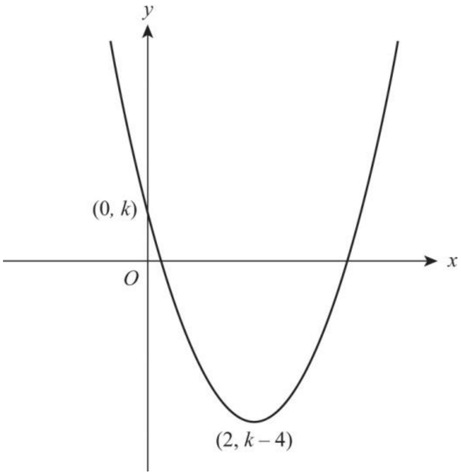
Q	Answer	Mark	Comments
1 a	$\mathrm{f}(2)=8-36+52-24=0$	M1	Substitution (seen or implied) to indicate use of factor theorem
		A1	Must be evaluated
		OR	
		M1 A1	Long division to show $(x-2)$ is a factor
b	$\begin{array}{r} x^2-7x+12 \\ (x-2)\overline{\big)\,x^3-9x^2+26x-24} \end{array}$	M1	Long division or inspection
	$\mathrm{f}(x)=(x-2)(x^2-7x+12)$	M1	Express as product of linear factor and three-term quadratic (with at least 2 correct terms)
	$\mathrm{f}(x)=(x-2)(x-3)(x-4)$	A1	Correct factors
2 a i	$a=2$	B1	
a ii	$b=16$	B1	
b	$\log_3(2x)=\log_3\left(\frac{6}{x}\right)$	M1	Use rules of log laws to combine RHS
	$2x=\frac{6}{x}$	M1	Forming an equation in x
	$x=\sqrt{3}$	A1	Note: $x=\pm\sqrt{3}$ is *not* correct since x cannot be negative
3	$\frac{\mathrm{d}y}{\mathrm{d}x}=6x^2+6x-4$	M1	Attempt at differentiating equation of curve
		A1	Correct expression obtained for derivative
	At $x=1$, $m_{\text{tangent}}=6\times1^2+6\times1-4=8$	M1	Use of derivative to find gradient of tangent at $x=1$
	At $x=1$, $m_{\text{normal}}=-\frac{1}{m_{\text{tangent}}}=-\frac{1}{8}$	A1	Use of $m_{\text{normal}}\times m_{\text{tangent}}=-1$ for $\perp$ lines
	$y(1)=2\times1^3+3\times1-4\times1-1=0$	B1	Evaluate y at $x=1$
	$y=-\frac{1}{8}(x-1)$		
	$y=\frac{1}{8}-\frac{1}{8}x$	A1	Or equivalent form of this straight line

4	$f'(x)=3x^2-4x+3$	A1	Derivative completely correct
	Discriminant ⇒ $16-4\times3\times3=-20<0$	M1	Evaluate b^2-4ac and show it is less than zero
	Hence $f'(x)=0$ has no solutions, and so there are no turning points on the graph.	R1	Make a deduction and conclude
		R1	A completely correct argument which is clear and easy to follow
5 a	$1 + 7(-x^2) + 21(-x^2)$	M1	Must have coefficients
	$1 - 7x^2 + 21x^4$	A1	All three terms correct
b	${}^7C_5 \times (1)^2 \times (-1)^5$	M1	Including either ${}^7C_5$ or 21
	$=-21$	A1	
6 a	$\frac{1}{\cos^2\theta}-\tan^2\theta$		
	$\equiv\frac{1}{\cos^2\theta}-\left(\frac{\sin\theta}{\cos\theta}\right)^2$	M1	Use of $\frac{\sin\theta}{\cos\theta}=\tan\theta$
	$\equiv\frac{1-\sin^2\theta}{\cos^2\theta}$		
	$\equiv\frac{\cos^2\theta}{\cos^2\theta}$	M1	Use of $\sin^2\theta=1-\cos^2\theta$
	$\equiv 1$	A1	Complete proof
		R1	A completely correct argument which is clear and easy to follow
b	$2\cos x=\frac{1}{\cos^2 x}-\tan^2 x=1$	M1	Use of result from **a**
	$\cos x=\frac{1}{2}$	M1	
	$x=-60°,\ 60°$	A1	Both solutions required
7	$f'(x)=\lim_{h\to0}\frac{f(x+h)-f(x)}{h}$	M1	Use of definition of derivative
	$=\lim_{h\to0}\frac{3(x+h)^2-3x^2}{h}$	M1	Substitute $f(x)=3x^2$
	$=\lim_{h\to0}\frac{3x^2+6xh+3h^2-3x^2}{h}$		
	$=\lim_{h\to0}(6x+3h)$	A1	Simplified expression
	$=6x$	B1	Let $h\to0$ and conclude
		R1	Complete and accurate proof

