<table>
<tr><th>Question</th><th colspan="4">Scheme</th><th>Marks</th><th>AOs</th></tr>
<tr><td rowspan="4">10 (a)</td><td colspan="4">Finds any two vectors $\pm\overrightarrow{PQ}$, $\pm\overrightarrow{PR}$ or $\pm QR$
$\pm\begin{pmatrix}0\\-2\\-1\end{pmatrix}$ or $\pm\begin{pmatrix}-3\\1\\1\end{pmatrix}$ or $\pm\begin{pmatrix}-3\\3\\2\end{pmatrix}$ two out of three values correct
is sufficient to imply the correct method</td><td>M1</td><td>3.1a</td></tr>
<tr><td colspan="4">Applies the vector equation of the plane formula $\boldsymbol{r} = \boldsymbol{a} + \lambda\boldsymbol{b} + \mu\boldsymbol{c}$
Where a is any coordinate from P, Q & R and vectors b and c come from an attempt at finding any two vectors that lie on the plane.</td><td>M1</td><td>1.1b</td></tr>
<tr><td colspan="4">A correct equation for the plane $\boldsymbol{r} = \mathbf{a} + \lambda\boldsymbol{b} + \mu\boldsymbol{c}$
$\mathbf{a} = \begin{pmatrix}3\\2\\-1\end{pmatrix}$ or $\begin{pmatrix}3\\0\\-2\end{pmatrix}$ or $\begin{pmatrix}0\\3\\0\end{pmatrix}$
b and c are any two vectors from $\pm\begin{pmatrix}0\\-2\\-1\end{pmatrix}$ or $\pm\begin{pmatrix}-3\\1\\1\end{pmatrix}$ or $\pm\begin{pmatrix}-3\\3\\2\end{pmatrix}$</td><td>A1</td><td>1.1b</td></tr>
<tr><td colspan="4"></td><td>(3)</td><td></td></tr>
<tr><td rowspan="2">(b)</td><td>Applies
‘their’$\boldsymbol{b}.\begin{pmatrix}1\\-3\\6\end{pmatrix}$
AND
‘their’$\boldsymbol{c}.\begin{pmatrix}1\\-3\\6\end{pmatrix}$</td><td>Alternative 1
Finds ‘their b’ – ‘their c’ or vice versa and applies the dot product with $\begin{pmatrix}1\\-3\\6\end{pmatrix}$ AND one of their b or c</td><td>Alternative 2
Applies
‘their’$\boldsymbol{b}.\begin{pmatrix}x\\y\\z\end{pmatrix}$
AND
‘their’$\boldsymbol{c}.\begin{pmatrix}x\\y\\z\end{pmatrix}$
and solves to find values of x, y and z</td><td>Alternative 3
Applies the dot product between their answer to part (a) and the vector$\begin{pmatrix}1\\-3\\6\end{pmatrix}$</td><td>M1</td><td>1.1b</td></tr>
<tr><td colspan="2">Show that both dot product(s) = 0 therefore the lawn is perpendicular</td><td>Alternative 2
Shows results is parallel to $\begin{pmatrix}1\\-3\\6\end{pmatrix}$ therefore the lawn is perpendicular</td><td>Alternative 3
Achieves the value -9 and concludes as a constant therefore the lawn is perpendicular</td><td>A1</td><td>2.4</td></tr>
</table>

		(2)	
	Outside Specification for this paper – using the cross product Finds the cross product between 'their **b**' and 'their **c**' and either compares with the vector $\begin{pmatrix}1\\-3\\6\end{pmatrix}$ to show parallel or applies the dot product formula with the vector $\begin{pmatrix}1\\-3\\6\end{pmatrix}$ to show parallel	M1	1.1b
	Concludes **parallel** therefore the lawn is **perpendicular**	A1	2.4
(c)	Attempts $\begin{pmatrix}x\\y\\z\end{pmatrix}.\begin{pmatrix}1\\-3\\6\end{pmatrix}=\boldsymbol{a}.\begin{pmatrix}1\\-3\\6\end{pmatrix}$ where $\boldsymbol{a}=\begin{pmatrix}3\\2\\-1\end{pmatrix}$ or $\begin{pmatrix}3\\0\\-2\end{pmatrix}$ or $\begin{pmatrix}0\\3\\0\end{pmatrix}$ Allow $\boldsymbol{r}.\begin{pmatrix}1\\-3\\6\end{pmatrix}=\boldsymbol{a}.\begin{pmatrix}1\\-3\\6\end{pmatrix}$ for this mark	M1	1.1b
	$x-3y+6z=-9$ or $x-3y+6z+9=0$	A1	1.1b
		(2)	
(d)	Finds the vector $\overrightarrow{ST}$ or $\overrightarrow{TS}$ and uses it as the direction vector in the formula $\mathbf{r}=\mathbf{a}+\lambda\mathbf{d}$ Two out three values correct is sufficient to imply the correct method	M1	3.3
	$\mathbf{r}=\mathbf{a}+\lambda\mathbf{d}$ where $\boldsymbol{a}=\begin{pmatrix}1\\-3\\-5\end{pmatrix}$ or $\begin{pmatrix}-5\\7\\1\end{pmatrix}$ and $\boldsymbol{d}=\pm\begin{pmatrix}-6\\10\\6\end{pmatrix}$	A1	1.1b
		(2)	
(e)	For example: The lawn(ground) may not be flat The bar may not be straight	B1	3.5b
		(1)	
(f)	Applies the distance formula with the midpoint $(-2, 2, -2)$ $\frac{\lvert(-2\times1)+(-3\times2)+(6\times-2)+9\rvert}{\sqrt{1^2+(-3)^2+6^2}}$	M1	3.4
	= 1.62 m or 162 cm	A1	1.1b

