OCR
RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced Subsidiary GCE

Unit **G492:** Understanding Processes/Experimentation and Data Handing

Mark Scheme for June 2013

Oxford Cambridge and RSA Examinations

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations available in Scoris

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct response
AE	Arithmetic error
	Wrong physics or equation

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument
owtte	Or words to that effect

1. Annotations should be made as follows:
   - For both QWC questions 10d & 12c, and put × next to pencil icon if QWC not awarded
   - in any question where part marks are awarded, put ✓ at point of award for each mark awarded so that ticks = marks total for that part for any question with a candidate response which does not gain marks, put × or ^ as appropriate
   - additional blank pages (26 & 27) should be annotated if there is no working on them and if marked with ^ if they are blank. These pages are be appended to the bottom of 13(c)(ii) and are easily accessed if you click the 'fit vertically' icon (11th on the icon bar).

2. Calculated answers are shown to 3 significant figures for the convenience of markers. Candidates are expected to express answers to an appropriate number of significant figures, often 2. In this paper, excessive number of sig. figs. Is penalised in 11(c)(ii) only.

3. 'Show that' calculations need evidence of evaluation but rounding error should not be penalised. Accept reverse argument.

Question			Answer	Marks	Guidance
1	(a)		N m	1	
	(b)		J s^{-1}	1	
	(c)		kg m s^{-2}	1	
			Total	**3**	

Question			Answer	Marks	Guidance
2	(a)		**A**	1	
	(b)		**C**	1	
	(c)		**B**	1	
			Total	**3**	

Question			Answer	Marks	Guidance
3			1st and 5th boxes and no others	2	One mark each. If both correct plus one extra tick, 1 mark only.
			Total	**2**	

Question			Answer	Marks	Guidance
4	(a)		energy per second, E = 11 W × 0.45 = 4.95 J (1)m; (1)e	2	Allow rounding to 4.9 or 5.0 J
	(b)		photon energy, $E = hf$ = 6.6 × 10^{-34} J s × 6.0× 10^{14} Hz = 3.96 × 10^{-19} J (1)m (1)e number of photons s^{-1} = 4.95 J/3.96 × 10^{-19} J = 1.25 × 10^{19} (1)	3	Allow ecf from (a) Allow use of **own** value for photon energy for the 3rd marking point as this mark is independent. Allow rounding 1.2 or 1.3 × 10^{19}
			Total	**5**	

Question			Answer	Marks	Guidance
5	(a)		1st box (doubling λ and halving b)	1	No marks if any extra tick present
	(b)		Added tip-to-tail they form a closed shape/they curl up and close	1	**allow** a sketch of at least 3 similar arrows tip-to-tail. allow other valid vector representations of zero resultant from at least 3 components
			Total	**2**	

Question			Answer	Marks	Guidance
6	(a)		1500 N (1); forwards/in the direction the car is moving (1)	2	Allow an arrow, or 'right' (assumed relative to the page) but reject 'east' or 'bearing 90 °'
	(b)		$a = F/m$ = 1500 N/1940 kg = 0.773 m s^{-2} (1)m; (1)e	2	e.c.f own answer to (a)
	(c)		$P = Fv$ = 5800 N × 22 m s^{-1} = 127 600 W = 130 000 W(1)m; (1)e	2	if any force other than 5800 N used, allow max (1) for correct calculation with own force. Penalise rounding errors (>3sf) on this question.
			Total	**6**	
			Section A Total	**21**	

