4761 Mechanics 1

Q 1		mark	comment	sub
(i)	$0.5\times8\times10=40$ m	M1	Attempt to find whole area or … If *suvat* used in 2 parts, accept any *t* value $0\le t\le 8$ for max.	2
(ii)		A1	cao	
	$0.5\times5(T-8)=10$	M1	$0.5\times5\times k=10$ seen. Accept ±5 and ±10 only. If *suvat* used need whole area; if in 2 parts, accept any *t* value $8\le t\le T$ for min.	
		B1	Attempt to use $k = T - 8$.	
	$T = 12$	A1	cao. [Award 3 if $T = 12$ seen]	3
(iii)				
	40 – 10 = 30 m	B1	FT **their** 40.	1
		6		

Q 2		mark	comment	sub
(i)				
	$\sqrt{10^2+24^2}=26$ so 26 N	B1		
	arctan ($^{10}/_{24}$)	M1	Using arctan or equiv. Accept arctan ($^{24}/_{10}$) or equiv.	
	= 22.619… so 22.6° (3 s. f.)	A1	Accept 157.4°.	3
(ii)				
	W = $-w$ **j**	B1	Accept $\begin{pmatrix}0\\-w\end{pmatrix}$ and $\begin{pmatrix}0\\-w\mathrm{j}\end{pmatrix}$	1
(iii)				
	$\mathbf{T}_1 + \mathbf{T}_2 + \mathbf{W} = \mathbf{0}$	M1	Accept in any form and recovery from **W** = w **j**. Award if not explicit and part (ii) and **both** k and w correct.	
	$k = -10$	B1	Accept from wrong working.	
	$w = 34$	B1	Accept from wrong working but not – 34. [Accept – 10 **i** *or* 34 **j** but not both]	3
		7		

Q 3		mark	comment	sub
(i)				
	The line is not straight	B1	Any valid comment	1
(ii)				
	$a = 3 - 6t/8$	M1	Attempt to differentiate. Accept 1 term correct but not $3 - \frac{3t}{8}$.	
	$a(4) = 0$	F1		
	The sprinter has reached a steady speed	E1	Accept 'stopped accelerating' but not just $a = 0$. Do not FT $a(4) \neq 0$.	3
(iii)				
	We require $\int_1^4 \left(3t - \frac{3t^2}{8}\right) \mathrm{d}t$	M1	Integrating. Neglect limits.	
	$= \left[\frac{3t^2}{2} - \frac{t^3}{8}\right]_1^4$	A1	One term correct. Neglect limits.	
	$= (24 - 8) - \left(\frac{3}{2} - \frac{1}{8}\right)$	M1	Correct limits subst in integral. Subtraction seen. If arb constant used, evaluated to give $s = 0$ when $t = 1$ and then sub $t = 4$.	
	$= 14\frac{5}{8}$ m (14.625 m)	A1	cao. Any form. [If trapezium rule used M1 use of rule (must be clear method and at least two regions) A1 correctly applied M1 At least 6 regions used A1 Answer correct to at least 2 s.f.)]	4
		8		

Q 4		mark	comment	sub
(i)	$32\cos\alpha t$	B1		1
(ii)	$32\cos\alpha\times 5 = 44.8$	M1	FT **their** x.	
	so $160\cos\alpha = 44.8$ and $\cos\alpha = 0.28$	E1	Shown. Must see some working e.g $\cos\alpha$ = 44.8/160 or 160 $\cos\alpha$ = 44.8. If 32 × 0.28 × 5 = 44.8 seen then this needs a statement that 'hence $\cos\alpha$ = 0.28'.	2
(iii)	$\sin\alpha = 0.96$	B1	Need not be explicit e.g. accept sin(73.73…) seen.	
	either			
	$0 = (32\times 0.96)^2 - 2\times 9.8\times s$	M1	Allow use of 'u' = 32, g = ± (10, 9.8, 9.81).	
		A1	Correct substitution.	
	s = 48.1488… so 48.1 m (3 s. f.)	A1	cao	
	or			
	Time to max height is given by 32 × 0.96 -9.8 T = 0 so T = 3.1349….	B1	Could use ½ total time of flight to the horizontal.	
	y = 32 × 0.96 t – 4.9 t^2	M1	Allow use of 'u' = 32, g = ± (10, 9.8, 9.81) May use $s = \frac{(u+v)}{2}t$.	
	putting t = T, y = 48.1488 so 48.1 m (3 s. f.)	A1	cao	4
		7		

