

GCE

Physics B (Advancing Physics)

Unit **G491**: Physics in Action

Advanced Subsidiary GCE

Mark Scheme for June 2014

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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.

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1. These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation	Meaning
 BP	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
 BOD	Benefit of doubt given
 CON	Contradiction
 X	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

2. 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

3. The following questions should be annotated with ticks to show where marks have been awarded in the body of the text: 2a, 3c, 7a, 8aii, 8bii, 8biii, 9ai, 9aiii, 9b, 9c, 10a, 10ci, 10cii, 10ciii
4. Please ensure that rounding errors RE and significant figure errors SF are only penalised a maximum **once** for each candidate. Places where these should be looked for will usually be indicated in the mark-scheme.

IMPORTANT UPDATE:

ADDITIONAL OBJECTS: You **must** annotate the additional objects for each script you mark. If no credit is to be awarded for the additional object, please use annotation as agreed at the SSU, likely to be 'seen', a cross or the highlighting tool.

Crossed Out, Rubric Error (Optional Questions) and Multiple Responses

Crossed-out Responses: Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions: Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses: When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).

When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses: When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**): Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**): If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response): Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

Question	Answer	Marks	Guidance
1	s^{-1} ; m^{-1} ; m^{-3}	3	not equivalent units not listed e.g. Hz / D
	Total	3	

Question	Answer	Marks	Guidance
2(a)	waveform is periodic / (main peaks) repeats itself regularly ; but more complex than pure sine wave / has harmonics / higher frequency (oscillations) / other (smaller) oscillations / smaller peaks (between large ones)	1 1	idea of time required not constant wavelength or reference to length not just reference to repeated main peaks not smaller frequencies / noise
(b)	evaluation $(11 \times 1000 / 40) = 275 \approx 280$ (Hz)	1	(11 waves in 40 ms / 3.6 ms / wave) accept answers in range 270 to 280 Hz
	Total	3	

Question	Answer	Marks	Guidance
3(a)	12 k(Hz)	1	12 000 (Hz)
(b)	9 (bits)	1	ignore $2^9 = 512$ if answer not stated not 8.6 (bits)
(c)	bandwidth \approx bit rate / \approx bit rate /2 bit rate = sampling frequency x bits per sample	1 1	not reference to (highest f – lowest f) allow 1 mark for evaluation $108 \text{ k} / 108/2 = 54 \text{ k}$ allow 2 marks for evaluation with bandwidth units Hz accept ecf on (a) x (b) accept bandwidth = sampling frequency x bits per sample for 2 marks
	Total	4	

Question	Answer	Marks	Guidance
4(a)(b)(c)	10^3 ; 10^{-6} ; 10^{-6}	3	
	Total	3	

Question	Answer	Marks	Guidance
5 (a)	$n = I / e \quad / \quad = 8 \times 10^{-12} / 1.6 \times 10^{-19} ;$ 5×10^7	1 1	method: words / numbers / algebra ; evaluation one POT error can score 1, two POT errors score 0
	Total	2	

Question	Answer	Marks	Guidance
6(a)	$V^2 / R \quad / \quad 12^2 / 4.7 \quad ;$	1	method: words / numbers / algebra accept $I = 2.6 \text{ A}$ for 1 st mark alternative method
	30.6 / 31 (W) / 31.8 (W) or 31.2 (W) premature rounding	1	evaluation accept $P = IV$ correctly evaluated for 2 nd mark
(b)	method $L = RA / \rho \quad / \quad 4.7 \times 1.8 \times 10^{-8} / (4.5 \times 10^{-7}) ;$ $= 0.188 \quad / \quad = 0.19 \text{ (m)}$	1 1	method: words / numbers / algebra evaluation accept 0.2 (m) no S.F. penalty here not 0.20 / 0.18 (m) R.E.
	Total	4	

Question	Answer	Marks	Guidance
7(a)	f further from lens ; λ similar use marking tool all wavelengths should be between the length of the red (min) and green (max)	2	ignore curvature if correct sign / waves to right of focus / position of first wavefront expect wavefronts to F
(b)	<u>smaller</u> because lens adds less curvature to the wavefronts / because light is not slowed so much / because light is not refracted so much	1	accept <u>smaller</u> because f larger / because $P = 1/f$ ignore response to (a) standalone mark ignore bent less Scroll down this image to check that page 6 of the paper has no candidate response to be credited. Use BP annotation on every blank page. Responses must be annotated / marked and credited to relevant question total. If no credit due use ^ annotation to show work seen.
	Total	3	
	Total Section A	22	

