

GCE

Physics B (Advancing Physics)

Advanced Subsidiary GCE

Unit G491: Physics in Action

Mark Scheme for January 2012

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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.

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Annotations available in SCORIS

Annotation	Meaning
[1][1]	Benefit of doubt given
CON	Contradiction
×	Incorrect response
IND	Error carried forward
177	Follow through
RAG	Not answered question
2.00	Benefit of doubt not given
201	Power of 10 error
A	Omission mark
RE.	Rounding error
E1.0	Error in number of significant figures
✓	Correct response
AE	Arithmetic error
?	Wrong physics or equation

Subject-specific Marking Instructions

Annotations on the detailed mark scheme

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

Question		on	Answer	Marks	Guidance
1	(a)		Pa ; S	2	do not accept any ≡ units not listed e.g. N m ⁻² ; A V ⁻¹ accept PA
	(b)		W ; V	2	do not accept any ≡ units not listed e.g. J s ⁻¹ ; J C ⁻¹
2	(a)		3800 (Hz)	1	
	(b)		8000 (Hz)	1	not 7600 (Hz)
	(c)		$2^7 = 128 \ (\approx V_{total} / V_{noise})$	1	accept log 2 (128) = 7
	(d)		$8000 \times 7 = 56 \times 10^3 \text{ (bit s}^{-1}\text{)}$	1	allow ecf on (b) x 7 e.g. $7600 \times 7 = 53.2 \times 10^3$ (bit s ⁻¹)
3	(a)		less noise(s) / sharper / contrast changed / brightness changed / edges clearer	1	ignore smoother accept more details are visible / darker AW not less pixelated
	(b)			2	3 links correct scores 2/2 1 or 2 link(s) correct scores 1/2 CON multiple connections from any box
4	(a)		B and E ringed (or any clear consistent indication)	2	one mark for each correct but each extra ring above 2 removes 1 mark
	(b)	(i)	$V = \varepsilon - Ir / = 3.0 - 0.45 \times 0.38$; = 2.83 (V)	2	method; evaluation requires 3 rd S.F. because show that
		(ii)	$(R = V/I = 2.83 / 0.45) = 6.3 (\Omega)$	1	evaluation ecf on voltage from (bi) if less than 3 V accept 6.2(2) (Ω) on show that p.d. value of 2.8 V accept potential divider calculation
5	(a)		centre of X placed at lens focus or <u>vertically</u> aligned within marking tool	1	accept labelled point / line / arrow ending at focus ± 1 mm align marking tool to edge of last incoming wavefront
	(b)		adds curvature (to the wavefronts arriving at lens)	1	accept zero curvature entering lens and positive curvature leaving lens accept curves waves (if correct sense of curve is explicit) e.g. curves waves converging / curves to a focus not adds negative curvature / just lens focuses / curves waves not bends waves / any credit for refraction explained

Q	uestio	n Answer	Marks	Guidance
6		v = c/n / = 3 x 10 ⁸ / 2.4 = 1.25 x 10 ⁸ (m s ⁻¹)	1	method accept algebraic / numerical evaluation accept 1.3 x 10 ⁸ (m s ⁻¹) not 1.2 x 10 ⁸ (m s ⁻¹)
7	(a)	diameter	1	accept 0.25 (± 0.01) mm / D
	(b)	has largest % / largest relative uncertainty / has largest % of measurement standalone mark even if error in (a)	1	not has largest uncertainty / because diameter squared accept ± 4% estimate in diameter if calculated or ± 8% estimate in area if calculated or ± % uncertainty is doubled because D squared
		Total	22	

