Pearson Edexcel

# Mark Scheme (Unused)

## January 2022

Pearson Edexcel International Advanced Level In Mechanics M3 (WME03) Paper 01

| Question Number | Scheme | Marks |
|---|---|---|
| **1(a)** | $T_{AP} = 6mg$ | M1 |
| | $\frac{6mgx}{8a} = 6mg$ | M1 |
| | $AP = 16a$ | A1 |
| | | (3) |
| **1(b)** | $2mg = \frac{6mgy}{3a}$ | M1 |
| | $y = a$ | A1 |
| | $PQ = 4a$ | A1 (3) |
| | | **(6)** |
| | **Notes for question 1** | |
| **1(a)** | M1 for resolving vertically for the system | |
| | M1 Use of Hooke's Law to set up an equation using their tension<br>M0 if $11a$ is used for natural length | |
| | A1 cao | |
| **1(b)** | M1 M0 if $11a$ is used for natural length | |
| | A1 cao | |
| | A1 cao | |

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|---|---|---|
| **2.** | $T\cos\theta(+R) = mg$ | M1A1 |
| | $T\sin\theta = ma\sin\theta\dfrac{2g}{a}$ $\quad (T = 2mg)$ | M1A1 |
| | $\cos\theta < \dfrac{1}{2}$ or $\cos\theta \le \dfrac{1}{2}$ or $\cos\theta = \dfrac{1}{2}$ | M1 |
| | $\theta > 60$ or $\theta \ge 60$ | A1 |
| | $90 > \theta > 60$ or $90 > \theta \ge 60$ | A1 |
| | | **(7)** |
| | **Notes for question 2** | |
| | M1 for resolving vertically, correct no. of terms, $T$ resolved | |
| | A1 for a correct equation | |
| | M1 for equation of motion horizontally | |
| | A1 for a correct unsimplified equation | |
| | M1 for producing an appropriate inequality in $\cos\theta$<br>Allow an equation | |
| | A1 Must come from an inequality. | |
| | A1 cao | |
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| **3(a)** | $a = v\dfrac{\mathrm{d}v}{\mathrm{d}x} = -\dfrac{2}{(2x+1)^3}$ separate and integrate | M1 |
| | $\dfrac{1}{2}v^2 = \dfrac{1}{2(2x+1)^2} + (C)$ | A1 |
| | $x = 0, v = 1 \Rightarrow C = 0$ | M1 |
| | $v = \dfrac{1}{(2x+1)}$ | A1 |
| | | (4) |
| **3(b)** | $\dfrac{\mathrm{d}x}{\mathrm{d}t} = \dfrac{1}{(2x+1)}$ separate and integrate | M1 |
| | $x^2 + x + (D) = t$ | A1 |
| | Complete the square: $(x+\frac{1}{2})^2 - \frac{1}{4} = t$<br>or use quadratic formula: $x = \dfrac{-1 \pm \sqrt{1+4t}}{2}$ | M1 |
| | $x = \dfrac{1}{2}(\sqrt{(4t+1)} - 1)$ * | A1* (4) |
| | | **(8)** |
| | **Notes for question 3** | |
| **3(a)** | M1 allow omission of - sign, powers increasing by 1 | |
| | A1 correct equation, but allow omission of $C$ | |
| | M1 use of initial conditions to find $C$ | |
| | A1 cso | |
| **3(b)** | M1 powers increasing by 1 | |
| | A1 correct equation, but allow omission of $D$ | |

| Question Number | Scheme | Marks |
|---|---|---|
| | M1 complete the square | |
| | A1* given answer correctly obtained, with at least one line of working and justification of positive root e.g. $x > 0$ | |
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| **4(a)** | $\overline{x} = \dfrac{\pi\int_0^r x\left(r^2 - x^2\right)\mathrm{d}x}{\frac{2\pi r^3}{3}}$ | M1A1 |
| | $= \dfrac{\left[r^2\dfrac{x^2}{2} - \dfrac{x^4}{4}\right]_0^r}{\frac{2r^3}{3}}$ | A1 |
| | $= \dfrac{3r}{8}$* | A1* |
| | | (4) |
| **4(b)** | Mass ratios: $\dfrac{2\pi r^3}{3}$ $\quad \pi r^2 h$ $\quad \left(\dfrac{2\pi r^3}{3} + \pi r^2 h\right)$ | B1 |
| | Distances: $\dfrac{5r}{8}$ $\quad \left(r + \dfrac{1}{2}h\right)$ $\quad \overline{y}$ | B1 |
| | $\left(\dfrac{2\pi r^3}{3} \times \dfrac{5r}{8}\right) + \pi r^2 h\left(r + \dfrac{1}{2}h\right) = \left(\dfrac{2\pi r^3}{3} + \pi r^2 h\right)\overline{y}$ | M1A1 |
| | $\overline{y} = \dfrac{5r^2 + 12rh + 6h^2}{8r + 12h}$ * | A1* |
| | | (5) |
| **4(c)** | $r = \dfrac{5r^2 + 12rh + 6h^2}{8r + 12h}$ | M1 |
| | $r = \sqrt{2}h$ | A1 |
| | | (2) |
| | | **(11)** |
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| | **Notes for question 4** | |

