Paper 2 Option D

Further Pure Mathematics 1 Mark Scheme (Section A)

Question	Scheme	Marks	AOs
1(a)	$\sec x - \tan x = \dfrac{1}{\frac{1-t^2}{1+t^2}} - \dfrac{2t}{1-t^2}$	M1	2.1
	$= \dfrac{1+t^2}{1-t^2} - \dfrac{2t}{1-t^2} = \dfrac{1-2t+t^2}{1-t^2}$	M1	1.1b
	$= \dfrac{(1-t)^2}{(1-t)(1+t)} = \dfrac{1-t}{1+t}$ *	A1*	2.1
		(3)	
(b)	$\dfrac{1-\sin x}{1+\sin x} = \dfrac{1-\frac{2t}{1+t^2}}{1+\frac{2t}{1+t^2}}$	M1	1.1a
	$= \dfrac{1+t^2-2t}{1+t^2+2t}$	M1	1.1b
	$= \dfrac{(1-t)^2}{(1+t)^2} = \left(\dfrac{1-t}{1+t}\right)^2 = (\sec x - \tan x)^2$ *	A1*	2.1
		(3)	
		(6 marks)	

Notes:

(a)

M1: Uses $\sec x = \dfrac{1}{\cos x}$ and the t-substitutions for both $\cos x$ and $\tan x$ to obtain an expression in terms of t

M1: Sorts out the $\sec x$ term, and puts over a common denominator of $1-t^2$

A1*: Factorises both numerator and denominator (must be seen) and cancels the $(1+t)$ term to achieve the answer

(b)

M1: Uses the t-substitution for $\sin x$ in both numerator and denominator

M1: Multiples through by $1+t^2$ in numerator and denominator

A1*: Factorises both numerator and denominator and makes the connection with part (a) to achieve the given result

Question	Scheme	Marks	AOs
2	£300 purchased one hour after opening $\Rightarrow V_0 = 3$ and $t_0 = 1$; half an hour after purchase $\Rightarrow t_2 = 1.5$, so step h required is 0.25	B1	3.3
	$t_0 = 1,\ V_0 = 3,\ \left(\frac{\mathrm{d}V}{\mathrm{d}t}\right)_0 \approx \frac{3^2 - 1}{1^2 + 3} = 2$	M1	3.4
	$V_1 \approx V_0 + h\left(\frac{\mathrm{d}V}{\mathrm{d}t}\right)_0 = 3 + 0.25 \times 2 = \ldots$	M1	1.1b
	$= 3.5$	A1ft	1.1b
	$\left(\frac{\mathrm{d}V}{\mathrm{d}t}\right)_1 \approx \frac{3.5^2 - 1.25}{1.25^2 + 1.25 \times 3.5} \left(= \frac{176}{95}\right)$	M1	1.1b
	$V_2 \approx V_1 + h\left(\frac{\mathrm{d}V}{\mathrm{d}t}\right)_1 = 3.5 + 0.25 \times \frac{176}{95} = 3.963\ldots$, so £396 (nearest £)	A1	3.2a
		(6)	
			(6 marks)

Notes:

B1: Identifies the correct initial conditions and requirement for h

M1: Uses the model to evaluate $\frac{\mathrm{d}V}{\mathrm{d}t}$ at t_0, using their t_0 and V_0

M1: Applies the approximation formula with their values

A1ft: 3.5 or exact equivalent. Follow through their step value

M1: Attempt to find $\left(\frac{\mathrm{d}V}{\mathrm{d}t}\right)_1$ with their 3.5

A1: Applies the approximation and interprets the result to give £396

Question	Scheme	Marks	AOs
3	$\frac{1}{x} < \frac{x}{x+2}$		
	$\frac{(x+2)-x^2}{x(x+2)} < 0$ or $x(x+2)^2 - x^3(x+2) < 0$	M1	2.1
	$\frac{x^2-x-2}{x(x+2)} > 0 \Rightarrow \frac{(x-2)(x+1)}{x(x+2)} > 0$ or $x(x+2)(2-x)(x+1) < 0$	M1	1.1b
	At least two correct critical values from $-2, -1, 0, 2$	A1	1.1b
	All four correct critical values $-2, -1, 0, 2$	A1	1.1b
	$\{x \in \mathbb{R}: x < -2\} \cup \{x \in \mathbb{R}: -1 < x < 0\} \cup \{x \in \mathbb{R}: x > 2\}$	M1 A1	2.2a 2.5
		(6)	
			(6 marks)