Q	Question		Answer	Marks	Guidance
8	(a)		stiff / high YM; so does not stretch (too far under stress) / tough / not brittle; so does not break easily / cracks don't propagate / so does not snap easily	2	only allow stiffness / YM / toughness if qualified by explanation that needs large value explanation must be linked to the property accept compliant; so flexible to bend around pulley accept elastic; returns to its original length when unstressed not strong / hard / ductile / malleable / durable
	(b)		method x-area = F/σ / = 5.4 x10 ⁴ / 1.1 x 10 ⁸ evaluation = 4.9 x 10 ⁻⁴ (m ²)	1 1	method accept algebra / numbers not just $\sigma = F/A$ evaluation accept $5 \times 10^{-4} \text{ m}^2$ / 4.9 cm^2 / 5 cm^2
	(c)	(i)	method $\varepsilon = \sigma / E / = 1.1 \times 10^8 / 2.1 \times 10^{11}$ evaluation = $0.00052(4) \ (\approx 0.05 \%)$	1	method accept algebra / numbers evaluation needs 2 or more S.F. for show that ignore attempts to convert to %
		(ii)	method $x = \varepsilon \times L$ / = 0.00052 x 650 evaluation = 0.34 m	1	method accept algebra / numbers not just $\epsilon = x/L$ If working from YM then must have $x = FL/AE$ for first mark accept 0.32(5) m using show that strain 0.05% accept ecf on strain from (ci) x 650 max 1 for calculating with ϵ % (POT)
	(d)		for safety (margin) / awareness of engineering safety limits / avoid getting near to permanently changing length of the cable	1	accept to avoid getting near to plastic / permanent deformation in cable accept to stay well below elastic limit accept to allow for material / manufacturing defects accept to allow for cyclic loading / fatigue / corrosion not just elastic limit is yield point not just so cable does not break / snap / crack / fail
			Total	9	

