

**Physics A**

Advanced GCE

Unit **G484**: The Newtonian World

**Mark Scheme for June 2012**

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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.

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


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## Annotations

| Annotation  | Meaning                                |
|---|--|
|    | 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              |

The abbreviations, annotations and conventions used in the detailed mark scheme are:

| 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

Q2a, Q2bii, Q3bi, Q5a should be full annotated on all scripts. Ticks are preferred on **all** questions where credit is given.


### Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more sf.

If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.

Any exception to this rule will be mentioned in the Guidance Column.

| Question     |     |       | Answer  | Marks        | Guidance  |
|--------------|-----|-------|---|--------------|---|
| 1            | (a) | (i)   | Force changes the momentum of / accelerates / decelerates the object  | B1           | <b>Allow:</b> Change of speed / velocity / direction of <u>motion</u>   |
|              | (b) | (i)   | Force x time <u>for which the force acts</u> / <u>duration of collision</u>   | B1           | <b>Allow:</b> $F \Delta t$ with both symbols defined<br><b>Not:</b> change of momentum  |
|              |     | (ii)  | Area under graph = impulse OR Area = change in momentum<br><br>final velocity = Area under graph / mass   | B1<br><br>B1 | <b>Allow:</b> Area under graph = $mv$ OR ... = $m(v-u)$<br><br><b>Note:</b> $v$ must be the subject to score this mark  |
|              | (c) | (i)   | mean force on ball x time = increase in momentum of ball<br>mean force = $\frac{0.058 \times 52}{4.2 \times 10^{-3}}$<br><br>= 720 (N)                | C1<br><br>A1 | Mark for correct substitution<br><br><b>Note:</b> Answer to 3 sf is 718 (N)<br>Bald 720 (N) scores 2 marks  |
|              |     | (ii)  | momentum change of racket = momentum (change) of ball<br><br>$M(38 - 32) = 0.058 \times 52$<br><br>$M = \frac{0.058 \times 52}{6}$<br><br>= 0.50 (kg) | C1<br><br>A1 | <b>Allow:</b> use of mean force from c(i) and time 4.2ms .<br>Possible ECF from c(i)<br><br><b>Note:</b> Answer to 3 sf is 0.503 (kg)<br><b>Allow:</b> 0.5 (kg) |
|              |     | (iii) | The person / hand / arm holding the racket also changes momentum (AW)   | B1           | <b>Not:</b> references to angles or initial speed of ball   |
| <b>Total</b> |     |       |   | <b>9</b>     |   |

| Question     |     | Answer   | Marks                        | Guidance   |
|--------------|-----|--|------------------------------|--|
| 2            | (a) | acceleration proportional to <u>displacement</u> (from the equilibrium position)<br><br>and is always acting towards the equilibrium position / the mid-point of the motion (AW)   | B1<br><br>B1                 |  <b>displacement</b> must be spelled correctly to score the mark.<br><b>Allow:</b> acceleration proportional to distance from <u>equilibrium position</u> with equilibrium spelled correctly for first B1<br><br><b>Allow:</b> 'acceleration is in the opposite direction to displacement' for the second B1 mark<br><b>Use tick or cross on Scoris</b> |
|              | (b) | (i) $v_{\max} = 2\pi f A$ $f = 1/0.08 = 12.5$<br><br>$v_{\max} = 2\pi \left( \frac{1}{0.080} \right) \times 1.2 \times 10^{-3} (= 2\pi \times 12.5 \times 1.2 \times 10^{-3})$<br><br>$v_{\max} = 9.4 \times 10^{-2} \text{ (m s}^{-1}\text{)}$  | C1<br><br>A1                 | $\left. \begin{array}{l} \text{If } A = 0.6 \text{ mm used} \\ v_{\max} = 2\pi \left( \frac{1}{0.080} \right) \times 0.6 \times 10^{-3} \quad (\checkmark) \\ v_{\max} = 4.7 \times 10^{-2} \text{ (m s}^{-1}\text{)} \quad (\checkmark) \end{array} \right\}$<br><b>Note:</b> Answer to 3 sf is $9.42 \times 10^{-2} \text{ (m s}^{-1}\text{)}$<br><b>Allow:</b> 1 mark for $94(.2) \text{ (m s}^{-1}\text{)}$ not converting mm to m     |
|              |     | (ii) This occurs at the highest point (top) of the oscillations<br>When acceleration of plate equals/exceeds free fall acceleration /g/ 9.81<br><br>$g = (2\pi f)^2 A_0$ hence $A_0 = \frac{9.81}{\left( 2\pi \times \frac{1}{0.080} \right)^2}$<br><br>$A_0 = 1.6 \times 10^{-3} \text{ (m)}$ | B1<br>B1<br><br>C1<br><br>A1 | <b>Allow:</b> equation with any subject for this mark<br><br><b>Note:</b> Answer to 3 sf is $1.59 \times 10^{-3} \text{ (m)}$  |
|              | (c) | (i) Resonance<br>Driving / drum frequency matches natural frequency (of casing ) (AW)  | B1<br>B1                     |  |
|              |     | (ii) Graph with peak amplitude <b>less than</b> original peak amplitude<br>Similar shape curve with peak at the <b>same</b> or <b>lower</b> frequency than given curve<br>Curve is lower than given curve at all frequencies   | M0<br><br>A1<br>A1           | Must see this before subsequent marks can be scored.   |
| <b>Total</b> |     |  | <b>12</b>                    |  |

