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EDEXCEL A LEVEL FURTHER MATHEMATICS: QUESTIONS BY TOPIC

Further Vectors (6)

Core Pure Mathematics 2 · Topic 6

3 questions · 35 marks · Mark schemes included

Pearson Edexcel A Level Further Mathematics (9FM0), June 2019 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

QUESTION	SOURCE	MARKS	PAGE
3.8 GEOMETRIC INTERPRETATION OF SIMULTANEOUS EQUATIONS		1 Qs · 14 marks	3
1. Q6 <i>also Topic 3</i>	Paper 2: Core Pure Mathematics 2 October2020	14	4
6.5 INTERSECTIONS AND SHORTEST DISTANCES		2 Qs · 21 marks	8
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QUESTIONS

3 questions · 35 marks · 2 sub-topics



SUB-TOPIC 3.8

GEOMETRIC INTERPRETATION OF SIMULTANEOUS EQUATIONS

Sub-topic 3.8 · 1 question · 14 marks · lowest tariff first



Question 6 continued





(Total for Question 6 is 14 marks)



SUB-TOPIC 6.5

INTERSECTIONS AND SHORTEST DISTANCES

Sub-topic 6.5 · 2 questions · 21 marks · lowest tariff first



8. Two birds are flying towards their nest, which is in a tree.

Relative to a fixed origin, the flight path of each bird is modelled by a straight line.

In the model, the equation for the flight path of the first bird is

$$\mathbf{r}_1 = \begin{pmatrix} -1 \\ 5 \\ 2 \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ a \\ 0 \end{pmatrix}$$

and the equation for the flight path of the second bird is

$$\mathbf{r}_2 = \begin{pmatrix} 4 \\ -1 \\ 3 \end{pmatrix} + \mu \begin{pmatrix} 0 \\ 1 \\ -1 \end{pmatrix}$$

where λ and μ are scalar parameters and a is a constant.

In the model, the angle between the birds' flight paths is 120°

- (a) Determine the value of a .

(4)

- (b) Verify that, according to the model, there is a common point on the flight paths of the two birds and find the coordinates of this common point.

(5)

The position of the nest is modelled as being at this common point.

The tree containing the nest is in a park.

The ground level of the park is modelled by the plane with equation

$$2x - 3y + z = 2$$

- (c) Hence determine the shortest distance from the nest to the ground level of the park.

(3)

- (d) By considering the model, comment on whether your answer to part (c) is reliable, giving a reason for your answer.

(1)





(Total for Question 6 is 15 marks)





Question 2 continued

MARK SCHEMES

official mark schemes



Question	Scheme			Marks	AOs
6(a)	$ \mathbf{M} = k(-1-1) - 5(-1-2) + 7(1-2)$ $\{= 8 - 2k\}$			M1	1.1b
	Minors: $\begin{pmatrix} -2 & -3 & -1 \\ -12 & -k-14 & k-10 \\ -2 & k-7 & k-5 \end{pmatrix}$ Cofactors: $\begin{pmatrix} -2 & 3 & -1 \\ 12 & -k-14 & 10-k \\ -2 & 7-k & k-5 \end{pmatrix}$			M1	1.1b
	$\mathbf{M}^{-1} = \frac{1}{8-2k} \begin{pmatrix} -2 & 12 & -2 \\ 3 & -k-14 & 7-k \\ -1 & 10-k & k-5 \end{pmatrix}$			M1 A1	2.1 1.1b
				(4)	
(b)	$\mathbf{M}^{-1} = \frac{1}{4} \begin{pmatrix} -2 & 12 & -2 \\ 3 & -16 & 5 \\ -1 & 8 & -3 \end{pmatrix} \Rightarrow \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \mathbf{M}^{-1} \begin{pmatrix} 1 \\ p \\ 2 \end{pmatrix}$ Solve the equations simultaneously to achieve values for x, y and z $y + 3z = 2p - 2$ and $4y + 8z = -1p$ $x = \dots$, $y = \dots$, $z = \dots$			M1	3.1a
	$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} -\frac{1}{2} + 3p - 1 \\ \frac{3}{4} - 4p + \frac{5}{2} \\ -\frac{1}{4} + 2p - \frac{3}{2} \end{pmatrix}$			A1ft	1.1b
	$\left(\frac{12p-6}{4}, \frac{13-16p}{4}, \frac{8p-7}{4} \right)$ $\left(3p - \frac{3}{2}, \frac{13}{4} - 4p, 2p - \frac{7}{4} \right)$			A1	2.2a
				(3)	
(c)(i)					
	For consistency: E.g. eliminates z to find two equations from $3x + 2y = q + 2$ $3x + 2y = 7q - 1$ $18x + 12y = 15$	For consistency: E.g. eliminates x to find two equations from $y + 3z = 1 - 4q$ $3y + 9z = -3$ $y + 3z = 2q - 2$	For consistency: E.g. eliminates y to find two equations from $x - 2z = 2 - q$ $-x + 2z = 1 - 5q$ $-6x + 12z = -9$	M1	3.1a
	$q + 2 = 7q - 1$ e.g. $\Rightarrow q = \dots$	$-3 = 3(1 - 4q)$ e.g. $\Rightarrow q = \dots$	$-9 = 6(1 - 5q)$ e.g. $\Rightarrow q = \dots$	M1	1.1b
	$q = \frac{1}{2}$			A1	1.1b

