GCE

Physics B (Advancing Physics)

Unit **G491**: Physics in Action

Advanced Subsidiary GCE

Mark Scheme for June 2014

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
✘	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 ;	1	idea of time required **not** constant wavelength or reference to length **not** just reference to repeated main peaks
	but more complex than pure sine wave / has harmonics / higher frequency (oscillations) / other (smaller) oscillations / smaller peaks (between large ones)	1	**not** smaller frequencies / noise
(b)	evaluation (11 x 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 k / 108/2 = 54 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	

4

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

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

Question	Answer	Marks	Guidance
6(a)	V^2 / R / $12^2 / 4.7$;	1	method: words / numbers / algebra **accept** $I = 2.6$ A for 1st mark alternative method
	30.6 / 31 (W) / 31.8 (W) or 31.2 (W) premature rounding	1	evaluation **accept** $P = I V$ correctly evaluated for 2nd mark
(b)	method $L = RA / \rho$ / $4.7 \times 1.8 \times 10^{-8} / (4.5 \times 10^{-7})$;	1	method: words / numbers / algebra
	$= 0.188$ / $= 0.19$ (m)	1	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)**	resistance ratio changes / voltage is shared (between resistors) ;	**1**	applying the potential divider or voltage ratio equation with correct sense can score all 3 marks
			correct direction of change in resistance ratio (R_f / R_{LDR} increases or v.v.) ;	**1**	**expect** candidates to make clear which R they are talking about
			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 ;	**1**	**accept** voltage is shared in proportion to the resistances
			current increases ;		**not** current is constant (in series circuit)
			p.d. across R_{FIXED} rises / p.d. across LDR falls		**QoWC** 3rd mark only if steps in reasoning are clear and no logical errors
	(b)	**(i)**	change in output / change in input / Δdependent / Δindependent / Δy / Δx / ΔV_{out} / Δintensity / Δ_{out} / Δ_{in}	**1**	**ignore** ± signs **accept** gradient of graph **not** resolution / how sensitivity changes with intensity **not** voltage change for a set/given lux change (don't read for as per)

Question	Answer	Marks	Guidance
(ii)	sensible tangent / triangle ;	1	method from graph with Δlux $\geq$ 400 lux. If Δlux $<$ 400 max 2 out of 3 for in range answer chord method approximation from graph if in range max 1 mark
	e.g. (5 - 2.5 V) / (1900 lux) ;	1	**not** any credit 3.8 / 1000 (graph values) for last 2 marks **accept** sensible values from graph
	$\{1.2 \pm 0.2\} \times 10^{-3}$ (V lux^{-1})	1	evaluation **accept** in range 1.0×10^{-3} to 1.4×10^{-3} (V lux^{-1}) correct bare answer scores 3
(iii)	(V_{FIXED}) = 3.8 V ;	1	read from graph **accept** V = 3.8 (V) standalone credit
	EITHER I = 3.8 / 800 = 4.75 mA / 4.8 mA ;	1	**allow** small graph reading errors $\pm$ 0.1 V correctly worked through (in range 430 to 500 Ω) for the next 3 marks. Gross reading errors score 0 total.
	V_{LDR} = 6.0 - 3.8 = 2.2 V ;	1	
	R_{LDR} = 2.2 / 0.00475 = 460 Ω / 4.6(3) $\times 10^2$ Ω	1	
	OR potential divider equation or voltage ratio equation rearranged for R_{LDR} ; equation correctly substituted ; evaluation R_{LDR} = (4800 – 3040) / 3.8 = 460 Ω		**accept** substitution / rearrangement in either order e.g. 3.8 = 6.0 x 800 / (800 + R_{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 $\approx 10^{-18}$ m^2 / 60 x 10^{18} atoms m^{-2} ;	1	**accept** mass of 60 atoms = 1.2 x 10^{-24} kg alt first mark **accept** number of atoms between 55 to 65 for those who have tried to count
			mass per m^2 = 2 x 10^{-26} (kg) x 60 x 10^{18} (atoms m^{-2}) ;	1	**not** any further credit if area = 10^{-9} m^2 max 1 out of 3
			= 1.2 x 10^{-6} (kg)	1	**expect** 2 S.F. for show that in range (1.1 to 1.3) x 10^{-6} (kg)
	(a)	(ii)	(ρ = 1.2 x 10^{-6} / (1 x 1 x 0.34 x 10^{-9})) = 3500 kg m^{-3}	1	**accept** 3529 kg m^{-3} / 29(41) kg m^{-3} from show that **accept** ecf in range 3800 to 3200 kg m^{-3}
	(a)	(iii)	F = (σ_B x A) $\approx$ 4 x 10^{10} (Pa) ×(0.1 x 0.34 x 10^{-9} (m^2)) ;	1	method **expect** correct substitution of values
			1.4 (N)	1	evaluation **expect** 2 S.F. for show that **accept** 1.36 (N) **ORA** 1N of force gives stress = 2.9 x 10^{10} Pa ; < 4 x 10^{10} Pa
	(b)		$\sigma = I\,L\,/\,(VA)$ OR $\sigma = GL\,/\,A$ and $G = I\,/\,V$;	1	method **accept** $G = I\,/\,V$ = 4.4(7) x 10^{-11} S / R = 2.2(4) x 10^{10} Ω for first mark
			= 6.7 x 10^{-15} x 0. 34 x 10^{-9} / (0.15 x 10^{-3}) x {200 x 10^{-9}}^{2} ;	1	**accept** inverse substitution for ρ substitution penalise each **POT** error by a mark lost
			= 3.8 x 10^{-7} (Sm^{-1})	1	evaluation

