

Mark Scheme (Results) Summer 2010

GCE

GCE Mechanics M2 (6678/ 01)

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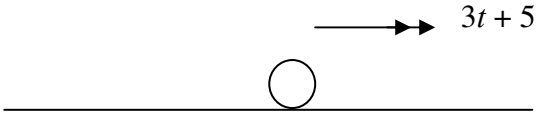
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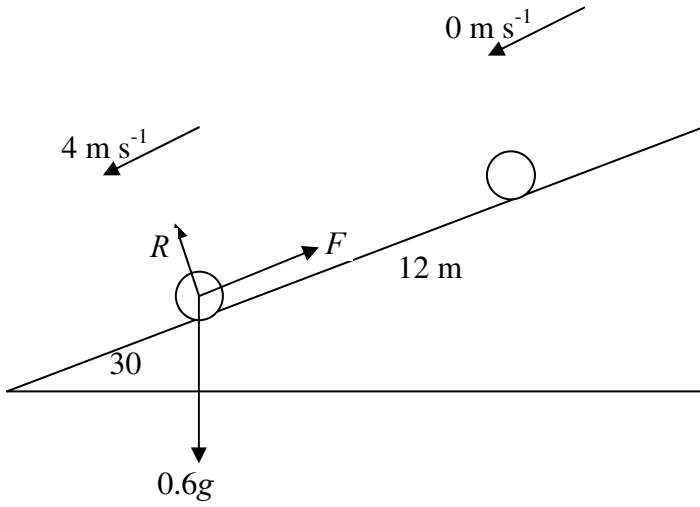
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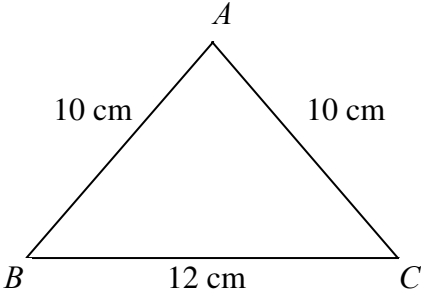
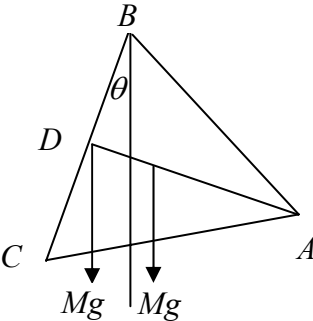
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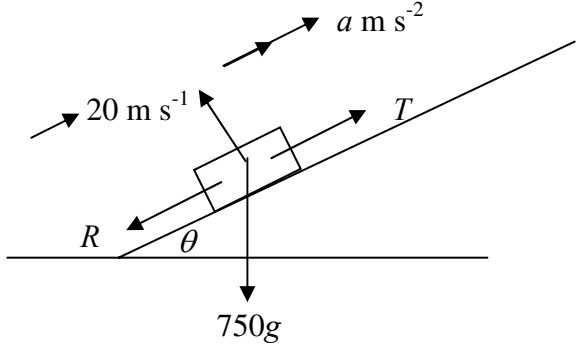
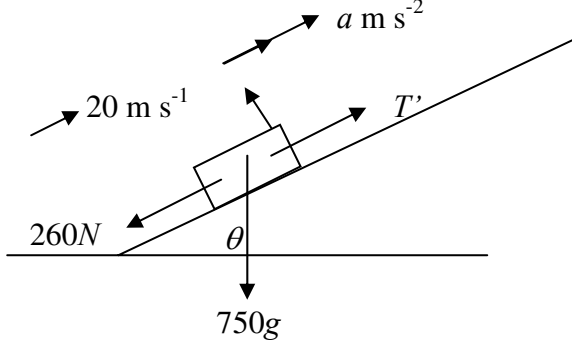
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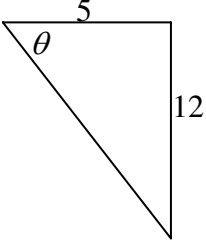
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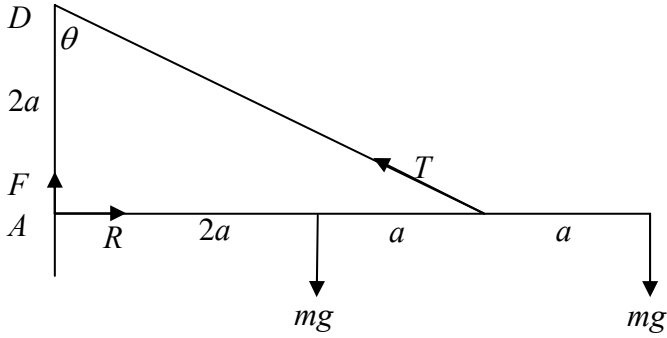
| Question Number | Scheme | Marks |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Q1 | <div style="text-align: center;">  </div> $\frac{dv}{dt} = 3t + 5$ $v = \int (3t + 5) dt$ $v = \frac{3}{2}t^2 + 5t \quad (+c)$ $t = 0 \quad v = 2 \Rightarrow c = 2$ $v = \frac{3}{2}t^2 + 5t + 2$ $t = T \quad 6 = \frac{3}{2}T^2 + 5T + 2$ $12 = 3T^2 + 10T + 4$ $3T^2 + 10T - 8 = 0$ $(3T - 2)(T + 4) = 0$ $T = \frac{2}{3} \quad (T = -4)$ $\therefore T = \frac{2}{3} \quad (\text{or } 0.67)$ | <p>M1*</p> <p>A1</p> <p>B1</p> <p>DM1*</p> <p>M1</p> <p>A1</p> <p style="text-align: right;">[6]</p> |

