Section A

1(i) | x | -2 | -1 | 0 | 1 | 2 | | y | 1.0655 | 1.1696 | 1.4142 | 1.9283 | 2.8964 | $A \approx$ ½×1{1.0655+2.8964+2(1.1696+1.4142+1.9283)} = 6.493	B2,1,0 M1 A1 [4]	table values formula 6.5 or better www
(ii) Smaller, as the trapezium rule is an over-estimate in this case and the error is less with more strips	B1 B1 [2]	
2 $x=\dfrac{1}{1+t} \Rightarrow 1+t=\dfrac{1}{x}$ $\Rightarrow$ $t=\dfrac{1}{x}-1$ $y=\dfrac{1-t}{1+2t} = \dfrac{1-\frac{1}{x}+1}{1+\frac{2}{x}-2}$ $=\dfrac{2-\frac{1}{x}}{\frac{2}{x}-1}=\dfrac{2x-1}{2-x}$	M1 A1 M1 M1 A1 [5]	attempt to solve for t oe substituting for t in terms of x clearing subsidiary fractions
3 $(3-2x)^{-3}=3^{-3}(1-\frac{2}{3}x)^{-3}$ $=\dfrac{1}{27}(1+(-3)(-\frac{2}{3}x)+\dfrac{(-3)(-4)}{2}(-\frac{2}{3}x)^2+...)$ $=\dfrac{1}{27}(1+2x+\frac{8}{3}x^2+...)$ $=\dfrac{1}{27}+\dfrac{2}{27}x+\dfrac{8}{81}x^2+...$ Valid for $-1<-\frac{2}{3}x<1$ $\Rightarrow$ $-\frac{3}{2}<x<\frac{3}{2}$	M1 B1 B2,1,0 A1 M1 A1 [7]	dealing with the ‘3’ correct binomial coeffs 1, 2, 8/3 oe cao

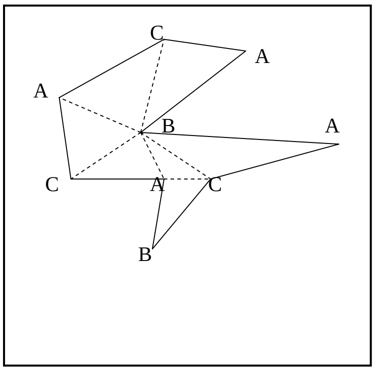
4(i) $\overrightarrow{AB} = \begin{pmatrix} 2 \\ 3 \\ -5 \end{pmatrix}, \overrightarrow{BC} = \begin{pmatrix} 5 \\ 0 \\ 2 \end{pmatrix}$ $\overrightarrow{AB}.\overrightarrow{BC} = \begin{pmatrix} 2 \\ 3 \\ -5 \end{pmatrix}.\begin{pmatrix} 5 \\ 0 \\ 2 \end{pmatrix} = 2\times5+3\times0+(-5)\times2=0$ $\Rightarrow$ AB is perpendicular to BC.	B1 B1 M1E1 [4]	
(ii) AB = $\sqrt{(2^2 + 3^2 + (-5)^2)} = \sqrt{38}$ BC = $\sqrt{(5^2 + 0^2 + 2^2)} = \sqrt{29}$ Area = ½ $\times\sqrt{38} \times \sqrt{29}$ = ½ $\sqrt{1102}$ or 16.6 units^2	M1 B1 A1 [3]	complete method ft lengths of both AB, BC oe www
5 LHS = $\dfrac{2\sin\theta\cos\theta}{1+2\cos^2\theta-1}$ $= \dfrac{2\sin\theta\cos\theta}{2\cos^2\theta}$ $= \dfrac{\sin\theta}{\cos\theta} = \tan\theta = \text{RHS}$	M1 M1 E1 [3]	one correct double angle formula used cancelling cos θ's
6(i) $\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} -8-3\lambda \\ -2 \\ 6+\lambda \end{pmatrix}$ Substituting into plane equation: $2(-8-3\lambda) -3(-2) + 6 + \lambda = 11$ $\Rightarrow$ $-16 - 6\lambda + 6 + 6 + \lambda = 11$ $\Rightarrow$ $5\lambda = -15$, $\lambda = -3$ So point of intersection is (1, –2, 3)	B1 M1 A1 A1ft [4]	
(ii) Angle between $\begin{pmatrix} 2 \\ -3 \\ 1 \end{pmatrix}$ and $\begin{pmatrix} -3 \\ 0 \\ 1 \end{pmatrix}$ $\cos\theta = \dfrac{2\times(-3)+(-3)\times0+1\times1}{\sqrt{14}\sqrt{10}}$ = (–)0.423 $\Rightarrow$ acute angle = 65°	B1 M1 A1 A1 [4]	 allow M1 for a complete method only for any vectors

