mark scheme

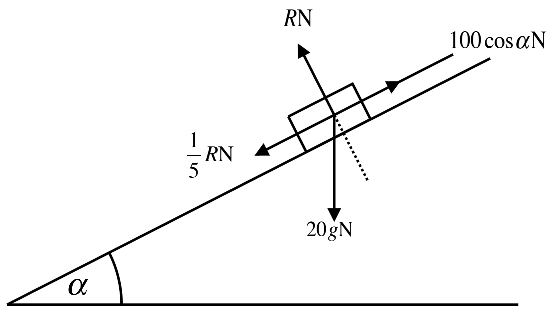
Practice Paper A : Mechanics 1

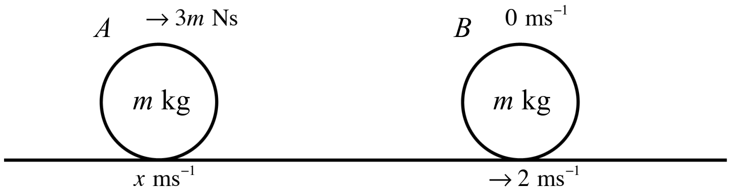
Question Number	General Scheme		Marks
1	$s = 0.1$ m , $u = 3$ ms^{-1}, $a = -g$ ms^{-2}, $t = ?$ Use of $s = ut + \frac{1}{2}at^2 \rightarrow 0.1 = 3t - 4.9t^2$ $4.9t^2 - 3t + 0.1 = 0$	**M1** – use of $s = ut + \frac{1}{2}at^2$ **A1** – correct values for s, u, a and t	**M1** **A1**
	$t = \frac{3 \pm \sqrt{3^2 - 4(4.9)(0.1)}}{2(4.9)}$	**M1** – correct method to solve *their* 3TQ	**M1**
	$\therefore t = 0.576...,\ 0.0353....$ $\therefore t = 0.57,\ 0.035$	**A1ft** – one correct value of t, ft *their* 3TQ **A1** – both values of t correct to 2 or 3 sf **cao**	**A1** **A1**
		Total	**5**

2 (a)	$\mathbf{v} = \dfrac{\mathbf{i}-\mathbf{j}-(3\mathbf{i}+6\mathbf{j})}{4} = -0.5\mathbf{i} - 3.5\mathbf{j}$	**M1** – method to find velocity vector of S **A1** – correct velocity vector	**M1** **A1**
	$\mathbf{r} = 3\mathbf{i}+6\mathbf{j}+t(-0.5\mathbf{i}-3.5\mathbf{j})$ $\therefore \mathbf{r} = (3-0.5t)\mathbf{i}+(6-3.5t)\mathbf{j}$	**dM1** – use of $\mathbf{r} = \mathbf{r}_0 + \mathbf{v}t$ **A1** – cao **AG**	**M1** **A1** **(4)**
(b)	When north, $\mathbf{i}=0$: $3 = 0.5t \rightarrow t = 6\ s$	**M1** – sets $3-0.5t=0$	**M1**
	$\mathbf{r} = (3-0.5(6))\mathbf{i}+(6-3.5(6))\mathbf{j}$	**M1** – substitutes *their* value of t into $\mathbf{r}$	**M1**
	$\therefore \mathbf{r} = -15\mathbf{j}$	**A1** – correct position vector	**A1** **(3)**
(c)	$\mathbf{r} = -7\mathbf{i}-64\mathbf{j}$	**B1** – correct position vector after 20 seconds	**B1**
	displacement $= -7\mathbf{i}-64\mathbf{j}-(3\mathbf{i}+6\mathbf{j})$ $(= -10\mathbf{i}-70\mathbf{j})$	**M1** – works out displacement by doing *their* value for the position vector of S at $t=20$ – position vector of S at $t=0$	**M1**
	$\therefore$ distance travelled = $\sqrt{10^2+70^2}$ $= \sqrt{5000} = 50\sqrt{2}$	**dM1** – use of Pythagoras to find distance **A1** – correct distance **OE**	**M1** **A1** **(4)**
		Total	**11**

