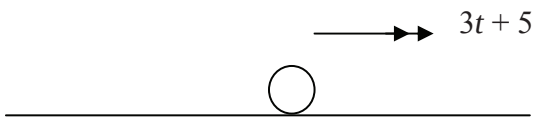
WME02/01: Mechanics 2

Question Number	Scheme	Marks
Q1		
	$\frac{dv}{dt} = 3t + 5$	
	$v = \int (3t+5)\,dt$	M1*
	$v = \frac{3}{2}t^2 + 5t \quad (+c)$	A1
	$t = 0 \;\; v = 2 \;\; \Rightarrow \;\; c = 2$	B1
	$v = \frac{3}{2}t^2 + 5t + 2$	
	$t = T \qquad 6 = \frac{3}{2}T^2 + 5T + 2$	DM1*
	$12 = 3T^2 + 10T + 4$	
	$3T^2 + 10T - 8 = 0$	
	$(3T-2)(T+4) = 0$	M1
	$T = \frac{2}{3} \quad (T = -4)$	
	$\therefore T = \frac{2}{3} \quad (\text{or } 0.67)$	A1
		[6]

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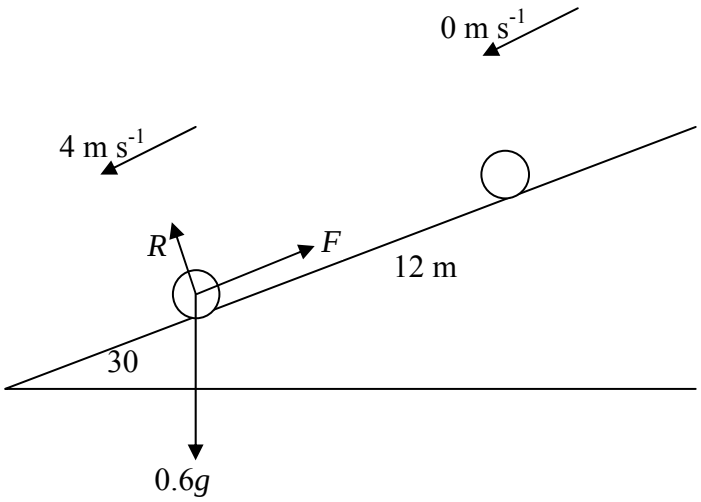
Q2		
(a)	K.E gained $= \frac{1}{2} \times 0.6 \times 4^2$ P.E. lost $= 0.6 \times g \times (12 \sin 30)$ Change in energy = P.E. lost - K.E. gained $= 0.6 \times g \times 12 \sin 30 - \frac{1}{2} \times 0.6 \times 4^2$ $= 30.48$ Work done against friction $= 30$ or 30.5 J	M1 A1 A1 A1 (4)
(b)	R$(\uparrow)$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

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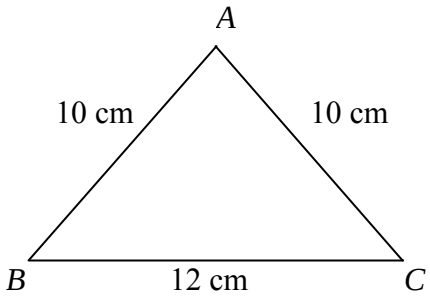
Q3		

(a)		*AB*	*AC*	*BC*	frame		
	mass ratio	10	10	12	32		B1
	dist. from *BC*	4	4	0	$\overline{x}$		B1

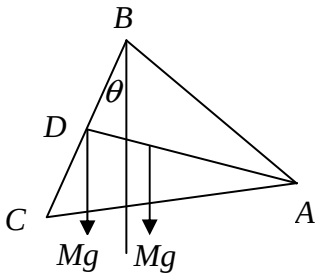
Moments about *BC*:

$$10\times4+10\times4+0=32\overline{x}$$ M1 A1

$$\overline{x}=\frac{80}{32}$$

$$\overline{x}=2\tfrac{1}{2}\quad(2.5)$$ A1 (5)

(b)



Moments about *B*:

$$Mg\times6\sin\theta=Mg\times\left(\overline{x}\cos\theta-6\sin\theta\right)$$ M1 A1 A1

$$12\sin\theta=\overline{x}\cos\theta$$

$$\tan\theta=\frac{\overline{x}}{12}$$

$$\theta=11.768.....=11.8^{\circ}$$ A1 (4)

Alternative method :

C of M of loaded frame at distance $\frac{1}{2}\overline{x}$ from *D* along *DA* B1

$$\tan\theta=\frac{\frac{1}{2}\overline{x}}{6}$$ M1 A1

$$\theta=11.768.....=11.8^{\circ}$$ A1

[9]

