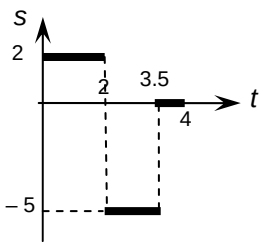
4761 Mechanics 1

1 (i)	$0 < t < 2$, $v = 2$ $2 < t < 3.5$ $v = -5$	B1 B1	Condone '5 downwards' and ' – 5 downwards'	2
(ii)		 B1 B1	Condone intent – e.g. straight lines free-hand and scales not labelled; accept non-vertical sections at $t = 2$ & 3.5. Only horizontal lines used and 1st two parts present. BOD t-axis section. One of 1st 2 sections correct. FT (i) and allow if answer correct with (i) wrong All correct. Accept correct answer with (i) wrong. FT (i) only if 2nd section –ve in (i)	2
(iii)	(A) upwards; (B) and (C) downwards	E1	All correct. Accept +/- ve but not towards/away from O Accept forwards/backwards. Condone additional wrong statements about position.	1
				5
2 (i)	$\begin{pmatrix}12\\9\end{pmatrix} = \begin{pmatrix}2\\-3\end{pmatrix} + 4\mathbf{a}$ so $\mathbf{a} = \begin{pmatrix}2.5\\3\end{pmatrix}$	M1 A1	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ If vector **a** seen, isw.	2
(ii)	**either** $\mathbf{r} = \begin{pmatrix}-1\\2\end{pmatrix} + \begin{pmatrix}2\\-3\end{pmatrix} \times 4 + \frac{1}{2}\mathbf{a} \times 4^2$ $\mathbf{r} = \begin{pmatrix}27\\14\end{pmatrix}$ so $\begin{pmatrix}27\\14\end{pmatrix}$ m **or**	M1 A1 A1 M1 A1 A1 SC2 for $\begin{pmatrix}28\\12\end{pmatrix}$	For use of $\mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ with **their a.** Initial position may be omitted. FT **their a.** Initial position may be omitted. cao. Do not condone magnitude as final answer. Use of $\mathbf{s} = 0.5t(\mathbf{u} + \mathbf{v})$ Initial position may be omitted. Correct substitution. Initial position may be omitted. cao Do not condone mag as final answer.	3

(iii)	Using N2L $\mathbf{F} = 5\mathbf{a} = \begin{pmatrix}12.5\\15\end{pmatrix}$ so $\begin{pmatrix}12.5\\15\end{pmatrix}$ N	M1 F1	Use of $\mathbf{F} = m\mathbf{a}$ or $\mathbf{F} = mg\mathbf{a}$. FT **their a** only. Do not accept magnitude as final ans.	2
				7
3 (i)	$\lvert\mathbf{F}\rvert = \sqrt{(-1)^2 + 5^2}$ $= \sqrt{26} = 5.0990...$ = 5.10 (3 s. f.) Angle with **j** is arctan(0.2) so 11.309… so 11.3° (3 s. f.)	M1 A1 M1 A1	Accept $\sqrt{-1^2 + 5^2}$ even if taken to be $\sqrt{24}$ accept arctan(p) where $p = \pm 0.2$ or ± 5 o.e. cao	4
(ii)	$\begin{pmatrix}-2\\3b\end{pmatrix} = 4\begin{pmatrix}-1\\5\end{pmatrix} + \begin{pmatrix}2a\\a\end{pmatrix}$ $a = 1$, $b = 7$ so $\mathbf{G} = \begin{pmatrix}2\\1\end{pmatrix}$ and $\mathbf{H} = \begin{pmatrix}-2\\21\end{pmatrix}$ or $\mathbf{G} = 2\mathbf{i} + \mathbf{j}$ and $\mathbf{H} = -2\mathbf{i} + 21\mathbf{j}$	M1 M1 A1 A1	$\mathbf{H} = 4\mathbf{F} + \mathbf{G}$ soi Formulating at least 1 scalar equation from **their** vector equation soi a correct **or G** follows from their wrong a **H** cao	4
				8
4(i)	20cos 15 = 19.3185…. so 19.3 N (3 s. f.) in direction BC	B1	Accept no direction. Must be evaluated	1
(ii)	Let the tension be T T sin 50 = 19.3185…. so T = 25.2185… so 25.2 N (3 s. f.)	M1 F1	Accept $\sin \leftrightarrow \cos$ but not (i) × sin 50 FT **their** 19.3… only. cwo	2
(iii)	R + 20 sin 15 – 2.5g – 25.2185…× cos 50 = 0 R = 35.5337… so 35.5 N (3 s. f.)	M1 B1 A1 A1	Allow 1 force missing or 1 tension not resolved. FT T. No extra forces. Accept mass used. Accept $\sin \leftrightarrow \cos$. Weight correct All correct except sign errors. FT **their** T cao. Accept 35 or 36 for 2. s.f.	4
(iv)	The horizontal resolved part of the 20 N force is not changed.	E1	Accept no reference to vertical component but do not accept 'no change' to both components. No need to be explicit that value of tension in AB depends only on horizontal component of force at C	
				1
				8