	Alternative Equating coefficients leading to two out of three equations and solves to find values for a and b $4a + b = 2, 5a + b = 1, 7a + b = -1$ $\{a = -1, b = 6\}$	M1	3.1a
	Forms the fourth equation involving q $a + bq = 2$ and substitutes in the values of a and b to find a value for q	M1	1.1b
	$q = \frac{1}{2}$	A1	1.1b
	Finds a coordinate of intersection of the planes $4x + 5y + 7z = 1$ and $2x + y - z = 2$ e.g let $z = 0$ $4x + 5y = 1$ and $2x + y = 2$ $y = -1, x = 1.5$	M1	3.1a
	Substitutes the values for x, y and z into $x + y + z = q$ to reach a value for q	M1	1.1b
	$q = \frac{1}{2}$	A1	1.1b
(ii)	For example: $x = \lambda \Rightarrow 3\lambda + 2y = \frac{5}{2}, \lambda - 2z = \frac{3}{2} \Rightarrow y = f(\lambda), z = f(\lambda)$ $y = \lambda \Rightarrow 3x + 2\lambda = \frac{5}{2}, \lambda + 3z = 1 \Rightarrow x = f(\lambda), z = f(\lambda)$ $z = \lambda \Rightarrow 3y + 9\lambda = -3, -6x + 12\lambda = -9 \Rightarrow x = f(\lambda), y = f(\lambda)$	M1	3.1a
	Let $x = \lambda, \lambda = \frac{y - \frac{5}{4}}{-\frac{3}{2}} = \frac{z + \frac{3}{4}}{\frac{1}{2}}$ or $y = \frac{5}{4} - \frac{3}{2}\lambda, z = -\frac{3}{4} + \frac{1}{2}\lambda$ Let $y = \lambda, \lambda = \frac{x - \frac{5}{6}}{-\frac{2}{3}} = \frac{z + \frac{1}{3}}{-\frac{1}{3}}$ or $x = \frac{5}{5} - \frac{2}{3}\lambda, z = -\frac{1}{3} - \frac{1}{3}\lambda$ Let $z = \lambda, \lambda = \frac{x - \frac{3}{2}}{2} = \frac{y + 1}{-3}$ or $x = \frac{3}{2} + 2\lambda, y = -1 - 3\lambda$	A1	1.1b
	$\mathbf{r} = \frac{5}{4}\mathbf{j} - \frac{3}{4}\mathbf{k} + t(2\mathbf{i} - 3\mathbf{j} + \mathbf{k})$ o.e. $\mathbf{r} = \frac{5}{6}\mathbf{i} - \frac{1}{3}\mathbf{k} + t(2\mathbf{i} - 3\mathbf{j} + \mathbf{k})$ o.e. $\mathbf{r} = \frac{3}{2}\mathbf{i} - \mathbf{j} + t(2\mathbf{i} - 3\mathbf{j} + \mathbf{k})$ o.e.	M1 A1	1.1b 2.5
	Alternative (ii) Finds two different coordinates that lie on the line of intersection For example: setting $x = 0$ $\frac{5}{4}, -\frac{3}{4}$ setting $y = 0$ $\frac{5}{6}, 0, -\frac{1}{3}$ setting $z = 0$ $\frac{3}{2}, -1, 0$	M1 A1	3.1a 1.1b
	Finds the vector equation of the line passing through their two points	M1	1.1b
	$\mathbf{r} = \frac{5}{4}\mathbf{j} - \frac{3}{4}\mathbf{k} + t(2\mathbf{i} - 3\mathbf{j} + \mathbf{k})$ o.e.	A1	2.5

