Question	Scheme		Marks
1	$b^2 - 4ac < 0$ $(3k + 1)^2 + 4k < 0$	Correct use of discriminant.	M1
	$9k^2 + 10k + 1 < 0$	Forms quadratic inequality.	A1
	$(9k + 1)(k + 1) < 0$ or $k = \dfrac{-10 \pm \sqrt{10^2 - 4 \times 9 \times 1}}{2 \times 9}$	Attempts to find critical values by solving the quadratic.	M1
	$k = -1, -\dfrac{1}{9}$		A1
	$-1 < k < -\dfrac{1}{9}$		A1
			5 marks
2 (a)	$(x-2)^2 + (y+1)^2 = 20$	Rearranges equation and attempts to complete the square for terms in either x or y.	M1
	$C(2, -1)$	Correct coordinates given.	A1
	$r = \sqrt{20}$ (or $2\sqrt{5}$)	Exact value of radius seen. Ignore subsequent rounding.	A1
			3
(b)	$4^2 + (-5)^2 - 4 \times 4 + 2 \times (-5)$ $= 15$ [∴ P lies on the circle.]	Correct substitution of $x = 4$ and $y = -5$.	A1
			1
(c)	Gradient of radius $= \frac{-4}{2} = -2$	Correct value seen.	B1
	Gradient of tangent $= \frac{1}{2}$	Finds negative reciprocal of *their* radius gradient.	M1
	$y + 5 = \dfrac{1}{2}(x - 4)$ or $-5 = \dfrac{1}{2} \times 4 = c$	Substitutes *their* tangent gradient and $x = 4$ and $y = -5$ into either $(y - y_1) = m(x - x_1)$ or $y = mx + c$. This M1 dependent on previous M1.	dM1
	$y = \frac{1}{2}x - 7$ or $x - 2y - 14 = 0$	A correct equation seen. Do not penalise subsequent incorrect versions.	A1
			4
			8 marks
3 (a)	$2x = 240°, 300°, 600°, 660°$	Evidence of finding values of 2x in range $0° \leq x \leq 720°$ (e.g. sketch of sine curve, CAST)	M1
	$x = 120°, 150°, 300°, 330°$	First A1 for two correct values. Second A1 for all four values.	A1 A1
			3
(b)	$2(1 - \sin^2\theta) + \sin\theta = 1$	Attempts to use $\sin^2\theta + \cos^2\theta = 1$	M1

		to form quadratic equation in $\sin x$.	
	$2\sin^2\theta - \sin\theta - 1 = 0$	Correct quadratic equation.	A1
	$\sin\theta = -\frac{1}{2}, 1$	Finds two roots of quadratic equation.	A1
	$\theta = \frac{\pi}{2}, \frac{7\pi}{6}, \frac{11\pi}{6}$ or $\theta = 1.57, 3.67, 5.76$	First A1 for any correct value of θ. Second A1 for three correct values. (Accept decimal equivalents and ignore any values outside the range).	A1 A1
			5
			8 marks
4	$f(1) = 1^3 + a + b + 8 = 0$ $f(2) = 2^3 + 4a + 2b + 8 = 0$	Evidence of use of factor theorem.	M1
	$a + b = -9$ $2a + b = -8$	Simplifies to form at least one correct equation.	A1
		Attempts to solve *their* simultaneous equations	M1
	$a = 1, b = -10$	Correct values.	A1
			4 marks
	ALTERNATIVE METHOD		
	$f(x) = (x^2 - 3x + 2)(x + 4)$	Expresses correctly as product of quadratic and linear function.	M1
	$f(x) = x^3 + x^2 - 10x + 8$	Expands to form correct cubic equation.	A1
		Equates coefficients.	M1
	$a = 1, b = -10$	Correct values.	A1
			4 marks
5(a)	$y = (x + 1)^2 - 2(x + 1) + 4$	Evidence of use of $g(x + 1)$.	M1
	$y = x^2 + 3$	Expands and simplifies to form correct equation.	A1
			2
(b)	$y = 2(x^2 - 2x + 4)$	Evidence of use of $2g(x)$ (may be implied by correct answer).	M1
	$y = 2x^2 - 4x + 8$		A1
			2
			4 marks
6 (a)	$A = 2\pi rh + 2\pi r^2$ $(V =)\pi r^2 h = 500$	Forms correct equations for A and V.	B1
	$h = \frac{500}{r^2}$	Uses a correct method to eliminate h from surface area equation.	M1
	$A = 2\pi r^2 + \frac{1000}{r^2}$	Convincing algebraic manipulation.	A1
			3
(b)	$\frac{dA}{dr} = 4\pi r - \frac{1000}{r^2}$	Differentiates correctly.	B1
	Minimum when $\frac{dA}{dr} = 0$ $r^3 = \frac{1000}{4\pi}$	Puts their $\frac{dA}{dr} = 0$ and attempts to solve.	M1
	$r = 4.30$	Correct value.	A1
			3