8 a	$\lvert\mathbf{p}\rvert=\sqrt{3^2+4^2}=5$	M1	
	A vector parallel to **p** with magnitude 20 is 4**p** = 16**i** – 12**j**	M1 A1	Recognising required vector is 4**p** Correctly calculating 4**p**
b	$\hat{\mathbf{p}}=\frac{1}{5}\mathbf{p}=\frac{4}{5}\mathbf{i}-\frac{3}{5}\mathbf{j}$	M1	Recognising required vector is $\frac{1}{5}\mathbf{p}$
		A1	Correctly calculating $\frac{1}{5}\mathbf{p}$
9	$\lvert AB\rvert=\sqrt{3^2+1^2}=\sqrt{10}$	M1	Attempt at finding distance between any two points
	$\lvert BC\rvert=\sqrt{1^2+5^2}=\sqrt{26}$	A1	Distance between any two points correctly calculated
	$\lvert AC\rvert=\sqrt{2^2+4^2}=\sqrt{20}$	A1	All three distances between A, B and C correctly calculated
	$\cos ABC=\dfrac{10+26-20}{2\times\sqrt{10}\times\sqrt{26}}=0.4961...$	M1	Use of cosine rule with “their” lengths
	$ABC = 60.3°$	A1	
10 a	$\mathrm{f}\left(x\right)=\left(x-2\right)^2+k-4$	B1	Seen or implied
		B1 B1 B1	Correct shape of graph *y*-intercept labelled at $\left(0,\ k\right)$ Minimum point labelled at $\left(2,\ k-4\right)$
b	$x^2-4x+k=-2$ $x^2-4x+\left(k+2\right)=0$	M1	Equating $\mathrm{f}\left(x\right)=-2$ and forming three term quadratic in *k*
	$16-4\left(k+2\right)>0$	M1	Use of $b^2-4ac>0$ for quadratic to have two distinct solutions
	$k<2$	A1	

11 a	$V=(30-2x)(25-2x)x$	M1	At least two factors correct
	$=4x^3-110x^2+750x$	A1	
b	$\frac{\mathrm{d}V}{\mathrm{d}x}=12x^2-220x+750=0$ at max. V	M1	Attempt to differentiate V and equate to 0
		A1	Expression for $\frac{\mathrm{d}V}{\mathrm{d}x}$ correct
	$x=\frac{220\pm\sqrt{220^2-4(12)(750)}}{24}$	M1	Use of quadratic formula
	$x=4.5268...$ or $x=13.806...$	A1	Both solutions found
	$\frac{\mathrm{d}^2V}{\mathrm{d}x^2}=24x-220$	M1	Expression for $\frac{\mathrm{d}^2V}{\mathrm{d}x^2}$ correct
	$\left.\frac{\mathrm{d}^2V}{\mathrm{d}x^2}\right\|_{x=4.5268}<0 \Rightarrow$ max. at $x=4.5268$	A1	Determine $x=4.5268$ is a max.
	$V(4.5268)=$ $(30-2(4.5268))(25-2(4.5268))(4.5268)$	M1	Substitution of $x=4.5268$ into expression for V
	$V=1512\text{ cm}^3$	A1	Appropriate degree of accuracy
12	$(x+1)^2+(y-2)^2=16$	B1	Attempt to write circle as $(x+a)^2+(y-b)^2=r^2$
		B1	Equation of circle correct
	$(x+1)^2+(2x-2)^2=16$	M1	Substitute $y=2x$ into equation for circle
	$5x^2-6x+5=16$	M1	Attempt at expansion and simplification
	$5x^2-6x-11=0$	A1	Correct three term quadratic
	$(x-1)(5x-11)=0$	M1	Factorise or formula
	$x=-1$ or $\frac{11}{5}$	A1	Accept decimal equivalent
	$y=-2$ or $\frac{22}{5}$	A1	Accept decimal equivalent
	$\|AB\|=\sqrt{\left(\frac{11}{5}+1\right)^2+\left(\frac{22}{5}+2\right)^2}=7.16$	M1 A1	