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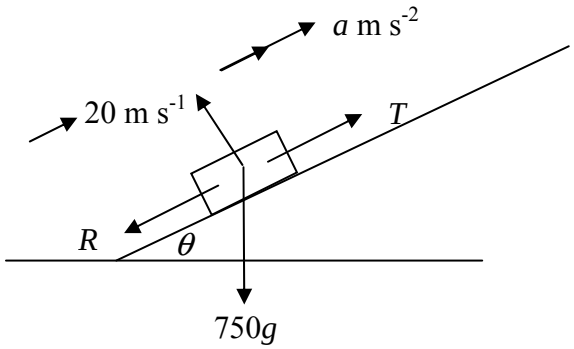
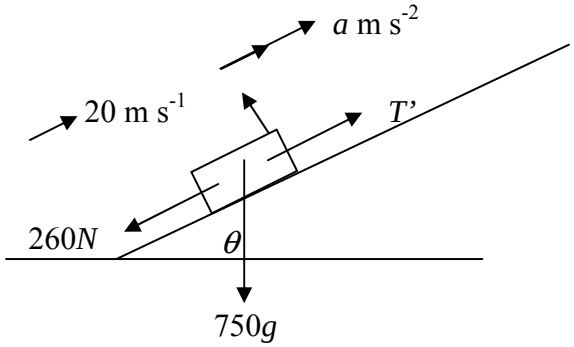
Q4		
(a)	$T = \frac{15000}{20} = 750$	M1
	R(parallel to road) $T = R + 750g\sin\theta$	M1 A1
	$R = 750 - 750\times 9.8\times \frac{1}{15}$	
	$R = 260$ *	A1 (4)
(b)		
	$T' = \frac{18000}{20} = 900$	M1
	$T' - 260 - 750g\times\sin\theta = 750a$	M1 A1
	$a = \frac{900 - 260 - 750\times 9.8\times \frac{1}{15}}{750}$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

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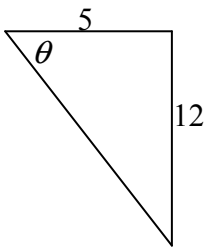
Question Number	Scheme	Marks
Q5 **(a)**	$\mathbf{I} = m\mathbf{v} - m\mathbf{u}$ $= 0.5\times 20\mathbf{i} - 0.5(10\mathbf{i} + 24\mathbf{j})$ $= 5\mathbf{i} - 12\mathbf{j}$ $\lvert 5\mathbf{i} - 12\mathbf{j}\rvert = 13$ Ns	M1 A1 M1 A1 (4)
(b)	 $\tan\theta = \frac{12}{5}$ $\theta = 67.38$ $\theta = 67.4°$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

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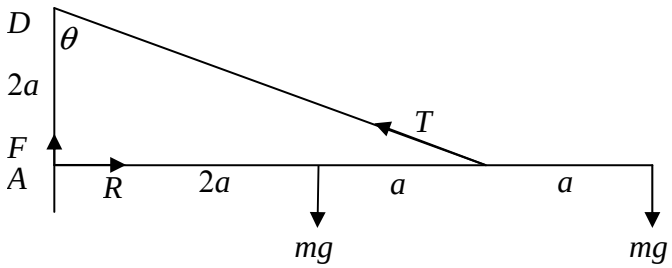
Question Number	Scheme	Marks
Q6		
(a)	M(A) $3a \times T\cos\theta = 2amg + 4amg$	M1 A1 A1
	$\cos\theta = \frac{2}{\sqrt{9+4}} = \frac{2}{\sqrt{13}}$	B1
	$\frac{6}{\sqrt{13}}T = 6mg$	
	$T = mg\sqrt{13}$ *	A1 (5)
(b)	$3a \times T \times \cos\theta = 2amg + 4aMg$	M1
	$T = \frac{(2mg + 4Mg)}{6}\sqrt{13}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

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

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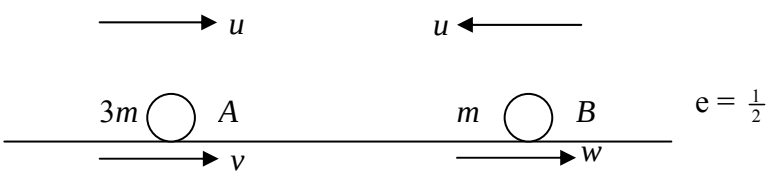
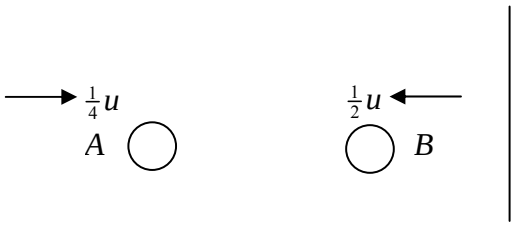
Question Number	Scheme	Marks
Q8		
(a)		
(i)	Con. of Mom: $3mu - mu = 3mv + mw$	
	$2u = 3v + w$ (1)	M1# A1
	N.L.R: $\frac{1}{2}(u+u) = w - v$	M1# A1
	$u = w - v$ (2)	
	(1) – (2) $u = 4v$	DM1#
	$v = \frac{1}{4}u$	A1
(ii)	In (2) $u = w - \frac{1}{4}u$	
	$w = \frac{5}{4}u$	A1 (7)
(b)	B to wall: N.L.R: $\frac{5}{4}u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