Q 5		mark	comment	sub
(i)				
	$\mathbf{v} = \mathbf{i} + (3-2t)\mathbf{j}$	M1	Differentiating **r.** Allow 1 error. Could use const accn.	
		A1		
	v(4) = **i** – 5**j**	F1	Do not award if $\sqrt{26}$ is given as vel (accept if **v** given and *v* given as well called speed or magnitude).	
				3
(ii)				
	a = – 2**j**	B1	Diff **v.** FT **their v.** Award if – 2**j** seen & isw.	
	Using N2L **F** = $1.5\times$ (– 2**j**)	M1	Award for $1.5\times(\pm$ **their a** or $a)$ seen.	
	so – 3**j** N	A1	cao Do not award if final answer is not correct. [Award M1 A1 for – 3**j** WW]	
				3
(iii)				
	$x = 2 + t$ and $y = 3t - t^2$	B1	Must have both but may be implied.	
	Substitute $t = x - 2$			
	so $y = 3(x-2) - (x-2)^2$	B1	cao. isw. Must see the form *y* = ….	
	$[= (x-2)(5-x)]$			
				2
		8		

Q 6		mark	comment	sub
(i)				
	Up the plane $T - 4g\sin 25 = 0$	M1	Resolving parallel to the plane. If any other direction used, all forces must be present. Accept $s \leftrightarrow c$. Allow use of *m*. No extra forces.	
	T = 16.5666… so 16.6 N (3 s. f.)	A1		
				2
(ii)				
	Down the plane, $(4+m)g\sin 25 - 50 = 0$	M1	No extra forces. Must attempt resolution in at least 1 term. Accept $s \leftrightarrow c$. Accept *Mg*sin25. Accept use of mass.	
		A1	Accept *Mg*sin25	
	m = 8.0724… so 8.07 (3 s. f.)	A1		
				3
(iii)				
	Diagram	B1	Any 3 of weight, friction normal reaction and *P* present	

		B1	in approx correct directions with arrows. All forces present with suitable directions, labels and arrows. Accept *W*, *mg*, 4*g* and 39.2.	2
(iv)				
	Resolving up the plane	M1	Resolving parallel to the plane or All forces must be present . Accept $s \leftrightarrow c$. Allow use of *m*. At least one resolution attempted and accept wrong angles. Allow sign errors.	
		B1	$P\cos 15$ term correct. Allow sign error.	
	$P\cos 15 - 20 - 4g\sin 25 = 0$	B1	Both resolutions correct. Weight used. Allow sign errors. FT use of *P*sin 15.	
		A1	All correct but FT use of *P*sin 15.	
	P = 37.8565…. so 37.9 N (3 s. f.)	A1		5
(v)				
	Resolving perpendicular to the plane	M1	May use other directions. All forces present. No extras. Allow $s \leftrightarrow c$. Weight not mass used. Both resolutions attempted. Allow sign errors.	
	$R + P\sin 15 - 4g\cos 25 = 0$	B1	Both resolutions correct. Allow sign errors. Allow use of *P*cos15 if *P*sin15 used in (iv).	
		F1	All correct. Only FT **their** *P* and their use of *P*cos15.	
	R = 25.729… so 25.7 N	A1	cao	4
		16		

If there is a consistent $s \leftrightarrow c$ error in the weight term throughout the question, penalise only two marks for this error. In the absence of other errors this gives
(i) 35.52… (ii) 1.6294… (iv) 57.486… (v) 1.688…

For use of mass instead of weight lose maximum of 2.

