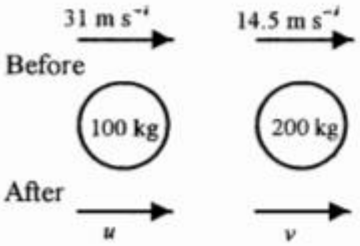
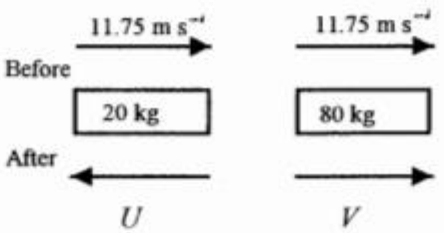
Mechanics Minor – Massive Past Paper Mix – Mark Schemes

M2 Jan 01 Q1

1. (i)	For A		
	$\rightarrow 100 \times 20 + 1100 = 100v$	M1 PCLM applied to A	
	so 31 m s^{-1} in original direction	E1 (Accept no direction given)	
	For B		
Either	$300 \times 20 = 31 \times 100 + 200v'$		
Or	$200 \times 20 - 1100 = 200v'$		
	$v' = 14.5$ so 14.5 m s^{-1} in original direction	F1 (Direction must be established)	[3]
(ii)		[Allow without M1]	
		B1 (Award if solution correct)	
PCLM	$300 \times 20 = 100u + 200v$	M1 PCLM	
	$u + 2v = 60$	A1 Any form	
	NEL		
	$\frac{v-u}{14.5-31} = -\frac{3}{4}$	M1 NEL	
	$4v - 4u = 49.5$	A1 Any form	
	Solving gives $u = 11.75$		
	so 11.75 m s^{-1} in original direction	E1 (Accept no direction specified)	[6]
(iii)			
PCLM	$100 \times 11.75 = -20U + 80V$	M1 Use of PCLM on A. Accept wrong sign A1	
	Also $U + V = 70$	B1 Signs must be consistent with PCLM	
	Solving gives $U = 44.25$		
	so 44.25 m s^{-1} in opposite to orig direction	E1 Direction must be explicit and justified	[4]
(iv)	PCLM overall		
	$\rightarrow 300 \times 20 = -20 \times 44.25 + 280W$	M1 Allow wrong masses	
	$W = 24.589..$ so about 24.6 m s^{-1} in original direction	A1 Accept no direction specified	[2]
		[Total 15]	

M2 Jan 01 Q2

2. (i)

$$24\begin{pmatrix}3\\2\end{pmatrix}+4\begin{pmatrix}7\\1\end{pmatrix}-6.25\begin{pmatrix}4\\2\end{pmatrix}=21.75\begin{pmatrix}\bar{x}\\\bar{y}\end{pmatrix}$$

M1 Appropriate method

B1 All masses correct

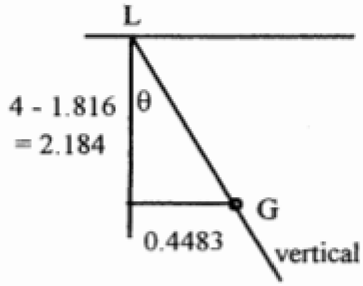
B1 At least two sets of coordinates correct on LHS

so (3.44827..., 1.81609..)

giving (3.45, 1.82), (3 s.f.) — E1 A1 [5]

[If separate components used, award the 2nd B1 if all the terms correct for 1 cpt]

(ii)



$\tan\theta = \frac{0.4483}{2.1839}$ — M1 Correct angle identified

$\theta = 11.600...^\circ$ — B1 Use of **their** $\bar{y}$ and given $\bar{x}$, including 4 – **their** 1.816.

so 11.6°, (3 s.f.) — A1 (Accept 11.7° found if rounded values used) [3]

(iii) 6.25 cm² has mass 0.05 kg

so density is 0.008 kg cm⁻² — B1 May be implied

So $21.75 \times 0.008g \times 0.4483 = 3F$ — M1 Moments used (allow mass instead of weight)

B1 Use of weight

$F = 0.2547...$ so about 0.255 N — A1 [4]

(iv) y coordinate unchanged so 1.82, (3 s.f.) — B1 Accept without comment

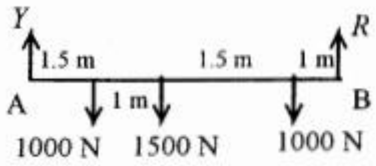
$21.75\bar{x} = 75 - 4\times7 + 4\times6$ — M1 Attempt to deal with the fold. Masses must be consistent. Total mass is **their** 21.75 from (iii).

