

# Mark Scheme (Results)

## Summer 2010

GCE

### GCE Mechanics M2 (6678/01)

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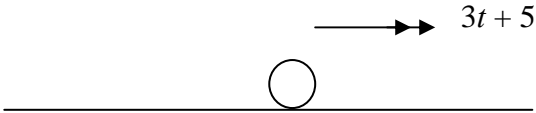
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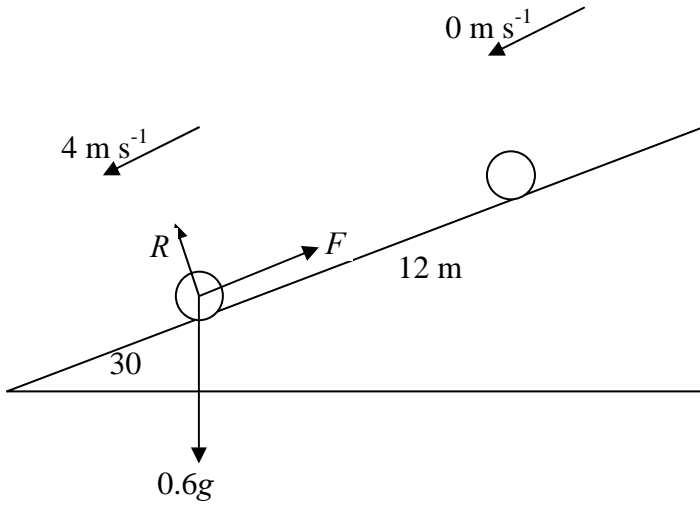
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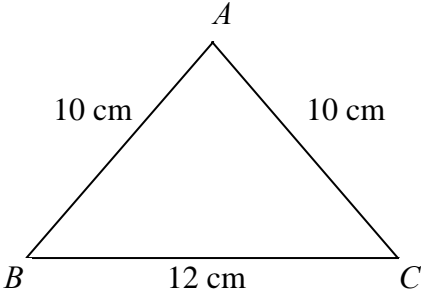
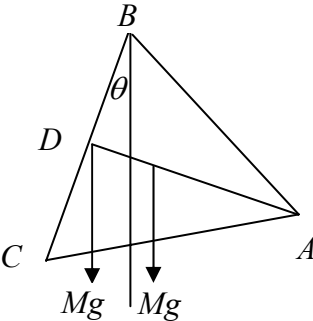
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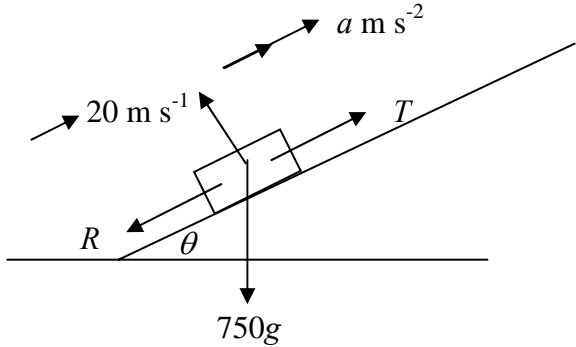
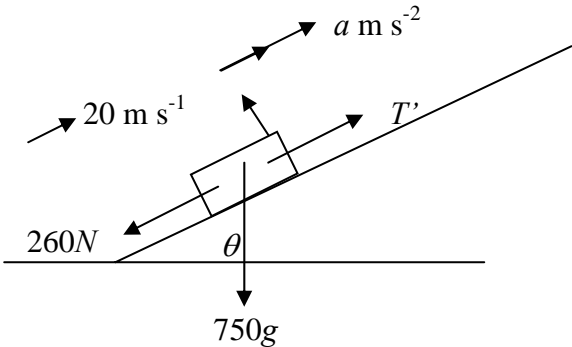
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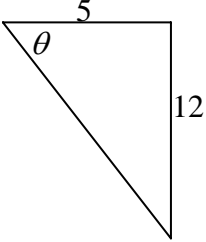
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 Mark Scheme