Question	Answer	Marks	Guidance
(c)	**(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. ;	1	First two marks awarded for two plausible applications. **not** pencils / lubricants / heat conduction / just cars / just cycles / just buildings / just clothing
	(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. ;	1	one application repeated only scores 1 mark even if both properties relevant
	high strength / low density / high stiffness (directional) **AND** specified conductivity (high / metallic / semiconducting / both / high charge carrier density)	1	Third mark awarded for a correctly stated property related to **each** application
	e.g. touch screen conducting layers separated by insulators, which contact under pressure / electrical cables useful to minimise heat losses / weight / size car bodies strong for protection against impact / light weight for fuel saving / strong and lightweight carrier bags stiffness anisotropy stiff to bear load and flexible to wrap around items	1	**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
	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 x size object / ≈ 5/100 x 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	1	method
			∴ v = 1/190 = 5.26 x 10⁻³ m / 5.3 mm	1	evaluation **accept** 5.26 mm **not** 5 mm / 0.005 m **SF** penalty **allow** 1 mark (from first 2) for sign error (u = + 0.1) giving 210 D and v = 4.8 mm
			f x 1.05 = 5 x 1.05 = 5.25 mm / (5.26 – 5.0) / 5.0 = 0.052 (5.2%)	1	calculation of 105% x f **allow** as standalone mark **only allow** credit for working in c(i) if referenced here **accept** 5.3% **not** any credit for u v transposition leading to -5.3 mm and 5%

Question		Answer	Marks	Guidance
(c)	**(iii)**	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	**1**	**credit** a sensible further problem explicitly stated e.g. resolution **accept** resolution too high / too low **not** just information lost / averaged
		EITHER		
		($M = v/u$ = pixel size / module size) 5/u = 0.002/1 in mm	**1**	**accept** calculations for other u values near to 2.5 m if supported by sensible reasoning
		u = (1/0.002) x 5 = 2500 mm / 2.5 m	**1**	
		OR		
		module image size = 1/500 x 1 mm / 2×10^{-6} m ;		
		pixel size = 2 mm / 1000 / 2×10^{-6} m		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.
		Total	**13**	
		Total Section B	**38**	
		Total for paper	**60**	