$\bar{x} = 3.2643...$ so 3.26, (3 s.f.) — A1 cao [3]

[Total 15]

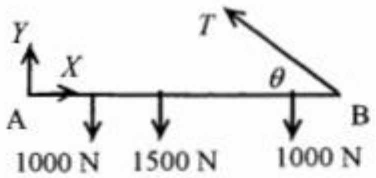
M2 Jan 01 Q3

3\. (i)



Working	Marks
(diagram above)	B1 Diagram. Ignore horizontal forces. Lengths not required.
A↷ $1.5 \times 1000 + 2.5 \times 1500 + 4 \times 1000 = 5R$	M1 Moments about A. Must show terms. B1 Moment of weight of beam
$9250 = 5R$ $R = 1850$ so 1850 N vert upwards	E1 Direction not required [4]

(ii)



Working	Marks
(diagram above)	B1 Diagram. Must have X and Y or resultant. Award if method correct with correct signs and angles.
$\tan\theta = \frac{3}{5}$, $\sin\theta = \frac{3}{\sqrt{34}}$	B1 Either seen or implied
Either A↷ $9250 = 5T\sin\theta$	M1 Moments about A B1 Dealing with moment of T ($\sin\theta$ need not be evaluated)
$T = 3595.75..$ so 3596 N (4 s.f.)	A1 Accept 2 s.f. or better. [5]
Or Using (i) $T\sin\theta = 1850$	M1 B1 for $T\sin\theta$.
$T = \frac{1850\sqrt{34}}{3} = 3595.75...$ so 3596 N (4 s.f.)	A1 Accept 2 s.f. or better.
(iii) Resolve horizontally and vertically	M1 Both attempted or resolve + moments
↑ $Y + 1850 = 3500$ so $Y = 1650$	B1
→ $X - T\cos\theta = 0 \Rightarrow X = 1850\cot\theta = \frac{9250}{3}$	B1 Accept any form
	M1 correct method for magnitude **or** direction
$\sqrt{1650^2 + (\frac{9250}{3})^2} = 3497.06..$ so 3497 N (4 s.f.)	A1 cao. Accept 2.s.f. or better
angle is $\arctan(\frac{3\times1650}{9250}) = 28.152...$ so about 28.2° above horizontal	A1 cao Accept 2 s.f. or better. Must specify or imply direction with horiz or vertical; accept a clear diagram. [6]
	[Total 15]

M2 Jan 01 Q4

4. (i)	$50 \times 6000 = 300\ 000$ J	B1	[1]
(ii)			
Either	Considering the total work done	M1 Must have weight term	
	$25F + 1500g\sin 20 \times 25 = 300000$	B1 B1 Each term on LHS	
	$F = 6972.30..$ so 6972 N (4 s.f.)	A1 Accept 2 or 3 s.f.	
Or	Tension in wire is $\frac{6000}{0.5} = 12000$	M1 Use of $T = \frac{P}{v}$, explicit or implied. A1	
	so $12000 = F + 1500g\sin 20$	M1 Must have weight term	
	$F = 6972.30..$ so 6972 N (4 s.f.)	A1 Accept 2 or 3 s.f.	[4]
(iii)	$\mu = \frac{6972.30...}{1500\times 9.8\times\cos 20}$	M1 Use of $F = \mu R$ B1 Correct R	
	$= 0.50474...$ so 0.50 (2 s.f.)	E1	[3]
(iv)	New $F_{max} = 0.5(1500g\cos 20 + 16000\sin 15)$	M1 Attempt to find new F	
	$= 8977.293....$	A1 Need not be evaluated	
Either	Using work-energy	M1 Equating WD by shovel to WD against friction + GPE + KE	
	$16000\cos 15x$ $= 8977.293...x + 1500g\sin 20x + \frac{1}{2}\times 1500 \times 2.5^2$	B1 B1 for KE term B1 Other terms (FT for friction)	
	$x = 3.233...$ so 3.23 m (3 s.f.)	A1 cao	
Or	Using N2L	M1 Use of N2L **and** 'uvast'	
	$16000\cos 15 - 8977.293.. - 1500g\sin 20 = 1500a$	M1 Accept no weight term. All other forces present.	
	$a = 0.966549...$	A1 Need not be evaluated. FT for friction.	
	$2.5^2 = 0 + 2as$	B1 (or other valid sequence of '*uvast*''. FT wrong a.	
	$x = 3.233...$ so 3.23 m (3 s.f.)	A1 cao	[7]

