OCR
Oxford Cambridge and RSA

# GCE

# Physics A

Unit **G484**: The Newtonian World

Advanced GCE

# Mark Scheme for June 2017

## Annotations

| Annotation | Meaning |
|---|---|
| BOD | Benefit of doubt given |
| BP | Blank Page |
| 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 |

| 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 |

**Subject-specific Marking Instructions**

**All questions should be annotated with ticks where marks are allocated; One tick per mark.**

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | a | | Energy of $\propto = 5.2 \times 10^{6} \times 1.6 \times 10^{-19}$ ( $= 8.32 \times 10^{-13}$ (J))<br>$E = \frac{1}{2} mv^2$ so<br>$v = \sqrt{\frac{2 \times 8.32 \times 10^{-13}}{6.6 \times 10^{-27}}}$<br>$= 1.6 \times 10^{7}$ (m s$^{-1}$) | C1<br><br>A1<br>A0 | Must see some working<br>**Allow:** Max 1 mark for<br>$4 \times 10^{16}$ (not converting to J) or<br>$1.6 \times 10^{4}$ (not converting MeV to eV)<br>$5.1 \times 10^{5}$ (using keV rather than MeV) |
| | b | | Any **three** from<br>• Total **momentum** of system / particles is conserved (as there are no external forces) / Increase in momentum of Sr nucleus equals decrease in momentum of alpha-particle<br>• (Electrostatic) force (of repulsion) acts on (Sr) nucleus<br>• (By Newton's 2nd law Sr) nucleus accelerates (away from alpha particle)<br>• Sr acceleration increases and then decreases (to zero)<br>• Force on Sr nucleus $\propto$ rate of change of momentum of alpha particle. (AW) | B1 × 3 | ✎ **momentum / accelerate(s) / acceleration** must be spelled correctly to score corresponding mark |
| | c | | (Momentum is conserved)<br>$6.6 \times 10^{-27} \times 1.6 \times 10^{7} = 1.3 \times 10^{-25} \times V$<br><br>$V = 8.1 \times 10^{5}$ (m s$^{-1}$) | C1<br><br>A1 | **Possible ECF from (a)**<br>**Allow** full marks for use of $2 \times 10^{7}$ for speed of alpha particle giving $V = 1.0 \times 10^{6}$ (m s$^{-1}$) |
| | d | | $\Delta(mv) = 2 \times 6.6 \times 10^{-27} \times 1.6 \times 10^{7}$ ($= 2.11 \times 10^{-19}$)<br>$F\Delta t = 4.8 \times \Delta t = 2.11 \times 10^{-19}$<br><br>$\Delta t = 4.4 \times 10^{-20}$ (s) | C1<br><br>A1 | **Possible ECF from (a)**<br><br>**Allow** full marks for use of $2 \times 10^{7}$ for speed of alpha particle giving $\Delta t = 5.5 \times 10^{-20}$ (s) |
| | | | **Total** | 9 | |

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| **2** | **a** | | (Fig. 2.1 shows) *a* and *x* are in opposite directions<br><br>(Fig. 2.2 shows that magnitude of) *a* is proportional to *x* because graph is a straight line <u>through the origin</u> | **B1**<br><br>**B1** | **Allow** *a* is towards the equilibrium position<br><br>Reason must be given |
| | **b** | | gradient = $\omega^2 = \frac{40}{50 \times 10^{-3}} = 800$<br><br>$T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{800}} = 0.22$ (s) | **C1**<br><br>**A1** | **Allow** : use of equation and one point from graph<br><br>**Allow:** Max 1 mark for $T$ = 7 (s) (not converting mm to m) |
| | **c** | **i** | $[k] = \left[\frac{ma}{x}\right] = \frac{\text{kg} \times \text{m s}^{-2}}{\text{m}}$<br>$[k] = \text{kg s}^{-2}$ | **C1**<br><br>**A1** | **Allow:** C1 mark for any subject |
| | | **ii** | $\frac{k}{m}$ is gradient<br>$\frac{k}{m} = 800$ ($\text{s}^{-2}$) | <br>**A1** | **Possible ECF from (b)**<br><br>Ignore sign |
| | **d** | | • The period / frequency of the oscillations would remain the same<br>• Successive **amplitude(s)** would decrease in magnitude<br>• energy is dissipated as heat / thermal energy / work is done against friction (AW) | **B1**<br>**B1**<br>**B1** | ✐ **amplitude** must be spelled correctly to score this mark<br>**Allow:** 1 mark for bald statement that motion would be 'damped harmonic ' or suitable sketch. |