 (i) Idea of (two) resistors in series / sharing the (total) p.d. (in proportion to their resistances) (ii) resistance ratio R_{flood} / R	Question		on	Answer	Marks	Guidance
Correct sense) ratio rises (so p.d. across R _{fixed} rises) ORA OR total R less; so current increases through fixed resistor (and p.d. across it rises) (b) (i) (sensitivity) decreases (as temperature rises) (ii) gradient / ΔV/ΔT / Δy/Δx / Δoutput / Δinput / change dependent / change independent variables values e.g. 0.5 / 20 (iii) from graph V (fixed at 70°C) = 3.7 V method mark: any correctly substituted divider equation e.g. R/800 = 3.7 / 2.3 OR I = 2.3 / 800 = 2.9 mA R = 1300 / 1290 / 1287 (Ω) 1 current across / current remains constant when R _{thermistor} changes V thermistor falls so V fixed rises scores 1 for physics not any credit for repeating root of question part explanation without physics errors and no more than 1 error in SPG for 3° QoWC mark 1 method look at graph below answers accept e.g. (3.7 -1.1) / 70 = (0.037) (V °C -¹) for max 1 2 accept values from graph / linear extrapolation of tangent at 70°C / sensible small triangles drawn on graph around 70 °C not any further credit for V / T calculations 0.053 (V °C -¹) (iii) from graph V (fixed at 70°C) = 3.7 V method mark: any correctly substituted divider equation e.g. R/800 = 3.7 / 2.3 OR I = 2.3 / 800 = 2.9 mA R = 1300 / 1290 / 1287 (Ω) 1 evaluation accept within range 0.021 to 0.029 (V °C -¹) 1 evaluation accept with thermistor method allow ecf on 3.6 to 3.8 V accept 3.7 / 6.0 = R/(R + 800) 2 evaluation accept other values in range 1275 to 1300 Ω for full credit (due to intermediate rounding); accept other values in outer range 1200 to 1400 Ω for max 2 not any further credit for R = 500 ± 10 (Ω)	9	(a)	(i)		1	AW accept algebraic versions e.g. $V_1 / V_2 = R_1 / R_2$
total <i>R</i> less; so current increases through fixed resistor (and p.d. across it rises) (b) (i) (sensitivity) decreases (as temperature rises) (ii) gradient / ΔV/ΔT / Δy/Δx / Δoutput / Δinput / change dependent / change independent variables values e.g. 0.5 / 20 1 accept values from graph / linear extrapolation of tangent at 70 °C / sensible small triangles drawn on graph around 70 °C not any further credit for V/T calculations 0.053 (V °C -¹) (iii) from graph V (fixed at 70°C) = 3.7 V method mark: any correctly substituted divider equation e.g. R/800 = 3.7 / 2.3 OR I = 2.3 / 800 = 2.9 mA R = 1300 / 1290 / 1287 (Ω) 1 not any credit for repeating root of question part explanation without physics errors and no more than 1 error in SPG for 3" QoWC mark 1 method look at graph below answers accept e.g. (3.7 -1.1) / 70 = (0.037) (V °C -¹) for max 1 2 accept values from graph / linear extrapolation of tangent at 70 °C / sensible small triangles drawn on graph around 70 °C not any further credit for V/T calculations 0.053 (V °C -¹) (iii) from graph V (fixed at 70°C) = 3.7 V method mark: any correctly substituted divider equation e.g. R/800 = 3.7 / 2.3 OR I = 2.3 / 800 = 2.9 mA R = 1300 / 1290 / 1287 (Ω) 1 evaluation accept other values in range 1275 to 1300 Ω for full credit (due to intermediate rounding); accept other values in outer range 1200 to 1400 Ω for max 2 not any further credit for R = 500 ± 10 (Ω)			(ii)			current across / current remains constant when R _{thermistor}
so current increases through fixed resistor (and p.d. across it rises) (b) (i) (sensitivity) decreases (as temperature rises) (ii) gradient / $\Delta V / \Delta T$ / $\Delta y / \Delta x$ / $\Delta output / \Delta input / change dependent / change independent variables values e.g. 0.5 / 20 1 accept values from graph / linear extrapolation of tangent at 70 ^{\circ}\text{C} / sensible small triangles drawn on graph around 70 ^{\circ}\text{C} (iii) from graph V(\text{fixed at }70 ^{\circ}\text{C}) = 3.7 ^{\circ}\text{V} method mark: any correctly substituted divider equation e.g. R / 800 = 3.7 / 2.3 ^{\circ}\text{C} or I = 2.3 / 800 = 2.9 ^{\circ}\text{mA} R = 1300 / 1290 / 1287 (\Omega) 1 evaluation accept within range 1200 to 1400 \Omega for full credit (due to intermediate rounding); accept often values in outer range 1200 to 1400 \Omega for formax 2 not any further credit for R = 500 \pm 10 ^{\circ} (\Omega)$				OR		$V_{\text{thermistor}}$ falls so V_{fixed} rises scores 1 for physics
it rises part explanation without physics errors and no more than 1 error in SPG for 3° QoWC mark						not any credit for repeating root of question
(ii) gradient / ΔV/ΔT / Δy/Δx / Δoutput / Δinput / change dependent / change independent variables values e.g. 0.5 / 20 1 accept values from graph / linear extrapolation of tangent at 70 °C / sensible small triangles drawn on graph around 70 °C not any further credit for V / T calculations 0.053 (V °C -¹) evaluation = 0.025 (V °C -¹) (iii) from graph V(fixed at 70 °C) = 3.7 V method mark: any correctly substituted divider equation e.g. R/800 = 3.7 / 2.3 OR I = 2.3 / 800 = 2.9 mA R = 1300 / 1290 / 1287 (Ω) 1 method look at graph below answers accept e.g. (3.7 -1.1) / 70 = (0.037) (V °C -¹) for max 1 1 accept values from graph / linear extrapolation of tangent at 70 °C / sensible small triangles drawn on graph around 70 °C not any further credit for V / T calculations 0.053 (V °C -¹) 1 evaluation accept within range 0.021 to 0.029 (V °C -¹) 1 standalone mark reading from graph not any tolerance but credit even if associated with thermistor method allow ecf on 3.6 to 3.8 V accept 3.7 / 6.0 = R / (R + 800) R = 1300 / 1290 / 1287 (Ω) 1 evaluation accept other values in range 1275 to 1300 Ω for full credit (due to intermediate rounding); accept other values in outer range 1200 to 1400 Ω for max 2 not any further credit for R = 500 ± 10 (Ω)				it rises)		part explanation without physics errors and no more than 1 error in SPG for 3 rd QoWC mark
change dependent / change independent variables values e.g. $0.5/20$ 1 accept values from graph / linear extrapolation of tangent at 70 °C / sensible small triangles drawn on graph around 70 °C not any further credit for V/T calculations 0.053 (V °C $^{-1}$) evaluation = 0.025 (V °C $^{-1}$) 1 (iii) from graph $V(_{\text{fixed at 70°C}}) = 3.7 \text{ V}$ method mark: any correctly substituted divider equation e.g. $R/800 = 3.7/2.3$ OR $I = 2.3/800 = 2.9 \text{ mA}$ $R = 1300 / 1290 / 1287$ (Ω) 1 accept e.g. $(3.7 - 1.1)/70 = (0.037)$ (V °C $^{-1}$) for max 1 accept values from graph / linear extrapolation of tangent at 70 °C / sensible small triangles drawn on graph around 70 °C not any further credit for V/T calculations 0.053 (V °C $^{-1}$) 1 2 3 3 4 3 4 3 4 3 5 5 6 7 8 7 8 8 8 9 9 9 9 9 9 9 9 9 9		(b)	(i)	(sensitivity) decreases (as temperature rises)		
at 70°C / sensible small triangles drawn on graph around 70°C not any further credit for V/T calculations 0.053 (V $^{\circ}\text{C}^{-1}$) evaluation = 0.025 (V $^{\circ}\text{C}^{-1}$) 1 evaluation accept within range 0.021 to 0.029 (V $^{\circ}\text{C}^{-1}$) 1 standalone mark reading from graph not any tolerance but credit even if associated with thermistor method allow ecf on 3.6 to 3.8 V accept $3.7/6.0 = R/(R+800)$ R = 1300 / 1290 / 1287 (Ω) 1 evaluation accept other values in range 1275 to 1300 Ω for full credit (due to intermediate rounding); accept other values in outer range 1200 to 1400 Ω for max 2 not any further credit for $R = 500 \pm 10$ (Ω)			(ii)		1	
(iii) from graph $V(_{fixed at 70^{\circ}C}) = 3.7 \text{ V}$ method mark: any correctly substituted divider equation e.g. $R/800 = 3.7/2.3$ OR $I = 2.3/800 = 2.9 \text{ mA}$ 1 standalone mark reading from graph not any tolerance but credit even if associated with thermistor method allow ecf on 3.6 to 3.8 V accept $3.7/6.0 = R/(R+800)$ 1 evaluation accept other values in range 1275 to 1300 Ω for full credit (due to intermediate rounding); accept other values in outer range 1200 to 1400 Ω for max 2 not any further credit for $R = 500 \pm 10$ (Ω)				values e.g. 0.5 / 20	1	at 70 °C / sensible small triangles drawn on graph around 70 °C
method mark: any correctly substituted divider equation e.g. $R/800 = 3.7/2.3$ OR $I = 2.3/800 = 2.9$ mA $R = 1300 / 1290 / 1287 (\Omega)$ $R = 1300 / 1290 / 1290 (\Omega)$ $R = 1300 / 1290$				evaluation = $0.025 \text{ (V }^{\circ}\text{C}^{-1}\text{)}$	1	evaluation accept within range 0.021 to 0.029 (V °C ⁻¹)
method mark: any correctly substituted divider equation e.g. $R/800 = 3.7/2.3$ OR $I = 2.3/800 = 2.9$ mA $R = 1300 / 1290 / 1287 (\Omega)$ $R = 1300 / 1290 / 1290 (\Omega)$ $R = 1300 / 1290 (\Omega)$ $R = 130$			(iii)	from graph $V(_{\text{fixed at }70^{\circ}\text{C}}) = 3.7 \text{ V}$	1	
for full credit (due to intermediate rounding); accept other values in outer range 1200 to 1400 Ω for max 2 not any further credit for $R = 500 \pm 10$ (Ω)					1	method allow ecf on 3.6 to 3.8 V
Total 11				$R = 1300 / 1290 / 1287 (\Omega)$	1	for full credit (due to intermediate rounding); accept other values in outer range 1200 to 1400 Ω for max 2
				Total	11	