3	$\text{m}(A):\ 20g(1)-294(2.5)+Mg(3.5)=0$	**M2** – moments equation about any point with three terms (condone two errors) **A1** – correct moments equation	**M2** **A1**
	$M=15.714...=16(\text{N})$	**A1** – correct value of M or R_A	**A1**
	$R(\uparrow^+): R_A+294-20g-Mg=0$ $\therefore R_A=55.9972...=56(\text{N})$	**M1** – resolves vertically to obtain secondary equation or uses another moments equation **A1** – correct second equation **A1** – both M and R_A found correct to two or three significant figures	**M1** **A1** **A1** **(7)**
ALT	Moments equations about other points: $\text{m}(\text{centre}):\ R_A(1)-294(1.5)+Mg(2.5)=0$ $\text{m}(C):\ 294(1)-20g(2.5)+R_A(3.5)=0$ $\text{m}(B):\ 20g(1.5)-R_A(2.5)-Mg(1)=0$ Accept moments equations about any other points as long as they are clearly defined.		
		Total	**7**

4 (a)	$R\left(\rightarrow^{+}\right): T_{AC}\cos 30 - 5\cos 45 = 0$	**M1** – attempts to resolve in horizontal plane, must see two terms. Condone $\sin/\cos$ errors **A1** – correct equation	**M1** **A1**
	$T_{AC} = \dfrac{5\cos 45}{\cos 30} = 4.0824... = 4.08\,(\text{N})$	**A1** – cao	**A1** **(3)**
(b)	$R\left(\uparrow^{+}\right): T_{AC}\sin 30 + 5\sin 45 - (10+k)g = 0$	**M1** – attempts to resolve in vertical plane, must see three terms. Condone $\sin/\cos$ errors **A1ft** – correct equation ft *their* T_{AC}	**M1** **A1**
	$k = \dfrac{(4.02824...)\sin 30 + 5\sin 45}{g} - 10$		
	$k = -9.4337... = -9.4$	**A1** – cao to two or three significant figures	**A1** **(3)**
NOTE	Working in radians throughout will automatically sacrifice the final **A1** in (a) and (b).		
	Total		**6**

5	Relevant diagram: 		
	$R(\nwarrow^{+}): R - 20g\cos\alpha = 0$ $R = 20g\cos\alpha$	**M1** – resolves perpendicular to the plane **A1** – correct R	**M1** **A1**
	$R(\nearrow^{+}): 100\cos\alpha - \frac{1}{5}(20g\cos\alpha) - 20g\sin\alpha = 0$	**B1** – use of $\frac{1}{5}R$ at any stage (may even appear on a diagram) **M1** – resolves parallel to the plane with three terms **A1** – correct equation	**B1** **M1** **A1**
	$\therefore 100\cos\alpha - 4g\cos\alpha = 20g\sin\alpha$ $\therefore \cos\alpha(100 - 4g) = 20g\sin\alpha$		
	$\therefore \tan\alpha = \frac{100 - 4g}{20g}$	**dM1** – use of $\tan\alpha = \frac{\sin\alpha}{\cos\alpha}$ **A1** – correct expression	**M1** **A1**
	$\therefore \alpha = 17.234... = 17^{\circ}$	**A1** – correct angle given to two or three significant figures. Accept 0.30 for radian equivalent	**A1**
		Total	**8**

6 (a)	Relevant diagram: 		
	speed of A after impulse = $3\ \left(\text{ms}^{-1}\right)$	**B1** – correct speed of A, can be implied	**B1**
	By COLM: $3m = mx + 2m$ $x = 3 - 2 = 1\ \left(\text{ms}^{-1}\text{ to the right}\right)$	**M1** – applies the conservation of linear momentum **A1** – correct equation **A1** – correct value for the speed of A after collision	**M1** **A1** **A1** **(4)**
(b)	Relevant diagram: 		
	By COLM: $2m = mx + 2mx$	**M1** – applies the conservation of linear momentum **A1** – correct equation	**M1** **A1**
	$3x = 2$ $x = \frac{2}{3}\ \left(\text{ms}^{-1}\text{ to the right}\right)$	**A1** – correct value of x	**A1** **(3)**
(c)	Yes there will be a subsequent collision because both *A* and *B* move to the right after *B* collides with *C* and the speed of *A* > speed of *B*.	**B1** – a correct conclusion conveying all the underlined ideas owtte	**B1** **(1)**
		Total	**8**