Question			Answer	Marks	Guidance
7	(a)		$a = \Delta v/t$ = 35 m s^{-1}/0.05 s = 700 m s^{-2} (1)m; (1)e; $F = ma$ = 0.44 kg × 700 m s^{-2} = 308 N (1)	3	ecf own value of acceleration See general instruction 16 about 'show that' questions.
	(b)		F_{max} = 590 N (1); $a = F_{max}/m$ = 590 N/0.44 kg = 1340 m s^{-2} (1); 1340 m s^{-2}/9.8 m s^{-2} = 137 ≈ 140	3	allow F_{max} in range 580 N – 600 N 'show that' calculations need evidence of evaluation but rounding error should not be penalised
	(c)		$v_{initial}$ = 0 from t = 0 to 0.018 s ≤ t ≤ 0.022 s (1); v_{final} = 35 m s^{-1} (1); v_{final} is constant , starting at time t, 0.068 ≤ t ≤ 0.072 s, to the end(1); smooth curve joining $v_{initial}$ to maximum value of v (1)	4	v_{final} should be the maximum value of v not straight line for this marking point. Graph which copies F graph (possibly slightly higher) dropping to v<5 before 0.08 s can get 1max (for mp1).
			Total	**10**	

Question			Answer	Marks	Guidance
8	(a)		waves reflected at end/waves travelling both directions **and** superpose/interfere (1); to give places where they (always) superpose/interfere destructively to give zero amplitude /nodes (1); to give positions where they superpose /interfere constructively to give maximum amplitude/antinodes (1)	3	Allow 'cancel' or '(180 °) out of phase' or 'in antiphase Allow 'add' or 'in phase'
	(b)		λ = 2 × 1.8 m/6 = 0.6 m $v = f\lambda$ = 50 Hz × 0.6 m = 30 m s^{-1} (1)m; (1)e	2	**allow** use of equation from (c) award 1 mark for use of wrongly deduced λ
	(c)		each 'loop' is ½λ (1); n × ½λ = 1.8 m ⇒ $\lambda_{(n)}$ = 2 × 1.8 m/n (1)	2	Must be clear from response or this mp is not awarded Approach must be algebraic (possibly in words) not arithmetic
	(d)		example (1); correct description of formation and type of wave involved (1)	2	Context must be clear, e.g. wind instrument, microwave oven, laboratory demonstration Can be longitudinal/transverse or sound (not 'air') /microwaves in the above
			Total	**9**	

Question			Answer	Marks	Guidance
9	(a)	(i)	$v = at$ = 9.8 m s^{-2} × 0.3 s = 2.94 m s^{-1} (1)	1	
		(ii)	$s=½gt^2$ =0.5 × 9.8 m s^{-2} (0.3 s)^2 = 0.441 (m) (1)m; (1)e	2	evaluation mark needs evidence of actual calculation See general instruction 16 about 'show that' questions. Allow valid approaches using other suvat equations.
	(b)	(i)	velocity increments are equal / $v \propto t$ (shown)	1	
		(ii)	distance travelled in consecutive time intervals is increasing	1	
	(c)	(i)	v = 0 (throughout this interval so it hasn't moved)	1	
		(ii)	v used is that at the beginning of each interval (1); true mean v is larger, so actual distance fallen is greater/model s is too small (1); s at end of 1st interval = 0 on the model, which is incorrect (1)	2	Any two points
		(iii)	Use a smaller time interval/Δt reduced (1); would start moving sooner/ velocity is modified more frequently/smaller 'steps' in s or v so smoother changes. (1)	2	Any one point for the 2nd mark. It must explain why it is better.
			Total	**10**	