| Question Number | Scheme | Marks |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|
| Q2 |  <p>(a) K.E. gained = $\frac{1}{2} \times 0.6 \times 4^2$ P.E. lost = $0.6 \times g \times (12 \sin 30)$ Change in energy = P.E. lost - K.E. gained $= 0.6 \times g \times 12 \sin 30 - \frac{1}{2} \times 0.6 \times 4^2$ $= 30.48$ Work done against friction = 30 or 30.5 J</p> | <p>M1 A1 A1 A1 (4)</p> |
| (b) | <p>$R (\uparrow) \quad R = 0.6g \cos 30$ $F = \frac{30.48}{12}$ $F = \mu R$ $\mu = \frac{30.48}{12 \times 0.6g \cos 30}$ $\mu = 0.4987$ $\mu = 0.499 \text{ or } 0.50$</p> | <p>B1 B1ft M1 A1 (4) [8]</p> |

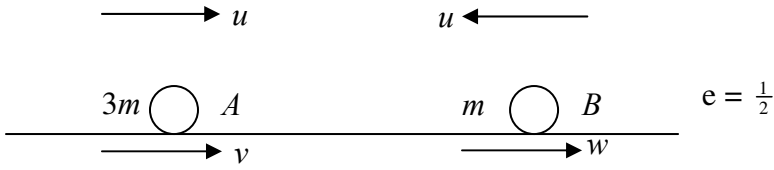

| Question Number | Scheme | | | | | Marks |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|----|-----------|---------------------------------------------------------------------------|
| Q3 |  | | | | | |
| (a) | | AB | AC | BC | frame | |
| | mass ratio | 10 | 10 | 12 | 32 | B1 |
| | dist. from BC | 4 | 4 | 0 | \bar{x} | B1 |
| | <p>Moments about BC:</p> $10 \times 4 + 10 \times 4 + 0 = 32\bar{x}$ $\bar{x} = \frac{80}{32}$ $\bar{x} = 2\frac{1}{2} \quad (2.5)$ | | | | | <p>M1 A1</p> <p>A1 (5)</p> |
| (b) |  <p>Moments about B:</p> $Mg \times 6 \sin \theta = Mg \times (\bar{x} \cos \theta - 6 \sin \theta)$ $12 \sin \theta = \bar{x} \cos \theta$ $\tan \theta = \frac{\bar{x}}{12}$ $\theta = 11.768 \dots = 11.8^\circ$ <p>Alternative method : C of M of loaded frame at distance $\frac{1}{2}\bar{x}$ from D along DA</p> $\tan \theta = \frac{\frac{1}{2}\bar{x}}{6}$ $\theta = 11.768 \dots = 11.8^\circ$ | | | | | <p>M1 A1 A1</p> <p>A1 (4)</p> <p>B1</p> <p>M1 A1</p> <p>A1</p> <p>[9]</p> |

| Question Number | Scheme | Marks |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| <p>Q4</p> <p>(a)</p> |  $T = \frac{15000}{20} = 750$ <p>R(parallel to road) $T = R + 750g \sin \theta$</p> $R = 750 - 750 \times 9.8 \times \frac{1}{15}$ $R = 260 *$ | <p>M1</p> <p>M1 A1</p> <p>A1 (4)</p> |
| <p>(b)</p> |  $T' = \frac{18000}{20} = 900$ $T' - 260 - 750g \times \sin \theta = 750a$ $a = \frac{900 - 260 - 750 \times 9.8 \times \frac{1}{15}}{750}$ $a = 0.2$ | <p>M1</p> <p>M1 A1</p> <p>A1 (4)</p> <p>[8]</p> |