	$\mathbf{r} = \frac{5}{6}\mathbf{i} - \frac{1}{3}\mathbf{k} + t(2\mathbf{i} - 3\mathbf{j} + \mathbf{k}) \text{ o.e.}$ $\mathbf{r} = \frac{3}{2}\mathbf{i} - \mathbf{j} + t(2\mathbf{i} - 3\mathbf{j} + \mathbf{k}) \text{ o.e.}$		
	Alternative (ii): Outside the spec Finds the cross product of two normal vectors and a coordinate that lies on all three planes	M1	3.1a
	Correct cross product $\begin{vmatrix} 4 & 5 & 7 \\ 1 & 1 & 1 \end{vmatrix} = \begin{vmatrix} 4 & 5 & 7 \\ 2 & 1 & -1 \end{vmatrix} = \begin{vmatrix} 2 & 1 & 1 \\ 3 & 1 & -1 \end{vmatrix} \text{ or } \begin{vmatrix} 1 & 1 & 1 \\ 2 & 1 & -1 \end{vmatrix} = \begin{vmatrix} 12 & 18 & -3 \end{vmatrix}$	A1	1.1b
	Uses the point and the direction vector to find the equation of the line	M1	1.1b
	$\mathbf{r} = \frac{5}{4}\mathbf{j} - \frac{3}{4}\mathbf{k} + t(2\mathbf{i} - 3\mathbf{j} + \mathbf{k}) \text{ o.e.}$	A1	1.1b
		(7)	
(14 marks)			
Notes			
(a) M1: Correct method to find the determinant. Condone one sign slip M1: A correct first step in obtaining the inverse. Could be the matrix of minors or cofactors. Condone sign slips as long as the intention is clear. M1: Fully correct method to obtain the inverse. Attempts matrix of minors, cofactors, transposes and 1/determinant A1: Correct matrix (b) M1: A complete strategy for solving the given equations e.g. multiplies the given coordinates by their inverse or solves simultaneously to achieve values for x, y and z A1ft: Correct calculation on their inverse matrix (unsimplified) or at least on correct value if solving simultaneously A1: Correct coordinates (c)(i) M1: Uses a correct strategy that will lead to establishing a value for q. E.g. eliminating one of x, y or z M1: Solves a suitable equation to obtain a value for q A1: Correct value (c)(i) Alternative 1 M1: Equating coefficients leading to two out of three equations and solves to find values for a and b M1: Solves a suitable equation to obtain a value for q using their values for a and b (c)(i) Alternative 2 M1: Finds a coordinate of intersection of the planes $4x + 5y + 7z = 1$ and $2x + y - z = 2$ M1: Substitutes the values for x, y and z into $x + y + z = q$ to reach a value for q A1: Correct value (ii) M1: Uses a correct strategy to obtain the Cartesian equation of the line or the general coordinates A1: Correct Cartesian equation or coordinates in terms of a parameter.			



M1: Uses their Cartesian equation to correctly extract the position and direction to form a vector equation for the required line

A1: Correct equation (o.e.) look out for multiples of the direction vector

Alternative (ii)

M1: Finds two different coordinates that lie on the line of intersection

A1: Correct coordinates

M1: Uses their coordinates to find the vector equation of the line that passes through them.

A1: Correct equation (o.e.), look out for multiples of the direction vector. Must have $\mathbf{r} = \dots$

Alternative (ii) outside spec

M1: Finds the cross product between the normal vectors of two of the planes and a coordinate that lies on all three planes. If a coordinate is found in (i) it must be used in this part to award this mark.