| Question Number | Scheme | Marks |
|---|---|---|
| **4(a)** | M1 for use of $\bar{x} = \dfrac{\pi\int_0^r xy^2\,\mathrm{d}x}{\frac{2\pi r^3}{3}}$ | |
| | A1 for $\bar{x} = \dfrac{\pi\int_0^r x\left(r^2 - x^2\right)\mathrm{d}x}{\frac{2\pi r^3}{3}}$ | |
| | M1 for integrating with powers increasing by 1 | |
| | A1* for given answer correctly obtained | |
| **4(b)** | B1 correct mass ratios | |
| | B1 correct distances (for their parallel axis) | |
| | M1 for use of a moments equation with correct terms<br>(Allow about a parallel axis) | |
| | A1 for correct unsimplified equation (for their parallel axis) | |
| | A1* for given answer correctly obtained | |
| **4(c)** | M1 for equating given answer to $r$ oe | |
| | A1 cao | |
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| Question Number | Scheme | Marks |
|---|---|---|
| **5(a)** | $\frac{1}{2}mu^2 - \frac{1}{2}mv^2 = mga(1+\cos\theta)$ | M1A2,1,0 |
| | $mg\cos\theta = \frac{mv^2}{a}$ | M1A1 |
| | Eliminate $\theta$ | M1 |
| | $3v^2 = u^2 - 2ag$ * | A1* |
| | | (7) |
| **5(b)** | Vertical motion: $-\frac{a\sqrt{3}}{2} = (v\sin 30^o)T - \frac{1}{2}gT^2$ | M1A1 |
| | Solve for $T$: $T = \frac{v \pm \sqrt{v^2 + 4ag\sqrt{3}}}{2g}$ | M1 |
| | Use $v^2 = ag\frac{\sqrt{3}}{2}$ and $T > 0$ to show the given answer: $T = \frac{2v}{g}$ | A1* |
| | | (4) |
| **5(c)** | Horizontal motion: $x = v\cos 30^o \times \frac{2v}{g}$ | M1 |
| | $= \frac{3a}{2}$ and hence taut (= $a$ + $a$sin30°)* | A1* |
| | | (2) |
| | | **(13)** |
| | **Notes for question 5** | |
| **5(a)** | M1 for an energy equation with the correct terms | |
| | A2 for a correct equation, A1 for an equation with at most one error | |
| | M1 for an equation of motion towards $O$ with correct terms, condone sign errors and sin/cos confusion ($R$ may appear) | |
| | A1 for a correct equation ($R$ = 0 must be used at some point) | |
| | M1 for eliminating $\theta$ | |
| | A1* for given answer correctly obtained | |
| **5(b)** | M1 for equation for vertical motion ,with correct terms, condone sign errors and sin/cos confusion | |
| | A1 for a correct equation | |
| | M1 for solving for $T$ | |
| | A1* for correctly obtaining the given answer | |
| **5(c)** | M1 for equation for horizontal motion ,with correct terms, condone sign errors and sin/cos confusion | |
| | A1* for given answer correctly justified | |
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| Question Number | Scheme | Marks |
|---|---|---|
| **6(a)** | $mg = \frac{\lambda \times 4l}{2l} => \lambda = \frac{1}{2}mg$ | M1 A1 |
| | $mg - \frac{\frac{1}{2}mg(x+4l)}{2l} = m\ddot{x}$ (or $x$ replaced by $-x$ on both sides) | M1 A2,1,0 |
| | $-\frac{g}{4l}x = \ddot{x}$ , hence SHM (with $\omega = \sqrt{\frac{g}{4l}}$ ) | A1 |
| | $T = \frac{2\pi}{\omega}$ | M1 |
| | $2\pi\sqrt{\frac{4l}{g}} = 4\pi\sqrt{\frac{l}{g}}$ * | A1* |
| | | (8) |
| **6(b)** | Their $\omega \times 2l$ | M1 |
| | $\sqrt{gl}$ | A1 |
| | $\frac{1}{2}mgl$ | A1 |
| | | (3) |
| **6(c)** | $-l = 2l\cos\omega t$ | M1A1 |
| | $t = \frac{2\pi}{3\omega}$ | M1 |
| | $\frac{1}{3}T$ | A1 |
| | | (4) |
| | | **(15)** |
| | **Notes for question 6** | |
| **6(a)** | M1 Resolving vertically and using Hooke's Law | |
| | A1 cao | |
| | M1 equation of motion in a general position with correct no. of terms, allow use of accln instead of derivative | |
| | A2 for a correct equation, A1 for an equation with at most one error | |
| | A1 for correct equation in correct form | |
| | M1 Use of correct formula | |
| | A1* Given answer correctly obtained | |
| **6(b)** | M1 for use of correct formula | |
| | A1 for correct speed | |
| | A1 cao | |
| **6(c)** | M1 for complete method to find *t* | |
| | A1 for correct equation(s) ($\omega$ does not need to be substituted for this mark) | |
| | M1 for solving for *t* | |
| | A1 cso | |
| | | |