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|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| Q5 (a) | $\mathbf{I} = m\mathbf{v} - m\mathbf{u}$ $= 0.5 \times 20\mathbf{i} - 0.5(10\mathbf{i} + 24\mathbf{j})$ $= 5\mathbf{i} - 12\mathbf{j}$ $ 5\mathbf{i} - 12\mathbf{j} = 13 \text{ Ns}$ | M1 A1 M1 A1 (4) |
| (b) |  $\tan \theta = \frac{12}{5}$ $\theta = 67.38$ $\theta = 67.4^\circ$ | M1 A1 (2) |
| (c) | $\text{K.E. lost} = \frac{1}{2} \times 0.5(10^2 + 24^2) - \frac{1}{2} \times 0.5 \times 20^2$ $= 69 \text{ J}$ | M1 A1 A1 (3) [9] |

| Question Number | Scheme | Marks |
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| Q6 |  <p>(a)</p> $M(A) \quad 3a \times T \cos \theta = 2amg + 4amg$ $\cos \theta = \left(\frac{2}{\sqrt{9+4}} \right) = \frac{2}{\sqrt{13}}$ $\frac{6}{\sqrt{13}} T = 6mg$ $T = mg\sqrt{13} \quad *$ | <p>M1 A1 A1 B1 A1 (5)</p> |
| (b) | $3a \times T \times \cos \theta = 2amg + 4aMg$ $T = \frac{(2mg + 4Mg)}{6} \sqrt{13} \leq 2mg\sqrt{13}$ $mg + 2Mg < 6mg$ $M \leq \frac{5}{2} m \quad *$ | <p>M1 A1 A1 (3) cso [8]</p> |

| Question Number | Scheme | Marks |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| Q7 (a) | Vertical motion: $v^2 = u^2 + 2as$ $(40 \sin \theta)^2 = 2 \times g \times 12$ $(\sin \theta)^2 = \frac{2 \times g \times 12}{40^2}$ $\theta = 22.54 = 22.5^\circ$ (accept 23) | M1 A1 A1 (3) |
| (b) | Vert motion $P \rightarrow R$: $s = ut + \frac{1}{2}at^2$ $-36 = 40 \sin \theta t - \frac{g}{2}t^2$ $\frac{g}{2}t^2 - 40 \sin \theta t - 36 = 0$ $t = \frac{40 \sin 22.54 \pm \sqrt{(40 \sin 22.54)^2 + 4 \times 4.9 \times 36}}{9.8}$ $t = 4.694\dots$ Horizontal P to R: $s = 40 \cos \theta t$ $= 173 \text{ m}$ (or 170 m) | M1 A1 A1 A1 M1 A1 (6) |
| (c) | Using Energy: $\frac{1}{2}mv^2 - \frac{1}{2}m \times 40^2 = m \times g \times 36$ $v^2 = 2(9.8 \times 36 + \frac{1}{2} \times 40^2)$ $v = 48.0\dots$ $v = 48 \text{ m s}^{-1}$ (accept 48.0) | M1 A1 A1 (3) [12] |

| Question Number | Scheme | Marks |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| <p>Q8</p> <p>(a)</p> <p>(i)</p> |  <p>Con. of Mom: $3mu - mu = 3mv + mw$ $2u = 3v + w$ (1)</p> <p>N.L.R: $\frac{1}{2}(u + u) = w - v$ $u = w - v$ (2)</p> <p>(1) - (2) $u = 4v$ $v = \frac{1}{4}u$</p> <p>(ii) In (2) $u = w - \frac{1}{4}u$ $w = \frac{5}{4}u$</p> | <p>M1# A1 M1# A1 DM1# A1 A1 (7)</p> |
| <p>(b)</p> | <p>B to wall: N.L.R: $\frac{5}{4}u \times \frac{2}{5} = V$ $V = \frac{1}{2}u$</p> | <p>M1 A1ft (2)</p> |
| <p>(c)</p> |  <p>B to wall: $\text{time} = 4a \div \frac{5}{4}u = \frac{16a}{5u}$</p> <p>Dist. Travelled by A = $\frac{1}{4}u \times \frac{16a}{5u} = \frac{4}{5}a$</p> <p>In t secs, A travels $\frac{1}{4}ut$, B travels $\frac{1}{2}ut$</p> <p>Collide when speed of approach = $\frac{1}{2}ut + \frac{1}{4}ut$, distance to cover = $4a - \frac{4}{5}a$</p> <p>$\therefore t = \frac{4a - \frac{4}{5}a}{\frac{3}{4}u} = \frac{16a}{5} \times \frac{4}{3u} = \frac{64a}{15u}$</p> <p>Total time = $\frac{16a}{5u} + \frac{64a}{15u} = \frac{112a}{15u}$ *</p> | <p>B1ft B1ft M1\$ DM1\$ A1 A1 (6)</p> |

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