Q1				
(i)	$\rightarrow \quad 40 - P\cos 60 = 0$ $P = 80$	M1 A1 A1	For any resolution in an equation involving P. Allow for $P = 40\cos 60$ or $P = 40\cos 30$ or $P = 40\sin 60$ or $P = 40\sin 30$ Correct equation cao	3
(ii)	$\downarrow \quad Q + P\cos 30 = 120$ $Q = 40\left(3 - \sqrt{3}\right) = 50.7179\ldots$ so 50.7 (3 s. f.)	M1 A1	Resolve vert. All forces present. Allow $\sin \leftrightarrow \cos$ No extra forces. Allow wrong signs. cao	2
				5

Q2				
(i)	Straight lines connecting (0, 10), (10, 30), (25, 40) and (45, 40)	B1 B1 B1	Axes with labels (words or letter). Scales indicated. Accept no arrows. Use of straight line segments and horiz section All correct with salient points clearly indicated	3
(ii)	$0.5(10+30)\times 10 + 0.5(30+40)\times 15 + 40\times 20$ = 200 + 525 + 800 = 1525	M1 M1 A1	Attempt at area(s) or use of appropriate *uvast* Evidence of attempt to find whole area cao	3
(iii)	$0.5\times 40\times T = 1700 - 1525$ so $20T = 175$ and $T = 8.75$	M1 F1	Equating triangle area to 1700 – **their** (ii) (1700 – **their** (ii))/20. Do not award for – ve answer.	2
				8

Q3				
(i)	String light and pulley smooth	E1	Accept pulley smooth alone	1
(ii)	$5g$ (49) N thrust	M1 B1 A1	Three forces in equilibrium. Allow sign errors. for $15g$ (147) N used as a tension $5g$ (49) N thrust. Accept $\pm 5g$ (49). Ignore diagram. [Award SC2 for $\pm 5g$ (49) N without 'thrust' and SC3 if it is]	3
				4

Q4				
(i)	$P - 800 = 20000 \times 0.2$ $P = 4800$	M1 A1 A1	N2L. Allow $F = mga$. Allow wrong or zero resistance. No extra forces. Allow sign errors. If done as 1 equn need m = 20 000. If A and B analysed separately, must have 2 equns with 'T'. N2L correct.	3
(ii)	New accn $4800 - 2800 = 20000a$ $a = 0.1$	M1 A1	$F = ma$. Finding new accn. No extra forces. Allow 500 N but not 300 N omitted. Allow sign errors. FT **their** P	2
(iii)	$T - 2500 = 10000 \times 0.1$ T = 3500 so 3500 N	M1 A1	N2L with new a. Mass 10000. All forces present for A or B except allow 500 N omitted on A. No extra forces cao	2
				7

Q5				
	Take F +ve up the plane $F + 40\cos 35 = 100\sin 35$ F = 24.5915… so 24.6 N (3 s. f.) up the plane	M1 B1 A1 A1	Resolve // plane (or horiz or vert). All forces present. At least one resolved. Allow sin ↔ cos and sign errors. Allow 100g used. Either $\pm 40\cos 35$ or $\pm 100\sin 35$ or equivalent seen Accept $\pm$ 24.5915… or $\pm$90.1237... even if inconsistent or wrong signs used. 24.6 N up the plane (specified or from diagram) or equiv all obtained from consistent and correct working.	4
				4

Q6				
(i)	$(-\mathbf{i}+16\mathbf{j}+72\mathbf{k})+(-80\mathbf{k})=8\mathbf{a}$ $\mathbf{a}=\left(-\frac{1}{8}\mathbf{i}+2\mathbf{j}-\mathbf{k}\right)\text{m s}^{-2}$	M1 E1	Use of N2L. All forces present. Need at least the **k** term clearly derived	2
(ii)	$\mathbf{r}=4(\mathbf{i}-4\mathbf{j}+3\mathbf{k})+0.5\times16\left(-\frac{1}{8}\mathbf{i}+2\mathbf{j}-\mathbf{k}\right)$ $= 3\mathbf{i} + 4\mathbf{k}$	M1 A1 A1	Use of appropriate **uvas***t* or integration (twice) Correct substitution (or limits if integrated)	3
(iii)	$\sqrt{3^2+4^2}=5$ so 5 m	B1	FT **their** (ii) even if it not a displacement. Allow surd form	1
(iv)	$\arctan\frac{4}{3}$ $= 53.130\ldots$ so 53.1° (3 s. f.)	M1 A1	Accept $\arctan\frac{3}{4}$. FT **their** (ii) even if not a displacement. Condone sign errors. (May use arcsin4/5 or equivalent. FT **their** (ii) and (iii) even if not displacement. Condone sign errors) cao	2
				8