Notes:

M1: Gathers terms on one side and puts over common denominator, or multiply by $x^2(x+2)^2$ and then gather terms on one side

M1: Factorise numerator or find roots of numerator or factorise resulting in equation into 4 factors

A1: At least 2 correct critical values found

A1: Exactly 4 correct critical values

M1: Deduces that the 2 "outsides" and the "middle interval" are required. May be by sketch, number line or any other means

A1: Exactly 3 correct intervals, accept equivalent set notations, but must be given as a set e.g. accept $\mathbb{R} - ([-2, -1] \cup [0, 2])$ or $\{x \in \mathbb{R}: x < -2 \text{ or } -1 < x < 0 \text{ or } x > 2\}$

Question	Scheme	Marks	AOs
4(a)	Identifies glued face is triangle *ABC* and attempts to find the area, e.g. evidences by use of $\frac{1}{2}\lvert\mathbf{AB}\times\mathbf{AC}\rvert$	M1	3.1a
	$\frac{1}{2}\lvert\mathbf{AB}\times\mathbf{AC}\rvert = \frac{1}{2}\lvert(-2\mathbf{i}+3\mathbf{j}+\mathbf{k})\times(-\mathbf{i}+\mathbf{j}+2\mathbf{k})\rvert$	M1	1.1b
	$=\frac{1}{2}\lvert 5\mathbf{i}+3\mathbf{j}+\mathbf{k}\rvert$	M1	1.1b
	$=\frac{1}{2}\sqrt{35}\,(\text{m}^2)$	A1	1.1b
		(4)	
	Alternative		
	Identifies glued face is triangle *ABC* and attempts to find the area, e.g. evidences by use of $\frac{1}{2}\sqrt{\lvert\mathbf{AB}\rvert^2\lvert\mathbf{AC}\rvert^2-(\mathbf{AB.AC})^2}$	M1	3.1a
	$\lvert\mathbf{AB}\rvert^2=4+9+1=14,\quad \lvert\mathbf{AC}\rvert^2=1+1+4=6$ and $\mathbf{AB.AC}=2+3+2=7$	M1	1.1b
	So area of glue is = $\frac{1}{2}\sqrt{('14')('6')-('7')^2}$	M1	1.1b
	$=\frac{1}{2}\sqrt{35}\ (\text{m}^2)$	A1	1.1b
		(4)	
(b)	Volume of parallelepiped taken up by concrete is e.g. $\frac{1}{6}(\mathbf{OC}.(\mathbf{OA}\times\mathbf{OB}))$	M1	3.1a
	$=\frac{1}{6}(\mathbf{i}+\mathbf{j}+2\mathbf{k}).(2\mathbf{i}\times(3\mathbf{j}+\mathbf{k}))$	M1	1.1b
	$=\frac{10}{6}=\frac{5}{3}$	A1	1.1b
	Volume of parallelepiped is 6 × volume of tetrahedron (= 10), so volume of glass is difference between these, viz. $10-\frac{5}{3}=\ldots$	M1	3.1a
	Volume of glass $=\frac{25}{3}(\text{m}^3)$	A1	1.1b
		(5)	

Question	Scheme	Marks	AOs
	4(b) Alternative		
	$-\mathbf{j}+3\mathbf{k}$ is perpendicular to both $\mathbf{OA} = 2\mathbf{i}$ and $\mathbf{OB} = 3\mathbf{j}+\mathbf{k}$	M1	3.1a
	Area $AOB = \frac{1}{2}\times\lvert\mathbf{OA}\rvert\times\lvert\mathbf{OB}\rvert = \frac{1}{2}\times 2\times\sqrt{10} = \sqrt{10}$	A1	1.1b
	$\mathbf{i}+\mathbf{j}+2\mathbf{k}-p(-\mathbf{j}+3\mathbf{k}) = \mu(2\mathbf{i})+\lambda(3\mathbf{j}+\mathbf{k}) \Rightarrow p = \frac{1}{2}$ and so height of tetrahedron is $h = \frac{1}{2}\lvert-\mathbf{j}+3\mathbf{k}\rvert = \frac{1}{2}\sqrt{10}$	M1	3.1a
	Volume of glass is $V = 5 \times$ Volume of tetrahedron $= 5\times\frac{1}{3}\sqrt{10}\times\frac{1}{2}\sqrt{10}$	M1	1.1b
	$= \frac{25}{3}\left(\text{m}^3\right)$	A1	1.1b
		(5)	
(c)	The glued surfaces may distort the shapes / reduce the volume of concrete Measurements in m may not be accurate The surface of the concrete tetrahedron may not be smooth Pockets of air may form when the concrete is being poured	B1	3.2b
		(1)	
		(10 marks)	