Question		on	Answer	Marks	Guidance
10	(a)	(i)	(M = v/u = 0.055/10) = 0.0055	1	evaluation accept 5.5 x 10 ⁻³ ignore - ve signs
		(ii)	P OR $1/f = 1/v - 1/u$ / = 1/0.055 - 1/(-10)	1	method accept clear statement of approximation $P \approx {}^{1}/_{v} / f \approx v / P \approx 1/0.055$ accept calculation of $f = 0.0547$ m for 1 st mark
			= 18.3 (D)	1	evaluation accept 18.2 (D) must have 3 S.F. for show that not 18.1 (D) (from sign error)
		(iii)	magnification x <i>D</i> / using similar triangles 67 mm x 0.0055	1	method allow ecf mag (ai) x D correctly evaluated for 2 marks accept 67 mm / 182 (NB 1 / M = 182)
			= 0.00037 m (≈ 0.4 mm)	1	evaluation 0.37 / 0.3685 mm must have at least 2 S.F. for show that
	(b)	(i)	= $70 \times 0.37 \approx 26$ / 25.9 (integer not necessary) (= 70×0.4 = 28) using show that value	1	accept 70 x 0.3685 = 25.8 accept ecf for image size from (aiii) in mm x 70 not 4690
		(ii)	= 67 mm / 25.8 = 2.6 x 10 ⁻³ (m) (= 67 / 28 = 2.39 mm) using show that value	1	accept 2.6 mm / 1 S.F. answers so 3 mm OR 2 mm accept other methods 1/70 mm / 0.0055 OR 1/70 mm x 182 / similar triangles methods
	(c)		= 0.085(2) m (based on <u>+</u> 1 pixel on each image) must have unit	1	accept 0.0826 m OR 0.083 m (based on ± 1 pixel) accept any answers in range 0.082 m to 0.086 m allow ecf on (0.08 + bii) OR (0.08 + 2 x bii) up to max value of 0.090 m
			bii is the resolution of ball's position (at 10 m from camera) / recognition that on CCD resolution is to nearest integer of pixels standalone explanation	1	accept AW and other sensible comments: accept reasoning about whole numbers of pixels / about use of 1 or 2 pixels uncertainty in 2 images not any credit for answers that imply a "perfect" measurement
			Total	9	