| Question     |     |      | Answer   | Marks                | Guidance   |
|--------------|-----|------|--|----------------------|--|
| 3            | (a) | (i)  | Arrow (labelled $F$ ) directed towards centre of circle  | B1                   | <b>Allow:</b> arrow drawn parallel to the string   |
|              |     | (ii) | Resultant force ( $F$ ) acts at $90^\circ$ to motion / velocity of bung<br>so no work done is done by $F$ (hence no change in speed)   | B1<br>B1             | <b>Allow:</b> No component of $F$ acts in the direction of motion (B1)<br>hence there is no acceleration <u>in the direction of motion</u> (AW) (B1) |
|              | (b) | (i)  | Student <u>tries to rotate</u> bung at <u>constant radius</u> / <u>tries to keep</u> reference mark at end of tube (AW)<br>Force $F$ is calculated using $F = Mg$ , where $M$ is mass of slotted masses<br><br>Measure time $t$ for $n$ revolutions of the bung (hence calculate $T$ for 1 revolution).<br><br>Measure radius $r$ when <u>stationary</u><br><br>Calculate $v$ using $2\pi r n / t$ (or $2\pi r / T$ ). | B1<br>B1<br>B1<br>B1 | <b>Not:</b> bald 'constant radius'<br><br><b>Not :</b> $F = \text{weight}$<br><br><b>Not:</b> 'take time for 1 revolution'                           |
|              |     | (ii) | <b>1</b> Straight line of positive gradient <u>passing through the origin</u><br><br><b>2</b> $F = \frac{m}{r} v^2$ hence gradient = $\frac{m}{r}$<br><br>Mass = <u>gradient</u> (of graph) $\times$ radius (of orbit)   | B1<br>B1<br>B1       | Cannot award this mark if graph is curved<br><br>Can score this mark if graph is curved  |
| <b>Total</b> |     |      |  | <b>11</b>            |  |

| Question     |         | Answer  | Marks                              | Guidance   |
|--------------|---------|---|------------------------------------|--|
| 4            | (a) (i) | Energy required to raise the temperature of a unit mass of a substance by unit temperature rise.  | B1                                 | <b>Allow:</b> $c = \frac{Q}{m\Delta\theta}$ with all symbols defined.  |
|              | (ii)    | LH of fusion is energy needed to change (a substance) from <u>solid to liquid</u><br>LH of vaporisation is energy needed to change (a substance) from <u>liquid to gas/vapour</u>   | B1                                 | Allow: a single reference to energy (either statement acceptable)  |
|              | (b) (i) | <b>A to B:</b> KE of molecules <u>increases</u> AND PE of molecules (small) <u>increases</u><br><b>B to C:</b> KE of molecules <u>remain constant</u> AND PE of molecules <u>increases</u>  | B1<br>B1                           |  |
|              | (ii)    | $c_{solid}$ is <b>less than</b> $c_{liquid}$<br><br>Correct reason<br><b>Eg</b> gradient for solid is greater than gradient for liquid AND gradient is inversely proportional to specific heat capacity (AW)}   | B1<br><br>B1                       |  |
|              | (c) (i) | <u>In one second</u><br>volume flowing through = $(3.6 \times 10^{-3} / 60) = 6.0 \times 10^{-5}$<br>mass flowing through = $6.0 \times 10^{-5} \times 1000 = (6.0 \times 10^{-2})$<br><br>Energy gained by water $E = mc \Delta\theta = 0.060 \times 4200 \times (36.7 - 17.4)$<br>(= 4864)<br><br>Power of heater = $E / t = 4864 / 1$<br>Power of heater = $4.9 \times 10^3$<br>$\approx 5 \text{ kW}$ | C1<br>C1<br><br>C1<br><br>A1<br>A0 | <b>Alternative</b><br><u>In one minute</u><br>volume flowing through = $3.6 \times 10^{-3}$<br>mass flowing through = 3.6 (C1)<br>Energy gained<br>$E = mc \Delta\theta = 3.6 \times 4200 \times (36.7 - 17.4)$ (C1)<br>(= $2.92 \times 10^5 \text{ J}$ )<br>Power = $E / t = 2.92 \times 10^5 / 60$ (C1)<br>Power of heater = $4.9 \times 10^3$ (A1)<br>$\approx 5 \text{ kW}$ (A0) |
|              | (ii)    | EITHER<br>rate of flow of water changes<br><b>because</b> water pressure changes<br><br>OR<br>Inlet temperature changes<br><b>because</b> ambient temperature changes   | M1<br>A1                           |  |
| <b>Total</b> |         |   | <b>12</b>                          |  |



