# Marking Scheme

## #1

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| 10 | *(a)* | | Flux changes in ring as it approaches [or recedes from] magnet (1)<br>Emf induced (1) [or by implication by next marking point]<br>Current induced (complete circuit) (1)<br>[Motor effect force] opposes motion or energy lost or Lenz's law stated(1) | | 4 | | 4 | | |
| | *(b)* | | Nothing [or equiv](1)<br>Always opposes motion (Lenz) / field in opposite direction / current in opposite [not: the force opposite] (1) | | 2 | | 2 | | |
| | *(c)* | | Length = $2\pi r$ used (1) [0.157 m]<br>$R = \frac{1.59\times10^{-8}\times2\pi\times0.025}{2.4\times10^{-5}}$ seen<br>(or $1.04\times10^{-4}$ [Ω] seen) (1) | 1 | 1 | | 2 | 1 | |
| | *(d)* | | Ohm's law used (1)<br>Emf = $\frac{BNA}{t}$ i.e. Faraday's used (1) [= 0.55 mV]<br>[NB c.s.a of wire used → no credit and no ecf]<br>Answer, $\frac{B}{t}$ = 0.29 T $s^{-1}$ (or 0.28 depending on rounding)(1) | 1 | 1<br>1 | | 3 | 2 | |
| | | | **Question 10 total** | **2** | **9** | **0** | **11** | **3** | **0** |

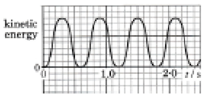
## #2

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| | *(a)* | | Falling amplitude (1)<br>[Air] resistance **or** dissipative forces **or** equivalent (1) | 2 | | | 2 | | |
| | *(b)* | | $T = 2\pi\sqrt{\frac{0.200}{22.0}}$ [s] (1)<br>= 0.599 [s] (1)<br>*T* read from graph = 0.60 [s] (1)<br>Prediction convincing [no significant difference] (1) | | | 4 | 4 | 2 | |
| | *(c)* | | Point at 0.15 s marked – no tolerance (first displacement zero) (1)<br>$v_{max} = 0.020 \times \frac{2\pi}{0.60}$ [m $s^{-1}$] (1)<br>= 0.21 m $s^{-1}$ **UNIT** (1)<br>Too large owing to energy dissipation in first quarter cycle (1)<br>**Accept** less detailed reason, such as 'because of damping'<br>**Alternative for last 3 marks:**<br>$v_{max} = 0.018 \times \frac{2\pi}{0.60}$ [m $s^{-1}$] (1)<br>= 0.19 m $s^{-1}$ **UNIT** (1)<br>Too small because amplitude has fallen or equivalent (1)<br>**Alternative for last 3 marks (mean found):**<br>$v_{max} = 0.019 \times \frac{2\pi}{0.60}$ [m $s^{-1}$] (2)<br>= 0.20 m $s^{-1}$ **UNIT** (1) no comment required | 1 | 1<br>1<br>1 | | 4 | 2 | |
| | *(d)* | | Data from one maximum or minimum on the graph (other than at $t$ = 0) substituted into the given equation or equivalent accept slips (1)<br>$\lambda = 0.35$ [$s^{-1}$] [$\pm0.03$ $s^{-1}$] (1) | | 2 | | 2 | 1 | |
| | | | **Question total** | **3** | **5** | **4** | **12** | **5** | **0** |