Question 4 notes:

Accept use of column vectors throughout

(a)

M1: Shows an understanding of what is required via an attempt at finding the area of triangle *ABC*

M1: Any correct method for the triangle area is fine

M1: Finds $\mathbf{AB}$ and $\mathbf{AC}$ or any other appropriate pair of vectors to use in the vector product and attempts to use them

A1: Correct procedure for the vector product with at least 1 correct term $\frac{1}{2}\sqrt{35}$ or exact equivalent

(a) Alternative

M1: Finds two appropriate sides and attempts the scalar product and magnitudes of two of the sides

M1: May use different sides to those shown

M1: Correct full method to find the area of the triangle using their two sides

A1: $\frac{1}{2}\sqrt{35}$ or exact equivalent

Question 4 notes continued:	
(b)	
M1:	Attempts volume of concrete by finding volume of tetrahedron with appropriate method
M1:	Uses the formula with correct set of vectors substituted (may not be the ones shown) and vector product attempted
A1:	Correct value for the volume of concrete
M1:	Attempt to find total volume of glass by multiplying their volume of concrete by 6 and subtracting their volume of concrete. May restart to find the volume of parallelepiped
A1:	$\frac{25}{3}$ only, ignore reference to units
(b)	**Alternative**
M1:	Notes (or works out using scalar products) that $-\mathbf{j}+3\mathbf{k}$ is a vector perpendicular to both $\mathbf{OA} = 2\mathbf{i}$ and $\mathbf{OB} = 3\mathbf{j}+\mathbf{k}$
A1:	Finds (using that **OA** and **OB** are perpendicular), area of $AOB = \sqrt{10}$
M1:	Solves $\mathbf{i}+\mathbf{j}+2\mathbf{k} - p(-\mathbf{j}+3\mathbf{k}) = \mu(2\mathbf{i}) + \lambda(3\mathbf{j}+\mathbf{k})$ to get the height of the tetrahedron $\left[(\mu=\lambda=)\ p=\frac{1}{2},\ \text{so } h=\frac{1}{2}\left\|-\mathbf{j}+3\mathbf{k}\right\| = \frac{1}{2}\sqrt{10}\right]$
M1:	Identifies the correct area as 5 times the volume of the tetrahedron (may be done as in main scheme via the difference)
A1:	$\frac{25}{3}$ only, ignore reference to units
(c)	
B1:	Any acceptable reason in context

Question	Scheme	Marks	AOs
5(a)	$y^2 = (8p)^2 = 64p^2$ and $16x = 16(4p^2) = 64p^2$ $\Rightarrow P(4p^2, 8p)$ is a general point on C	B1	2.2a
		(1)	
(b)	$y^2 = 16x$ gives $a = 4$, or $2y\frac{dy}{dx} = 16$ so $\frac{dy}{dx} = \frac{8}{y}$	M1	2.2a
	$l: y - 8p = \left(\frac{8}{8p}\right)\left(x - 4p^2\right)$	M1	1.1b
	leading to $py = x + 4p^2$ *	A1*	2.1
		(3)	
(c)	$B\left(-4, \frac{10}{3}\right)$ into $l \Rightarrow \frac{10p}{3} = -4 + 4p^2$	M1	3.1a
	$6p^2 - 5p - 6 = 0 \Rightarrow (2p - 3)(3p + 2) = 0 \Rightarrow p = ...$	M1	1.1b
	$p = \frac{3}{2}$ and l cuts x-axis when $\frac{3}{2}(0) = x + 4\left(\frac{3}{2}\right)^2 \Rightarrow x = ...$	M1	2.1
	$x = -9$	A1	1.1b
	$p = \frac{3}{2} \Rightarrow P(9, 12) \Rightarrow \text{Area}(R) = \frac{1}{2}(9 - -9)(12) - \int_0^9 4x^{\frac{1}{2}}dx$	M1	2.1
	$\int 4x^{\frac{1}{2}}dx = \frac{4x^{\frac{3}{2}}}{\left(\frac{3}{2}\right)} (+c)$ or $\frac{8}{3}x^{\frac{3}{2}} (+c)$	M1	1.1b
		A1	1.1b
	$\text{Area}(R) = \frac{1}{2}(18)(12) - \frac{8}{3}\left(9^{\frac{3}{2}} - 0\right) = 108 - 72 = 36$ *	A1*	1.1b
		(8)	

