

**GCE**

**Physics B (Advancing Physics)**

Unit **G494**: Rise and Fall of the Clockwork Universe

Advanced GCE

**Mark Scheme for June 2017**

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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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## Annotations

Annotation	Meaning
	Blank page
	Benefit of doubt given
	Contradiction
	Incorrect Response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct Response
	Arithmetic error
	Wrong physics or equation

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

<b>Annotation</b>	<b>Meaning</b>
/	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
<b>IGNORE</b>	Statements which are irrelevant
<b>ALLOW</b>	Answers that can be accepted
( )	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
<b>ECF</b>	Error carried forward
<b>AW</b>	Alternative wording
<b>ORA</b>	Or reverse argument
<b>owtte</b>	Or Words to That Effect
<b>EOR</b>	Evidence Of (the) Rule

**Subject-specific Marking Instructions**

Unless otherwise told in the marking scheme:

- Do not accept answers to 1 significant figure. All answers should be to 2 SF or greater.
- Correct answers to numerical questions score full marks.

**INTRODUCTION**

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question		Answer	Marks	Guidance
1	(a)	$\text{N m}^{-2}$ (1)	1	
	(b)	$\text{kg m s}^{-2}$ (1)	1	
2	(a)	1.0(3) s (1)	1	do NOT accept '1'
	(b)	(1) The first marking point can be achieved in either of the following two ways: Calculating the initial charge: $Q_0 = 4700 \times 10^{-6} \times 3 / 0.0141(\text{C})$  Stating/calculating that after 1 time constant, the charge is reduced to 36.8% / 37% / by a factor of 0.368 / 0.37  $= 5.2 / 5.19 / 5.3 \times 10^{-3} \text{ C}$ (1)	2	Can use $Q = Q_0 e^{-t/RC}$  bald answer gains both marks
3		Evidence that the students understands that they must assess the area between the curve and the x-axis. (1)  Accept values in the range $6.5 - 6.8 \times 10^4 \text{ J}$ (1)	2	Accept as evidence ... 1 big square = $10^4 \text{ J}$ $\frac{1}{4}$ of BIG square = 2500J 1 small square = 100J  Note that the area (i.e., the potential) should be around the value $3.4 \times 10^4 \text{ J/kg}$  Bald answer gains both marks.
4	a	3.4(43) (1)	1	
	b	The (cosmological) redshift is due to the stretching of space(time) (1)  (the increased distance means there has been) a greater time of travel (for light) / light has been expanding for longer (1)	2	Ignore ref to the galaxy itself moving through space. Ignore references to the Doppler Effect.  It needs to be clear that the redshift is <i>due to</i> the expansion of space e.g., <i>the further the source from Earth, the more it is redshifted as it passes through expanding space</i> would not get the mark because it is not linking the redshift explicitly as <i>due to</i> the expanding space.

Question	Answer	Marks	Guidance
5	$120 \times 28 \times 4200 / 10.5 \times 10^3$ (1) $= 1300 / 1340 / 1344 / 1333 / 1346 \text{ s}$ (1)	2	Accept answers that round to 1300s however, if the answer falls outside the typical values, check there is no glaring mistake made with the numbers.  $1.34 \times 10^6 = 1 \text{ mark [POT]}$
6	a	1	
	b	2	Allow ECF for the value of $\gamma$ from 6(a)  Bald answer gains both marks.
7	a	1	Allow any correct mark that is vertically at the correct time.
	b	1	Allow any correct mark that is vertically at the correct time.
8	$v_{rms} = \sqrt{\frac{3PV}{Nm}}$ $v_{rms} = \sqrt{\frac{3 \times 1.4 \times 10^{-10} \times 2.4 \times 10^{-3}}{1 \times 10^8 \times 6.8 \times 10^{-27}}} \quad (1)$ $= 1218 / 1220 / 1200 \text{ ms}^{-1}$ (1)	2	Also credit the correct evaluation for $v_{rms}^2 = 1.48 \times 10^6 \text{ m}^2/\text{s}^2$
	<b>Section A Total</b>	<b>19</b>	

Question	Answer	Marks	Guidance
9 (a)	line perpendicular to equipotentials passing through X by eye (1)  Correct direction (towards the asteroid) (1)	2	
(b)	$F = -6.7 \times 10^{-11} \times 7.0 \times 10^{19} \times 2.9 \times 10^2 / (1.45 \times 10^5)^2$ (1)  $= 64 / 64.4 / 64.5 / 65 \text{ N}$ (1)	2	Ignore '-' sign
(c) (i)	Answer based on $F = m \frac{v^2}{r}$ :  $v = \left( \frac{2\pi r}{d} \right) = \frac{2\pi \times 1.45 \times 10^5}{(320 \times 60)} = 47.5$ (1)  $F = 2.9 \times 10^2 \times v^2 / 1.45 \times 10^5$ (1)  $= 4.5(03) \text{ N}$ (1)  <u>ALTERNATIVE ANSWER:</u> Answer based on $F = m\omega^2 r$ :  $\omega = \left( \frac{2\pi}{T} \right) = \frac{2\pi}{(320 \times 60)} = 3.27 \times 10^{-4}$ (1)  $F = (m\omega^2 r) = 290 \times (3.27 \times 10^{-4})^2 \times 1.45 \times 10^5$ (1)  $= 4.5(03) \text{ N}$ (1)  <u>Centripetal</u> force less than weight of vehicle. (1)	4	If the conversion to 's' is not done, $T=320\text{s}$ and ... $v = 2850\text{m/s}$ $F = 16200\text{N}$ (2 marks)  If the conversion to 's' is not done, $T=320\text{s}$ and ... $\omega = 1.96 \times 10^{-2} \text{ rad/s}$ $F = 16200\text{N}$ (2 marks)
(c) (ii)	There would be no effect (on the vehicle's likelihood of staying on the surface) (1)  Centripetal force: weight ratio is independent of mass AW (1)	2	
	<b>total</b>	<b>10</b>	