#3

| Question | | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| 5 | *(a)* | (i) | | Correct substitution of data (1)<br>$\ell = 1.43\ \text{m}$ (1) | 1 | 1 | | 2 | 2 | 2 |
| | | (ii) | I | Recognisable cosine graph of amplitude 0.050 m (1)<br>Zeros at approximately 0.6 s, 1.8 s, 3.0 s, that is correct period [even if –cosine graph] (1) | | 2 | | 2 | 1 | 2 |
| | | | II | $x\ [/\text{m}] = 0.050 \cos 2\pi \frac{1.6}{2.4}$ or equivalent or by implication (1)<br>$x = -0.025$ m (1)<br>If no working given, 0 marks for any incorrect answer (e.g. –0.24 m) | | 2 | | 2 | 2 | 2 |
| | | | III | $v\ [/\text{m s}^{-1}] = -0.050 \times \frac{2\pi}{2.4} \sin 2\pi \frac{1.6}{2.4}$ or equivalent (1)<br>$v = 0.11\ \text{m s}^{-1}$ (1)<br>For tangent method on sketch graph, award the second mark for $0.11 \pm 0.03\ \text{m s}^{-1}$ | | 2 | | 2 | 2 | 2 |
| | | | IV | 2.0 s | | 1 | | 1 | | 1 |
| | *(b)* | | | **A: Meaning of resonance**<br>A1 Term applies to forced oscillations.<br>A2 Forced oscillations occur when a system is subjected to a periodic driving force.<br>A3 Resonance occurs at a particular frequency of driving force…<br>A4 .. which is the same frequency as the system's natural frequency<br>A5 At resonance the amplitude of the oscillations is a maximum [for a given amplitude of driving force].<br><br>**B: How effects can be lessened**<br>B1 System mentioned where resonance is a nuisance (e.g suspension bridge).<br>B2 A little information given about the oscillations and/or the driving force for this system.<br>B3 Increasing the damping will lessen the amplitude of the oscillations.<br>B4 Making sure the forcing frequency avoids the system's natural frequency (e.g. by shifting system's natural frequency) will also lessen amplitude | 6 | | | 6 | | |
| | | | | **5-6 marks**<br>**Expect**: A2 + A4 + A5,<br>B1 + B2 + (B3 or B4)<br>There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.<br><br>**3-4 marks**<br>**Expect**: (A1 or A2) + (A3 or A4) + A5<br>B1 + (B3 or B4)<br>There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.<br><br>**1-2 marks**<br>**Expect** 3 points with at least 1 point made from each of A and B.<br>There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.<br><br>**0 marks**<br>No attempt made or no response worthy of credit. | | | | | | |
| | | | | **Question 5 total** | 7 | 8 | 0 | 15 | 7 | 9 |

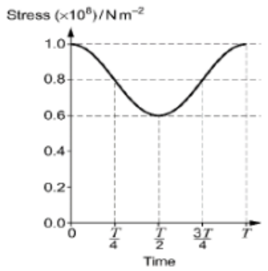
# 4

| Question | | | Marking details | AO1 | AO2 | AO3 | Total | Maths | Prac |
|---|---|---|---|---|---|---|---|---|---|
| 5 | *(a)* | | [Motion such that] acceleration proportional to displacement from a fixed point [1]<br>but in opposite direction or directed towards that point [1]<br>or<br>$a = -\omega^2 x$ with $a$ = acceleration and $x$ = displacement [1]<br>$\omega$ [or $\omega^2$] constant [1] | 2 | | | 2 | | |
| | *(b)* | (i) | $T$ = 1.2[0] s (from graph) or by implication [1]<br>Correct re-arrangement $k = \frac{4\pi^2 m}{T^2}$ at any stage or by impl. [1]<br>$k$ = 4.80 N m$^{-1}$ **unit mark** [1] | | 3 | | 3 | 2 | |
| | | (ii) | Correct use of $v_{max} = A\omega$ [= 0.209 m s$^{-1}$] or by implic [1]<br>Correct use of $E_k = \frac{1}{2}mv^2$ ecf on slips in $v_{max}$ [1]<br>$E_{k\,max}$ = 3.8 × 10$^{-3}$ J [1] | 1<br>1 | 1 | | 3 | 2 | |
| | | (iii) | <br><br>Zeros at $t$ = 0, 0.6 s, 1.2 s, 1.8 s, 2.4 s [1]<br>KE never negative with equal peaks [1]<br>Smooth (sinusoidal) curve [1] | 1<br>1 | 1 | | 3 | 2 | |
| | *(c)* | | Reasonable straight line of best fit drawn [1]<br>Straight line expected as equation equivalent to<br>$\ln A = \ln A_0 - \lambda t$ [1]<br>Some comment about scatter of points – either supporting or casting doubt on straight line [1]<br>$\lambda$ = –gradient or by impl. [1]<br>Gradient calculated correctly e.g. 0.014 [s$^{-1}$] No *second* penalty for mishandling minus sign [1] | | | 5 | 5 | 3 | 5 |
| | | | **Question 5 total** | 6 | 5 | 5 | 16 | 9 | 5 |