5(i)	$a = 6t - 12$	M1 A1	Differentiating cao	2
(ii)	We need $\int_1^3 (3t^2 - 12t + 14)\mathrm{d}t$ $= \left[t^3 - 6t^2 + 14t\right]_1^3$ **either** $= (27 - 54 + 42) - (1 - 6 + 14)$ $= 15 - 9 = 6$ so 6 m **or** $s = t^3 - 6t^2 + 14t + C$ $s = 0$ when $t = 1$ gives $0 = 1 - 6 + 14 + C$ so $C = -9$ Put $t = 3$ to give $s = 27 - 54 + 42 - 9 = 6$ so 6 m.	M1 A1 M1 A1 M1 A1	Integrating. Neglect limits. At least two terms correct. Neglect limits. Dep on 1st M1. Use of limits with attempt at subtraction seen. cao Dep on 1st M1. An attempt to find C using $s(1) = 0$ and then evaluating $s(3)$. cao	4
(iii)	$v > 0$ so the particle always travels in the same (+ve) direction As the particle never changes direction, the final distance from the starting point is the displacement.	E1 E1	Only award if explicit Complete argument	
				2
				8
6 (i)	Component of weight down the plane is $1.5 \times 9.8 \times \frac{2}{7} = 4.2$ N	M1 E1	Use of mgk where k involves an attempt at resolution Accept $1.5 \times 9.8 \times \frac{2}{7} = 4.2$ or $14.7 \times \frac{2}{7} = 4.2$ seen	2
(ii)	Down the plane. Take F down the plane. $4.2 - 6.4 + F = 0$ so $F = 2.2$. Friction is 2.2 N down the plane	M1 A1	Allow sign errors. All forces present. No extra forces. Must have direction. [Award 1 for 2.2 N seen and 2 for 2.2 N down plane seen]	2
(iii)	F up the plane N2L down the plane $4.2 - F = 1.5 \times 1.2$ so $F = 4.2 - 1.8 = 2.4$ Friction is 2.4 N up the plane	M1 A1 A1 A1	N2L. $F = ma$. No extra forces. Allow weight term missing or wrong Allow only sign errors ± 2.4 cao. Accept no reference to direction if $F = 2.4$.	4
(iv)	$2^2 = 0.8^2 + 2 \times 1.2 \times s$ $s = 1.4$ so 1.4 m	M1 A1 A1	Use of $v^2 = u^2 + 2as$ or sequence All correct in 1 or 2-step method	3

