Section A

1		$3-x<4(x-1)$ $\Rightarrow 3-x<4x-4$ $\Rightarrow 7<5x$ $\Rightarrow x>\frac{7}{5}$	B1 B1 B1 **3**	Sight of $4x-4$ Sight of ax and b where either $a=5$ or $b=7$ oe Final answer WWW
2		$=1-\binom{12}{1}x+\binom{12}{2}x^2-\binom{12}{3}x^3$ $=1-12x+66x^2-220x^3$ *Ignore terms of higher power*	B1 B1 B1 **3**	Signs and powers 2 out of 3 coefficients worked out All coefficients and 1
3	**(i)**	Remainder is f(−1) $=-1-5-2+8=0$ *For long division x^3+x^2 in working and x^2 in quotient must be seen for M1* *Or by inspection $(x+1)(x^2+\ldots)$ for M1*	M1 A1 **2**	Or long division 0 must be seen or implied
	(ii)	$x^3-5x^2+2x+8=0$ $\Rightarrow (x+1)(x^2-6x+8)=0$ $\Rightarrow (x+1)(x-2)(x-4)=0$ $\Rightarrow x=-1,2,4$ *Allow ans with no working*	M1 DM1 A1 **3**	Factorise cubic to give $(x+1)(ax^2+bx+c)$ Solve their quadratic
		Alt: Trial to find one root: $x=2, 4$ M1, A1 $\Rightarrow x=-1, 2, 4$ A1		

4	**(i)**	$\left(\frac{5}{6}\right)^4 = \frac{625}{1296} = 0.4823$	M1 A1 **2**	Either form or 0.482 isw
	(ii)	$1-\left(\frac{5}{6}\right)^4 - 4\left(\frac{5}{6}\right)^3\left(\frac{1}{6}\right)$ $= 1 - \frac{625}{1296} - \frac{500}{1296} = 1 - 0.4823 - 0.3858$ $= \frac{171}{1296} = \frac{19}{144} = 0.1319$	M1 B1 B1 A1 **4**	1 − 2 terms 4 soi Powers Ans in either form or 0.132
		Alt: Add three terms M1 $6\left(\frac{5}{6}\right)^2\left(\frac{1}{6}\right)^2 + 4\left(\frac{5}{6}\right)\left(\frac{1}{6}\right)^3 + \left(\frac{1}{6}\right)^4$ B1 both coeffs, B1 powers $= 0.11574 + 0.01543 + 0.00077$ $= 0.1319$ A1 ans		

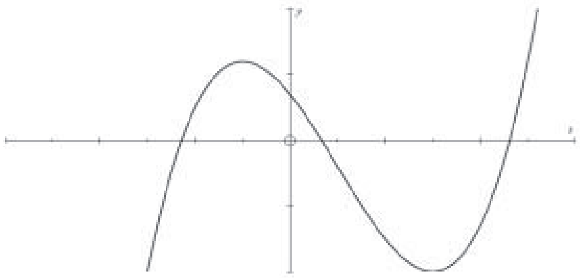
<table>
<tr><td>5</td><td>(i)</td><td>$\frac{dy}{dx} = 3x^2 - 6x - 9$
$= 0$ when $3x^2 - 6x - 9 = 0 \Rightarrow x^2 - 2x - 3 = 0$
$\Rightarrow (x-3)(x+1) = 0 \Rightarrow x = 3, -1$
When $x = -1, y = 12$
$\frac{d^2y}{dx^2} = 6x - 6 < 0$ when $x = -1$ so maximum

Allow SC1 for (–1, 12) with no working</td><td>M1
A1

A1
M1
A1

5</td><td>Diffn and set = 0
Derived fn

Stationary point
To find nature of turning points</td></tr>
<tr><td></td><td></td><td>Alternative ways to demonstrate maximum at $x = -1$
Value of y
<table>
<tr><td>– 1 –</td><td>– 1</td><td>–1 +</td></tr>
<tr><td>$y < 12$</td><td>$y = 12$</td><td>$y < 12$</td></tr>
</table>
M1 A1

Gradient of tangent
<table>
<tr><td>– 1 –</td><td>– 1</td><td>–1 +</td></tr>
<tr><td>$\frac{dy}{dx} > 0$</td><td>$\frac{dy}{dx} = 0$</td><td>$\frac{dy}{dx} < 0$</td></tr>
<tr><td>/</td><td>—</td><td>\</td></tr>
</table>
M1 A1</td><td></td><td>Allow at most one integer either side (typically, $x = –2$, 0 if turning point is correct)</td></tr>
<tr><td></td><td>(ii)</td><td></td><td>B1

1</td><td>General shape:
turning points in correct quadrants
Intercept on y axis in [0,12]
Does not turn back on itself.</td></tr>
<tr><td>6</td><td>(i)</td><td>$u = 90, v = 6, s = 2016$
$\Rightarrow 6^2 = 90^2 + 2a \times 2016$
$\Rightarrow a = -\frac{90^2 - 6^2}{4032} = -\frac{8064}{4032} = -2 \text{ m s}^{-2}$</td><td>M1
A1
A1