A1: Correct cross product

M1: Uses the coordinate and the cross product to find the equation of the line

A1: Correct equation (o.e.), look out for multiples of the direction vector. Must have $\mathbf{r} = \dots$

Question	Scheme	Marks	AOs
8(a)	A complete method to use the scalar product of the direction vectors and the angle 120° to form an equation in a $\frac{\begin{pmatrix} 2 \\ a \\ 0 \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 1 \\ -1 \end{pmatrix}}{\sqrt{2^2 + a^2} \sqrt{1^2 + (-1)^2}} = \cos 120$	M1	3.1b
	$\frac{a}{\sqrt{4 + a^2} \sqrt{2}} = -\frac{1}{2}$	A1	1.1b
	$2a = -\sqrt{4 + a^2} \sqrt{2} \Rightarrow 4a^2 = 8 + 2a^2 \Rightarrow a^2 = 4 \Rightarrow a = \dots$	M1	1.1b
	$a = -2$	A1	2.2a
		(4)	
(b)	Any two of i: $-1 + 2\lambda = 4$ (1) j: $5 + \text{'their'} - 2'\lambda = -1 + \mu$ (2) k: $2 = 3 - \mu$ (3)	M1	3.4
	Solves the equations to find a value of $\lambda \left\{ = \frac{5}{2} \right\}$ and $\mu \{ = 1 \}$	M1	1.1b
	$r_1 = \begin{pmatrix} -1 \\ 5 \\ 2 \end{pmatrix} + \frac{5}{2} \begin{pmatrix} 2 \\ \text{'their'} - 2' \\ 0 \end{pmatrix}$ or $r_2 = \begin{pmatrix} 4 \\ -1 \\ 3 \end{pmatrix} + 1 \begin{pmatrix} 0 \\ 1 \\ -1 \end{pmatrix}$	dM1	1.1b
	$(4, 0, 2)$ or $\begin{pmatrix} 4 \\ 0 \\ 2 \end{pmatrix}$	A1	1.1b
	Checks the third equation e.g. $\lambda = \frac{5}{2}: \mathbf{L} \quad \mathbf{HS} = 5 - 2\lambda = 5 - 5 = 0$ $\mu = 1: \mathbf{R} \quad \mathbf{HS} = -1 + \mu = -1 + 1 = 0$ therefore common point/intersect/consistent/tick or substitutes the values of λ and μ into the relevant lines and achieves the same coordinate	B1	2.1
		(5)	
(c)	Full attempt to find the minimum distance from the point of intersection (nest) to the plane (ground) E.g. Minimum distance = $\frac{ 2 \times '4' + (-3) \times '0' + 1 \times '2' - 2 }{\sqrt{2^2 + (-3)^2 + 1^2}} = \dots$ Alternatively $\mathbf{r} = \begin{pmatrix} '4' \\ '0' \\ '2' \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ -3 \\ 1 \end{pmatrix}$ $2('4' + 2\lambda) - 3('0' - 3\lambda) + ('2' + \lambda) = 2 \Rightarrow$ $\lambda = \dots \left\{ -\frac{4}{7} \right\}$	M1	3.1b
		A1ft	3.4