Question	Scheme	Marks	AOs
	5(c) Alternative 1		
	$B\left(-4, \frac{10}{3}\right)$ into $l \Rightarrow \frac{10p}{3} = -4 + 4p^2$	M1	3.1a
	$6p^2 - 5p - 6 = 0 \Rightarrow (2p-3)(3p+2) = 0 \Rightarrow p = ...$	M1	1.1b
	$p = \frac{3}{2}$ into l gives $\frac{3}{2}y = x + 4\left(\frac{3}{2}\right)^2 \Rightarrow x = ...$	M1	2.1
	$x = \frac{3}{2}y - 9$	A1	1.1b
	$p = \frac{3}{2} \Rightarrow P(9, 12) \Rightarrow \text{Area}(R) = \int_0^{12} \left(\frac{1}{16}y^2 - \left(\frac{3}{2}y - 9\right)\right) dy$	M1	2.1
	$\int \left(\frac{1}{16}y^2 - \frac{3}{2}y + 9\right) dy = \frac{1}{48}y^3 - \frac{3}{4}y^2 + 9y \ (+c)$	M1	1.1b
		A1	1.1b
	$\text{Area}(R) = \left(\frac{1}{48}(12)^3 - \frac{3}{4}(12)^2 + 9(12)\right) - (0)$ $= 36 - 108 + 108 = 36$ *	A1*	1.1b
		(8)	
	5(c) Alternative 2		
	$B\left(-4, \frac{10}{3}\right)$ into $l \Rightarrow \frac{10p}{3} = -4 + 4p^2$	M1	3.1a
	$6p^2 - 5p - 6 = 0 \Rightarrow (2p-3)(3p+2) = 0 \Rightarrow p = ...$	M1	1.1b
	$p = \frac{3}{2}$ and l cuts px-axis when $\frac{3}{2}(0) = x + 4\left(\frac{3}{2}\right)^2 \Rightarrow x = ...$	M1	2.1
	$x = -9$	A1	1.1b
	$p = \frac{3}{2} \Rightarrow P(9, 12)$ and $x = 0$ in $l: y = \frac{2}{3}x + 6$ gives $y = 6$ $\Rightarrow \text{Area}(R) = \frac{1}{2}(9)(6) + \int_0^9 \left(\left(\frac{2}{3}x + 6\right) - \left(4x^{\frac{1}{2}}\right)\right) dx$	M1	2.1
	$\int \left(\frac{2}{3}x + 6 - 4x^{\frac{1}{2}}\right) dx = \frac{1}{3}x^2 + 6x - \frac{8}{3}x^{\frac{3}{2}} \ (+c)$	M1	1.1b
		A1	1.1b
	$\text{Area}(R) = 27 + \left(\left(\frac{1}{3}(9)^2 + 6(9) - \frac{8}{3}\left(9^{\frac{3}{2}}\right)\right) - (0)\right)$ $= 27 + (27 + 54 - 72) = 27 + 9 = 36$ *	A1*	1.1b
		(8)	
		(12 marks)	

Question 5 notes:

(a)

B1: Substitutes $y_P = 8p$ into y^2 to obtain $64p^2$ and substitutes $x_P = 4p^2$ into $16x$ to obtain $64p^2$ and concludes that P lies on C

(b)

M1: Uses the given formula to deduce the derivative. Alternatively, may differentiate using chain rule to deduce it