3</td><td>Using correct formula
Correct substitution</td></tr>
<tr><td></td><td>(ii)</td><td>$u = 90, v = 6, a = -2$
$\Rightarrow 6 = 90 - 2t$
$\Rightarrow t = \frac{84}{2} = 42$ secs
The two parts can be the other way round</td><td>M1

A1

2</td><td>Using correct formula</td></tr>
</table>

7	(i)	$\frac{\sin\theta}{\cos\theta}+\frac{\cos\theta}{\sin\theta}=\frac{\sin^2\theta+\cos^2\theta}{\sin\theta\cos\theta}$ $=\frac{1}{\sin\theta\cos\theta}$	B1 **1**	
		Alt: $\sin^2\theta+\cos^2\theta=1$ $\Rightarrow \sin\theta+\frac{\cos^2\theta}{\sin\theta}=\frac{1}{\sin\theta}$ $\Rightarrow \frac{\sin\theta}{\cos\theta}+\frac{\cos\theta}{\sin\theta}=\frac{1}{\sin\theta\cos\theta}$		
	(ii)	$\sin\theta\cos\theta=\frac{1}{4}\Rightarrow\frac{\sin\theta}{\cos\theta}+\frac{\cos\theta}{\sin\theta}=4$ $\Rightarrow \tan\theta+\frac{1}{\tan\theta}=4$	M1 A1 **2**	Using **(i)** and tan
	(iii)	$\tan\theta+\frac{1}{\tan\theta}=4\Rightarrow\tan^2\theta+1=4\tan\theta$ $\Rightarrow t^2-4t+1=0$ $t=\frac{4\pm\sqrt{16-4}}{2}=2\pm\sqrt{3}\ \ (=3.732 \text{ and } 0.268)$ $\Rightarrow \theta=15^0 \text{ and } 75^0$ *Sp Case B1 for 15 and B1 for 75 with no supporting working*	M1 M1 A1 A1 **4**	Clear fractions to give 3 term quadratic Sub numbers into correct quadratic 3sf or more Rounds to these
8		$v=60\left(t^4-10t^3+25t^2\right)$ $\Rightarrow s=\int_0^5\left(60t^4-600t^3+1500t^2\right)\mathrm{d}t$ $=\left[12t^5-150t^4+500t^3\right]_0^5$ $=6250$ m If 60 is left out then 4/5 only.	M1 A2,1 DM1 A1 **5**	Integrate Terms 1 each error Sub t = 5 Cao

9	(i)	Centre is $\left(\frac{1+15}{2},\frac{3+1}{2}\right)=(8,2)$ Nb Working with vectors to give diameter = [14,2] and so radius = [7,1] giving centre (15 – 7, 3 –1) is correct.	B1 B1 **2**	For 8 WWW For 2 WWW
	(ii)	$\lvert PC\rvert=\sqrt{(8-1)^2+(2-3)^2}=\sqrt{50}=5\sqrt{2}$	M1 A1 **2**	For $\sqrt{50}$
		Alt: Length of diameter = $\sqrt{(15-1)^2+(3-1)^2}=\sqrt{14^2+2^2}$ $=\sqrt{200}=10\sqrt{2}$ $\Rightarrow$ Radius = $5\sqrt{2}$		
	(iii)	$(x-8)^2+(y-2)^2=50$ $\Rightarrow x^2+y^2-16x-4y+64+4-50=0$ $\Rightarrow x^2+y^2-16x-4y+18=0$	M1 A1 **2**	Correct use of formula including 50 and using their midpoint.
10	(i)	Sub (0,4) Gives $k=\frac{1}{2}$	M1 A1 **2**	
	(ii)	Sub (0, 4) Gives $c=-\frac{1}{4}$	M1 A1 **2**	
	(iii)	When $x = 3$ $y=-\frac{1}{4}(3-2)^2(3-4)=0.25$ for cubic Or when x= 3, y > 0 for cubic John's model is better	B1 DB1 **2**	