	$\mathbf{r} = \begin{pmatrix} 4 \\ 0 \\ 2 \end{pmatrix} + \left(-\frac{4}{7}\right) \begin{pmatrix} 2 \\ -3 \\ 1 \end{pmatrix} = \begin{pmatrix} \frac{20}{7} \\ \frac{12}{7} \\ \frac{10}{7} \end{pmatrix}$ Minimum distance = $\sqrt{\left(2 \times -\frac{4}{7}\right)^2 + \left(-3 \times -\frac{4}{7}\right)^2 + \left(1 \times -\frac{4}{7}\right)^2} =$ $\dots$ $= \sqrt{\left(4 - \frac{20}{7}\right)^2 + \left(0 - \frac{12}{7}\right)^2 + \left(2 - \frac{10}{7}\right)^2} = \dots$		
	$\frac{8}{\sqrt{14}}$ or $\frac{4\sqrt{14}}{7}$ or awrt 2.1	A1	2.2b
		(3)	
	Alternative Find perpendicular distance from plane to the origin $2x - 3y + z = 2$ $n = \sqrt{2^2 + (-3)^2 + 1^2} = \sqrt{14}$ shortest distance = $\frac{2}{\sqrt{14}}$ Find perpendicular distance from the plane containing the point of intersection to the origin $2x - 3y + z = \begin{pmatrix} 4 \\ 0 \\ 2 \end{pmatrix} \cdot \begin{pmatrix} 2 \\ -3 \\ 1 \end{pmatrix} = 10$ shortest distance = $\frac{10}{\sqrt{14}}$ Minimum distance = $\frac{10}{\sqrt{14}} - \frac{2}{\sqrt{14}}$	M1 A1ft	3.1b 3.4
	$\frac{8}{\sqrt{14}}$ or $\frac{4\sqrt{14}}{7}$ or awrt 2.1	A1	2.2b
		(3)	
(d)	For example Not reliable as the birds will not fly in a straight line Not reliable as angle between flights paths will not always be 120° Not reliable/reliable as the ground will not be flat/smooth Not reliable as bird's nest is not a point	B1	3.2b
		(1)	
(13 marks)			
Notes:			
(a) M1: See scheme, allow a sign slip and cos 60 A1: Correct simplified equation in a, cos 120 must be evaluated to $-\frac{1}{2}$ and dot product calculated Note: If the candidate states either $\left \frac{a \cdot b}{ a b }\right = \cos \theta$ or $\left \frac{a}{\sqrt{4+a^2}\sqrt{2}}\right = \cos 60$ then has the equation $\frac{a}{\sqrt{4+a^2}\sqrt{2}} = \frac{1}{2}$ award this mark. If the module of the dot product is not seen then award A0 for this equation.			

dM1: Solve a quadratic equation for a , by squaring and solving an equation of the form $a^2 = K$ where $K > 0$

A1: Deduces the correct value of a from a correct equation. Must be seen in part (a) using the angle between the lines.

Alternative cross product method

M1: $\begin{vmatrix} 2 & a & 0 \\ 0 & 1 & -1 \end{vmatrix} = \sqrt{2^2 + a^2} \sqrt{1^2 + (-1)^2} \sin 120$

A1: $\sqrt{a^2 + 8} = \sqrt{4 + a^2} \sqrt{2} \frac{\sqrt{3}}{2}$

Then as above

Note If they use the point of intersection to find a value for a this scores no marks

(b)

M1: Uses the model to write down any two correct equations

M1: Solve two equations simultaneously to find a value for μ and λ

dM1: Dependent on previous method mark. Substitutes μ and λ into a relevant equation. If no method shown two correct ordinates implies this mark.

A1: Correct coordinates. May be seen in part (c)

B1: Shows that the values of μ and λ give the same third coordinate or point of intersection and draws the conclusion that the **lines intersect/common point/consistent** or tick.

Note: If an incorrect value for a is found in part (a) but in part (b) they find that $a = -2$ this scores

B0 but all other marks are available

(c) This is M1M1A1 on ePen marking as M1 A1ft A1

M1: Full attempt to find the minimum distance from a point to a plane. Condone a sign slip with the value of d .

A1ft: Following through on their point of intersection. Uses the model to find a correct expression for minimum distance from the nest to the ground

A1: Correct distance

Alternative

M1: Find the shortest distance from a point to plane by finding the perpendicular distance from the given plane to the origin and the perpendicular distance from the plane contacting their point of intersection to the origin and subtracts

A1ft: Following through on their point of intersection. Uses the model to find a correct expression for minimum distance from the nest to the ground

A1: Correct distance

(d)

B1: Comments on one of the models

- Flight path of the birds modelled as a straight line
- Angle between flight paths modelled as 120°
- The bird's nest is modelled as a point
- Ground modelled as a plane