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| 2 | e | i | • **C** continues to move in a straight line as the tube rotates ( by N1st Law) stretching the spring.<br>• Spring exerts a force on **C** which provides the centripetal acceleration ( by Newton's 2nd law) to rotate **C** ( in a circle of appropriate radius). | **B1**<br><br>**B1** | No credit for bald statement of laws. They must be applied to the problem. |
| | | ii | Any **four** from<br>• Measure natural length of spring **OR**<br>Measure mass of **C** with balance/scale(s).<br>• Rotate at <u>constant</u> speed and video apparatus and ruler<br>• Measure *R* from video<br>• Find period *T* from video and speed *v* from 2πR/T<br>• Measure extension from video **OR**<br>calculate extension, *x*, from *R* and natural length<br>• Use spring constant and $F = kx$ / Hooke's law **OR**<br>substitute *M, v R* into $F = Mv^2/R$ to find force *F* | **B1 x 4** | |
| | | iii1 | *FR* / Nm | **B1** | Must have appropriate unit (ignore any prefix) |
| | | iii2 | $m = FR / v^2$ [any subject]<br><br>mass is gradient of graph | **C1**<br><br>**A1** | **Possible ecf from (iii)1** |
| | | | **Total** | **19** | |

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| 3 | a | | $g = \frac{GM}{R^2}$<br>$\frac{g_{Mars}}{g_{Earth}} = \left(\frac{GM_{Mars}}{R^2_{Mars}}\right)\left(\frac{R^2_{Earth}}{GM_{Earth}}\right) = \left(\frac{1}{(3400)^2}\right)\left(\frac{(6400)^2}{9.3}\right)$<br>$g_{Mars} = 0.38 \times 9.81$<br>$g_{Mars} = 3.74 \approx 3.7$ $(\mathrm{N\,kg^{-1}})$ | C1<br><br>A1 | **Allow:** use of recalled mass of Earth (~6 x $10^{24}$ kg) and G from data tables **OR** calculation of mass of Earth from *g* = 9.81 m $s^{-1}$<br><br>**C1** mark is for substitution into appropriate formula **OR** mass of Mars = 6.45 x $10^{23}$ (kg)<br><br>Possible **FT** from their mass of Mars |
| | b | i | • Vertical acceleration on Mars is less than on Earth (AW)<br>• time of fall on Mars is greater than time of fall on Earth (AW)<br>• horizontal distance travelled will be greater on Mars | B1<br>B1<br>A0 | |
| | | ii | • Value of max height will be too small<br>• *g* /*a* will reduce as height increases / $g \propto 1/r^2$ / SUVAT equations only apply if *a* is constant | B1<br>B1 | **Allow** 1 out of 2 marks for 'air resistance will reduce the height' |

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| | c | i1 | • orbit must be over equator / equatorial<br>• period must be one Martian day / 8.9 x $10^4$ s<br>• direction of rotation must be the same as that of Mars / must travel in orbit parallel to a point on surface of Mars | B1<br>B1<br>B1 | **Allow** : same <u>angular</u> speed as Mars |
| | | i2 | $GM_{Mars} = gR^2 = 3.74 \times (3400 \times 10^3)^2 \quad (= 4.3 \times 10^{13})$<br>$T^2 = \frac{4\pi^2}{GM_{Mars}} r^3$<br>$r = \sqrt[3]{\frac{4.3 \times 10^{13} \times (8.9 \times 10^4)^2}{4\pi^2}}$<br>$r = 2.1 \times 10^7$ (m) | C1<br>A1 | **Possible** ECF for mass of Mars from (a)<br>**Allow: C1** mark for substitution of values into correct equation written with any subject.<br>**Allow:** $r = \sqrt[3]{\frac{6.67 \times 10^{-11} \times 6.45 \times 10^{23} (8.9 \times 10^4)^2}{4\pi^2}}$<br>$r = 2.1 \times 10^7$ (m) |
| | | ii | $T = \sqrt{\frac{4\pi^2 r^3}{GM_{Mars}}} = \sqrt{\frac{4\pi^2 \times ((3400 + 9000) \times 10^3)^3}{4.3 \times 10^{13}}}$<br>$T = 4.2 \times 10^4$ (s)<br>number of images $= \frac{4.2 \times 10^4}{25} = 1700$ | C1<br>C1<br>A1 | **Possible ECF from** their $GM_{Mars}$ in c(i)**2** or mass of Mars from (a)<br>**Allow :** Alternative method using $T^2 \propto r^3$ eg<br>$T = \left(\sqrt{\frac{(12400 \times 10^3)^3}{(2.1 \times 10^7)^3}}\right) \times 8.9 \times 10^4$ = 4.2 x $10^4$ (s)<br>**Allow:** 2 out of 3 marks for $T$ = 2.6 x $10^4$ (s) leading to approximately 1034 images [uses 9000 km as radius of orbit]<br>**Possible FT** from their value of $T$ |
| | | | **Total** | **14** | |