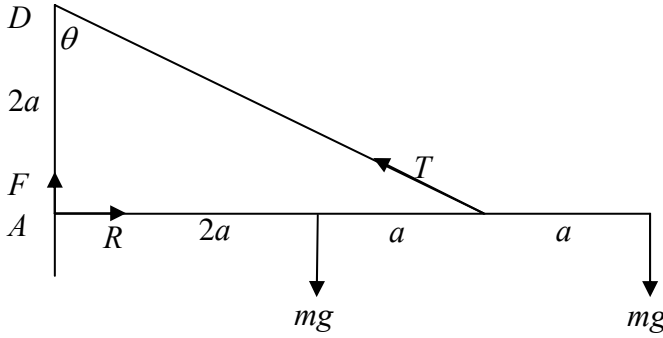
Question Number	Scheme	Marks
Q1	<div style="text-align: center;">  </div> $\frac{dv}{dt} = 3t + 5$ $v = \int (3t + 5) dt$ $v = \frac{3}{2}t^2 + 5t \quad (+c)$ $t = 0 \quad v = 2 \Rightarrow c = 2$ $v = \frac{3}{2}t^2 + 5t + 2$ $t = T \quad 6 = \frac{3}{2}T^2 + 5T + 2$ $12 = 3T^2 + 10T + 4$ $3T^2 + 10T - 8 = 0$ $(3T - 2)(T + 4) = 0$ $T = \frac{2}{3} \quad (T = -4)$ $\therefore T = \frac{2}{3} \quad (\text{or } 0.67)$	<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 = <math>\frac{1}{2} \times 0.6 \times 4^2</math>  P.E. lost = <math>0.6 \times g \times (12 \sin 30)</math>  Change in energy = P.E. lost - K.E. gained  <math>= 0.6 \times g \times 12 \sin 30 - \frac{1}{2} \times 0.6 \times 4^2</math>  <math>= 30.48</math>  Work done against friction = 30 or 30.5 J</p>	<p>M1 A1 A1  A1 (4)</p>
(b)	<p>R (<math>\uparrow</math>) <math>R = 0.6g \cos 30</math>  <math>F = \frac{30.48}{12}</math>  <math>F = \mu R</math>  <math>\mu = \frac{30.48}{12 \times 0.6g \cos 30}</math>  <math>\mu = 0.4987</math>  <math>\mu = 0.499</math> 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><b>Alternative method :</b> C of M of loaded frame at distance <math>\frac{1}{2}\bar{x}</math> 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>

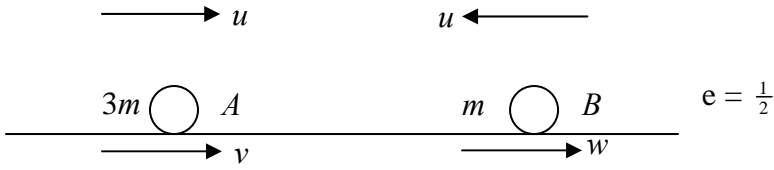

Question Number	Scheme	Marks
Q4	<div style="text-align: center;">  </div> <p>(a)</p> $T = \frac{15000}{20} = 750$ <p>R(parallel to road) <math>T = R + 750g \sin \theta</math></p> $R = 750 - 750 \times 9.8 \times \frac{1}{15}$ $R = 260 *$	<p>M1</p> <p>M1 A1</p> <p>A1 (4)</p>
(b)	<div style="text-align: center;">  </div> <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>

Question Number	Scheme	Marks
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
Q6      (a)	 <p style="margin-left: 20px;"> <math>M(A) \quad 3a \times T \cos \theta = 2amg + 4amg</math>  <math>\cos \theta = \left( \frac{2}{\sqrt{9+4}} \right) \frac{2}{\sqrt{13}}</math>  <math>\frac{6}{\sqrt{13}} T = 6mg</math>  <math>T = mg\sqrt{13} \quad *</math> </p>	<p>M1 A1 A1 B1  A1 (5)</p>
(b)	<p> <math>3a \times T \times \cos \theta = 2amg + 4aMg</math>  <math>T = \frac{(2mg + 4Mg)}{6} \sqrt{13} \leq 2mg\sqrt{13}</math>  <math>mg + 2Mg &lt; 6mg</math>  <math>M \leq \frac{5}{2} m \quad *</math> </p>	<p>M1 A1  A1 (3)  [8] cs0</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>(ii)</p>	 <p>Con. of Mom: <math>3mu - mu = 3mv + mw</math>  <math>2u = 3v + w</math> (1)</p> <p>N.L.R: <math>\frac{1}{2}(u + u) = w - v</math>  <math>u = w - v</math> (2)</p> <p>(1) - (2)  <math>u = 4v</math>  <math>v = \frac{1}{4}u</math></p> <p>In (2)  <math>u = w - \frac{1}{4}u</math>  <math>w = \frac{5}{4}u</math></p>	<p>M1# A1 M1# A1 DM1# A1 A1 (7)</p>
<p>(b)</p>	<p><math>B</math> to wall: N.L.R: <math>\frac{5}{4}u \times \frac{2}{5} = V</math>  <math>V = \frac{1}{2}u</math></p>	<p>M1 A1ft (2)</p>
<p>(c)</p>	 <p><math>B</math> to wall: time = <math>4a \div \frac{5}{4}u = \frac{16a}{5u}</math></p> <p>Dist. Travelled by <math>A = \frac{1}{4}u \times \frac{16a}{5u} = \frac{4}{5}a</math></p> <p>In <math>t</math> secs, <math>A</math> travels <math>\frac{1}{4}ut</math>, <math>B</math> travels <math>\frac{1}{2}ut</math></p> <p>Collide when speed of approach = <math>\frac{1}{2}ut + \frac{1}{4}ut</math>, distance to cover = <math>4a - \frac{4}{5}a</math></p> <p><math>\therefore t = \frac{4a - \frac{4}{5}a}{\frac{3}{4}u} = \frac{16a}{5} \times \frac{4}{3u} = \frac{64a}{15u}</math></p> <p>Total time = <math>\frac{16a}{5u} + \frac{64a}{15u} = \frac{112a}{15u}</math> *</p>	<p>B1ft B1ft M1\$ DM1\$ A1 A1 (6)</p> <p>15</p>



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