Then states unrelia

Any correct answer seen, ignore any other incorrect answers



Question	Scheme	Marks	AOs
2(a)	Shortest distance = $\frac{ 2 \times 3 + 4 \times (-5) + (-1) \times 2 - 3 }{\sqrt{2^2 + 4^2 + (-1)^2}} = \dots$	M1	1.1b
	awrt 4.15 or $\frac{19}{\sqrt{21}}$ or $\frac{19\sqrt{21}}{21}$	A1	1.1b
		(2)	
(b)	$\overrightarrow{AB} = \begin{pmatrix} 6 \\ -2 \\ 1 \end{pmatrix} - \begin{pmatrix} 3 \\ -5 \\ 2 \end{pmatrix} = \begin{pmatrix} 3 \\ 3 \\ -1 \end{pmatrix}$ or $\overrightarrow{BA} = \begin{pmatrix} 3 \\ -5 \\ 2 \end{pmatrix} - \begin{pmatrix} 6 \\ -2 \\ 1 \end{pmatrix} = \begin{pmatrix} -3 \\ -3 \\ 1 \end{pmatrix}$	M1	3.4
	$\mathbf{r} = \begin{pmatrix} 6 \\ -2 \\ 1 \end{pmatrix} + \lambda \begin{pmatrix} 3 \\ 3 \\ -1 \end{pmatrix}$ or $\mathbf{r} = \begin{pmatrix} 3 \\ -5 \\ 2 \end{pmatrix} + \lambda \begin{pmatrix} 3 \\ 3 \\ -1 \end{pmatrix}$ $\mathbf{r} = \begin{pmatrix} 6 \\ -2 \\ 1 \end{pmatrix} + \lambda \begin{pmatrix} -3 \\ -3 \\ 1 \end{pmatrix}$ or $\mathbf{r} = \begin{pmatrix} 3 \\ -5 \\ 2 \end{pmatrix} + \lambda \begin{pmatrix} -3 \\ -3 \\ 1 \end{pmatrix}$	A1	3.3
		(2)	
(c)	$\cos \theta = \frac{\begin{pmatrix} 3 \\ 3 \\ -1 \end{pmatrix} \cdot \begin{pmatrix} 2 \\ 4 \\ -1 \end{pmatrix}}{\sqrt{3^2 + 3^2 + (-1)^2} \times \sqrt{2^2 + 4^2 + (-1)^2}} \Rightarrow \theta = \dots$ or $90 - \theta = \dots$	M1	3.1b
	$(\phi =) 72^\circ$	A1	1.1b
		(2)	
(d)	Distance = $\sqrt{3^2 + 3^2 + (-1)^2} = \sqrt{19} = \text{awrt } 4.36$	B1	1.1b
		(1)	
(e)	Not likely to match, as unlikely that the flight path of the arrow will be a straight line.	B1	3.2b
		(1)	
(8 marks)			

Notes:**(a)**

M1: Correct method to find the shortest distance. Condone $\pm d$ in the formula. Longer methods are possible. E.g. if done after part (d), then $\sqrt{19} \cos 17.97\dots$ is a correct method. Another approach is to

form the general line $\mathbf{r} = \begin{pmatrix} 3 \\ -5 \\ 2 \end{pmatrix} + \mu \begin{pmatrix} 2 \\ 4 \\ -1 \end{pmatrix}$, substitute into plane equation $\Rightarrow \mu = \frac{19}{21}$ then scale the

normal vectors magnitude: $\frac{19}{21} \times \sqrt{2^2 + 4^2 + (-1)^2} = \dots$

A1: Correct exact distance or awrt 4.15

(b)

M1: Finds the direction of the line. Accept either direction and implied by 2 out of three coordinates correct if no method shown.

A1: Correct model for the flight path of the arrow. Must be an equation ie, including the $\mathbf{r} = \dots$ (but condone $l = \dots$ or other letter).

(c)

M1: A complete method to find the required angle or angle between normal and plane. Uses the dot product of the direction vector of the line and normal vector of the plane to find the angle (need not subtract from 90 for this mark). Allow if a (single) minor slip is made if the method is clearly attempting to use the correct vectors.

Note may use $\sin \phi = \frac{\begin{pmatrix} 3 \\ 3 \\ -1 \end{pmatrix} \cdot \begin{pmatrix} 2 \\ 4 \\ -1 \end{pmatrix}}{\sqrt{3^2 + 3^2 + (-1)^2} \times \sqrt{2^2 + 4^2 + (-1)^2}} \Rightarrow \phi = \dots$ directly.

A1: Correct final angle.

(d)

B1: $\sqrt{19}$ or awrt 4.36

(e)

B1: States not likely to match (or equivalent wording) **and** gives a suitable reason why. This will most commonly be that the arrow will not travel in a straight line, but e.g. accept “the arrow is not a particle so the tip may travel into the target, not stop at the plane”.

Do not accept answers that suggest the arrow will travel less far than the answer to (d). Do not accept “air resistance” arguments unless they specifically refer to the arrow not travelling in a straight line.