Question	Answer	Marks	Guidance
8 (a) (i)	R and LDR correct symbols in complete series circuit	1	either way round ignore labelling / Voltmeter if drawn accept for LDR (with /without) circle and 2 arrows / variable resistor / general transducer symbol for LDR (thermistor) not LED or lamp or fuse or photodiode or other symbols
(a) (ii)	<p>resistance ratio changes / voltage is shared (between resistors) ;</p> <p>correct direction of change in resistance ratio (R_f / R_{LDR} increases or v.v.) ;</p> <p>Link resistance to p.d. by : use of potential divider equation or voltage ratio = resistance ratio OR as light intensity rises R_{LDR} falls so R_{total} falls ;</p> <p>current increases ;</p> <p>p.d. across R_{FIXED} rises / p.d. across LDR falls</p>	<p>1</p> <p>1</p> <p>1</p>	<p>applying the potential divider or voltage ratio equation with correct sense can score all 3 marks</p> <p>expect candidates to make clear which R they are talking about</p> <p>accept voltage is shared in proportion to the resistances</p> <p>not current is constant (in series circuit)</p> <p>QoWC 3rd mark only if steps in reasoning are clear and no logical errors</p>
(b) (i)	<p>change in output / change in input /</p> <p>$\Delta_{dependent} / \Delta_{independent}$ /</p> <p>$\Delta y / \Delta x$ / $\Delta V_{out} / \Delta intensity$ / $\Delta_{out} / \Delta_{in}$</p>	1	<p>ignore \pm signs accept gradient of graph</p> <p>not resolution / how sensitivity changes with intensity</p> <p>not voltage change for a set/given lux change (don't read for as per)</p>

Question	Answer	Marks	Guidance
(ii)	sensible tangent / triangle ; e.g. $(5 - 2.5 \text{ V}) / (1900 \text{ lux})$; $\{1.2 \pm 0.2\} \times 10^{-3} \text{ (V lux}^{-1}\text{)}$	1 1 1	method from graph with $\Delta\text{lux} \geq 400 \text{ lux}$. If $\Delta\text{lux} < 400$ max 2 out of 3 for in range answer chord method approximation from graph if in range max 1 mark not any credit 3.8 / 1000 (graph values) for last 2 marks accept sensible values from graph evaluation accept in range 1.0×10^{-3} to $1.4 \times 10^{-3} \text{ (V lux}^{-1}\text{)}$ correct bare answer scores 3
(iii)	$(V_{\text{FIXED}}) = 3.8 \text{ V}$; EITHER $I = 3.8 / 800 = 4.75 \text{ mA}$ / 4.8 mA ; $V_{\text{LDR}} = 6.0 - 3.8 = 2.2 \text{ V}$; $R_{\text{LDR}} = 2.2 / 0.00475 = 460 \Omega$ / $4.6(3) \times 10^2 \Omega$ OR potential divider equation or voltage ratio equation rearranged for R_{LDR} ; equation correctly substituted ; evaluation $R_{\text{LDR}} = (4800 - 3040) / 3.8 = 460 \Omega$	1 1 1 1	read from graph accept $V = 3.8 \text{ (V)}$ standalone credit allow small graph reading errors $\pm 0.1 \text{ V}$ correctly worked through (in range 430 to 500 Ω) for the next 3 marks. Gross reading errors score 0 total. accept substitution / rearrangement in either order e.g. $3.8 = 6.0 \times 800 / (800 + R_{\text{LDR}})$ 1380 Ω scores 2 out of 4 bare correct answer 460 Ω scores 4 marks
	Total	12	

Question	Answer	Marks	Guidance
9 (a) (i)	image area $\approx 10^{-18} \text{ m}^2$ / $60 \times 10^{18} \text{ atoms m}^{-2}$; mass per $\text{m}^2 = 2 \times 10^{-26} \text{ (kg)} \times 60 \times 10^{18} \text{ (atoms m}^{-2})$; $= 1.2 \times 10^{-6} \text{ (kg)}$	1 1 1	accept mass of 60 atoms = $1.2 \times 10^{-24} \text{ kg}$ alt first mark accept number of atoms between 55 to 65 for those who have tried to count not any further credit if area = 10^{-9} m^2 max 1 out of 3 expect 2 S.F. for show that in range $(1.1 \text{ to } 1.3) \times 10^{-6} \text{ (kg)}$
(a) (ii)	$(\rho = 1.2 \times 10^{-6} / (1 \times 1 \times 0.34 \times 10^{-9})) = 3500 \text{ kg m}^{-3}$	1	accept 3529 kg m^{-3} / $29(41) \text{ kg m}^{-3}$ from show that accept ecf in range 3800 to 3200 kg m^{-3}
(a) (iii)	$F = (\sigma_B \times A) \approx 4 \times 10^{10} \text{ (Pa)} \times (0.1 \times 0.34 \times 10^{-9} \text{ (m}^2))$; 1.4 (N)	1 1	method expect correct substitution of values evaluation expect 2 S.F. for show that accept 1.36 (N) ORA 1N of force gives stress = $2.9 \times 10^{10} \text{ Pa}$; $< 4 \times 10^{10} \text{ Pa}$
(b)	$\sigma = I L / (VA)$ OR $\sigma = GL / A$ and $G = I / V$; $= 6.7 \times 10^{-15} \times 0.34 \times 10^{-9} / (0.15 \times 10^{-3}) \times \{200 \times 10^{-9}\}^2$; $= 3.8 \times 10^{-7} \text{ (Sm}^{-1})$	1 1 1	method accept $G = I / V = 4.4(7) \times 10^{-11} \text{ S}$ / $R = 2.2(4) \times 10^{10} \Omega$ for first mark accept inverse substitution for ρ substitution penalise each POT error by a mark lost evaluation