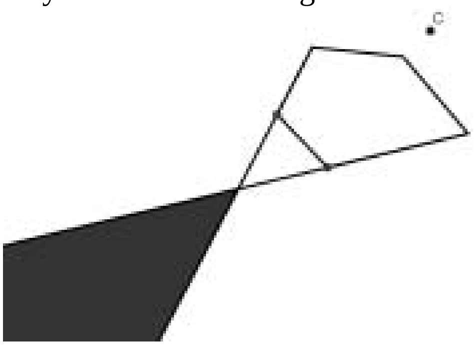
Section B

7(i) When $t = 0$, $v = 5(1 - e^0) = 0$ As $t \to \infty$, $e^{-2t} \to 0$, $\Rightarrow$ $v \to 5$ When $t = 0.5$, $v = 3.16$ m s^{-1}	E1 E1 B1 [3]	
(ii) $\frac{dv}{dt} = 5\times(-2)e^{-2t} = 10e^{-2t}$ $10 - 2v = 10 - 10(1 - e^{-2t}) = 10e^{-2t}$ $\Rightarrow$ $\frac{dv}{dt} = 10 - 2v$	B1 M1 E1 [3]	
(iii) $\frac{dv}{dt} = 10 - 0.4v^2$ $\Rightarrow$ $\frac{10}{100-4v^2}\frac{dv}{dt} = 1$ $\Rightarrow$ $\frac{10}{25-v^2}\frac{dv}{dt} = 4$ $\Rightarrow$ $\frac{10}{(5-v)(5+v)}\frac{dv}{dt} = 4$ * $\frac{10}{(5-v)(5+v)} = \frac{A}{5-v} + \frac{B}{5+v}$ $\Rightarrow$ $10 = A(5 + v) + B(5 - v)$ $v = 5 \Rightarrow 10 = 10A \Rightarrow A = 1$ $v = -5 \Rightarrow 10 = 10B \Rightarrow B = 1$ $\Rightarrow$ $\frac{10}{(5-v)(5+v)} = \frac{1}{5-v} + \frac{1}{5+v}$ $\Rightarrow$ $\int (\frac{1}{5-v} + \frac{1}{5+v})\,dv = 4\int dt$ $\Rightarrow$ $\ln(5+v) - \ln(5-v) = 4t + c$ when $t = 0$, $v = 0$, $\Rightarrow 0 = 4\times 0 + c \Rightarrow c = 0$ $\Rightarrow$ $\ln\left(\frac{5+v}{5-v}\right) = 4t$ $\Rightarrow$ $t = \frac{1}{4}\ln\left(\frac{5+v}{5-v}\right)$ *	 M1 E1 M1 A1 M1 A1 A1 E1 [8]	 for both A=1,B=1 separating variables correctly and indicating integration ft their A,B, condone absence of c ft finding c from an expression of correct form
(iv) When $t \to \infty$, $e^{-4t} \to 0$, $\Rightarrow$ $v \to 5/1 = 5$ when $t = 0.5$, $t = \frac{5(1-e^{-2})}{1+e^{-2}} = 3.8\,\text{m s}^{-1}$	E1 M1A1 [3]	
(v) The first model	E1 [1]	www