		(2)	
(g)	Must have an answer to part (f). Compares their answer to part (f) with 1.7 m and makes an appropriate comment about the model that is consistent with their answer to part (f). If their answer to part (f) is close to 1.7 (e.g. 1.5 to 1.8) they must compare and conclude that it is a good model. Otherwise they must compare and conclude that it is not a good model.	B1ft	3.5a
		(1)	
			(13 marks)

Notes:

(a)

M1: Finds any two vectors $\pm PQ,\ \pm\overrightarrow{PR}$ or $\pm\overrightarrow{QR}$ by subtracting relevant vectors. Two out three values correct is sufficient to imply the correct method.

M1: Applies the vector equation of the plane formula $\boldsymbol{r} = \boldsymbol{a} + \lambda\boldsymbol{b} + \mu\boldsymbol{c}$ where **a** is any point on the plane and the vectors **b** and **c** are any two from their $\pm\overrightarrow{PQ},\ \pm\overrightarrow{PR}$or $\pm\overrightarrow{QR}$

A1: Any correct equation for the plane. Must start with **r** =…

Allow multiples of their vectors ***b*** and ***c***

(b)

M1: Applies the dot product between their vectors **b AND c** with the vector $\begin{pmatrix}1\\-3\\6\end{pmatrix}$

A1: Shows both dot products = 0 and concludes that the lawn is **perpendicular** to the vector $\begin{pmatrix}1\\-3\\6\end{pmatrix}$

(b) Alternative 1

M1: Applies the dot product between their vector **b** – **c AND** one of their vectors **b** or **c** with the vector $\begin{pmatrix}1\\-3\\6\end{pmatrix}$

A1: Shows both dot products = 0 and concludes that the lawn is **perpendicular** to the vector $\begin{pmatrix}1\\-3\\6\end{pmatrix}$

(b) Alternative 2

M1: Applies the dot product between their vectors **b** and **c with** $\begin{pmatrix}x\\y\\z\end{pmatrix}$ and attempts to find values of x, y and z

A1: Shows results is **parallel** to $\begin{pmatrix}1\\-3\\6\end{pmatrix}$ therefore the lawn is **perpendicular.**

(b) Alternative 3

M1: Applies the dot product between their answer to part (a) and the vector $\begin{pmatrix} 1 \\ -3 \\ 6 \end{pmatrix}$

A1: Achieves the value -9 and concludes as a constant therefore the lawn is **perpendicular.**

(b) Outside Specification for this paper – using the cross product

M1: Finds the cross product between 'their **b**' and 'their **c**' and shows parallel to $\begin{pmatrix} 1 \\ -3 \\ 6 \end{pmatrix}$

A1: Concludes **parallel** therefore the **lawn** is **perpendicular.**

(c)

M1: Applies the formula $\mathbf{r.n} = \mathbf{a.n}$ where $\boldsymbol{n} = \begin{pmatrix} 1 \\ -3 \\ 6 \end{pmatrix}$ and $\boldsymbol{a} = \begin{pmatrix} 3 \\ 2 \\ -1 \end{pmatrix}$ or $\begin{pmatrix} 3 \\ 0 \\ -2 \end{pmatrix}$ or $\begin{pmatrix} 0 \\ 3 \\ 0 \end{pmatrix}$

A1: Correct Cartesian equation of the plane

(d)

M1: Finds the vector $\overrightarrow{ST}$ or $\overrightarrow{TR}$ and uses it as the direction vector in the formula. $\mathbf{r} = \mathbf{a} + \lambda \mathbf{d}$.
Two out three values correct is sufficient to imply the correct method.

A1: A correct equation including **r** =…

(e)

B1: States an acceptable limitation of the model for the lawn or bar.

(f)

M1: Applies the distance formula using the midpoint point $(-2, 2, -2)$ and the normal vector $\begin{pmatrix} 1 \\ -3 \\ 6 \end{pmatrix}$

A1: 1.62 m or 162 cm

(g)

B1ft: Compares their answer to part (f) with 1.7 and makes an assessment of the model with a reason with no contradictory statements.