Question	Answer	Marks	Guidance
(c)	<p>(i) mechanical e.g. cycle frames / car bodies / space elevator cable / carrier bags / space craft / aircraft / bridge cables / other built structures / protective clothing / bullet proof vests / graphene reinforcing a plastic composite etc. ;</p> <p>(ii) electrical e.g. solar cells / transistors / circuits / LEDs / doped layers to make gates / touch screen / sensors / electrical cables / connectors / switches / insulators (in semiconducting orientation) etc. ;</p> <p>high strength / low density / high stiffness (directional) AND specified conductivity (high / metallic / semiconducting / both / high charge carrier density) e.g. touch screen conducting layers separated by insulators, which contact under pressure / electrical cables useful to minimise heat losses / weight / size</p> <p>car bodies strong for protection against impact / light weight for fuel saving / strong and lightweight</p> <p>carrier bags stiffness anisotropy stiff to bear load and flexible to wrap around items</p>	<p>1</p> <p>1</p> <p>1</p> <p>1</p>	<p>First two marks awarded for two plausible applications. not pencils / lubricants / heat conduction / just cars / just cycles / just buildings / just clothing</p> <p>one application repeated only scores 1 mark even if both properties relevant</p> <p>Third mark awarded for a correctly stated property related to each application</p> <p>QoWC further detail or development of link between one property and application or two relevant properties applied to one application for 4th mark e.g. car bodies strong and low density / lightweight OR circuits using two orientations of graphene deposit to use metallic conduction for connectivity and semiconduction for constructing components / due to electrical anisotropy</p>
	Total	13	

Question	Answer	Marks	Guidance
10 (a)	contain more information / less error prone ;	1	accept more data / bits / details / other plausible suggestions not data security
	contain information in 2-d (rather than 1-d) / more combinations / more alternative / more possibilities / more patterns / better resolution required to measure bar width	1	accept in pixel form rather than “smeared” linear array / squares take less area than bars / AW not more variations
(b) (i)	$(33^2 / 8) = 136$ (bytes)	1	accept 136.125 (bytes) not 137 / 140 (bytes)
(b) (ii)	$2^8 / 256$	1	
(b) (iii)	to help with recognising the alignment / orientation of the code / so that bits are considered in correct order for reading by software	1	accept to recognise as QR code / detect edges / boundaries / corners of code / locate the data / to aid focus by scanner not parity bits
(c) (i)	size of image = $M \times$ size object / $\approx 5/100 \times 33$ mm = 1.7 mm (< 2.0 mm) OR check that $2/33 > 5/100$; comparing magnifications OR compare angles subtended at lens ; $33/100 < 2/5$	1 1	allow magnification = 0.05 for 1 mark accept 1.65 mm allow correct answer from $M = 20$ allow 1 out of 2 marks i.e. check actual $M < 2/33$ accept comparing triangles not any credit for correct $v = 5.3$ mm here (lens formula)
	(c) (ii)	$1/v = 1/(-0.1) + 1/(0.005) / = -10 + 200 = 190$ D $\therefore v = 1/190 = 5.26 \times 10^{-3}$ m / 5.3 mm $f \times 1.05 = 5 \times 1.05 = 5.25$ mm / $(5.26 - 5.0) / 5.0 = 0.052$ (5.2%)	1 1 1

Question	Answer	Marks	Guidance
(c) (iii)	<p>image of several QR modules can cover 1 camera pixel / details of code not resolved / there will only be 1 pixel per module at limit of resolution</p> <p>EITHER</p> <p>$(M = v/u = \text{pixel size} / \text{module size}) \quad 5/u = 0.002/1 \quad \text{in mm}$</p> <p>$u = (1/0.002) \times 5 = 2500 \quad \text{mm} \quad / \quad 2.5 \text{ m}$</p> <p>OR</p> <p>module image size = $1/500 \times 1 \text{ mm} \quad / \quad 2 \times 10^{-6} \text{ m} ;$</p> <p>pixel size = $2 \text{ mm} / 1000 \quad / \quad 2 \times 10^{-6} \text{ m}$</p>	<p>1</p> <p>1</p> <p>1</p>	<p>credit a sensible further problem explicitly stated e.g. resolution accept resolution too high / too low not just information lost / averaged</p> <p>accept calculations for other u values near to 2.5 m if supported by sensible reasoning</p> <p>Scroll down this image to check that page16 of the paper has no candidate response to be credited. Use BP annotation on every blank page. Responses must be annotated / marked and credited to relevant question total. If no credit due use ^ annotation to show attempt seen.</p>
	<p>Total</p> <p>Total Section B</p> <p>Total for paper</p>	<p>13</p> <p>38</p> <p>60</p>	

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