Question			Answer	Marks	Guidance
10	(a)		at 0° there are both red and green maxima (which add) (1)	1	Must show that they understand that both red and green are observed in this direction. Allow 'red and green not diffracted at this angle' or 'colours don't split up'. Minimal response is 'it contains both red and green light.'
	(b)	(i)	$d = 1.0 \times 10^{-3}$ m/820 = 1.22×10^{-6} m ($\approx 1 \times 10^{-6}$ m)	1	See general instruction 16 about 'show that' questions.
		(ii)	$n\lambda = d \sin\theta \Rightarrow d = n\lambda/\sin\theta$ $= 1 \times 635 \times 10^{-9}$ m / sin(31.4°) = 1.22×10^{-6} m (1)m; (1)e	2	See general instruction 16 about 'show that' questions.
	(c)		2nd order red maximum would require $n\lambda = d \sin\theta \Rightarrow 2 \times 635 \times 10^{-9}$ m = 1.22×10^{-6} m × sin θ $\Rightarrow \sin\theta = 1.04$ (1); which is not possible (1)	2	**allow** use of $d = 1\ \mu$m giving $\sin\theta = 1.27$ other valid methods are possible, eg $d < 2\lambda$ (1); so cannot get a path difference of 2λ (1) ignore 'so $\theta > 90°$'
	(d)		Energy of green photon: $E = hf = 6.6 \times 10^{-34}$ J s × 5.3×10^{14} Hz = 3.50×10^{-19} J (1); Energy of red photon: $E = hf = 6.6 \times 10^{-34}$ J s × 4.7×10^{14} Hz = 3.10×10^{-19} J (1); Energy from 2.4 V = $2.4 \times 1.6 \times 10^{-19}$ J = 3.8×10^{-19} J which is enough for both colours (1); Energy from 2.1 V = $2.1 \times 1.6 \times 10^{-19}$ J = 3.4×10^{-19} J which is enough for red but not green (1) energy calculations above can be combined as: voltage required for green = $(6.6 \times 10^{-34}$ J s × 5.3×10^{14} Hz)/1.6×10^{-19} J = 3.5×10^{-19} J/1.6×10^{-19} J = 2.19 (1); (2.4 V > 2.19 V but) 2.1 V < 2.19 V (1); voltage required for red = $(6.6 \times 10^{-34}$ J s × 4.7×10^{14} Hz)/1.6×10^{-19} J = 3.1×10^{-19} J/1.6×10^{-19} J = 1.94 (1); 1.94 V< 2.1 V (or 2.4 V) (1)	4	Four marks are: green photon energy (1); red photon energy (1); energy from 2.4 V related to photon energy (1); energy from 2.1 V related to photon energy (1) Energy available at the two voltages can include the photon energy calculations via calculations of the threshold frequencies, viz. 2.4 V is enough for any $f \leq 3.8 \times 10^{-19}$ J/$h = 5.82 \times 10^{14}$ Hz (i.e. both colours) 2.1 V is enough for any $f \leq 3.4 \times 10^{-19}$ J/$h = 5.09 \times 10^{14}$ Hz (i.e. red but not green) QWC is 'form and style appropriate to purpose' and requires relevant calculations for both red and green photons and a concluding comment. In the absence of calculations, allow smaller voltage means less energy released (1); red photons are less energetic than green ones (1); and so need a lower voltage to released them (1);
			Total	**10**	
			Section B Total	**39**	

Question			Answer	Marks	Guidance
11	(a)		Sensor **A** (90-34)/(20 -10) = 56/10 = 5.6 (1); Sensor **B** (33-8)/(20 -10) = 25/10 = 2.5 (1); units for **both** are mV °C $^{-1}$ or mV/°C (1)	3	Allow ± 2 on Δ V, i.e. 5.4-5.8 & 2.3 to 2.7 respectively sensitivity of **B** can be measured over any range **allow** eg V °C $^{-1}$ if attempt at conversion made, even if incorrectly done
	(b)	(i)	more sensitive (over that range) (1)	1	owtte
		(ii)	Linear / more sensitive over the greater part of the range (1)	1	or 'sensitivity is constant'. accept more sensitive at higher temperatures
	(c)	(i)	2.6 mV ~ 1 °C $\Rightarrow$ 0.1 mV ~ 0.1/2.6 °C = 0.0385 °C (1)m; (1)e	2	ecf from (a).
		(ii)	$\Delta\theta$ =100 mV/sensitivity of sensor B (2.5 mV ^{o}C $^{-1}$) Or determine $\Delta\theta$ from any two points 100 mV apart (1) m; answer in range 38 °C to 42 °C (1)e	2	allow ecf from (a) eg (47,100) and (7,0) – may need to check graph bald answer in range gets 2 marks no evaluation mark if > 3 sig figs
			Total	**9**	

