m m ⁻² = N m ⁻¹ \checkmark or reverse working from N=J/m	
(b)(i) $0.9 \text{ m} \checkmark$ [1](ii) $\frac{1}{2} \ge 9.8 \ge 1030 \ge (0.9)^2 \checkmark = 4090 \checkmark (J \text{ m}^{-2}) \sim 4100$ ecf from (b)(i)(iii) $4090 \ge 12 \checkmark = 49000 \approx 50 \text{ kW} \checkmark (W)$ (ecf from (b)(ii))[2](iii) $4090 \ge 500 \checkmark = 24500000 = 24.5 \text{ MW} \checkmark \text{ ecf}$ [4](iv)lots of damage/erosion / for conversion to electrical power \checkmark[1]11(a)increases and decreases \checkmark (can be stated or implied)Total[10]11(a)increases and decreases \checkmark (can be stated or implied)[4](b)(i) \ge resultant phasor amplitude = $4 \checkmark$ \bigcirc resultant phasor amplitude = $4 \checkmark$ \bigcirc resultant phasor amplitude = $(4 + 4)^{\frac{1}{2}} = 2.8 \checkmark$ method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max[3]		Stages must be shown clearly	[2]
(ii) $\frac{1}{2} \times 9.8 \times 1030 \times (0.9)^2 \checkmark = 4090 \checkmark (J m^{-2}) \sim 4100$ ecf from (b)(i) [2] (iii) $4090 \times 12 \checkmark = 49\ 000 \approx 50\ kW \checkmark (W)$ (ecf from (b)(ii)) $49\ 000 \times 500 \checkmark = 24\ 500\ 000 = 24.5\ MW \checkmark ecf$ [4] (iv) lots of damage/erosion / for conversion to electrical power \checkmark [1] 10] 11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar \checkmark [4] x: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = (4 + 4) ^{3/2} = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]	(b)(i)	0.9 m ✓	[1]
(iii) $4090 \times 12 \checkmark = 49\ 000 \approx 50\ kW \checkmark (W)$ (ecf from (b)(ii)) $49\ 000 \times 500 \checkmark = 24\ 500\ 000 = 24.5\ MW \checkmark ecf$ [4] (iv) lots of damage/erosion / for conversion to electrical power \checkmark [1] Total [10] 11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar \checkmark [4] x: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = (4 + 4) ^{1/2} = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]	(ii)	$\frac{1}{2} \ge 9.8 \ge 1030 \ge (0.9)^2 \checkmark = 4090 \checkmark (J \text{ m}^{-2}) \sim 4100$	501
(iii) 4090 x 12 \checkmark = 49 000 \approx 50 kW \checkmark (W) (ect from (b)(ii)) 49 000 x 500 \checkmark = 24 500 000 = 24.5 MW \checkmark ecf [4] (iv) lots of damage/erosion / for conversion to electrical power \checkmark [1] Total [10] 11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar \checkmark [4] (b)(i) x: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = (4 + 4) ^{1/2} = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]	()	ect from (b)(l)	[2]
(iv) lots of damage/erosion / for conversion to electrical power \checkmark [1] (iv) lots of damage/erosion / for conversion to electrical power \checkmark [1] Total [10] 11(a) increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar \checkmark [4] (b)(i) x: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = (4 + 4) ^{1/2} = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]	(111)	$4090 \times 12 \checkmark = 49000 \approx 50 \text{ kW} \checkmark (\text{W}) \text{ (ect from (b)(II))}$	[1]
(iv)Iots of damage/erosion / for conversion to electrical power v[1]Total[10]11(a)increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar \checkmark [4](b)(i)x: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = (4 + 4) ^{1/2} = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max[3]	(iv)	$49000\times500\vee-24500000-24.5\mathrm{MW}\vee\mathrm{ecc}$	[4] [4]
11(a)increases and decreases \checkmark (can be stated or implied) Between 0% and 16% \checkmark One of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar \checkmark [4](b)(i)x: resultant phasor amplitude = $4 \checkmark$ y: resultant phasor amplitude = $(4 + 4)^{\frac{1}{2}}$ = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max[3]	(1V)		[1]
(b)(i) Increases and decreases \checkmark (can be stated of implied) Between 0% and 16% \checkmark QWC: spelling, punctuation & grammar \checkmark [4] (b)(i) x: resultant phasor amplitude = 4 \checkmark y: resultant phasor amplitude = (4 + 4) ^{1/2} = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]	44(I Otal	ניין
(b)(i) Che of: cyclic/repeating / equally spaced / no sign of dying out \checkmark QWC: spelling, punctuation & grammar \checkmark [4] x: resultant phasor amplitude = $4 \checkmark$ y: resultant phasor amplitude = $(4 + 4)^{\frac{1}{2}} = 2.8 \checkmark$ method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]	11(a)	Between 0% and 16%	
(b)(i) QWC: spelling, punctuation & grammar \checkmark [4] (b)(i) x: resultant phasor amplitude = $4 \checkmark$ y: resultant phasor amplitude = $(4 + 4)^{\frac{1}{2}}$ = 2.8 \checkmark method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]		One of: cvclic/repeating / equally spaced / no sign of dving out	
