OCR
Oxford Cambridge and RSA

GCE

Physics B (Advancing Physics)

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

Advanced GCE

Mark Scheme for June 2015

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

The following questions should be annotated with ticks to show where marks have been awarded in the body of the text:

Unless stated otherwise in the mark scheme, accept calculations which round to the mark scheme answer for full marks.

Question		Answer	Marks	Guidance
1	a	N kg^{-1}	1	
	b	N m kg^{-1}	1	
2		EITHER red shift of light/radiation from (distant) <u>galaxies</u>; because galaxies are moving away from each other / have recessional velocity owtte ; OR (uniform) microwave background; which is red-shifted light from early universe;	 1 1	**ignore** references to expansion of the universe **accept** increase/stretching of wavelength as red shift **accept** galaxies moving away from Earth **accept** cosmological microwaves **accept** radiation for light
3		γ = 42/18 = 2.33; $v = c\sqrt{1-\frac{1}{\gamma^2}}$ $v = 3.0\times10^8\sqrt{1-\frac{1}{5.44}} = 2.7\times10^8\ \text{ms}^{-1}$	1 1 1	 **look for** evidence of correct transposition of data sheet formula **no ecf** for incorrect γ

4	a	initial KE = $\frac{1}{2}50\times200^2 = 1.00\times10^6$ J;
		final KE = $\frac{1}{2}(350+50)\times25^2 = 1.25\times10^5$ J $\approx 1.3\text{x}10^5$ J;
		inital momentum: 50 x 200 = 1.0×10^4 kg m s^{-1}, final momentum = (350 + 50) x 25 = 1.0×10^4 kg m s^{-1}
			1
			1
			1
				accept $1\text{x}10^6$ J
				look for full working in calculations, not just final value
				accept 400 as final mass if 350 + 50 shown elsewhere
				look for words like initial/before and final/after as labels to calculations of energy or momentum
				accept alphabetic suffixes e.g. **i**, **b**, **f** or **a** to *p* and *E* as labels

		work done deforming the spacecraft;	1	**accept** transfer to heat or thermal energy, **ignore** sound
5	b	C	1	
6	a	-0.3(0); -0.3(0); (0.015 - 0.05×0.45 =) -0.0075 ≈ -0.008	1 1 1	 **allow ecf** if *v* = incorrect Δv **no ecf** for incorrect *v*
6	b	any of the following: • formula has effectively infinite number of steps • not enough steps in the iterative calculation • time interval too long in iterative calculation • each iteration assumes constant speed	1	**accept** step-widths of zero time **ignore** constant acceleration other than zero acceleration

Question	Answer	Marks	Guidance
7	evidence of suitable test e.g. is ρT constant; test applied to all data to 2 s.f. or 3 s.f.; 273 x 1.29 = 352 (350) 283 x 1.25 = 354 (350) 293 x 1.20 = 352 (350) 303 x 1.16 = 351 (350)	1 1	**accept** calculations to more than 3 s.f with a conclusion which mentions that numbers are either not the same to 3 s.f. or the same to 2 s.f. **ignore** any conclusion about the truth of the relationship
8	EITHER measure time for half the sample to decay ($t_{1/2}$),use $\lambda = \frac{\ln 2}{t_{1/2}}$; OR take a known number of atoms, measure activity and use equation given; OR measure gradient (-λ) of a ln(activity)-time graph;	1	**accept** measure half-life from activity-time graph
9	B	1	
	Section A Total	**20**	

Question		Answer	Marks	Guidance
10	a	$\frac{mv^2}{r} = \frac{GMm}{r^2}$; evidence of $v = \frac{2\pi r}{T}$; algebraic manipulation to final formula;	1 1 1	**accept** $mr\omega^2$ as $\frac{mv^2}{r}$ **not** $\frac{mv^2}{r} = -\frac{GMm}{r^2}$ **accept** $\omega = \frac{2\pi}{T}$ **,** $v = r\omega$**,** $\omega = 2\pi f$ **look for** clear steps **ignore** loss of minus sign in final manipulation
	b	$V = \frac{4}{3}\pi r^3 = 1.098 \times 10^{21}\ \text{m}^3$; $M = \rho V = 2.7 \times 10^3 \times 1.098 \times 10^{21} = 2.96 \times 10^{24}$ kg	1 1	**look for** correct formula or evaluation **accept** $3.0\text{x}10^{24}$ with full working for [2] **accept** $V = 1.1\text{x}10^{21}\ \text{m}^3$ gives $2.97\text{x}10^{24}$ kg for [2]
	c i	any two points from: • time for pulse to reach moon = time for pulse to return; • radius of Moon / Earth is comparably negligible; • speed of pulse is constant (throughout the journey) **or** Earth's atmosphere does not affect speed of pulse **or** pulse travels at speed of light in a vacuum ($3\text{x}10^8\ \text{m s}^{-1}$) **or** speed of light is constant ;	2	**not** distance for time, **accept** (laser) light for pulse **not just** travels at the speed of light
	ii	$r = \frac{3.0 \times 10^8 \times 2.5}{2} = 3.75 \times 10^8$ m ; $G = \left(\frac{4\pi^2}{3.0 \times 10^{24}}\right)\frac{(3.75 \times 10^8)^3}{(2.4 \times 10^6)^2} = 1.2 \times 10^{-10}\ \text{N m}^2\ \text{kg}^{-2}$;	1 1	no ecf for incorrect value of r $r = 3.8\text{x}10^8$ m gives $G = 1.25\text{x}10^{-10}$ or $1.3\text{x}10^{-10}$
	iii	density / mass of Earth incorrect; need to use density of whole Earth / core and mantle are made of different material / density increases with increasing depth;	1 1	**accept** mass / density is too great **accept** orbit may not be circular for [1] **ignore** references to radius of Earth and Moon
		Total	**11**	