M1: Applies $y - 8p = m(x - 4p^2)$, with their tangent gradient m, which is in terms of p. Accept use of $8p = m(4p^2) + c$ with a clear attempt to find c

A1*: Obtains $py = x + 4p^2$ by **cso**

(c)

M1: Substitutes their $x = \text{"}-a\text{"}$ and $y = \frac{10}{3}$ into l

M1: Obtains a 3 term quadratic and solves (using the usual rules) to give $p = ...$

M1: Substitutes their p (which must be positive) and $y = 0$ into l and solves to give $x = ...$

A1: Finds that l cuts the x-axis at $x = -9$

M1: Fully correct method for finding the area of R

i.e. $\frac{1}{2}(\text{their } x_P - \text{"}-9\text{"})(\text{their } y_P) - \int_0^{\text{their } x_P} 4x^{\frac{1}{2}}\,dx$

M1: Integrates $\pm\lambda x^{\frac{1}{2}}$ to give $\pm\mu x^{\frac{3}{2}}$, where $\lambda, \mu \neq 0$

A1: Integrates $4x^{\frac{1}{2}}$ to give $\frac{8}{3}x^{\frac{3}{2}}$, simplified or un-simplified

A1*: Fully correct proof leading to a correct answer of 36

(c) Alternative 1

M1: Substitutes their $x = \text{"}-a\text{"}$ and $y = \frac{10}{3}$ into l

M1: Obtains a 3 term quadratic and solves (using the usual rules) to give $p = ...$

Substitutes their p (which must be positive) into l and rearranges to give $x = ...$

M1: Finds l as $x = \frac{3}{2}y - 9$

A1: Fully correct method for finding the area of R

M1: i.e. $\int_0^{\text{their } y_P} \left(\frac{1}{16}y^2 - \text{their}\left(\frac{3}{2}y - 9\right)\right)dy$

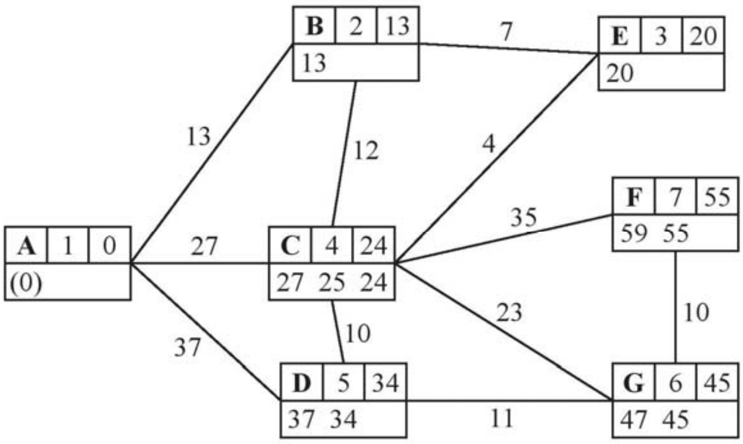
M1: Integrates $\pm\lambda y^2 \pm \mu y \pm \nu$ to give $\pm\alpha y^3 \pm \beta y^2 \pm \nu y$, where $\lambda, \mu, \nu, \alpha, \beta \neq 0$

A1: Integrates $\frac{1}{16}y^2 - \left(\frac{3}{2}y - 9\right)$ to give $\frac{1}{48}y^3 - \frac{3}{4}y^2 + 9y$, simplified or un-simplified

A1*: Fully correct proof leading to a correct answer of 36

Question 5 notes continued:	
(c)	**Alternative 2**
M1:	Substitutes their $x = "-a"$ and $y = \frac{10}{3}$ into *l*
M1:	Obtains a 3 term quadratic and solves (using the usual rules) to give $p = ...$
M1:	Substitutes their p (which must be positive) and $y = 0$ into *l* and solves to give $x = ...$
A1:	Finds that *l* cuts the *x*-axis at $x = -9$
M1:	Fully correct method for finding the area of *R* i.e. $\frac{1}{2}(\text{their } 9)(\text{their } 6) + \int_0^{\text{their } x_P} \left(\text{their}\left(\frac{2}{3}x + 6\right) - \left(4x^{\frac{1}{2}}\right)\right)\mathrm{d}y$
M1:	Integrates $\pm\lambda x \pm \mu \pm \nu x^{\frac{1}{2}}$ to give $\pm\alpha x^2 \pm \mu x \pm \beta x^{\frac{3}{2}}$, where $\lambda, \mu, \nu, \alpha, \beta \neq 0$
A1:	Integrates $\left(\frac{2}{3}x + 6\right) - \left(4x^{\frac{1}{2}}\right)$ to give $\frac{1}{3}x^2 + 6x - \frac{8}{3}x^{\frac{3}{2}}$, simplified or un-simplified
A1*:	Fully correct proof leading to a correct answer of 36