| Question Number | Scheme | Marks |
|---|---|---|
| **7(a)** | EPE Gain = $\dfrac{2mgx^2}{2a}$ | B1 |
| | PE loss = $mgx\sin\alpha$ | B1 |
| | WD against friction = $\mu mg\cos\alpha\times x$ | B1 |
| | $\mu mg\cos\alpha\times x = mgx\sin\alpha - \dfrac{2mgx^2}{2a}$ | M1 |
| | $x = AB = a(\sin\alpha - \mu\cos\alpha)$ * | A1* |
| | | (5) |
| **7(b)** | $\mu mg\cos\alpha\times y = mgy\sin\alpha - \dfrac{1}{2}mv^2 - \dfrac{2mgy^2}{2a}$ | M1A2,1,0 |
| | At max speed,<br>$\mu mg\cos\alpha = mg\sin\alpha - \dfrac{2mgy}{a}$ | M1 |
| | $y = \dfrac{1}{10}a$ | A1 |
| | Use their $y$ value to find the max speed | M1 |
| | $v = \sqrt{\dfrac{ag}{50}}$ oe | A1 |
| | | (7) |
| **7(b)** | $\mu mg\cos\alpha\times y = mgy\sin\alpha - \dfrac{1}{2}mv^2 - \dfrac{2mgy^2}{2a}$ | M1A2,1,0 |
| **7(c)** | At $B$, nett force down plane = $\dfrac{3}{5}mg - \dfrac{2mgx}{a} = \dfrac{1}{5}mg$ | M1 |
| | Max friction available = $\dfrac{1}{2}\times mg\times\dfrac{4}{5} = \dfrac{2}{5}mg$ | B1 |
| | Hence, friction = $\dfrac{1}{5}mg$ up and $P$ remains at $B$. | A1 |
| | | (3) |
| | | **(15)** |
| | **Notes for question 7** | |
| **7(a)** | B1 correct expression | |
| | B1 correct expression | |
| | B1 correct expression | |
| | M1 for energy equation dim correct with correct terms, condone sign errors | |
| | A1* for given answer correctly obtained | |
| **7(b)** | M1 for energy equation, dim correct with correct terms, condone sign errors | |
| | A2 for a correct unsimplified equation, A1 for for a correct unsimplified equation with at most one error | |
| | M1 for finding the resultant force parallel to the plane and equating to 0 or differentiating energy equation wrt $y$ and equating $\dfrac{\mathrm{d}v}{\mathrm{d}y}$ to 0 | |

| Question Number | Scheme | Marks |
|---|---|---|
| | A1 for correct value of $y$ | |
| | M1 for using their $y$ value to find the max speed | |
| | A1 cao | |
| **7(b)** | M1 for energy equation, dim correct with correct terms, condone sign errors | |
| **7(c)** | M1 for finding nett force up or down plane, correct terms, condone sign errors | |
| | B1 for max friction | |
| | A1 correct conclusion and justification | |
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