Question	Answer	Marks	Guidance
10 (a)	$n = \frac{0.6}{29} / 0.02069 \quad (1)$ $V = \frac{0.6 \times 8.3 \times 298}{29 \times 1 \times 10^5} / V = \frac{0.021 \times 8.3 \times 298}{1 \times 10^5} \quad (1)$ $= 5.1 \times 10^{-4} \text{ m}^3 \quad (1)$	3	Allow ECF for wrong calculation of $n$ Note: It must be clear that the incorrect number being used is what they intend to be the value for $n$ .  First two marking points can be conflated.  Full marks for correct answer
(b)	More frequent collisions (between air particles and walls of container) (1)  Greater rate of change of momentum (1)	2	Do not credit arguments based on the rearrangement of a formula e.g., $R$ , $T$ and $V$ are constant, $n$ has increased therefore, because $P = \frac{nRT}{V}$ , $P$ must increase.
(c)	Force due to air = $0.0017 \times \frac{9}{2} / 7.65 \times 10^{-3} \quad (1)$  $a = (7.65 \times 10^{-3} / 0.07) = 0.11 / 0.109 \text{ ms}^{-2} \quad (1)$  ALTERNATIVE ANSWER – based on momentum $p_{\text{car}} = 1.7 \times 10^{-3} \times 9 / 15.3 \times 10^{-3} \quad (1)$  (therefore $a$ ) = $0.11 / 0.109 \text{ ms}^{-2} \quad (1)$	2	The first mark can also be given for the thrust = $7.65 \times 10^{-3}$          109 / 110 = 1 mark (incorrect conversion to kg)
(d)	These marks are in groups of 2, for 'paired' answers. There are three arguments to consider – any two can be credited:  As air is expelled the pressure drops (1) ... therefore rate of change of momentum (of the expelled air) decreases AND $a$ decreases (1)  The mass decreases (1) ... $a=F/m$ AND $a$ increases (1)  Frictional effects on the car (1) ... reduces the total force, $F=ma$ AND $a$ decreases (1).		To get the 2 <sup>nd</sup> mark, the change in the acceleration must be stated i.e., is increases or decreases.
	<b>Total .</b>	<b>10</b>	

Question		Answer	Marks	Guidance
11	(a)	$\lambda = 0.16/4 \times 10^{10} = 4 \times 10^{-12}$ (1) half-life, $t_{1/2} = 0.693/4 \times 10^{-12} = 1.7 \times 10^{11}$ s (1) = 5400 / 5415 / 5420 / 5313 / 5310 / 5300 years (1)	3	Working must be shown but first two marking points can be conflated.
	(b) (i)	Correct y intercept at $N = 4.0 \times 10^{10}$ (1) Correct curve through at least two points (1)	2	For example: (5,500, $2.0 \times 10^{10}$ ), (11,000, $1.0 \times 10^{10}$ ).
	(b) (ii)	Read value read from $N = 2.0 \times 10^{10}$ to nearest half-square. Value should fall within the range: 5200 – 5600 years (1) Uncertainty in the range: 250 to 500 years (1)	2	Allow ECF for the wrong curve in (b)(i)
	(c) (i)	Activity = $0.16/2^{50000/5500}$ (1) 2.9 / 2.6 / 2.66 / $2.7 \times 10^{-4}$ Bq (1)	2	Calculation using $A = A_0 e^{-\lambda t}$
	(ii)	Low decay rate / low activity / large uncertainty AW (1) Contamination: (The addition of modern organic material will) produce higher decay rate (1) ... giving a younger age (1)	3	AW throughout
		<b>total</b>	<b>12</b>	

Question		Answer	Marks	Guidance
12	a	Acceleration towards equilibrium position / equilibrium point / the centre (of the motion) / midpoint of the oscillation AW (1)	1	Allow acceleration is always in a direction opposite to the displacement.
	b	$k = 4 \pi^2 f^2 m$ (1) $= 4 \pi^2 \times 0.9^2 \times 1.4$ (1) $= 44.8 \text{ Nm}^{-1}$ (1)	3	All working and own answer must be shown.
	c	i	1	Allow ECF for the value of $k$ from 12(b)  Allow use of $v_{\text{max}} = A\omega$ and $\frac{1}{2} m v_{\text{max}}^2$
	c	ii	3	Allow ECF for the value of total energy from (c)(i).  First marking point can be implicit
			<b>total</b>	<b>8</b>

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