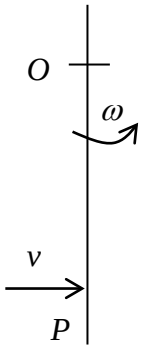
Edexcel
Success through qualifications

**Mock Paper Mark Scheme**

**Advanced Subsidiary/Advanced GCE**
General Certificate of Education

| Question number | Scheme | Marks |
|---|---|---|
| **1.** (*a*) | Reaction **R** is perpendicular to the wire, since the wire is smooth.<br>Hence **R.d** = 0. | B1 (1) |
| (*b*) | $\overrightarrow{AB} = (3\mathbf{i} - \mathbf{j} + 2\mathbf{k}) - (\mathbf{i} + \mathbf{j} - 3\mathbf{k}) = 2\mathbf{i} - 2\mathbf{j} + 5\mathbf{k}$ | M1 |
| | Work energy: $[2\mathbf{i} + 3\mathbf{j} + (x - 4.9)\mathbf{k}].(2\mathbf{i} - 2\mathbf{j} + 5\mathbf{k}) = \frac{1}{2} \times 0.5(4^2 - 2^2)$ | M1 A1 A1 |
| | $4 - 6 + 5(x - 4.9) = 3 \Rightarrow x = 5.9$ | A1 (6)<br>**(7)** |
| **2.** |  <br>MI of rod about *O* is $\frac{1}{3}m(2a)^2 + ma^2 = \frac{7}{3}ma^2$ | B1 |
| | Moment of momentum:<br>$3mv \times x = (\frac{7}{3}ma^2 + mx^2)\omega$ | M1 A1 A1 ft |
| | $x\omega = \frac{2}{3}v$ | M1 |
| | $\Rightarrow 3m \times \dfrac{3x\omega}{2} \times x = (\frac{7}{3}ma^2 + mx^2)\omega$<br>$\Rightarrow \frac{7}{2}x^2 = \frac{7}{3}a^2 \Rightarrow x = a\sqrt{\frac{2}{3}}$ | M1 A1 **(7)** |
| **3.** | Auxiliary equation $m^2 + 4m + 3 = 0 \Rightarrow m = -1$ or $-3$ | M1 |
| | $\Rightarrow \mathbf{r} = \mathbf{A}e^{-t} + \mathbf{B}e^{-3t}$ | A1 |
| | $t = 0,\ \dot{\mathbf{r}} = 2\mathbf{i} \Rightarrow \mathbf{A} + \mathbf{B} = 2\mathbf{i}$ | M1 A1 |
| | $t = 0,\ \dot{\mathbf{r}} = 2\mathbf{j} \Rightarrow -\mathbf{A} - 3\mathbf{B} = 2\mathbf{j}$ | |
| | Solving: $-2\mathbf{B} = 2\mathbf{i} + 2\mathbf{j}$ | |
| | $\Rightarrow \mathbf{B} = -(\mathbf{i} + \mathbf{j})$ | M1 A1 |
| | $\mathbf{A} = (3\mathbf{i} + \mathbf{j})$ | |
| | $\mathbf{r} = (3\mathbf{i} + \mathbf{j})e^{-t} - (\mathbf{i} + \mathbf{j})e^{-3t}$ | |
| | $t = \ln 2 \Rightarrow e^{-t} = \frac{1}{2},\ e^{-3t} = \frac{1}{8}$ | B1 |
| | $\mathbf{r} = \frac{1}{2}(3\mathbf{i} + \mathbf{j}) - \frac{1}{8}(\mathbf{i} + \mathbf{j}) = \frac{11}{8}\mathbf{i} + \frac{3}{8}\mathbf{j}$ | M1 A1 **(10)** |

