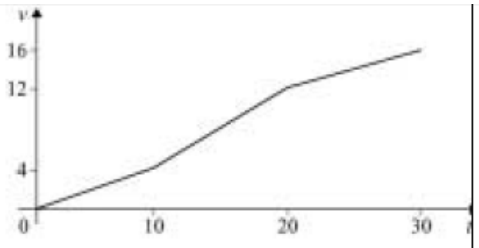
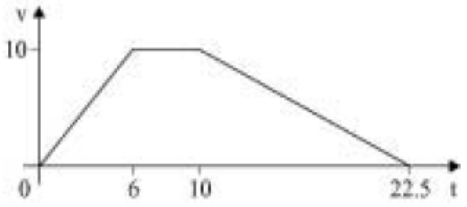
Mechanics 1 Kinematics Answers

2(a)	$\mathbf{v} = 4\mathbf{i} + (-3\mathbf{i} + 12\mathbf{j})t$	M1 A1	2	use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$
(b)	$t = 0.5,\ \mathbf{v} = 2.5\mathbf{i} + 6\mathbf{j}$	B1√		√ 2 terms and t subs
	Speed $= \sqrt{(2.5^2 + 6^2)}$	M1		2 terms
	Speed $= 6.5\,\text{m s}^{-1}$	A1√	3	√ 2 terms
	Total		**5**	

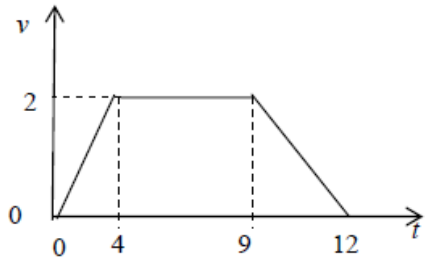
3(a)(i)	$s = ut + \frac{1}{2}at^2$			
	$25 = 0 + 4.9t^2$	M1		full method
	$t = 2.26\,\text{sec}$ (2.236) $(\text{if } g = 10)$ (2.259)	A1	2	
(ii)	$v^2 = u^2 + 2as$			
	$v^2 = 0 + 2 \times 9.8 \times 25$	M1		
	$v = 22.1\,\text{m s}^{-1}$ (21.913) (22.14)	A1	2	
(b)	(Time longer) air resistance slows down motion, links with motion, no contradictions	M1 A1	2	(or Time less) package large so less distance to travel
	Total		**6**	

6(a)(i)		B1 B1 B1	3	3 straight lines correct end points sensible scales + labelled v/t	
(ii)	$s=\frac{1}{2}\times10\times4+\frac{1}{2}\times(4+12)\times10+$ $\frac{1}{2}(12+16)\times10$ $s=240$ metres	M1 m1 A1 A1√	4	area attempt full method equation correct √ one slip	Or equation attempted full method all correct √ one slip
(iii)	Average speed $=\frac{240}{30}$ $=8\text{ms}^{-1}$	M1 A1√	2	√distance	
(iv)	Greatest acceleration $=2^{nd}$ stage $=\frac{12-4}{10}$ $=0.8\text{ms}^{2}$	M1 A1	2	cao	
(b)(i)	Less area below curve < area below line/velocity lower	B1 B1	2	no additional incorrect statements	
(ii)	Change in velocity more gradual oe	B1	1		
	Total		**14**		

1(a)	$s=0+\frac{1}{2}\times9.8\times4^{2}$	M1 A1		Full method Correct subs, accept ±9.8
	$s=78.4$ metres	A1	3	CAO (need positive)
(b)	Average speed $=\frac{78.4}{4}$	M1		Also accept full method with use of velocities at $t=0$ and 4, or at $t=2$
	$=19.6\text{ ms}^{-1}$	A1F	2	FT distance
(c)	Only force acting is weight	B1	1	Acc resistance forces negligible or ignored, (not friction, or air friction)
	Total		**6**	

3(a)	$v = u + at$ $0 = 10 + (-0.8) \times t$	M1		Full method with u, v used correctly Accept ± 0.8
	$t = 12.5$ sec	A1	2	CAO (correct subs and answer)
(b)		B1 B1 B1		each line, straight and correct end points SC: B1 for 3 lines giving correct shape but no values shown SC: first error in labelling times loses B1, repeated errors no further penalty
		B1	4	axes labelled v, t
(c)	distance $= \frac{1}{2} \times 10 \times (4 + 22.5)$	M1		Full correct method
		A1F		Correct subs, FT graph if final $t = 12.5$
	$= 132.5$ metres	A1F	3	FT one slip, AWRT 133
(d)	Acceleration unlikely to: change so abruptly or be constant or velocity unlikely to be constant	B1	1	
	Total		**10**	