Q7				
(i)	8 m s^{-1} (in the negative direction)	B1	Allow $\pm$ and no direction indicated	1
(ii)	$(t+2)(t-4)=0$ so $t = -2$ or 4	M1 A1	Equating v to zero and solving or subst If subst used then both must be clearly shown	2
(iii)	$a = 2t-2$ $a = 0$ when $t = 1$ $v(1) = 1-2-8 = -9$ so 9 m s^{-1} in the negative direction $(1,-9)$	M1 A1 F1 A1 B1	Differentiating Correct Accept -9 but not 9 without comment FT	5
(iv)	$\int_1^4 \left(t^2-2t-8\right)\,\mathrm{d}x$ $=\left[\frac{t^3}{3}-t^2-8t\right]_1^4$ $=\left(\frac{64}{3}-16-32\right)-\left(\frac{1}{3}-1-8\right)$ $= -18$ distance is 18 m	M1 A1 M1 A1 A1	Attempt at integration. Ignore limits. Correct integration. Ignore limits. Attempt to sub correct limits and subtract Limits correctly evaluated. Award if -18 seen but no need to evaluate Award even if -18 not seen. Do not award for -18. cao	5
(v)	$2\times 18 = 36$ m	F1	Award for $2\times$ **their** (iv).	1
(vi)	$\int_4^5 \left(t^2-2t-8\right)\,\mathrm{d}x = \left[\frac{t^3}{3}-t^2-8t\right]_4^5$ $=\left(\frac{125}{3}-25-40\right)-\left(-\frac{80}{3}\right)=3\frac{1}{3}$ so $3\frac{1}{3}+18=21\frac{1}{3}$ m	M1 A1 A1	$\int_4^5$ attempted or, otherwise, complete method seen. Correct substitution Award for $3\frac{1}{3}$ + **their** (positive) (iv)	3
				17

Q8				
(i)	$y = 25\sin\theta t + 0.5\times(-9.8)t^2$	M1	Use of $s = ut + \frac{1}{2}at^2$ .Accept sin, cos, 0.96, 0.28, ± 9.8, ± 10 , u = 25 and derivation of -4.9 not clear.	
	$= 7t - 4.9t^2$	E1	Shown including deriv of – 4.9. Accept $25\sin\theta t = 7t$ WW	
	$x = 25\cos\theta t = 25\times 0.96t = 24t$	B1	Accept $25\times 0.96t$ or $25\cos\theta t$ seen WW	3
(ii)	$0 = 7^2 - 19.6s$	M1	Accept sequence of *uvast*. Accept u=24 but not 25. Allow $u \leftrightarrow v$ and ± 9.8 and ± 10	
	s = 2.5 so 2.5 m	A1	+ve answer obtained by correct manipulation.	2
(iii)	Need $7t - 4.9t^2 = 1.25$ so $4.9t^2 - 7t + 1.25 = 0$	M1	Equate y to **their** (ii)/2 or equivalent.	
		M1	Correct sub into quad formula of their 3 term quadratic being solved (i.e. allow manipulation errors before using the formula).	
	t = 0.209209…. and 1.219361…	A1	Both. cao. [Award M1 A1 for two correct roots WW]	
	need 24× (1.219… - 0.209209…) = 24×1.01... so 24.2 m (3 s.f.)	B1	FT **their** roots (only if both positive)	4
(iv) (A)	$\dot{y} = 7 - 9.8t$	M1	Attempt at $\dot{y}$. Accept sign errors and u = 24 but not 25	
	$\dot{y}(1.25) = 7 - 9.8\times 1.25 = -5.25$ m s^{-1}	A1		
(B)	Falling as velocity is negative	E1	Reason must be clear. FT **their** $\dot{y}$ even if not a velocity Could use an argument involving time.	
(C)	Speed is $\sqrt{24^2 + (-5.25)^2}$	M1	Use of Pythag and 24 or 7 with **their** $\dot{y}$	
	= 24.5675… so 24.6 m s^{-1} (3 s. f.)	A1	cao	5

(v)	$y = 7t - 4.9t^2,\ x = 24t$	M1	Elimination of t	
	so $y = \frac{7x}{24} - 4.9\left(\frac{x}{24}\right)^2$	A1	Elimination correct. Condone wrong notation with interpretation correct for the problem.	
	$y = \frac{7x}{24} - 4.9 \times \frac{x^2}{576} = \frac{0.7x}{576}(240 - 7x)$	E1	If not wrong accept as long as $24^2 = 576$ seen. Condone wrong notation with interpretation correct for the problem.	
	either Need $y = 0$	M1		
	so $x = 0$ or $\frac{240}{7}$ so $\frac{240}{7}$ m	A1	Accept $x = 0$ not mentioned. Condone $0 \le X \le \frac{240}{7}$.	
	or	B1	Time of flight $\frac{10}{7}$ s	
		B1	Range $\frac{240}{7}$ m. Condone $0 \le X \le \frac{240}{7}$.	5
				19