(c)	$A = 2\pi(their\ r)^2 + \dfrac{1000}{(their\ r)}$		M1
	$A = 349$ cm^2	Ignore units.	A1
			2
			8 marks
7	$y = \int 6x^2 - 2x + 3\ dx$	Evidence of use of integration. As seen here or at least 2 correctly integrated terms.	M1
	$(y =)2x^3 - x^2 + 3x(+c)$	Correct integral.	A1
	$c = -2$	Substitutes $x = 1, y = 2$ to find c. Both *x* and *y* seen to be substituted, or no more than one error out of the five terms.	M1
	$y = 2x^3 - x^2 + 3x - 2$	'*y* =' now required.	A1
			4 marks
8 (a)	$\log x - \log y^3 + \log z^4$	Use of power rule for logs.	M1
	$\log \dfrac{xz^4}{y^3}$	cao	A1
			2
(b)	$\ln \frac{2x+1}{x} = 2$	Forms single logarithm.	M1
	$\dfrac{2x+1}{x} = e^2$	e^2 seen in a correct context	M1
	$x = \dfrac{1}{e^2 - 2}$	Correct rearrangement.	A1
			3
			5 marks
9 (a)	$y < 1$ or $f(x) < 1$		B1
			1
(b)	$x = \dfrac{-1}{y-1}$	Evidence of rearrangement and intention to change the subject	M1
	$f^{-1}(x) = \dfrac{-1}{x-1}$	Do not allow y or $f(x) = \ldots$	A1
	Domain: $x < 1$	Follow through from their (a)	B1
	Range: $y > 0$ or $f^{-1}(x) > 0$	If x and y wrong way round, penalise 1 mark	B1
			4
			5 marks
10	$\dfrac{dy}{dx} = v\dfrac{du}{dx} + u\dfrac{dv}{dx}$	Attempts to use product rule. Given for any form of the product rule written, or an attempt to substitute into the formula if du/dx and dv/dx seen, or an attempt to substitute into the formula where at least one of the derivatives is correct.	M1
	$u = e^{2x}$ $(\dfrac{du}{dx} =)2e^{2x}$	Differentiates e^{2x} correctly.	B1
	$v = \sin^2 x$	Differentiates $\sin^2 x$ correctly.	B1

	$(\frac{dv}{dx} =)2\sin x\cos x$		
	$\frac{dy}{dx} = \sin^2 x \times 2e^{2x} + e^{2x} \times 2\sin x\cos x$	Substitutes *their* u, v, $\frac{du}{dx}$, $\frac{dv}{dx}$ correctly into product rule formula.	M1
	$\frac{dy}{dx} = 2e^{2x}\sin^2 x + 2e^{2x}\sin x\cos x$ $\frac{dy}{dx} = 2e^{2x}\sin x\,(\sin x + \cos x)$	Correct working leading to answer given. $\frac{dy}{dx}$ must be seen at some point in the working.	A1
			5 marks
11	$x^2 - x - 2 = 0$	Equates the two functions to form this quadratic equation.	M1
	$x = 2, -1$		A1
	Area under $y = 5 + 3x - x^2$: $A = \int_{-1}^{2} 5 + 3x - x^2\,dx$	Attempts to find area under one of the curves using integration between *their* limits.	M1
	$A = \left[5x + \frac{3x^2}{2} - \frac{x^3}{3}\right]_{-1}^{2}$	Integrates one of the functions correctly.	A1
	$A = \frac{33}{2}$		A1
	Area under $y = x^2 + x + 1\,dx$: $A = \int_{-1}^{2} x^2 + x + 1\,dx$ $A = \left[\frac{x^3}{3} + \frac{x^2}{2} + x\right]_{-1}^{2}$	Integrates the other function correctly.	B1
	$A = \frac{15}{2}$		A1
	Shaded area $= \frac{33}{2} - \frac{15}{2}$	Finds difference between *their* two areas.	M1
	Shaded area $=\ 9$		A1
	ALTERNATIVE METHOD		
	$x^2 - x - 2 = 0$	Equates the two functions to form this quadratic equation.	M1
	$x = 2, -1$		A1
	$f(x) = x^2 + x + 1 - (5 + 3x - x^2)$ or $f(x) = 5 + 3x - x^2 - (x^2 + x + 1)$	Subtracts one equation from the other.	M1
	$f(x) = 2x^2 - 2x - 4$ or $f(x) = -2x^2 + 2x + 4$		A1
	$A = \int_{-1}^{2} 2 - 2x - 4\,dx$ or $A = \int_{-1}^{2} -2x^2 + 2x + 4\,dx$		M1
	$A = \left[\frac{2x^3}{3} - x^2 - 4x\right]_{-1}^{2}$ or		A1