(v)	Diagrams	B1	Frictions and coupling force correctly labelled with arrows.	
		B1	All forces present and properly labelled with arrows.	
	either			
	Up the plane	M1	N2L. $F = ma$. No extra forces. Condone sign errors.	
	$10 - 3.5\times 9.8\times \frac{2}{7} - (2.3+0.7) = 3.5a$		Allow total/part weight **or** total/part friction omitted (but not both). Allow mass instead of weight and mass/weight not or wrongly resolved.	
		B1	Correct overall mass and friction	
	$a = -0.8$ so 0.8 m s^{-2}.			
	down the plane	A1	Clear description or diagram	
	For barge B up the plane			
	$T - 2\times 9.8\times \frac{2}{7} - 0.7 = 2\times(-0.8)$	M1	N2L on one barge with **their** $\pm a$ ($\neq 1.2$ or 0). All forces present and weight component attempted. No extra forces. Condone sign errors.	
	$T = 4.7$ so 4.7 N. Tension	A1	cao	
	or (separate equations of motion)		In eom for A **or** B allow weight or friction missing and also allow mass used instead of weight and wt not or wrongly resolved. In other equn weight component attempted and friction term present.	
	Barge A	M1	N2L. Do not allow $F = mga$. No extra forces. Condone sign errors.	
	Barge B	M1	N2L. Do not allow $F = mga$. No extra forces. Condone sign errors.	
		M1	Solving a pair of equns in a and T	
	$a = -0.8$ so 0.8 m s^{-2}.			
	down the plane	A1	Clear description or diagram	
	$T = 4.7$ so 4.7 N. Tension	A1	cao cwo	
				7
				18
7 (i)	$y(0) = 1$	B1		1
	Either			
(ii)	$\frac{1}{2}(20+5) - 5 = 7.5$	M1	Use of symmetry e.g. use of $\frac{1}{2}(20+5)$	
		A1	12.5 o.e. seen	
		A1	7.5 cao	
	or	M1	Attempt at y' and to solve $y' = 0$	
		A1	$k(15 - 2x)$ where $k = 1$ or $\frac{1}{100}$	
		A1	7.5 cao, seen as final answer	
	$y(7.5) = \frac{1}{100}(100 + 15\times 7.5 - 7.5^2)$	M1	FT **their** 7.5	
	$= \frac{25}{16}$ (1.5625) so 1.5625 m	E1	AG [SC2 only showing 1.5625 leads to $x = 7.5$]	5

(iii)	$4.9t^2 = \frac{25}{16}$ (1.5625)	M1	Use of $s = ut + 0.5at^2$ with $u = 0$. Condone use of $\pm 10,\ \pm 9.8,\ \pm 9.81$. If sequence of *suvat* used, complete method required.	
	$t^2 = 0.31887\ldots$ so $t = \pm 0.56469\ldots$	A1	In any method only error accepted is sign error	
	Hence 0.565 s (3 s. f.)	E1	AG. Condone no reference to –ve value. www. 0.565 must be justified as answer to 3 s. f.	3
(iv)	$\dot{x} = \frac{12.5}{0.56469...} = 22.1359...$	M1	or 25 / (2×0.56469..)	
		B1	Use of 12.5 or equivalent	
	so 22.1 m s $^{-1}$ (3 s. f.))	E1	22.1 must be justified as answer to 3 s. f. Don't penalise if penalty already given in (iii).	
	Either			
	Time is $\frac{20}{12.5} \times 0.56469...$ s	M1		
	so 0.904 s (3 s. f.)	A1	cao Accept 0.91 (2 s. f.)	
	or			
	Time is $\frac{20}{22.1359...}$ s	M1		
	= 0.903507… so 0.904 s (3 s. f.)	A1	cao Accept 0.91 (2 s. f.)	
	or			
	(iii) $+ \frac{7.5}{\textbf{their } \dot{x}}$	M1		
	so 0.904 s (3 s. f.)	A1	cao Accept 0.91 (2 s. f.)	5
(v)	$v = \sqrt{\dot{x}^2 + \dot{y}^2}$	M1	Must have attempts at both components	
	$\dot{y}^2 = 0^2 + 2 \times 9.8 \times \frac{25}{16}$ or	M1	Or equiv. $u = 0$. Condone use of $\pm 10,\ \pm 9.8,\ \pm 9.81$.	
	$\dot{y} = 0 + 9.8 \times 0.5646...$		Accept wrong *s* (or *t* in alternative method)	
	= $\frac{245}{8}$ (30.625) or $\dot{y} = \pm 5.539...$	A1	Or equivalent. May be implied. Could come from (iii) if $v^2 = u^2 + 2as$ used there. Award marks again.	
	so $v = \sqrt{490 + 30.625}$ = 22.8172… m s $^{-1}$			
	so 22.8 m s $^{-1}$ (3 s. f.)	A1	cao. www	4
				18