(b)(i) x: resultant phasor amplitude = $4 \checkmark$ y: resultant phasor amplitude = $(4 + 4)^{\frac{1}{2}} = 2.8 \checkmark$ method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]		QWC: spelling, punctuation & grammar√	[4]
y: resultant phasor amplitude = $(4 + 4)^{\frac{1}{2}} = 2.8 \checkmark$ method \checkmark evaluation (scale drawing tolerance 2.6 to 3.0) for missing scale factor (x=2, y = 1.4) 2 marks max [3]	(b)(i)	x: resultant phasor amplitude = 4 ✓	
(scale drawing tolerance 2.6 to 3.0) for missing scale factor ($x=2$, $y = 1.4$) 2 marks max [3]		y: resultant phasor amplitude = $(4 + 4)^{\frac{1}{2}}$ = 2.8 \checkmark method \checkmark evaluation	
for missing scale factor $(x=2, y = 1.4)$ 2 marks max [3]		(scale drawing tolerance 2.6 to 3.0)	
		for missing scale factor (x=2, y = 1.4) 2 marks max	[3]
(ii) prob related to (amplitude) ² idea \checkmark 16 for x, 8 for y \checkmark	(ii)	prob related to $(\text{amplitude})^2$ idea \checkmark 16 for x, 8 for y \checkmark	
4 for x, 2 for $y \checkmark (ecf)$ from (b)(i)		4 for x, 2 for $y \checkmark (ecf)$ from (b)(i)	[0]
(iii) Dhagara antiphaga ((:::)	Phasers antiphase ([2]
(iii) Pridsors antipridse * so prob / resultant phasor amplitude = $0 \sqrt{(quantum explanation only)}$	(11)	Finasors antipliase \star	
'photons' are out of phase gets no marks		'photons' are out of phase gets no marks	[2]
Total [11]		Total	[11]
Section B total [40]		Section B total	[40]

Section C				
Question Number	Answer	Max Mark		
12(a)(i)	Any two points from:			
	Systematic error (clock 'second' is wrong) ✓			
	Random uncertainty due to reaction time is negligible \checkmark			
	Effect is to give an answer which is too great \checkmark	[2]		
(ii)	Any two points from:			
	No/ negligible(e.g. effect of temperature) systematic error \checkmark			
	Random uncertainty e.g. alignment problems, varying length at different places ✓			
	Effect is to give greater confidence in the length than is justified by the measurement \checkmark	[2]		
(b)	(i) Use more accurate clock /correct for incorrect duration by comparing with accurate time signal√; get several people to measure simultaneously, and plot data to find mean/median/ reject outliers√			
	OR (ii) repeat measurement several times along different parallel lines along the room \checkmark and plot data to find mean/median/reject outliers \checkmark ;			
	NOT just repeat measurement	[2]		
	Total	[6]		
13(a)	(very fast therefore) need large distance ✓ very short interval to time✓	[2]		
(b)	Any three points from:			
	Very large ✓ reduction in uncertainties ✓			
	Progression over many years ✓			
	Up to two examples of creative approach can be each \checkmark if distinct and explained, e.g. octagonal mirror, allowing for effect of air, doing in			
	QWC: appropriate form and style ✓	[4]		
(c)	uncertainties in the metre greater than in $2/f$ measurement \checkmark	[1]		
(d)	Horizontal line within one scale division of 200 700 v	[1]		
(u)	Michelson Middelstaedt Anderson and Bergstrand \checkmark			
	All 4 names needed	[2]		
		[2]		
14 (2)(:)	$\frac{1000}{1000}$	[o]		
14 (a)(l)	Angle = $\sin^{-1}(4.0/120) \neq = 1.9^{-1} \approx 2^{-1} \neq 100$ Must show a calculated result, not just guote 2°, for the second mark.	[2]		
(ji)	$v = w/t = 0, 100\sqrt{0.164} \sqrt{= 0.610} \text{ m s}^{-1}$ (Can be reverse argument from			
("7	0.610 m s^{-1})	[2]		
(iii)	Both measurements used are to 3 S.F.✓			
	Result cannot be stated to greater precision than least precise datum \checkmark	[2]		
(b)(i)	(0.1/4.0)× 100 = 2.5% ✓m✓e	[2]		
(ii)	Absolute uncertainty in height same ✓ smaller fraction ✓ of height	[2]		
(iii)	Repeat several times \checkmark and take averages \checkmark			
	QWC: clear organisation√	[3]		
	Total	[13]		

Section C				
Question Number	Answer	Max Mark		
Question Number 15 (a)(i) (ii) (iii) (b) (b) 4 3.5 3 2.5 3 2.5 1.5 1.5 1.5	Answer $\sqrt{2}/m^2 s^{-2}$ (0.37) (0.78) (1.2) 1.7 2.0 2.6 3.6 All 4 correct for the mark Allow 3 S.F. but not more (values 1.69, 1.96, 2.56 & 3.60 s) Sensible axes labelled with quantity and unit \checkmark points \checkmark line \checkmark No as line does not pass through origin \checkmark (graph below) Can be numerical. g.p.e. = mgh = 0.992 × 9.8 × 0.04 \checkmark = 0.39 J \checkmark k.e. = $\frac{1}{2} mv^2 = \frac{1}{2} \times 0.992 \times 0.37 \checkmark = 0.18 J \checkmark$ Work done against resistive forces \checkmark	Max Mark [1] [4] [1] [6]		
0.5				
0	5 10 15 20 25 h/cm			
	Total	[12]		
Section C total				
	Paper Total	[100]		