Question		Answer	Marks	Guidance
11 (a)	(i)	(25 / 12) = 2.08 (A)	1	2.1 (A) to 2 S.F. not 2 (A) to 1 S.F.
	(ii)	(2.08 / 12) = 0.17(3) (S)	1	0.17 (S) to 2 S.F. not 0.2 (S) accept 0.174 / 0.175 / 0.18 (S) from rounding accept ecf on ai / 12 correctly evaluated
(b)		many / high density of ; free / delocalised / unbound / gas / sea of / soup ; electrons which act as ; movement of charge carriers / transfer (negative) charge / carry charge	1 1 1	any 3 / 4 marking points in a well organised sentence for 3 rd QWC mark ignore lattice of positive ions accept idea of flow of charge / idea of drift velocity of charge must mention charge in motion not just are charged
(c)	(i)	there are no free charge carriers / electrons	1	accept electrons are localised in ionic/covalent bonds accept not many / few / low density free electrons
	(ii)	lamp runs hot / heating identified as a problem ceramics don't melt in the lamp ORA for plastics ceramics have a high(er) melting point (scores 2 heating implicit)	1 1	accept plausible thermal properties explained e.g. ceramics have a small(er) thermal expansion so pins do not loosen / ceramics better / good thermal conductors so do not overheat for 2 marks (running hot is implicit) not heat resistance / temperature resistance for 2 nd mark
	(iii)	plastics are tough(er) / not brittle / less brittle (than ceramics)	1	accept AW less likely to break under impacts ignore safer because plastic is electrical insulator / cheaper / easier to manufacture / easy to mould / durable
		Total	9	

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