7 (a)	Considering *A*: $T-3g=3a$ Considering *B*: $7g-T=7a$	**M1** – considers one of the masses and uses N2L **A1** – a correct equation for both *A* and *B*	**M1** **A1**
	$4g=10a \rightarrow a=3.92\ (\text{ms}^{-2})$ $T=41.2\ (\text{N})$	**A1** – correct a to two or three significant figures **A1** – correct T to two or three significant figures	**A1** **A1** **(4)**
(b)	$R_P-2T=0$	**M1** – considers the entire system and forms a correct equation	**M1**
	$R_P=82.4\ (\text{N})$	**A1ft** – correct value for the resultant force on the pulley ft *their* (a)	**A1** **(2)**
(c)	$s=0.1$, $u=0$, $v=?$, $a=3.92$ $v=\sqrt{2(3.92)(0.1)}=0.8854...$	**M1** – attempts to find the speed of $(A$ and$)$ B when B hits the ground using $v^2=u^2+2as$ **A1** – correct value for speed of B as it hits the ground	**M1** **A1**
	$s=?$, $u=0.8854...$, $v=0$, $a=-g$ $s=\dfrac{0^2-(0.8854)^2}{2(-g)}=0.0399...$	**dM1** – attempts to find the height A gains after B hits the ground using $v^2=u^2+2as$ **A1ft** – correct value for s ft *their* value for the speed of B as it hits the ground	**M1** **A1**
	$x=0.5+0.1+\text{their } 0.0399$ $x=0.64$	**M1** – correct method to find x **A1** – correct value of x to two or three significant figures, cso	**M1** **A1** **(6)**
		Total	**12**

8 (a)	Consider system: $5400-750-500=(2400+1000)a$	**M1** – resolves horizontally and considers the entire system **A1** – correct equation	**M1** **A1**
	$a=1.2205...=1.22\ \left(\text{ms}^{-2}\right)$	**A1** – correct value for the acceleration of the system	**A1** **(3)**
(b)	$1.22=\dfrac{v-0}{10}$	**M1** – use of $v=u+at$ **OE**	**M1**
	$v=12.2\ \left(\text{ms}^{-1}\right)$	**A1ft** – correct value for the speed of the system when $t=10$ ft *their* (a)	**A1** **(2)**
(c)	Consider Caravan (or Trailer): $5400-750-T=2400(1.220...)$	**M1** – applies N2L to either the caravan or trailer **A1** – correct equation	**M1** **A1**
	$\therefore T=1720\ (\text{N})$	**A1** – correct value for the tension in the tow bar **AWRT**	**A1** **(3)**
(d)	$a=-0.3676...$	**B1** – correct value for the deceleration of the system	**B1**
	$s=\dfrac{v^2-u^2}{2a}=\dfrac{0-(1.22\times 30)^2}{-2(0.3676...)}$ $=1820\ (\text{m})$	**M1** – use of $v^2=u^2+2as$ to find distance travelled by the system **A1** – correct equation **A1** – correct value for the distance travelled **AWRT**.	**M1** **A1** **A1** **(4)**
NOTE	For part (d), some candidates may go on to calculate the total distance travelled by the system from $t=0$. Provided 1820 (m) is seen, you should ignore this subsequent working and still award these candidates full credit.		
(e)	Considers Caravan (or Trailer): $F-750=2400(-0.3676...)$	**M1** – considers either the caravan or trailer using N2L	**M1**
	$\therefore \lvert F\rvert=130\ (\text{N})$	**A1** – correct value of the magnitude of the force in the rod	**A1**
	(Since negative,) the force is a tension.	**A1** – identifies it is a tension force (reason not needed)	**A1** **(3)**
(f)	**B1** – correct shape of the speed-time graph (starts off at 0, increases and then decreases, triangle shape) **B1** – line for when the system is accelerating should be steeper than the line for decelerating **B1** – $t=0,30$ shown on the graph (values of v not necessary) Candidates with errors in the previous parts can score **B0 B0 B1** for a correct speed time graph ft their values		**B1** **B1** **B1** **(3)**
		Total	**18**