		Mark	Comment	Sub
1(i)	$6\ \text{m s}^{-1}$ $4\ \text{m s}^{-2}$	B1 B1	Neglect units. Neglect units.	2
(ii)	$v(5) = 6 + 4 \times 5 = 26$ $s(5) = 6 \times 5 + 0.5 \times 4 \times 25 = 80$ so 80 m	B1 M1 A1	Or equiv. FT (i) and **their** $v(5)$ where necessary. cao	3
(iii)	distance is 80 + $26 \times (15-5) + 0.5 \times 3 \times (15-5)^2$ = 490 m	M1 **M1** A1	Their 80 + attempt at distance with $a = 3$ Appropriat *uvast* . Allow $t = 15$. FT **their** v(5). cao	3
		8		

		Mark	Comment	
2	$a = 12 - 6t$	M1 A1	Differentiation, at least one term correct.	
	a = 0 gives t = 2	F1	Follow **their** a	
	$x = \int (2 + 12t - 3t^2)\mathrm{d}x$	M1	Integration indefinite or definite, at least one term correct.	
	$2t + 6t^2 - t^3 + C$	A1	Correct. Need not be simplified. Allow as definite integral. Ignore C or limits	
	x = 3 when t = 0	M1	Allow x = ± 3 or argue it is $\int_0^2$ from A then ± 3	
	so $3 = C$ and $x = 2t + 6t^2 - t^3 + 3$	A1	Award if seen WWW or $x = 2t + 6t^2 - t^3$ seen with +3 added later.	
	$x(2) = 4 + 24 - 8 + 3 = 23$ m	B1	FT **their** t and **their** x if obtained by integration but not if -3 obtained instead of +3. [If 20 m seen WWW for displacement award SC6] [Award SC1 for position if constant acceleration used for displacement and then +3 applied]	8
		8		

		mark		sub
3	$(v =)12 - 3t^2$	M1	Differentiating	
		A1	Allow confusion of notation, including $x =$	
	$v = 0 \Rightarrow 12 - 3t^2 = 0$	M1	Dep on 1st M1. Equating to zero.	
	so $t^2 = 4$ and $t = \pm 2$	A1	Accept one answer only but no extra answers. FT only if quadratic or higher degree.	
	$x = \pm 16$	A1	cao. Must have both and no extra answers.	
				5

4		mark	notes
(i) (A)	4 m	B1	
(B)	$12 - (-4) = 16$ m	M1 A1	Looking for distance. Need evidence of taking account of +ve and –ve displacements.
(C)	$1 < t < 3.5$	B1 B1	The values 1 and 3.5 Strict inequality
(D)	$t = 1$, $t = 3.5$	B1 6	Do not award if extra values given.
(ii)	$v = -8t + 8$ $a = -8$	M1 A1 F1 3	Differentiating
(iii)	$8t + 8 = 4$ so $t = 0.5$ so 0.5 s $-8t + 8 = -4$ so $t = 1.5$ so 1.5 s	B1 B1 2	FT **their** v. FT **their** v.
(iv)	**method 1** Need velocity at $t = 3$ $v(3) = -8 \times 3 + 8 = -16$ **either** $v = \int 32\ \mathrm{d}t = 32t + C$ $v = -16$ when $t = 3$ gives $v = 32t - 112$ $y = \int (32t - 112)\mathrm{d}t = 16t^2 - 112t + D$ $y = 0$ when $t = 3$ gives $y = 16t^2 - 112t + 192$ **or** $y = -16 \times (t-3) + \frac{1}{2} \times 32 \times (t-3)^2$ (so $y = 16t^2 - 112t + 192$) **method 2** Since accn is constant, the displacement y is a quadratic function. Since we have $y = 0$ at $t = 3$ and $t = 4$ $y = k(t-3)(t-4)$ When $t = 3.5$, $y = -4$ so $-4 = k \times \frac{1}{2} \times -\frac{1}{2}$ so $k = 16$ (and $y = 16t^2 - 112t + 192$)	 B1 M1 A1 M1 A1 M1 A1 M1 A1 M1 A1 B1 M1 A1 5	 FT **their** v from (ii) Accept $32t + C$ or $32t$. SC1 if $\int_3^4 32\mathrm{d}t$ attempted. Use of **their** -16 from an attempt at v when t=3 FT **their** v of the form $pt + q$ with $p \neq 0$ and $q \neq 0$. Accept if at least 1 term correct. Accept no D. cao Use of $s = ut + \frac{1}{2}at^2$ Use of **their** -16 (not 0) from an attempt at v when t=3 and 32. Condone use of just t Use of $t \pm 3$ cao Use of a quadratic function (condone no k) Correct use of roots k present Or consider velocity at $t = 3$ cao Accept k without y simplified.
		16	

		mark	comment	sub
5(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		

6				
(i)	8 m s^{-1} (in the negative direction)	B1	Allow ± 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