[Total 15]

M3 Jan 01 Q1

1. (i)	$T^{-1} = (MLT^{-2})^{\alpha}L^{\beta}(ML^{-1})^{\gamma}$	M1 A1	
	$0 = \alpha + \gamma$		
	$0 = \alpha + \beta - \gamma$	M1	two equations
	$-1 = -2\alpha$	M1	third equation
	$\alpha = \frac{1}{2},\ \beta = -1,\ \gamma = -\frac{1}{2}$	E1	
(ii)	$T = \frac{500\times0.045}{0.9}$	M1	Hooke's law
	$= 25$ N	A1	
(iii)	$40 = \frac{500(0.81-l_0)}{l_0}$	M1 A1 equation	
	$40l_0 = 405 - 500l_0$	M1	solving
	$l_0 = 0.75$	A1	
(iv)	$\frac{f_A}{f_B} = \left(\frac{T_A}{T_B}\right)^{\frac{1}{2}}\left(\frac{l_A}{l_B}\right)^{-1}\left(\frac{z_A}{z_B}\right)^{-\frac{1}{2}}$	M1	using formula for f_A or f_B
	$= \left(\frac{25}{40}\right)^{\frac{1}{2}}\left(\frac{0.945}{0.81}\right)^{-1}\left(\frac{0.9m/0.945}{0.75m/0.81}\right)^{-\frac{1}{2}}$	M1	attempt ratio
		M1	0.75/0.81 or 0.9/0.945 or equivalent seen
	$= 0.668$ so ratio 0.668:1 or 1:1.497	A1	or any equivalent form

M2 Jun 01 Q1

(i) Before P → ← Q

2 m s^{-1} $\frac{4}{3} \text{ m s}^{-1}$

After PQ →

$v \text{ m s}^{-1}$

PCLM

$55 \times 2 - 45 \times \frac{4}{3} = 100v$ — M1 PCLM applied

B1 signs consistent

$v = 0.5$ so 0.5 m s^{-1} — A1

in original direction of Percy — F1 Either explicit or implied by diagram

Impulse is $|55(2 - 0.5)| = 82.5$ Ns — F1 [5]

(ii) Before PQ → R →

0.5 m s^{-1} $v \text{ m s}^{-1}$

After PQ → R →

0.1 m s^{-1} $v' \text{ m s}^{-1}$

PCLM

$50 + 60v = 10 + 60v'$ — M1 PCLM

$3v' - 3v = 2$ — A1 Any form

NEL

$\frac{v' - 0.1}{v - 0.5} = -0.2$ — M1 Including consistent use of signs

$v' + 0.2v = 0.2$ — A1 Any form

Solving

$v = -\frac{7}{18}$, $v' = \frac{5}{18}$

So before, $-\frac{7}{18} \text{ m s}^{-1}$ (opp dir to PQ) — A1

after, $\frac{5}{18} \text{ m s}^{-1}$ (same dir as PQ) — A1

(Award max A1 for final answers unless directions both specified or implied by Diagram) [6]

M2 Jun 01 Q2

(i)	$20 \times 9.8 \times 5 \times \sin 35 - \frac{1}{2} \times 20 \times (6^2 - 4^2)$	M1 Difference in GPE and KE B1 GPE term B1 Either KE term	
	$= 362.104..$ so 362 J (3sf)	A1 Accept 2 sf	[4]
(ii)	$5F = 362.104...$ so $F = 72.4209...$	B1	
	$R = 20 \times 9.8 \times \cos 35$	B1	
	$\mu = 0.4510...$ so 0.45 (2sf)	M1 Use of $F = \mu R$	
		E1	[4]
iii)	$\mu mg \cos 35 = mg \sin 35$	M1	
	$\mu = 0.70$ (2sf)	A1 (Accept WW for both marks)	[2]
iv)	$72.2492.. \times x + 520 - 20gx \sin 35$	M1 Use of work-energy, allow 1 term missing	
	$= \frac{1}{2} \times 20 \times 6^2$	B1 Equation contains GPE term M1 All relevant terms present A1 Signs correct	
	$x = 3.982...$ so 3.98 m (3 sf)	A1 cao	[5]
		[FT original μ from (ii) for full marks]	
		[Total 15]	