Decision Mathematics 1 Mark Scheme (Section **B**)

Question	Scheme	Marks	AOs
6(a)		M1 A1 A1	1.1b 1.1b 1.1b
	Path: ABECDGF	A1	1.1b
	Length: 55 (metres)	A1ft	1.1b
		(5)	
(b)	AB + DG = 13 + 11 = 24 ←	M1	1.1b
	A(BEC)D + B(ECD)G = 34 + 32 = 66	A1	1.1b
	A(BECD)G + B(EC)D = 45 + 21 = 66	A1	1.1b
	Repeat arcs: AB, DG	A1ft	2.2a
		(4)	
(c)	Length = 189 + 24 = 213 (metres)	B1ft	1.1b
		(1)	
(d)	$189 + x + 34 = 213 + 2x$	M1	3.1b
	$x = 10$ so BG is 10 m	A1	1.1b
		(2)	
			(12 marks)

Notes:

(a)
M1: For a larger number replaced by a smaller one in the working values boxes at C, D, F or G
A1: For all values correct (and in correct order) at A, B, C and D
A1: For all values correct (and in correct order) at E, F & G
A1: For the correct path
A1ft: For 55 or ft their final value at F

(b)
M1: For 3 correct pairings of the four odd nodes (A,B, D & G)
A1: At least two pairings and totals correct
A2: All three pairings and totals correct
A3ft: Selecting their shortest pairing, and stating that these arcs should be repeated

Question **6** notes continued:
(c) **B1ft:** For 213 or 189 + their shortest repeat **M1:** For translating the information in the question in to an equation involving x, $2x$ and 34 **A1:** For a correct equation leading to BG = 10 (m)

Question	Scheme	Marks	AOs
7	Objective line drawn or at least two vertices tested	M1	3.1a
	For solving y = 4x and 8x + 7y = 560 to find the exact co-ordinate of the optimal point, must reach either x = or y =	M1	1.1a
	$x = 15\frac{5}{9}$ and $y = 62\frac{2}{9}$	A1	1.1b
	Finding at least two points with integer co-ordinates from (15 ± 1, 63 ± 2)	M1	1.1b
	Testing at least two points with integer co-ordinates	M1	1.1b
	x = 15 and y = 63	A1	2.2a
	So the teacher should buy 15 pens and 63 pencils	A1ft	3.2a
			(7 marks)

Notes:

M1: Selecting an appropriate mathematical process to solve the problem – either drawing an objective line with the correct gradient (or reciprocal gradient), or testing at least two vertices in C

M1: Solving simultaneous equations

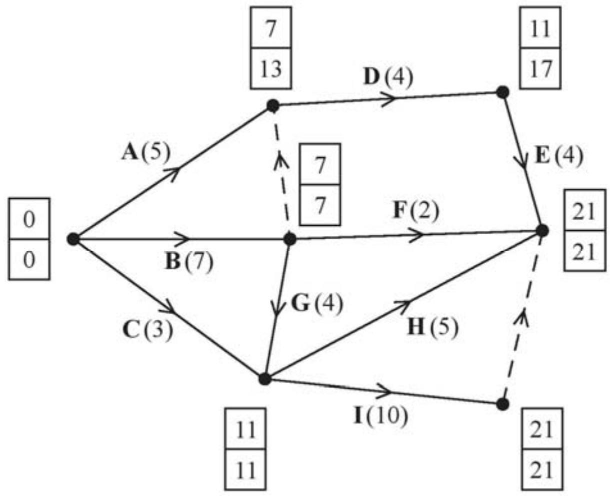
A1: cao

M1: Recognition that outcome from this model is non-integer and integer solutions are required – testing two points with integer co-ordinates in at least one of $y \geq 4x$ and $8x + 7y \geq 560$