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| 4 | a | | charge flowing = $I\,\Delta t = 45 \times 10^{-3} \times 1.6 = (72 \times 10^{-3}$ C)<br><br>number of electrons $= \frac{72\times10^{-3}}{1.6\times10^{-19}} = 4.5\times10^{17}$ | A1 | |
| | b | | $\lambda = \frac{hc}{eV} = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{1.6\times10^{-19}\times130\times10^{3}}$<br>$\lambda = 9.6\times10^{-12}$ (m) | C1<br>A1 | |
| | c | | electrical power = $IV$ =130 × 10$^{3}$ × 45 × 10$^{-3}$ = 5850 W<br><br>rate of heat produced = 0.9 x 5850 = 5265 W<br><br>5265 = $m$ x 4200 x 10<br><br>$m$ = 0.125 (kg s$^{-1}$)<br><br>$V = \frac{m}{\rho} = \frac{0.125}{1000} = 1.25\times10^{-4}$ (m$^{3}$ s$^{-1}$) | C1<br><br>C1<br><br>A1 | **Allow:** electrons energy = 4.5 x 10$^{17}$ x 130 x 10$^{3}$ in 1.6 s.<br>$\text{power} = \frac{4.5\text{ x }10^{17}\text{ x }130\text{ x }10^{3}\times1.6\times10^{-19}}{1.6} = 5850\text{ W}$<br><br>**Allow:** Full marks for correct use of 5 x 10$^{17}$ electrons.<br>Giving V = 1.4 x 10$^{-4}$ (m³ s$^{-1}$) |
| | | | **Total** | **6** | |

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| 5 | a | i | Selection of **two or more** points from the curve and calculation of $pV$ for each point or comparison of values<br><br>hence $pV$ constant / p ∝ 1/V / Boyle's law is obeyed | M1<br><br>A1 | Ignore units in calculation |
| | | ii | • mass of gas / number of molecules must be constant/fixed<br><br>• Temperature must be constant | B1<br><br>B1 | **Allow:** system must be closed |
| | | iii | Straight line graph with positive gradient<br><br>negative intercept on the mass axis (equal to mass of piston) | B1<br><br>B1 | |
| | b | i | $n = \frac{pV}{RT} = \frac{1.0\times10^5 \times (4/3)\pi \times 1.0^3}{8.31\times(273+17)} = (174)$<br><br>mass $= 4.0\times10^{-3} \times 174 = 0.70$ (kg) | C1<br><br>A1 | **Allow:** 1 mark for mass = 5.6 kg [incorrect radius]<br>**Allow:** 1 mark for mass = 12 kg [incorrect *T* ] |
| | | ii | $p_2 = \frac{p_1V_1T_2}{V_2T_1}$<br><br>$= \frac{1.0\times10^5 \times 1.0^3 \times 240}{4.5^3 \times 290}$<br><br>$p_2 = 9.1\times10^2$ (Pa) | C1<br><br>A1 | **Allow:** Use of $p = \frac{nRT}{V}$ with their *n* from **b(i)**<br><br>**Allow:** 1 mark for $p_2$ = 2100 (Pa) [incorrect *T* ] |
| | | iii | Use of internal energy ∝ *T*<br><br>$\frac{\text{internal energy at max height}}{\text{internal energy at ground}} = \frac{240}{290}$ = 0.83 | C1<br><br>A1 | **Not** ratio = 1.9 [incorrect *T* ] |
| | | | **Total** | **12** | |

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