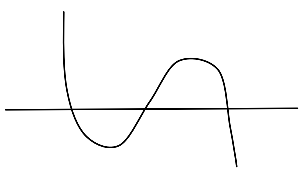
		mark	comment	sub
1(i)	0	B1		1
(ii)	$v = 36 + 6t - 6t^2$	M1 A1	Attempt at differentiation	2
(iii)	$a = 6 - 12t$	M1 F1	Attempt at differentiation	2
(iv)	Take *a* = 0 so $t = 0.5$ and *v* = 37.5 so 37.5 m s^{-1}	M1 A1 A1	Allow table if maximum indicated or implied FT **their** *a* cao Accept no justification given that this is maximum	3
(v)	**either** Solving $36 + 6t - 6t^2 = 0$ so *t* = -2 or *t* = 3 **or** Sub the values in the expression for *v* Both shown to be zero A quadratic so the only roots **then** *x*(-2) = -34 *x*(3) = 91	M1 B1 E1 M1 E1 B1 B1 B1	A method for two roots using **their** *v* Factorization or formula or … of **their** expression Shown Allow just 1 substitution shown Both shown Must be a clear argument cao cao	5
(vi)	$\lvert x(3) - x(0)\rvert + \lvert x(4) - x(3)\rvert$ = $\lvert 91 - 10\rvert + \lvert 74 - 91\rvert$ = 98 so 98 m	M1 A1 A1	Considering two parts Either correct cao [SC 1 for *s*(4) – *s*(0) = 64]	3
(vii)	At the SP of *v* *x*(-2) = -34 i.e. < 0 and *x*(3) = 91 i.e. > 0 Also *x*(-4) = 42 > 0 and *x*(6) = -98 < 0  so three times	M1 B1 B1	Or any other valid argument e.g find all the zeros, sketch, consider sign changes. Must have some working. If only a sketch, must have correct shape. Doing appropriate calculations e.g. find all 3 zeros; sketch cubic reasonably (showing 3 roots); sign changes in range 3 times seen	3
		19		

		mark		Sub
2(i)	$a = 24 - 12t$	M1 A1	Differentiate cao	2
(ii)	Need $24t - 6t^2 = 0$ $t = 0, 4$	M1 A1	Equate $v = 0$ and attempt to factorise (or solve). Award for one root found. Both. cao.	2
(iii)	$s = \int_0^4 \left(24t - 6t^2\right) \mathrm{d}t$ $= \left[12t^2 - 2t^3\right]_0^4$ $\left(12 \times 16 - 2 \times 64\right) - 0$ $= 64$ m	M1 A1 M1 A1	Attempt to integrate. No limits required. Either term correct. No limits required Sub $t = 4$ in integral. Accept no bottom limit substituted or arb const assumed 0. Accept reversed limits. FT **their** limits. cao. Award if seen. [If trapezium rule used. M1 At least 4 strips: M1 enough strips for 3 s. f. A1 (dep on 2nd M1) One strip area correct: A1 cao]	4
	total	8		

3	(i)		$v=\int(4-t)\mathrm{d}t$	M1	Attempt to integrate	
			$v=4t-\frac{1}{2}t^2+c \quad (t=0, v=0 \Rightarrow c=0)$		Condone no mention of arbitrary constant	
			$v=4t-\frac{1}{2}t^2$ for $0 \le t \le 4$	A1		
			When $t=4$, $v=8$ and for $t>4$, $a=0$ so $v=8$ for $t>4$	B1 **[3]**	$a=0$ must be seen or implied	
	(ii)		$s=\int(4t-\frac{1}{2}t^2)\mathrm{d}t$	M1		
			$s=2t^2-\frac{1}{6}t^3$	A1	Again condone no mention of arbitrary constant	
			When $t=4$, Nina has travelled $2\times4^2-\frac{1}{6}\times4^3=21\frac{1}{3}$ m	A1		
			When $t=5\frac{1}{3}$, Nina has travelled $21\frac{1}{3}+8\times1\frac{1}{3}=32$ m	F1 **[4]**	Allow follow through from their $21\frac{1}{3}$ Exact answer required; if rounded to 32, award 0	
	(iii)		When $t=5\frac{1}{3}$, Marie has run $6\times5\frac{1}{3}=32$ m.		Allow an equivalent argument that when Marie has run 32 m, $t=5\frac{1}{3}$, as for Nina	
			Nina has also run 32 m so caught up Marie	B1 **[1]**	This mark is dependent on an answer 32 in part (ii) but allow this where it is a rounded answer and in this particular case the rounding can be in part (iii)	

		mark	notes
4(i)	For P: the distance is $8T$	B1	Allow – ve. Allow any form.
	For Q: the distance is $\frac{1}{2} \times 4 \times T^2$	B1	Allow – ve. Allow any form.
		2	
(ii)	Require $8T + \frac{1}{2} \times 4 \times T^2 = 90$	M1	For linking correct expressions or **their** expressions from (i) with 90. Condone sign errors and use of displacement instead of distance. Condone '= 0' implied.
		A1	The expression is correct or correctly derived from **their** (i). Reason not required.
	so $8T + 2T^2 - 90 = 0$		
	so $T^2 + 4T - 45 = 0$	E1	Must be established. Do not award if **their** 'correct expression' comes from incorrect manipulation.
	This gives		
	$(T - 5)(T + 9) = 0$	M1	Solving to find +ve root. Accept $(T + 5)(T - 9)$.
	so $T = 5$ since $T > 0$	A1	Condone 2^{nd} root not found/discussed but not both roots given.
		5	
		7	

5(i)	$a = 6t - 12$	M1 A1	Differentiating cao	2
(ii)	We need $\int_1^3 (3t^2 - 12t + 14)\,dt$ $= \left[t^3 - 6t^2 + 14t\right]_1^3$ **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 $s(3)$. ca	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