8(i) AC = 5sec α $\Rightarrow$ CF = AC tan β = 5sec α tan β $\Rightarrow$ GF = 2CF = 10sec α tan β *	B1 M1 E1 [3]	oe AC$\tan\beta$
(ii) CE = BE – BC = 5 tan($\alpha + \beta$) – 5 tan α = 5(tan($\alpha + \beta$) – tan α) $= 5\left(\dfrac{\tan\alpha+\tan\beta}{1-\tan\alpha\tan\beta}-\tan\alpha\right)$ $= 5\left(\dfrac{\tan\alpha+\tan\beta-\tan\alpha+\tan^2\alpha\tan\beta}{1-\tan\alpha\tan\beta}\right)$ $= \dfrac{5(1+\tan^2\alpha)\tan\beta}{1-\tan\alpha\tan\beta}$ $= \dfrac{5\tan\beta\sec^2\alpha}{1-\tan\alpha\tan\beta}$ *	 E1 M1 M1 DM1 E1 [5]	 compound angle formula combining fractions $\sec^2 = 1 + \tan^2$
(iii) $\sec^2 45° = 2$, tan 45° = 1 $\Rightarrow$ $\text{CE} = \dfrac{5t\times 2}{1-t} = \dfrac{10t}{1-t}$ $\text{CD} = \dfrac{10t}{1+t}$ $\Rightarrow$ $\text{DE} = \dfrac{10t}{1-t}+\dfrac{10t}{1+t} = 10t(\dfrac{1}{1-t}+\dfrac{1}{1+t})$ $= 10t\left(\dfrac{1+t+1-t}{(1-t)(1+t)}\right) = \dfrac{20t}{1-t^2}$ *	B1 M1 A1 M1 E1 [5]	used substitution for both in CE or CD oe for both adding their CE and CD
(iv) cos 45° = 1/√2 $\Rightarrow$ sec α = √2 $\Rightarrow$ GF = 10√2 tan β = 10√2 t	M1 E1 [2]	
(v) DE = 2GF $\Rightarrow$ $\dfrac{20t}{1-t^2} = 20\sqrt{2}t$ $\Rightarrow$ $1 - t^2 = 1/\sqrt{2} \Rightarrow t^2 = 1 - 1/\sqrt{2}$ * $\Rightarrow$ t = 0.541 $\Rightarrow$ β = 28.4°	 E1 M1 A1 [3]	 invtan t

<table>
<tr><th>Qn</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(i)</td><td>6 correct marks</td><td>B1</td></tr>
<tr><td>1(ii)</td><td>Either state both m and n odd or give a diagram (doorways between rooms not necessary)
justification</td><td>B1

B1ft</td></tr>
<tr><td>2(i)</td><td>$\frac{9-1}{4} = 2 = \left\lfloor \frac{4+1}{2} \right\rfloor$</td><td>B2
(B1 for LHS correct)</td></tr>
<tr><td>2(ii)</td><td><table><tr><td>x</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>$\left\lceil \frac{x}{2} \right\rceil$</td><td>1</td><td>1</td><td>2</td><td>2</td><td>3</td></tr></table></td><td>B2,1,0</td></tr>
<tr><td>3.</td><td>If each of A, B and C appeared at least four times then the total number of vertices would have to be at least 3×4=12</td><td>E2</td></tr>
<tr><td>4(i)</td><td></td><td>M1
allow if one error

A1</td></tr>
<tr><td>4(ii)</td><td>Two points labelled B above clearly marked (or f.t. from (i))</td><td>A1</td></tr>
<tr><td>5(i)</td><td>True.
Two cameras at the vertices labelled A or at the vertices labelled B would cover the entire gallery</td><td>A1
M1 for either</td></tr>
<tr><td>5(ii)</td><td>False.
One camera at either vertex labelled A would be sufficient (or C on RHS)</td><td>A1
M1</td></tr>
<tr><td>6</td><td>Anywhere in shaded region

correct construction
correct shading</td><td>M1
A1</td></tr>
</table>