Question	Answer	Marks	Guidance
11 **a**	molecules bounce off the ground; any **two** of the following 1. each bounce transfers momentum to ground 2. force on ground is rate of transfer of momentum 3. pressure is force per unit area	3	**accept** collide with the ground **accept** impulse as momentum transfer **/** change **ignore** algebraic formulae e.g. $F = \frac{\Delta p}{\Delta t}$, $P = \frac{F}{A}$, $\Delta p = mv - mu$ QWC: first marking point
b **i**	$NkT = \frac{1}{3}Nm\overline{c^2}$; T = 293 K; $\sqrt{\overline{c^2}} = \sqrt{\frac{3kT}{m}} = 512\,\text{ms}^{-1} \approx 510\text{ m s}^{-1}$	1 1 1	**not** $kT = \frac{1}{2}m\overline{c^2}$ **ecf** T:= 20 K gives 134 ms^{-1} for [2] **allow** $\overline{c^2} = 2.62 \times 10^5$ for [2]
ii	any **one** of the following assumptions 1. elastic collisions 2. molecules impact surface at right angles to it 3. all molecules moving at rms speed evidence of use of $F = PA$ (= 1.0x10^5 x 0.56 = 5.6×10^4 N); EITHER $F = \frac{\Delta p}{\Delta t} = \frac{2nm\sqrt{\overline{c^2}}}{1}$ and n = 1.2×10^{27} s^{-1}; (2) OR $F = \frac{\Delta p}{\Delta t} = \frac{nm\sqrt{\overline{c^2}}}{1}$ and n = 2.3x10^{27} s^{-1}; (1)	1 1 2	$\sqrt{\overline{c^2}}$ = 500 m s^{-1} gives 2.4x10^{27} s^{-1}
	Total	**10**	

Question			Answer	Marks	Guidance
12	a	i	$(R = \frac{V}{I} =) \frac{6.0}{2.7 \times 10^{-3}} = 2.2(2) \times 10^{3}\,\Omega$	1	
		ii	EITHER use of half-life = 0.69RC = 33±1 s / 53±1 s; OR use of RC = 1/e drop time = 49±1 s / 69±1 s; OR data from graph, use of $I = I_0 e^{-t/RC}$; C = 2.2±0.3×10^{-2} F	1 1	evidence of method [1] correct answer [1]
	b	i	$\Delta Q = C\Delta V = 470 \times 10^{-6} \times 0.12 = 5.64 \times 10^{-5}$ C ; $I = \frac{\Delta Q}{\Delta t} = \frac{5.64 \times 10^{-5}}{60} = 9.4 \times 10^{-7}$ A $= 0.94$ μA ;	1 1	 **no** ecf on incorrect ΔQ
		ii	energy required; for an electron to break free (from an atom) / enter the conduction band / become a free electron / move freely within the insulator;	1 1	 **not** just to get from one plate to the other
		iii	use of $\ln I = \ln A - \frac{\varepsilon}{kT}$ to eliminate A; ε = 3.9×10^{-20} J;	1 1	look for method which will eliminate A [1] corrrect answer for [2]
			Total	**9**	

Question			Answer	Marks	Guidance
13	a		large amplitude (vertical) oscillations; make it dangerous/unpleasant for occupants of lift ;	1 1	**ignore** references to sideways oscillations / swinging **accept** break cables
	b	i	use of $k = \frac{F}{x}$ or $F = kx$; use of $\frac{F}{A} = E\frac{x}{L}$ to obtain required expression	1 1	**accept** $k = \frac{F}{\Delta L}$
		ii	$k = \frac{2.0\times10^{11}\times2.5\times10^{-4}}{300} = 1.67\times10^{5}\ \text{Nm}^{-1}$ $T = (2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{1500+640}{1.67\times10^{5}}}) = 0.711\ \text{s}$ $f = \frac{1}{T} = \frac{1}{0.711} = 1.4\ \text{Hz}$	1 1 1	 **no ecf** on incorrect *k* **allow ecf** if mass is just 1500 kg (1.7 Hz) or 640 kg (2.6 Hz) for [2]
	c	i	idea that damping requires friction / energy transfer from lift AND slowing down the lift / reducing efficiency of lift	1	
		ii	EITHER reducing *L* (to increase *k*); raising f_0 (above 2 Hz); OR increasing mass of load / cage; lowering f_0 (below 0.2 Hz); OR decreasing mass of load / cage raising f_0 (above 2 Hz) OR increasing csa of cables (to increase *k*) raising f_0 (above 2 Hz); OR use a cable material which is stiffer / increased *E*; raising f_0 (above 2 Hz)	 1 1	any realistic modification [1] which is explained [1] **not** increasing *L* **not** reducing csa of cables **not** more elastic material QWC against second marking point (organise information clearly)
			Total	**10**	

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