M1: Testing at least two integer solutions in $y \geq 4x$ or $8x + 7y \geq 560$ and C

A1: cao – deducing from tests which integer solution is both valid and optimal

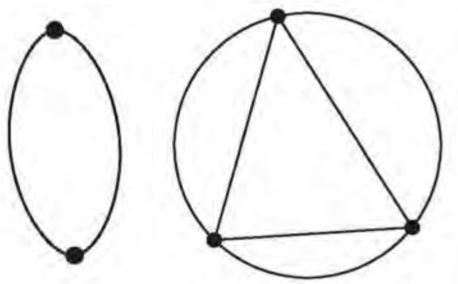
A1ft: Interpreting solution in the context of the question – gives their integer values for x and y in the context of pens and pencils

Question	Scheme	Marks	AOs
8(a)(b)		M1 A1 A1	1.1b 1.1b 1.1b
		(3)	
		M1 A1	2.1 1.1b
	The number(s) at the end of activity E indicate this project can be completed in 21 days	A1ft	2.2a
	Critical activities: B, G, I	A1	1.1b
		(4)	
			(7 marks)

Notes:

M1: At least 5 activities and one dummy, one start
A1: A,B,C,D,F,G and first dummy correct
A1: E,H,I correct, second dummy correct and one finish

M1: All boxes completed, number generally increasing L to R (condone one "rogue")
A1: All values cao
A1: Deduction that result in diagram indicates that project can be completed in 21 days (all boxes completed, numbers generally increasing in the direction of the arrows for the top boxes and generally decreasing in the opposite direction of the arrow for the bottom boxes)
A1: Critical activities correct

Question	Scheme	Marks	AOs
9(a)	e.g. a graph cannot contain an odd number of odd nodes e.g. number of arcs $= \dfrac{1+3+4+4+5}{2} = 8.5 \notin \mathbb{Z}$	B1	2.4
		(1)	
(b)(i)	$\left(2^{2x}-1\right)+\left(2^{x}\right)+\left(x+1\right)+\left(2^{x+1}-3\right)+\left(11-x\right)=2\left(18\right)$	M1	1.1b
	$2^{2x}+3\left(2^{x}\right)-28=0 \Rightarrow x=...$	M1	1.1b
	$\left(2^{x}+7\right)\left(2^{x}-4\right)=0 \Rightarrow x=2$	A1	1.1b
		(3)	
(b)(ii)	The order of the nodes are 9, 15, 3, 4, 5	M1	2.1
	Therefore the graph is neither Eulerian nor semi-Eulerian as there are more than two odd nodes	A1	2.4
		A1	2.2a
		(3)	
(c)		M1 A1	2.5 2.2a
		(2)	
			(9 marks)

Notes:

(a)
B1: Explanation referring to need for an even number of odd nodes oe

(b)
M1: Forming an equation involving the orders of the 5 odd nodes and 2(18)
M1: Simplifies to a quadratic in 2^x and attempts to solve
A1: 2 cao
M1: Construct an argument involving the order of the 5 nodes
A1: Explanation considering the number of odd nodes
A1: Deduction that therefore it is neither Eulerian nor semi-Eulerian

(c)
M1: Interprets mathematical language to construct a disconnected graph
A1: Deduce a correct graph

Question	Scheme	Marks	AOs
10	Minimise $(C =)\ 25x + 35y$	B1	3.3
	Subject to: $(500x + 800y \geqslant 150\ 000 \Rightarrow)\ 5x + 8y \geqslant 1500$	B1	3.3
	$\frac{7}{20}(x+y) \leqslant x \leqslant \frac{13}{20}(x+y)$	M1 M1	3.3 3.3
	Which simplifies to $7y \leqslant 13x$ **and** $13y \geqslant 7x$ $x, y \geqslant 0$	A1	1.1b
			(5 marks)

Notes:

B1: A correct objective function + minimise
B1: Translate information in to a correct inequality
M1: For translating the information given into the LHS inequality
M1: For translating the information given in to the RHS inequality
A1: Simplifying to the correct inequalities