6(a)	$\mathbf{d} = 3\mathbf{i} - 6\mathbf{j}$	B1		Accept $\pm\mathbf{d}$ or displacements of 3, 6 shown on a diagram
	$3\mathbf{i} - 6\mathbf{j} = (\mathbf{i} - 2\mathbf{j})t$	M1		Or equivalent method for t Accept ratio of vectors leading directly to ± 3
	$t = 3$	A1	3	CAO
(b)(i)	$\mathbf{r} = (\mathbf{i} - 2\mathbf{j}) \times 4 + \frac{1}{2} \times 2\mathbf{j} \times 16$	M1		Full method for vector expression giving change in position
		A1		For correct subs (gives $4\mathbf{i} + 8\mathbf{j}$)
	$+6\mathbf{i} - 4\mathbf{j}$	M1		
	$= 10\mathbf{i} + 4\mathbf{j}$	A1F	4	FT slip provided obtain vector expression $(\mathbf{u} = 0$ gives $6\mathbf{i} + 12\mathbf{j})$
(ii)	$A(3,2)$ $C(10,4)$ $\mathbf{d} = 7\mathbf{i} + 2\mathbf{j}$	M1		Attempt to find vector $\overrightarrow{AC}$ or $\overrightarrow{CA}$ (using candidate's C
	$\lvert\mathbf{d}\rvert = \sqrt{7^2 + 2^2}$ $AC = \sqrt{53} = 7.28$	A1F	2	FT $\mathbf{d}$ provided two non-zero components Accept $\sqrt{53}$
	Total		**9**	

2(a)		B1 B1 B1 B1	4	Starts and finishes at rest Correct shape Correct values on t-axis Correct values on v-axis Condone omission of the origin
(b)	$s=\frac{1}{2}(5+12)\times 2$ **or** $s=\frac{1}{2}\times 2\times 4+5\times 2+\frac{1}{2}\times 2\times 3=17$	M1		Use of the area under the graph (or equivalent) to find s
	$=17$	A1	2	Correct distance **SC** When 21 used instead of 12 allow full marks for $s=26$
(c)	$\max a=\frac{2}{4}=0.5$	B1		Maximum acceleration
	$300\times 0.5=T-300\times 9.8$	M1		Three term equation of motion using their a
		A1		Correct equation using $a=0.5$
	$T=2940+150=3090$	A1	4	Correct tension
			10	

5(a)	$v=\sqrt{0.3^2+0.1^2}=\sqrt{0.1}=0.316\ \text{ms}^{-1}$	M1A1	2	Use of Pythagoras to find v. Correct v
(b)	$\alpha=\tan^{-1}\left(\frac{0.3}{0.1}\right)=71.6°$	M1A1		Use of trigonometry with reasonable choice of sides to find α. Correct expression
		A1	3	Correct angle **CAO**
(i)	$t=\frac{15}{0.3}=50\text{s}$	M1		Use of s/v to find t with s and t consistent
		A1	2	Correct t
(ii)	$s=50\times\sqrt{0.1}=15.8\text{m}$	M1A1	2	Use of their t in $t\times v$ to find s or the use of trigonometry. Correct distance **CAO**
	Total		**9**	

8(a)	$75\mathbf{i} = (5\mathbf{i} - 2\mathbf{j}) \times 10 + \frac{1}{2}\mathbf{a} \times 10^2$	M1		Equation to find **a** from $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$
		A1		Correct expression
	$\mathbf{a} = \frac{75\mathbf{i} - 50\mathbf{i} + 20\mathbf{j}}{50} = 0.5\mathbf{i} + 0.4\mathbf{j}$	A1	3	**AG** Correct **a** from correct working
(b)	$\mathbf{r} = (5\mathbf{i} - 2\mathbf{j}) \times 8 + \frac{1}{2}(0.5\mathbf{i} + 0.4\mathbf{j}) \times 8^2$	M1		Expression for **r** using $t = 8$ with no extra terms
		A1		Correct expressions
	$= 56\mathbf{i} - 3.2\mathbf{j}$	A1	3	Correct position vector
(c)	$\mathbf{v} = (5 + 0.5t)\mathbf{i} + (0.4t - 2)\mathbf{j}$	M1A1		Expression for **v**. Correct expression
	$0.4t - 2 = 0$	dM1		**j** component equal to zero
	$t = \frac{2}{0.4} = 5$	A1		Correct t
	$\mathbf{r} = (5\mathbf{i} - 2\mathbf{j}) \times 5 + \frac{1}{2}(0.5\mathbf{i} + 0.4\mathbf{j}) \times 5^2$	dM1		Expression for **r** using t from **j** component equal to zero
	$= 31.25\mathbf{i} - 5\mathbf{j}$			
	$= 31.3\mathbf{i} - 5\mathbf{j}$	A1	6	Correct position vector
	Total		**12**	