Q 7		mark	comment	sub
	With the 11.2 N resistance acting to the left			
(i)				
	N2L $F - 11.2 = 8 \times 2$	M1	Use of N2L (allow $F = mga$). Allow 11.2 omitted; no extra forces.	
		A1	All correct	
	F = 27.2 so 27.2 N	A1	cao	
				3
(ii)	The string is inextensible	E1	Allow 'light inextensible' but not other irrelevant reasons given as well (e.g. smooth pulley).	
				1
(iii)		B1	One diagram with all forces present; no extras; correct arrows and labels accept use of words.	
		B1	Both diagrams correct with a common label.	
				2
(iv)	**method (1)**	M1	For either box or sphere, $F = ma$. Allow omitted force and sign errors but not extra forces. Need correct mass. Allow use of mass not weight.	
	box N2L $\rightarrow 105 - T - 11.2 = 8a$	A1	Correct and in any form.	
	sphere N2L $\uparrow$ $T - 58.8 = 6a$	A1	Correct and in any form. [box and sphere equns with consistent signs]	
	Adding 35 = 14a	M1	Eliminating 1 variable from 2 equns in 2 variables.	
	a = 2.5 so 2.5 m s^{-2}	E1		
	Substitute a = 2.5 giving T = 58.8 + 15	M1	Attempt to substitute in either box or sphere equn.	
	T = 73.8 so 73.8 N	A1		
	method (2)			
	105 – 11.2 – 58.8 = 14a	M1	For box and sphere, $F = ma$. Must be correct mass. Allow use of mass not weight.	
	a = 2.5	A1		
		E1	Method made clear.	
		M1	For **either** box **or** sphere, $F = ma$. Allow omitted force and sign errors but not extra forces. Need correct mass. Allow use of mass not weight.	
	either: box N2L $\rightarrow 105 - T - 11.2 = 8a$			
	or: sphere N2L $\uparrow$	A1	Correct and in any form.	

	$T - 58.8 = 6a$ Substitute a = 2.5 in either equn T = 73.8 so 73.8 N	M1 A1	Attempt to substitute in either box or sphere equn. [If AG used in either equn award M1 A1 for that equn as above and M1 A1 for finding T. For full marks, both values must be shown to satisfy the second equation.]	7
(v) **(A)**	g downwards	B1	Accept $\pm g,\ \pm 9.8,\ \pm 10,\ \pm 9.81$	1
(B)	Taking ↑ + ve, $s = -1.8$, u = 3 and $a = -9.8$ so $-1.8 = 3T - 4.9T^2$ and so $4.9T^2 - 3T - 1.8 = 0$	M1 E1	Some attempt to use $s = ut + 0.5at^2$ with $a = \pm 9.8$ etc $s = \pm 1.8$ and $u = \pm 3$. Award for a = g even if answer to (A) wrong. Clearly shown. No need to show +ve required.	2
(C)	See over			
(C)	Time to reach 3 m s^{-1} is given by $3 = 0 + 2.5t$ so t = 1.2 remaining time is root of quad time is 0.98513… s Total 2.1851…so 2.19 s (3 s. f.) With the 11.2 N resistance acting to the right	B1 M1 B1 A1	Quadratic solved and + ve root added to time to break. Allow 0.98. [Award for answer seen WW] cao	
(i)	F + 11.2 = 8 × 2 so F = 4.8		The same scheme as above	
(iii)			The 11.2 N force may be in either direction, otherwise the same scheme	
(iv)	The same scheme with + 11.2 N instead of – 11.2 N acting on the box method (1) box N2L $\rightarrow 105 - T + 11.2 = 8a$ sphere as before			

	method (2) 105 + 11.2 – 58.8 = 14*a* These give *a* = 4.1 and *T* = 83.4	Allow 2.5 substituted in box equation to give *T* = 96.2 If the sign convention gives as positive the direction of the sphere descending, *a* = – 4.1. Allow substituting *a* = 2.5 in the equations to give *T* = 43.8 (sphere) or 136.2 (box).	
(v)		In (C) allow use of a = 4.1 to give time to break as 0.73117..s. and total time as 1.716…s	4
	20		