	$A = \left[-\frac{2x^3}{3} + x^2 + 4x\right]_{-1}^{2}$		
	$A = \left(\frac{2}{3} \times 2^3 - 2^2 - 4 \times 2\right) - \left(\frac{2}{3} \times (-1) - (-1)^2 - 4 \times (-1)\right)$ or $A = \left(-\frac{2}{3} \times 2^3 + 2^2 + 4 \times 2\right) - \left(-\frac{2}{3} \times (-1) + (-1)^2 + 4 \times (-1)\right)$		A1
	$A = -9$ or $A = 9$		A1
	Shaded area = 9		A1
			9 marks
12 (a)	$v_x = 30\cos 40°$ $v_x = 22.98 \ldots$	Writes correct expression for horizontal or vertical component of 30 ms^{-1}.	B1
	$t = \frac{34}{22.98 \ldots}$	Divides 34 by *their* v_x.	M1
	$t = 1.479 \ldots$ $t = 1.48$		A1
			3
(b)	$v_y = 30\sin 40° - 9.8 \times (their\ t)$	Correct use of $v = u + at$ to find v_y.	M1
		Uses $30\sin 40°$ when considering vertical motion.	B1
	$v_y = 4.784 \ldots.$		A1
	$v_y = 4.78$ ms^{-1}	Answer rounded correctly, and units given.	
			3
(c)	Vector triangle using *their* v_x and v_y.	Evidence of attempt to combine v_x and v_y to find speed or angle.	M1
	$v = \sqrt{4.79^2 + 22.98^2}$ $v = 23.5$ ms^{-1}		A1
	$\theta = 11.8°$ above the horizontal.		M1 Uses correct triangle with their Vy A1
			3
			10 marks

13 (a)			
	$R + T\sin 20° = 50g\cos 30°$	Resolves forces perpendicular to slope – sin and cos wrong way round ok, +ve and –ve incorrect, ok.	M1
		Correct equation.	A1
	$T\cos 20° = 50g\sin 30° + F$	Resolves forces parallel to slope correctly.	M1 A1
	$T = \dfrac{50g\sin 30° + 0.25R}{\cos 20°}$	Uses $F = \mu R$ **and** attempts to solve the two simultaneous equations to find T.	M1
	$T = 342$ N		A1
			6
(b)			M1
	$T\cos 20° - 50g\sin 30° - F = 50 \times 5$	Method: Correct form of equation	M1 A1
	$R + Tsin20° = 50gcos30°$	Substitutes *their* R **and** attempts to rearrange to find T.	M1
	$T = 586$ N		A1
			4
			10 marks
14	$\bar{y} = \dfrac{124}{25} = 4.96$		B1
	$\sigma_y = \sqrt{\dfrac{746}{25} - (their\ \bar{y})^2}$	Substitutes summary statistics correctly into formula for standard deviation.	M1
	$\sigma_y = 2.29$	awrt	A1
	$\bar{x} = 14.92$		B1
	$\sigma_x = 4.58$	awrt	A1
			5 marks
15	$H_0: p = 0.2$ $H_1: p < 0.2$	Uses p to write **both** hypotheses.	B1
	$X \sim B(40{,}0.2)$	Writes or uses $B(40{,}0.2)$	M1
	$P(X \leq 3) = 0.0285$ or Critical region of $X \leq 3$		A1
	$[0.0285 < 0.05]$ significant, reject H_0	Do not allow conflicting statements.	M1
	There is evidence to support the suppliers' **claim**. or The probability of a **ball** failing the bounce **test** is **less** than **0.2**.	Writes a correct contextual conclusion (to include the words in bold).	A1
			5 marks
16	$P(A\|B) = \dfrac{P(A \cap B)}{P(B)}$	Attempts to use formula for conditional probability.	M1
	$P(A \cap B) = \dfrac{3}{7} \times \dfrac{7}{10}$ $= 0.3$		A1
	Venn diagram	Correct diagram (in a box) with 0.2, 0.3, 0.4 and 0.1.	B1
	$P(A) \times P(B) \neq P(A \cap B)$		M1
	$P(A) \times P(B) = 0.5 \times 0.7$ $= 0.35$		A1

	$0.35 \neq 0.3$ ∴ Not independent.		
	ALTERNATIVE METHOD		
	$P(A\|B) \neq P(A)$		M1
	$\frac{3}{7} \neq 0.5$ ∴ Not independent.		A1
			5 marks