1(a)	$v = 0 + 1.5 \times 9.8$	M1		Use of constant acceleration equation to find v
	$= 14.7 \text{ ms}^{-1}$	A1	2	AG Correct v from correct working $1.5 \times 9.8 = 14.7$ is not enough on its own
(b)	$h = \frac{1}{2} \times 9.8 \times 1.5^2$	M1		Use of constant acceleration equation with $a = 9.8$ to find h
	$= 11.0$ m (to 3 sf)	A1	2	Correct h Allow 11 m; ignore negative signs
(c)	$5^2 = 0^2 + 2 \times 9.8s$	M1		Use of constant acceleration equation with $u = 0$ to find s
		A1		Correct equation
	$s = \frac{25}{19.6} = 1.28$ m (to 3 sf)	A1	3	Correct s Accept 1.27
	OR			
	$t = \frac{5}{9.8} = 0.510$			
	$s = \frac{1}{2}(0 + 5)\frac{5}{9.8} = 1.28$ m			
	OR			
	$s = 0 + \frac{1}{2} \times 9.8 \times \left(\frac{5}{9.8}\right)^2 = 1.28$ m			
	Total		**7**	

5(a)	$V = 150\tan 30°$	M1		Using trigonometry (usually tan or sine rule) to find V
	$= 86.6 \text{ ms}^{-1}$	A1	2	AG Correct answer from correct working (Division by 2 only acceptable if sin30° or cos60° seen)
	OR			
	$\frac{V}{\sin 30°} = \frac{150}{\sin 60°}$ AG			
	$V = 86.6 \text{ ms}^{-1}$			
(b)	$\frac{150}{v} = \cos 30°$	M1		Using trigonometry or Pythagoras to find v
		A1		Correct expression
	$v = \frac{150}{\cos 30°} = 173 \text{ ms}^{-1}$ (to 3sf)	A1	3	Correct answer
	Total		**5**	

8(a)	$\mathbf{u} = 5\mathbf{i}$ or $\begin{bmatrix} 5 \\ 0 \end{bmatrix}$	B1	1	Correct velocity
(b)	$\mathbf{v} = 5\mathbf{i} + (-0.2\mathbf{i} + 0.25\mathbf{j})t$	M1		Use of constant acceleration equation, with **u** and **a** not zero
		A1	2	Correct velocity M1A0 for using 5**j** or just 5
	OR			
	$\mathbf{v} = \begin{bmatrix} 5 - 0.2t \\ 0.25t \end{bmatrix}$			
(c)	$5 - 0.2t = 0$	M1		Easterly component zero
		A1		Correct equation
	$t = \frac{5}{0.2} = 25$ seconds	A1	3	Correct t
(d)	$\mathbf{r} = 5\mathbf{i} \times 25 + \frac{1}{2}(-0.2\mathbf{i} + 0.25\mathbf{j}) \times 25^2$	M1		Use of constant acceleration equation with t from part (c)
		A1F		Correct expression based on t from part (c)
	$= 62.5\mathbf{i} + 78.125\mathbf{j}$	A1		Correct simplification CAO
	$\theta = \tan^{-1}\left(\frac{62.5}{78.125}\right)$	dM1		Using tan to find the angle
		A1F		Correct expression based on t from part (c), with correct two values(either way)
	$= 038.7°$	A1	6	Correct angle Accept 38.6° or 039°
	OR			
	$\mathbf{r} = \frac{1}{2}(5\mathbf{i} + 6.25\mathbf{j}) \times 25$	(M1) (A1F) (A1)		
	$\theta = \tan^{-1}\left(\frac{5}{6.25}\right) = 038.7°$	(dM1) (A1F) (A1)		
	Total		**12**	