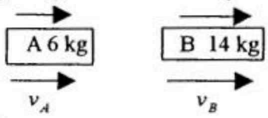
M2 Jun 01 Q3

(i)	$10\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = 2\begin{pmatrix}\frac{1}{2}\\ \frac{\sqrt{3}}{2}\end{pmatrix} + 2\begin{pmatrix}\frac{3}{2}\\ \frac{\sqrt{3}}{2}\end{pmatrix} + 3\begin{pmatrix}2.75\\ \frac{3\sqrt{3}}{4}\end{pmatrix} + 3\begin{pmatrix}5\\ \frac{3\sqrt{3}}{2}\end{pmatrix}$		
		M1 Appropriate method B1 Correct masses B1 At least two x cpts correct B1 At least two y cpts correct	
	(2.725, 1.516)	E1 A1	[6]
(ii)	cm gives a clockwise moment about C Reaction at A cannot give an a.c. moment	E1 Considering moments E1 Complete argument	[2]
iii)	Moments about C	M1	
	$2w = 25g \times 0.725$	A1 B1 Use of weight	
	$w =$ 88.8125 so about 88.81 N	A1 cao	[4]
iv)	Moments about A	M1	
	$3\frac{\sqrt{3}}{2}F = 25g \times 2.725$	A1 Must be a correct statement	
	$F = 256.968..$ so about 257 N	A1 Any reasonable accuracy	[3]
		[Total 15]	

M2 Jan 02 Q1

(i)	$5000 = F \times 2.5$ $F = 2000$ so 2000 N	M1 A1	Use of $P = Fv$	2
(ii)	$\frac{1}{2}\times 6000\times 3^2 - \frac{1}{2}\times 6000\times 2.5^2$ $= 8000\times 10 - W$ $W = 71750$ so 71750 J	M1 B1 B1 E1	Work-energy equation with all terms One KE term correct WD by driving force correct Clearly shown	
	Distance travelled is $\frac{2.5+3}{2}\times 10 = 27.5$ m	B1		
	Hence $F\times 27.5 = 71750$	M1	WD is Fd	
	$F = 2609.09...$ so 2610 N (3 s.f.)	A1		7
	or $3 = 2.5 + 10a$ so $a = 0.05$	M1 A1	Appropriate *uvast* For a	
	$3^2 = 2.5^2 + 2\times 0.05\times s$ so $s = 27.5$	B1		
	$\frac{8000}{2.75} - R = 6000\times 0.05$ so $R = 2609$	M1 A1	N2L and use of P/v	
	WD = $2609.09..\times 27.5 = 71750$ J	M1 A1	WD is Fd	
(iii)	Time taken is given by $100 = \frac{3+3.25}{2}\times t$ so $t = 32$	B1		
	WD is $\frac{1}{2}\times 6000(3.25^2 - 3^2)$	M1	Work-energy. All terms present	
	$+6000\times 9.8\times 100\times \frac{1}{20}$	M1 A1	Attempt at GPE change GPE change correct	
	$+2000\times 100$ $= 498687.5$	A1		
	$P = \frac{498687.5}{32} = 15583.98$ so 15.6 kW (3 s.f.)	F1	FT from **their** WD	6
	or Using *uvast* $a = 0.0078125$ $t = 32$	M1 A1 B1	Appropriate *uvast* + N2L	
	$F - 2000 - \frac{6000g}{20} = 6000a$	M1	N2L all terms present	
	so $F = 4986.875$	A1		
	Power is $\frac{4986.875\times 100}{32} = 15.6$ kW (3 s.f.)	F1		Total 15