# #5

| Question | | | Marking details | AO1 | AO2 | AO3 | Total | Maths | Prac |
|---|---|---|---|---|---|---|---|---|---|
| | (a) | (i) | Straight line through origin [1]<br>Negative gradient [1]<br>[1 mark for a whole answer like "Acceleration proportional to negative displacement" i.e. without referring to graph] | 2 | | | 2 | | |
| | | (ii) | 0.024 [m] | 1 | | | 1 | | |
| | | (iii) | $\omega^2 = \frac{0.60}{0.024}$ [= 25 s$^{-2}$] [1]<br>$T = \frac{2\pi}{5\ [s^{-1}]}$ **ecf on** $\omega^2$ [1]<br>$T$ = 1.26 [s] **no ecf** [1] | | 3 | | 3 | 3 | |
| | (b) | (i) | No. $l$ not measured to centre of sphere. | | | 1 | 1 | | 1 |
| | | (ii) | Graph gradient = $\frac{4\pi^2}{g}$ or equivalent [1]<br>Correct division sum set up to calculate gradient from graph [1]<br>Max gradient between 4.0 and 4.2 [s$^2$ m$^{-1}$] [1]<br>Min gradient between 3.7 and 3.9 [s$^2$ m$^{-1}$] [1]<br>$g$ = 9.9 m s$^{-2}$ **ecf** on mean gradient [1]<br>Uncertainty 5 % **ecf** on max and min gradients [1] | | | 6 | 6 | 4 | 6 |
| | (c) | (i) | Decreasing amplitude (or equivalent) | 1 | | | 1 | | |
| | | (ii) | Resistive or dissipative forces (or equivalent incl air res) [1]<br>[Always] oppose motion **or** transfer energy from system/ball [1] | 2 | | | 2 | | |
| | (d) | | Body, displaced and released, returns to equilibrium without oscillating **or** without overshoot [1]<br>Resistive force just large enough for this (or equiv) [1]<br>Car suspensions (or other plausible example) Accept bridges [1] | 3 | | | 3 | | |
| | | | **Question total** | 9 | 3 | 7 | 19 | 7 | 7 |

#6

| Question | | | Marking details | AO1 | AO2 | AO3 | Total | Maths | Prac |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Marks available | | | | | |
| (a) | (i) | | Substitution and re-arrange e.g.<br>$\Delta x_{max} = \frac{(1.0 \times 10^{8} \times 2.5)}{2.0 \times 10^{11}}$ [1]<br>$\Delta x_{max} = 1.25 \times 10^{-3}$ m or 1.25 mm [1]<br><br>Accept use of 1.25 mm to show $E_{steel} = 2.0 \times 10^{11}$ [N m$^{-2}$] | | 2 | | 2 | 2 | |
| | (ii) | | Stress required to reach elastic limit will remain constant irrespective of radius e.g. If radius is doubled the tension is increased by factor 4 [1]<br>$\Delta x_{max}$ (of this wire) will be the same (depends only on stress) [1]<br>$\Delta x_{max}$ does not depend on the radius, Natalie correct (or Simon incorrect) [1] | | | 3 | 3 | | |
| (b) | (i) | | Re-arrangement and substitute: $F = \frac{EA\Delta x}{l}$<br><br>i.e. $F = \frac{2.0 \times 10^{11} \times 1.0 \times 10^{-6} \Delta x}{2.5}$ [1]<br>$F = k\Delta x$ seen or implied [1]<br>Correct algebra to show $k = 8 \times 10^{4}$ [N m$^{-1}$] [1]<br>**Alternative:**<br>At elastic limit $k = \frac{100}{1.25 \times 10^{-3}}$ (= 80 kN m$^{-2}$) - award 3 marks | | 3 | | 3 | 3 | |
| | (ii) | | $mg = k\Delta x$ seen or implied [1]<br>$m = \frac{8.0 \times 10^{4} \times 1 \times 10^{-3}}{9.81}$<br>$m$ = 8.2 k[g] [1] | | 2 | | 2 | 1 | |
| (c) | (i) | | Substitution into $T = 2\pi\sqrt{\frac{m}{k}}$ [1] (**ecf** on $m$)<br><br>$T$ = 0.06[3 s] [1] | 1 | 1 | | 2 | 2 | |
| | (ii) | | Elastic limit must not be exceeded, so max possible displacement = 1.25 mm – 1.0 mm = 0.25 [mm] [1]<br>Substitution into $v_{max} = A\omega$ or equivalent:<br><br>e.g. $v_{max} = 0.25 \times 10^{-3} \times \frac{2\pi}{0.06}$ [1] (**ecf** on $T$ and $\Delta x_{max}$)<br><br>$v_{max}$ = 0.026 [m s$^{-1}$] [1] | 1 | 1<br><br>1 | | 3 | 2 | |
| | (iii) | | Stress in equilibrium position calculated or seen on graph i.e.<br>$= \frac{2.0 \times 10^{11} \times 1.0 \times 10^{-3}}{2.5}$ (= $0.8 \times 10^{8}$ N m$^{-2}$) [1]<br><br>Appropriate stress scale e.g. as shown or in steps of $0.2 \times 10^{8}$ N m$^{-2}$ [1]<br>Correct general shape with no reference to time/ stress scales [1]<br>Correct shape and stress and timings [1]<br> | | 4 | | 4 | 2 | |
| | | | **Question total** | **2** | **14** | **3** | **19** | **12** | **0** |