13 a	Gradient $=-\frac{2}{3}$	B1	
b	$y-1=$ "their **a**"$(x-1)$	FT1	
	$y=-\frac{2}{3}x+\frac{5}{3}$	M1	Attempt to write equation in the form $y=mx+c$ (where *m* and *c* are clear fractions) **or** $ay=bx+c$ (if already multiplied thro by denominator). *m* must be correct
	$2x+3y=5$	A1	
c	$x^2-4x-3=-\frac{2}{3}x+\frac{5}{3}$	M1	Equating *y* or substituting
	$3x^2-10x-14=0$	A1	Forming a correct three term quadratic in this, or equivalent, form
	$x=\frac{10\pm\sqrt{100+168}}{6}$	M1	Use of quadratic formula to solve "their" quadratic
	$x=\frac{5\pm\sqrt{67}}{3}$	A1	
14 a	$AC^2=12^2+15^2-2\times12\times15\times\cos 64°$	M1	Use of cosine rule with correct lengths/angle substituted
	$AC=14.5\text{ m}$	A1	
	$\text{Area}=\frac{1}{2}\times12\times15\times\sin 64°$	M1	Use of $\text{Area}=\frac{1}{2}ab\sin C$ with correct lengths/angle substituted
	$\text{Area}=80.9\text{ m}^2$	A1	
b	$\text{Depth}=5\text{ m}^3\div80.9\text{ m}^2=0.0168\text{ m}$ (to 3 sf)	M1 A1	
15	$(2x-1)(x+2)=0$	M1	Factorise (or formula) to find limits
	$x=0.5,\ -2$	A1	Correct limits
	$\int_{-2}^{0.5}(2x^2+3x-2)\,\mathrm{d}x$	M1	Attempt to integrate curve (ignore limits)
	$=\left[\frac{2}{3}x^3+\frac{3}{2}x^2-2x\right]_{-2}^{0.5}$	A1	Expression integrated correctly (ignore limits)
	$=\left(\frac{2}{3}(0.5)^3+\frac{3}{2}(0.5)^2-2(0.5)\right)$ $-\left(\frac{2}{3}(-2)^3+\frac{3}{2}(-2)^2-2(-2)\right)$	M1	Attempt to evaluate with "their" limits
	$=(-)5.208\text{ cm}^2$	A1	Correct value, with or without minus sign

	5.208 × £ 35.50 × 50 = £ 9244.24	M1 A1	Correct three terms multiplied together Correct cost obtained (rounding may vary)
16	Use of factor theorem to find a factor of $n^3+6n^2+11n+6$	M1	
	Attempt to fully factorise $n^3+6n^2+11n+6$	M1	Accept an attempt to write the expression as product of linear factor and three term quadratic
	$(n+1)(n+2)(n+3)$	A1	Three correct linear factors
	Factors are **consecutive** numbers for all *n*. Since in any set of three consecutive numbers, one must be a multiple of three, the expression must be divisible by three for all *n*.	A1 R1	Must state **consecutive** Completes rigorous and well-explained proof