| Question     |     | Answer  | Marks        | Guidance   |
|--------------|-----|---|--------------|--|
| 5            | (a) | Gas molecules move in <b>random / erratic / haphazard</b> motion (AW) :   | B1           | <b>Use tick or cross on Scoris</b><br>✍ <b>random / erratic / haphazard</b> must be spelled correctly to score the mark.                                   |
|              | (b) | (i) constant temperature  | B1           |  |
|              |     | (ii) $P_1V_1 = P_2V_2$<br>$350 \times 120 \times (A) = P_2 \times 55 \times (A)$<br>$P_2 = \frac{350 \times 120}{55}$<br>$= 760 \text{ (kPa)}$  | C1<br><br>A1 | <b>Note:</b> Answer to 3 sf is 764 (kPa)<br><b>Note:</b> $7.6 \times 10^5$ (kPa) scores 1 mark   |
|              |     | (iii) When a molecule collides with the (moving) piston it rebounds with higher speed / ke / momentum<br><br>(Mean) kinetic energy of molecules is <u>proportional / <math>\propto</math></u> to (Kelvin) temperature | B1<br><br>B1 | Must refer to collisions with piston or rebounds from piston not collisions within gas molecules.<br><br>Allow: $E_k = 3kT/2$ without definition of terms. |
| <b>Total</b> |     |   | <b>6</b>     |  |

| Question |     | Answer | Marks   | Guidance               |  |
|----------|-----|--------|---|------------------------|--|
| 6        | (a) | (i)    | Force between two (point) masses is proportional to the product of masses and inversely proportional to the square of the distance between them   | B1<br>B1               | <b>Not:</b> radius<br><b>Allow:</b> $F = GMm/r^2$ B1<br><b>All symbols defined</b> B1  |
|          |     | (ii)   | Force per (unit) mass   | B1                     | <b>Allow:</b> $g = F/m$ with symbols defined   |
|          | (b) | (i)    | $v = \frac{2\pi R}{T}$ $v = \frac{2\pi \times 1.2 \times 10^9}{16 \times 86400}$ $v = 5.5 \times 10^3 \text{ (ms}^{-1}\text{)}$   | C1<br><br>A1           | <b>Note:</b> Answer to 3 sf is $5.45 \times 10^3$<br><b>Allow:</b> 1 mark for $4.7 \times 10^3$ not converting days to s<br><b>Allow:</b> 1 mark for 5.5 not converting km to m  |
|          |     | (ii)   | $m_T \frac{v^2}{r} = \frac{GM_S m_T}{r^2}$ $M_S = \frac{v^2 r}{G}$ $M_S = \frac{(5.45 \times 10^3)^2 \times 1.2 \times 10^9}{6.67 \times 10^{-11}}$ $M = 5.3 \times 10^{26} \text{ (kg)}$ | C1<br><br>C1<br><br>A1 | <b>Allow:</b> alternative method using Kepler's third law<br><br>Possible ECF from b(i)<br><b>Note :</b> An answer of $5.3 \times 10^{26}$ (or $5.4 \times 10^{26}$ ) <b>without substitution shown</b> scores 2 marks since this is a 'show' question.<br><b>Note:</b> Use of $5.5 \times 10^3$ gives $5.4 \times 10^{26}$ (kg) |
|          | (c) |        | Reference to $T^2 = (4\pi^2 / GM) r^3$ OR $T^2 \propto r^3$   | B1                     |  |
|          |     |        | $\frac{T_R}{T_T} = \sqrt{\frac{r_R^3}{r_T^3}} \quad \text{OR} \quad \frac{T_R}{T_T} = \left(\frac{r_R}{r_T}\right)^{\frac{3}{2}}$   | B1                     | <b>Not:</b> $\left(\frac{T_R}{T_T}\right)^2 = \left(\frac{r_R}{r_T}\right)^3$  |
|          |     |        | <b>Total</b>  | <b>10</b>              |  |

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