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| **4.** (*a*) | $\mathbf{F} = (2\mathbf{j} + 3\mathbf{k}) + (\mathbf{i} + 4\mathbf{k}) = \mathbf{i} + 2\mathbf{j} + 7\mathbf{k}$ | M1 |
| | $\lvert \mathbf{F} \rvert = \sqrt{(1 + 4 + 49)} = \sqrt{54}$ N | M1 A1 (3) |
| (*b*) | **F** acts through point with p.v. **r** | |
| | $\Rightarrow \begin{pmatrix} x \\ y \\ z \end{pmatrix} \times \begin{pmatrix} 1 \\ 2 \\ 7 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} \times \begin{pmatrix} 0 \\ 2 \\ 3 \end{pmatrix} + \begin{pmatrix} 0 \\ 2 \\ 0 \end{pmatrix} \times \begin{pmatrix} 1 \\ 0 \\ 4 \end{pmatrix}$ | M1 |
| | $\begin{pmatrix} 7y - 2z \\ z - 7x \\ 2x - y \end{pmatrix} = \begin{pmatrix} -2 \\ -3 \\ 2 \end{pmatrix} + \begin{pmatrix} 8 \\ 0 \\ -2 \end{pmatrix}, = \begin{pmatrix} 6 \\ -3 \\ 0 \end{pmatrix}$ | A1 A1, A1 |
| | so $7y - 2z = 6$, $z - 7x = -3$, $2x - y = 0$ | |
| | $\Rightarrow y = 2x \Rightarrow$ e.g. $x = 0$, $y = 0$, $z = -3$ | M1 A1 |
| | Hence equation of line of action of **F** is | |
| | $\mathbf{r} = \begin{pmatrix} 0 \\ 0 \\ -3 \end{pmatrix} + \lambda \begin{pmatrix} 1 \\ 2 \\ 7 \end{pmatrix}$ | M1 A1 (8) |
| | | **(11)** |
| **5.** | $\longrightarrow v$ (Time $\delta t$) $\longrightarrow v + \delta v$ $\longrightarrow v + c$<br>$m$ $m + \delta m$ $-\delta m$ | |
| | $(m + \delta m)(v + \delta v) + (-\delta m)(v + c) - mv = 0$ | M1 A2, 1, 0 |
| | $\Rightarrow m\,\mathrm{d}v - c\,\mathrm{d}m = 0$ reducing equation | M1 |
| | $\int_V^{\frac{2}{3}V} \mathrm{d}v = c\int_M^m \frac{\mathrm{d}m}{m}$ separating variables | M1 |
| | $\left[ v \right]_V^{\frac{2}{3}V} = c\left[ \ln m \right]_M^m$ integration | M1 A1 |
| | $-\frac{1}{3}v = c \ln\left(\frac{m}{M}\right)$ applying limits | M1 |
| | $\Rightarrow m = M\mathrm{e}^{-\frac{V}{3c}}$ eliminating ln and $m$ = | M1 |
| | $\therefore$ Fuel used $= M - m = M(1 - \mathrm{e}^{-\frac{V}{3c}})$ | M1 A1 **(11)** |