M2 Jun 02 Q1

(i)	$6v = 12 \times 4$	M1	Impulse = Ft or $F = ma$ and $v = u + at$	
	$v = 8$ so 8 m s^{-1} in the direction of AB	A1	Direction not required	2
(ii)	before 			
	PCLM			
	$48 = 6\ v_A + 14\ v_B$	M1	Use of PCLM	
		A1	Any form	
	NEL			
	$\frac{v_B - v_A}{0 - 8} = -\frac{1}{4}$	M1	NEL. Accept sign errors.	
	$v_B - v_A = 2$	A1	Any form	
	Solving for v_B, $v_B = 3$	E1		
	$v_A = v_B - 2 = 1$	A1		6
			[If $v_B = 3$ assumed, M1 for NEL/PCLM and A1 for $v_A = 1$. Full marks if values justified in the other equation]	
(iii)	→ $6(1 - 8) = -42$ Ns opp direction to v_A	M1	Impulse.	
		A1	Direction must be clear. Accept –ve without explanation	2

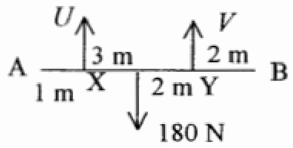
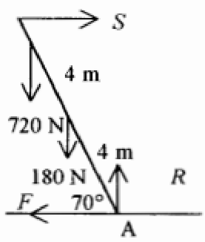
M2 Jun 02 Q2

(i)	GPE loss is $(6g-4g)\times 0.8 = 1.6g$ J (= 15.68 J)	M1 A1	GPE is *mgh* in any expression Accept either form	2
(ii)	$\frac{1}{2}(6+4)v^2 = 15.68$ so $v = 1.7708...$ so 1.77 m s^{-1}	M1 B1 A1	Equate Δ KE to Δ GPE Use of 10 kg and 15.68 FT **their** GPE loss	3
	or Use of N2L Use of *uvast* to give $a = 0.2g$ $v = 1.7708...$ so 1.77 m s^{-1}	M1 M1 A1	Attempt to find acceleration. [M0 for $a = g$] Must be appropriate. Accept a wrong but not $a = g$.	
(iii) (A)	$15.68 - 0.8\times 12 = \frac{1}{2}\times 10\times v^2$	M1	Work-energy including WD against resistance, GPE and KE. Accept sign error.	
	$v^2 = 1.216$	A1	FT from (i)	
	KE of B is $\frac{1}{2}\times 4\times v^2 = 2.432$ J	A1	FT from (i)	3
	or N2L and *uvast* to give accn 0.76 m s^{-2} $v^2 = 1.216$ KE 2.432 J	M1 A1 A1	N2L must be used. Resistance must be included.	
(B)	Suppose B rises an extra distance x $2.432 = 12x + 4\times 9.8\times x$ so $x = 0.0475$	M1 B1 F1	Trying to find this distance. Award without weight term All terms present. Accept sign error. Accept **their** KE from (A) FT	3
	or N2L $-12-4g = 4a$ $a = -12.8$ $x = 0.0475$	M1 A1 A1		
(C)	For downward motion $\frac{1}{2}\times 4\times v^2 = 0.8475g\times 4 - 12\times 0.8475$ $v = 3.39499...$ so 3.39 m s^{-1} (3 s.f.)	M1 B1 A1	Work-energy equation, all terms present. Signs correct. Use of 0.8 + **their** x cao	3
	or $s = 0.8475$ N2L and *uvast* giving accn 6.8 m s^{-2} $v = 3.39499...$ so 3.39 m s^{-1} (3 s.f.)	B1 M1 A1	Award for 0.8 + **their** x N2L and appropriate *uvast* cao	Tot 14

M2 Jun 02 Q3

(i)	$\bar{x} = \bar{y}$	B1	Symmetry; must be explicit.	
	For $\bar{x}$	M1	Method for c.m.	
	$(0.4^2 - 0.2^2)\bar{x} = 0.4^2 \times 0.2 - 0.2^2 \times 0.3$	B1	All masses correct	
		A1	At most one c.m. wrong. If vector used award if not more than one error in either x or y component	
	c.m. is at $\left(\frac{1}{6}, \frac{1}{6}\right)$	E1	[Award 1st B1 if other component calculated separately with same answer]	5
(ii)	$1.6\bar{x} = 0.4 \times 0.2 + 0.2 \times 0.4 + 0.2 \times 0.3 + 0.2^2 + 0.2 \times 0.1$	M1	Method for c.m.	
		B1	Masses correct	
		B1	At least two c.m. correct. If vector used then at least two c.m. have either x or y cpts correct.	
	$\bar{x} = \frac{0.28}{1.6} = 0.175$	E1		
	so (0.175, 0.175)	B1	Symmetry; must be explicit. [Award if other component calculated separately with same answer]	5
(iii)	For $\bar{x}$ of composite figure	M1	Method could lead to solution. Allow up to 2 parts of the figure missing.	
	$(1.6 \times 0.6 + 2 \times 0.12)\bar{x}$	B1	Total mass	
	$= 1.6 \times 0.6 \times 0.175 + 2 \times 0.12 \times \frac{1}{6}$	B1	First term [If divided into plane parts, award for 4 or equivalent parts correct]	
		B1	Second term [If divided into plane parts, award for 6 or equivalent parts correct]	
	so $\bar{x} = \frac{0.208}{1.2} = 0.17\dot{3} \left(= \frac{13}{75}\right)$	A1	cao. Award for x or y correct	
	so (0.173, 0.173, 0.3)	F1	$\bar{y}$ or $\bar{z}$ by symmetry (may be implied)	6
				Tot 16