Section B

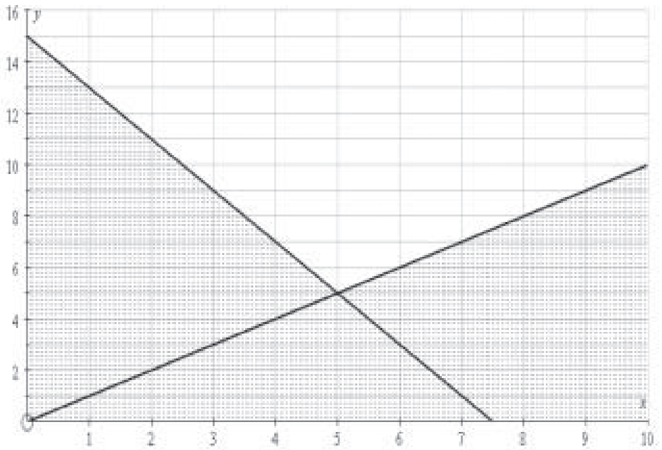
Allow 4 sf in this question

11	**(i)**	$\frac{AF}{\sin 70} = \frac{BF}{\sin 60} = \frac{100}{\sin 50}$ $\Rightarrow AF = \frac{100}{\sin 50} \times \sin 70 \ (= 122.7 \text{ m})$ $\Rightarrow BF = \frac{100}{\sin 50} \times \sin 60 = 113.1 \text{ m}$ oe	M1 A1 A1 M1 A1 **5**	Sin rule applied Sight of 50 and 70 Correct sine rule to find BF
		Alt: Cosine rule for BF: M1 $BF^2 = 100^2 + 122.7^2 - 2\times100\times122.7\times\cos60$ $= 12785$ BF = 113.1 A1		
	(ii)	$FT = AF \times \tan 10$ $= 122.7 \tan 10 = 21.6 \text{ m}$ *Anything that rounds to 21.6*	M1 A1 **2**	
	(iii)	$CF = 122.7\sin60$ $=106.3$ m Or: $= their\ BF \times \sin70$ $\Rightarrow \tan\theta = \frac{TheirFT}{TheirCF}$ $\Rightarrow \theta = 11.5^0$	M1 A1 M1 F1 A1 **5**	 Accept 106.2 or 106 Using tan correctly Substituting correctly Accept 11 or 12
		Alt: to find CF. Area of triangle $= \frac{1}{2} \times AF.AB \sin 60 = 5313$ M1 $\Rightarrow \frac{1}{2} \times CF \times 100 = 5313 \Rightarrow CF = 106.3$ A1		

12	**(i)**	$y=0.3x^2-1.5x$		
		$\frac{dy}{dx}=0.6x-1.5$	B1	Derivative
		When $x=5$ $g_t=1.5$	M1	Find g_t and use of $m_1 \times m_2=-1$
		$\Rightarrow g_n=-\frac{2}{3}$	A1	For g_n
		AB: $y=-\frac{2}{3}(x-5)$ $\Rightarrow 2x+3y=10$	A1 **4**	Line in any simplified form
	(ii)	Solve simultaneously: $3y+2x=10$ $2y+3x=0$ $6y+4x=20$ $6y+9x=0$ $5x=-20$ $\Rightarrow x=-4, y=6$ SC1: answer with no working	M1 F1 A1 **3**	Method to eliminate one variable x and y.
	(iii)	Area of triangle = $\frac{1}{2}\times5\times \textit{their } y=15$	E1	Might appear anywhere in this part
		Area under curve = $\int_0^5 (0.3x^2-1.5x)\,dx$	M1	Ignore limits here
		$=\left[0.1x^3-0.75x^2\right]_0^5$	A1	
		$=-6.25$	A1	Condone lack of –ve sign
		$\Rightarrow$ Area of card $=15+6.25=21.25$ *Other methods, follow scheme* *ieE1 Area of triangle* *M1 area as integral* *A1 Integrand* *A1 value for area* *A1 Final answer*	A1 **5**	

13	(i)	Ali: $\frac{72}{t}$ Beth: $\frac{72}{t+2}$	M1 A1 A1 **3**	Accept Beth: $\frac{72}{t}-3$
	(ii)	$\frac{72}{t}-\frac{72}{t+2}=3$ $\Rightarrow 72(t+2)-72t=3t(t+2)$ $\Rightarrow 72t+144-72t=3t(t+2)$ $\Rightarrow 3t(t+2)=144$	M1 A1 M1 A1 A1 **5**	Subtraction of their terms = 3 Multiply out and simplify
		Alternative (based on alternative answer to (i) $\frac{72}{\frac{72}{t}-3}=t+2$ M1 A1 $\Rightarrow 72t=(72-3t)(t+2)$ $\Rightarrow 72t=72t-3t^2+144-6t$ M1 A1 $\Rightarrow 3t^2+6t=144 \Rightarrow 3t(t+2)=144$ A1		
	(iii)	$3t(t+2)=144$ $\Rightarrow 3t^2+6t-144=0$ $\Rightarrow t^2+2t-48=0$ $\Rightarrow (t+8)(t-6)=0$ $\Rightarrow t=6$ $\Rightarrow$ Ali takes 6 hours and Beth takes 8 hours. SC1 for answer with no working	M1 A1 A1 A1 **4**	 For quadratic in simplified form. (See below) www

What is "simplified form"?
Either a quadratic with all three terms on left = 0 ready for the use of the formula
OR:
Divide through by 3 giving $t^2 + 2t = 48$ ready for solving by the completion of the square.

14	**(i)**	$200x + 100y \geq 1500$ oe	M1 A1 **2**	Deriving a linear inequality
	(ii)	$y \geq x$	B1 **1**	
	(iii)		B1 B1 E1 **3**	One line Other line Shading for both, ft their inequalities No Scales: B0, B0, E1 Condone scales not as instructed.
	(iv)	$C = 80x + 60y$ Correct point is (5, 5) Cost = £700 *In absence of OF, 80 ×5 + 60× 5 must be seen*	B1 B1 M1 A1 **4**	 Sub in OF
	(v)	Now minimum cost is at (7, 1) Giving £620 Nb (8, 0) gives £640	B1 B1 **2**	