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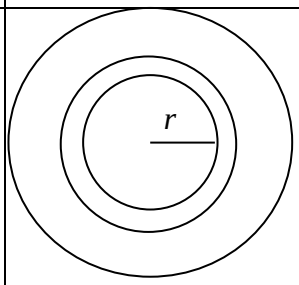
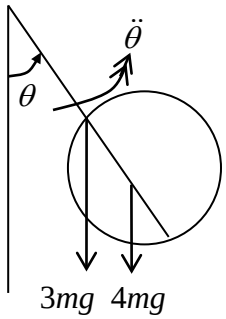
| **6.** (*a*) |  MI of element = $2\pi\rho r\delta r \times r^2$ | M1 |
| | $m = \pi\rho a^2$ | |
| | $\Rightarrow \mathrm{I} = \dfrac{2m}{a^2}\displaystyle\int_0^a r^3\,\mathrm{d}r$ | M1 |
| | $= \dfrac{2m}{a^2}\left[\dfrac{r^4}{4}\right]_0^a = \frac{1}{2}ma^2$ | A1 (3) |
| (*b*) | $\mathrm{I} = \mathrm{I}_{\mathrm{rod}} + \mathrm{I}_{\mathrm{disc}} = \frac{4}{3} \times 3m \times a^2, + \frac{1}{2} \times 4m\left(\dfrac{a}{2}\right)^2 + 4m\left(\dfrac{3a}{2}\right)^2$ | B1, M1 |
| | $= 4ma^2 + \dfrac{ma^2}{2} + 9ma^2$ | |
| | $= \frac{27}{2}ma^2$ | A1 (3) |
| (*c*) |  $\frac{27}{2}ma^2\,\ddot{\theta} = -3mg \times a\sin\theta - 4mg \times \dfrac{3a}{2}\sin\theta$ | M1 A2, 1, 0 |
| | $= -9mga\sin\theta$ | |
| | $\ddot{\theta} = -\dfrac{2g}{3a}\sin\theta$ | |
| | Small oscillations $\Rightarrow \sin\theta \approx \theta$ | M1 |
| | $\Rightarrow \ddot{\theta} = -\dfrac{2g}{3a}\theta$ which is SHM | A1 |
| | $T = 2\pi\sqrt{\dfrac{3a}{2g}}$ | A1 (6) |
| | | **(12)** |

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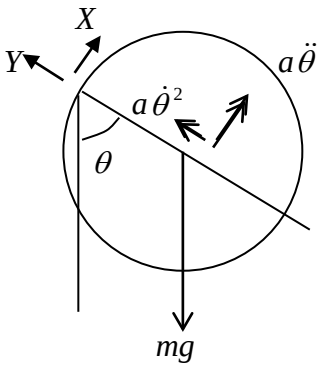
| **7.** (*a*) | MI of sphere about $L = \frac{2}{5}ma^2 + ma^2 = \frac{7}{5}ma^2$ | B1 |
| | Energy: $\frac{1}{2}\times\frac{7}{5}ma^2 \times \frac{18g}{7a} - \frac{1}{2}\times\frac{7}{5}ma^2 \times \omega^2 = mga(1-\cos\theta)$ | M1 A2, 1, 0 |
| | $\Rightarrow \frac{7}{10}a\omega^2 = \frac{8}{10}g + g\cos\theta$ | |
| | $\omega^2 = \frac{g}{7a}(8+10\cos\theta) = \frac{2g}{7a}(4+5\cos\theta)$ | A1 (5) |
| (*b*) | $\frac{7}{5}ma^2\ddot{\theta} = -mga\sin\theta \Rightarrow \ddot{\theta} = -\frac{5g}{7a}\sin\theta$ | M1 A1 (2) |
| | [or $2\omega\dot{\omega} = -\frac{10g}{7a}\sin\theta\times\omega \Rightarrow \dot{\omega} = -\frac{5g}{7a}\sin\theta$] | |
| (*c*) |  | |
| | $\dot{\theta} = 0$ when $\cos\theta = -\frac{4}{5}$ | B1 |
| | $Y - mg\cos\theta = ma\dot{\theta}^2$ | M1 |
| | $\dot{\theta} = 0$, $\cos\theta = -\frac{4}{5} \Rightarrow Y = -\frac{4mg}{5}$ | M1 A1 |
| | $X - mg\sin\theta = ma\ddot{\theta}$ | M1 |
| | $\dot{\theta} = 0$ and $\cos\theta = -\frac{4}{5} \Rightarrow \sin\theta = \frac{3}{5}$ | M1 |
| | $\Rightarrow \ddot{\theta} = -\frac{3g}{7a}$ | |
| | $\Rightarrow X = \frac{3mg}{5} - \frac{3mg}{7} = \frac{6mg}{35}$ | A1 |
| | Magnitude of force $= \sqrt{(X^2 + Y^2)}$ | M1 |
| | $= mg\left[\left(\frac{6}{35}\right)^2 + \left(\frac{4}{5}\right)^2\right]^{\frac{1}{2}}$ | |
| | $\approx 0.818\,mg$ | A1 (10) |
| | | **(17)** |