M2 Jun 02 Q4

(a) (i)		B1	Accept no or wrong dimensions Must have correct labels and arrows	1
(ii)	Moments about X			
	$3\times 180-5v=0$	M1	moments	
	$v=108$ so 108 N	A1		
	Resolve vertically			
	$U+V=180$	M1	Or take moments again	
	so $U=72$ so 72 N	A1	[Deduct one mark if $180g$ instead of 180]	4
(b) (i)				
	→ $F=S$	B1	Award for $R=900$ if moments taken about top of ladder	
	$\hat{A}$ $180\times 4\cos 70+720\times x\cos 70$	M1	Moments equation using angles with at least 2 terms	
		A1	One correct term	
		A1	Second correct term	
	$=8S\sin 70$			
	$\Rightarrow F=90\tan 20(1+x)$	E1	Clearly shown [Award 4/5 if $F=S$ not established by resolution]	5
(ii)	All other terms constant so $F\uparrow$ as $x\uparrow$	E1	Clearly explained.	
	Hence worst case is $x=8$	E1	[Award if $x=8$ used without explanation]	
	giving $F=810\tan 20$			
	with $R=900$	B1	Values of both R and F.	
	Since $F\le F_{max}=\mu R$,	M1	Use of $F=\mu R$	
	$\mu\ge\frac{810\tan 20}{900}=\frac{9\tan 20}{10}$ $(=0.3275...)$	A1	cao. Inequality required. Accept >. Accept inequality stated and not justified.	5
				Tot 15

M3 Jun 02 Q1

1(i)	[velocity] = LT^{-1} [acceleration] = LT^{-2}	B1		
	[force] = MLT^{-2}	B1		
				2
(ii)	[work done] = [F.d] = $MLT^{-2}.L = ML^2T^{-2}$	B1	Must be shown, not just stated	
	[KE] = [$\frac{1}{2}mv^2$] = $M(LT^{-1})^2 = ML^2T^{-2}$	B1		
	[GPE] = [mgh] = $M.LT^{-2}.L = ML^2T^{-2}$	B1		
				3
(iii)	$Y = \frac{Tl_0}{Ax}$	M1	rearranging	
	$[Y] = \frac{MLT^{-2}.L}{L^2.L}$	M1	substitute dimensions	
	$= ML^{-1}T^{-2}$	A1	cao	
				3
(iv)	$ML^2T^{-2} = (ML^{-1}T^{-2})^{\alpha}L^{\beta}L^{\gamma}$	M1	substitute dimensions	
	$\alpha = 1$	A1		
	$-1 + \beta + \gamma = 2$	M1	equating powers of L	
	$\beta + \gamma = 3$	A1	cao	
				4