Question			Answer	Marks	Guidance
12	(a)	(i)	v^2: 4.54 and 17.31 (1); sin θ 0.57 (1)	2	
		(ii)	Plotted points (2); best fit line (1)	3	all 3 in tolerance (allow ±½ small division) = (2); 2 correct = (1) by eye; may or may not go through origin
	(b)	(i)	Gradient from graph (1) m ; Evaluation of gradient (1) e; units = $m^2 s^{-2}$ or m^2/s^2 (1)	3	Need to have line & $\Delta(\sin\theta) \geq 0.1$ for method mark allow use of data points from table if close to the line (allow gradient of own line ecf) allow this mark for use of data points even if no line expect value in range 23 - 29
		(ii)	component of weight down ramp *F* is clearly identified and = *mg* sin θ (1); *a* = *F*/*m* (= *g* sin θ) (1)	2	accept F correctly labelled on diagram for first mark if linked to *mg* sin θ vertical acceleration would be (*mg*/*m* =) *g* (1); component of *g* down ramp = *g* sin θ (1)
		(iii)	u = 0 m s^{-1} so $v^2 = 2as = 2(g \sin\theta)s = 2gs \sin\theta$ (1); gradient = 2*gs* = 2*g* × 1.4 m = 2.8 (m) *g* (1)	2	(u = 0 not necessary, but may be seen) must be algebraic treatment, not arithmetic
		(iv)	*g* = (gradient)/ 2.8 (1) m, e	1	ecf own gradient (candidate may recalculate it) Accept clear and correct suvat methods
	(c)		Identify factor affecting value of *g* obtained (1);(1); Correctly linked to affect on calculated value of *g* (1);(1)	4	**allow** systematic error or uncertainty QWC is organise information clearly and coherently. This would not be awarded unless the effect of **both** factors on the final value is identified.
			Total	**17**	

Question			Answer	Marks	Guidance
13	(a)	(i)	0.1 s to 0.5 s (1);	1	ignore number of sig figs
		(ii)	3.2 km/300 000 km s $^{-1}$ = 1.07 ×10^{-5} s ≈ 10^{-5} s (1);	1	See general instruction 16 about 'show that' questions.
		(iii)	10^{-5} s « answer to (a)(i) (so could not be detected)(1); compared with 3.2 km/(answer to (a)(i)) ≈ 6 to 30 km s $^{-1}$ (1)	2	first mark is for comparing (a)(i) and (ii) second mark is for using (a)(i) with the 3.2 km
	(b)	(i)	% uncertainty=(50 km s $^{-1}$×100%)/(299 910 km s $^{-1}$) = 0.0167% = 0.02% (1); so uncertainty should be thought of as small (1)	2	Can consider as a fraction (0.00017 or 1/6000) but needs a quantitative comparison for the first mark Second mark can only be awarded if a calculation has been done
		(ii)	uncertainty is </≈ speed correction (1); difference no longer negligible/two speeds now distinguishable/able to confidently assign a particular (higher) value for *c* (1)	2	
		(iii)	difference = (299 910 - 299 792.458) km s^{-1} = 118 (km s^{-1}) 118 (km s^{-1}) (1); This is> quoted uncertainty (of 50 km s^{-1}) M may have underestimated his uncertainty (1)	2	1st mark is for **calculating** the values 2nd mark is **comparing** the values for sensible comment on the quality of the uncertainty estimate. Can also compare 299 792.458 with (299 910 – 50)
	(c)	(i)	hard to find centre (to either with greater precision than about ½ cm) because each hotspot is irregular and large.	1	NOT it's on a 1cm grid so that is the resolution owtte
		(ii)	inter-hotspot distance ≈ ½λ ≈ 6 cm ⇒ λ = 12 cm (1); *c* = *f*λ = 2.45 × 10^{9} Hz × 0.12 m = 2.94 × 10^{8} m s $^{-1}$ (1); uncertainty in measurement is about 1 cm in 6 cm, so uncertainty in *c* = 2.94 × 10^{8} m s $^{-1}$/6 = 0.49 × 10^{8} (1);	3	**allow** 5 cm ≤ ½λ ≤ 7 cm; must get λ for this mark can use own λ can use own λ and may use uncertainty other than 1/6 if deduced in (c)(i)
			Total	**14**	
			Section C Total	**40**	

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