M2 Jan 01 Q2

(i)	$10m\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=4m\begin{pmatrix}-3\\ 4\end{pmatrix}+3m\begin{pmatrix}0\\ 0\end{pmatrix}+m\begin{pmatrix}2\\ 0\end{pmatrix}+2m\begin{pmatrix}5\\ 4\end{pmatrix}$	M1 A1	Appropriate method for at least one cpt **Either** at least two non-zero RHS terms correct **or** all masses and at least 3 cpts correct	
	giving (0, 2.4)	A1 A1 A1	All correct Each cpt	5
(ii)	By symmetry $\bar{x}=1$	B1	Accept no reason given	
	$12m\bar{y}=5m\times 2+2m\times 0+5m\times 2\Rightarrow \bar{y}=\frac{5}{3}$	M1 A1 M1 A1	Lengths of rods and their mass Award for method using appropriate masses and c.m. at mid-points of rods	5
(iii)	$22m\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=10m\begin{pmatrix}0\\ 2.4\end{pmatrix}+12m\begin{pmatrix}1\\ \frac{5}{3}\end{pmatrix}$	M1	Any correct method	
	giving $\left(\frac{6}{11},2\right)$	F1 F1	Each component	3
(iv)	Take moments about line of symmetry **either** for composite body	M1	Award for any clear attempt	
	$22mg\left(1-\frac{6}{11}\right)=Mg\times 1$	B1	Distance on LHS Award for use of **their** values. Condone use of mass not weight.	
	Hence $M = 10m$	A1	cao	3
	or omitting rods			
	$(10m+M)\times 1\times g=10m\times 0+M\times 2\times g$ giving $M = 10m$	M1 A1 A1	Any clear attempt using original values or quoting c.m. Use of **their** values if c.m. quoted. All terms present. Accept mass used. cao	
		Tot 16		

M2 Jan 02 Q3

(i)	Driving force F and resistance R			
	$32000 = 25F$ giving $F = 1280$	M1	Use of $P = Fv$	
	also $F - R = 0$ so $R = 1280$ and resistance is 1280 N	A1	Need some reference to $F = R$	
	$1280 \times 100 = 128000$ J	M1 F1	Use of WD = Fd	4
(ii)	Use of work-energy	M1	Must have KE term + WD by engine	
	$\frac{1}{2} \times 800v^2 - \frac{1}{2} \times 800 \times 25^2$	M1 A1	One correct KE term Both KE terms correct	
	$= 45000 \times 10$	B1	Work done by engine	
	-340000	A1	All correct	
	hence $v = 30$	E1		6
(iii)	**either** Use of work-energy	M1	Use of work-energy with KE and GPE	
	$\frac{1}{2} \times 800 \times 15^2 - \frac{1}{2} \times 800 \times 35^2$	M1 A1	Attempt at GPE Correct GPE including sign	
	$= -200 \times \frac{1}{14} \times 9.8 \times 800 - J$ $J = 288\ 000$ so 288 000 J	A1 F1	All signs correct	5
	or *uvast* up the plane $15^2 = 35^2 + 2a \times 200$	M1	Use of appropriate *uvast*	
	so $a = -2.5$	A1	Accept sign not clearly defined	
	N2L up the plane $-F - 800g \times \frac{1}{14} = 800 \times -2.5$	M1	Use of N2L with all forces present. Condone sign errors.	
	$F = 1440$ WD is $1440 \times 200 = 288$ kJ	A1 F1	FT error in F.	
		Tot 15		

M2 Jan 03 Q4

(i)	Resolving down the plane			
	$840\sin\alpha \le F_{max}$ Perp to plane	B1	Accept $= F$	
	$R = 840\cos\alpha$	B1		
	$F_{max} = \mu R$ Hence $840\sin\alpha \le 840\mu\cos\alpha$	M1	Allow for $F = \mu R$ used.	
	and $\mu \ge \tan\alpha = \frac{7}{24}$	E1	Award only if inequality clearly established and value of tan demonstrated [for $\mu = \tan\alpha$ WW, award SC1 with or without evaluation of tan]	4
(ii)	Parallel $P\cos\alpha$ Perp to plane downwards $P\sin\alpha$	B1 B1	Accept all forces resolved Accept all forces resolved	
	Moment c.w. is $2P\cos\alpha - 3P\sin\alpha$	M1	FT components and lengths	
	$= \frac{P}{25}(2\times24 - 3\times7) = \frac{27P}{25}$	E1	Clearly shown	4
(iii)	Must have P, weight through G (approx), F plane parallel and thro' base and R perp to plane thro' upper face	B1	All correct. Accept F and R combined at top edge	
	Moment of weight about AB is	M1	Attempt to find moment of weight about AB	
	c.w. $-840\cos\alpha\times1 - 840\sin\alpha\times1 = \frac{-5208}{5}$ N m	A1		
	Sum of moments about AB is zero so $\frac{27P}{25} = \frac{5208}{5}$	M1 A1	Equating moments about AB. Dependent on previous M1	
	and $P = 964.444....$ so 964 (3 s. f.)	E1		6
		Tot 14		