Q1.

10	(i)	_	eneral point of l or m in component form, e.g. $(1 + s, 1 - s, 1 + 2s)$ or $+2t, 1+t$	В1	
		*	least two corresponding pairs of components and solve for s or t	M1	
			t=-1 or $t=-2$	A1	
			t all three component equations are satisfied	Al	[4]
		verify tha	an tinee component equations are satisfied	Ai	[4]
	(ii)	Carry out	correct process for evaluating the scalar product of the direction vectors of		
		l and m		M1	
			correct process for the moduli, divide the scalar product by the product of		
		the modul	i and evaluate the inverse cosine of the result	M1	
		Obtain an	swer 74.2° (or 1.30 radians)	A1	[3]
	(iii)	EITHER:	Use scalar product to obtain $a - b + 2c = 0$ and $2a + 2b + c = 0$	В1	
	,		Solve and obtain one ratio, e.g. a: b	M1	
			Obtain $a:b:c=5:-3:-4$, or equivalent	Al	
			Substitute coordinates of a relevant point and values for a , b and c in		
			general equation of plane and evaluate d	M1	
			Obtain answer $5x - 3y - 4z = -2$, or equivalent	A1	
		OR 1:	Using two points on l and one on m, or vice versa, state three equations in		
			a, b, c and d	B1	
			Solve and obtain one ratio, e.g. a: b	M1	
			Obtain a ratio of three of the unknowns, e.g. $a:b:c=-5:3:4$	A1	
			Use coordinates of a relevant point and found ratio to find the fourth		
			unknown, e.g. d	M1	
			Obtain answer $-5x + 3y + 4z = 2$, or equivalent	A1	
		OR 2:	Form a correct 2-parameter equation for the plane,		
			e.g. $\mathbf{r} = \mathbf{i} + \mathbf{j} + \mathbf{k} + \lambda(\mathbf{i} - \mathbf{j} + 2\mathbf{k}) + \mu(2\mathbf{i} + 2\mathbf{j} + \mathbf{k})$	B1	
			State three equations in x, y, z, λ and μ	M1	
			State three correct equations	Al	
			Eliminate λ and μ	M1	
			Obtain answer $5x - 3y - 4z = -2$, or equivalent	A1	
		OR 3:	Attempt to calculate vector product of direction vectors of I and m	M1	
			Obtain two correct components of the product	A1	
			Obtain correct product, e.g. $-5i + 3j + 4k$	A1	
			Form a plane equation and use coordinates of a relevant point to		
			calculate d	M1	
			Obtain answer $-5x + 3y + 4z = 2$, or equivalent	Al	[5]

Q2.

Obtain pos State or in Using the Using the and evalua Obtain ans	in plane equation and solve for λ sition vector $4\mathbf{i} + 3\mathbf{j}$, or equivalent apply a correct vector normal to the plane, e.g. $3\mathbf{i} - \mathbf{j} + 2\mathbf{k}$ correct process, evaluate the scalar product of a direction vector for l and a normal for correct process for the moduli, divide the scalar product by the product of the module the inverse cosine or inverse sine of the result swer 26.5° (or 0.462 radians) State $a + 2b + 2c = 0$ or $3a - b + 2c = 0$	M1 A1	[3] [4]
State or in Using the Using the and evalua Obtain ans	apply a correct vector normal to the plane, e.g. $3\mathbf{i} - \mathbf{j} + 2\mathbf{k}$ correct process, evaluate the scalar product of a direction vector for l and a normal for correct process for the moduli, divide the scalar product by the product of the module the inverse cosine or inverse sine of the result swer 26.5° (or 0.462 radians)	B1 p M1 duli M1 A1	
Using the Using the and evaluate Obtain and	correct process, evaluate the scalar product of a direction vector for <i>l</i> and a normal for correct process for the moduli, divide the scalar product by the product of the module the inverse cosine or inverse sine of the result swer 26.5° (or 0.462 radians)	p M1 luli M1 A1	[4]
Using the Using the and evaluate Obtain and	correct process, evaluate the scalar product of a direction vector for <i>l</i> and a normal for correct process for the moduli, divide the scalar product by the product of the module the inverse cosine or inverse sine of the result swer 26.5° (or 0.462 radians)	M1 A1	[4]
Using the and evalua Obtain ans	correct process for the moduli, divide the scalar product by the product of the modute the inverse cosine or inverse sine of the result swer 26.5° (or 0.462 radians)	M1 A1	[4]
Obtain ans	ate the inverse cosine or inverse sine of the result swer 26.5° (or 0.462 radians)	M1 A1	[4]
			[4]
EITHER:	State $a + 2b + 2c = 0$ or $3a - b + 2c = 0$	D.	
Diriibit.		B1	
	Obtain two relevant equations and solve for one ratio, e.g. <i>a</i> : <i>b</i>	M1	
	Obtain $a:b:c=6:4:-7$, or equivalent	A1	
	Substitute coordinates of a relevant point in $6x + 4y - 7z = d$ and evaluate d	M1	
	Obtain answer $6x + 4y - 7z = 36$, or equivalent	A1	
OR1:	Attempt to calculate vector product of relevant vectors,	711	
OII.	e.g. $(\mathbf{i} + 2\mathbf{j} + 2\mathbf{k}) \times (3\mathbf{i} - \mathbf{j} + 2\mathbf{k})$	M1	
	Obtain two correct components of the product	A1	
	- 10.1. 17 No 1 Th 1 No 1 No.	7	
OR2:			
01121			
			[5]
•	OR2:	Obtain correct product, e.g. $6\mathbf{i} + 4\mathbf{j} - 7\mathbf{k}$ Substitute coordinates of a relevant point in $6x + 4y - 7z = d$ and evaluate d Obtain answer $6x + 4y - 7z = 36$, or equivalent Attempt to form 2-parameter equation with relevant vectors State a correct equation, e.g. $\mathbf{r} = 2\mathbf{i} - \mathbf{j} - 4\mathbf{k} + \lambda(\mathbf{i} + 2\mathbf{j} + 2\mathbf{k}) + \mu(3\mathbf{i} - \mathbf{j} + 2\mathbf{k})$ State three equations in x, y, z, λ, μ Eliminate λ and μ Obtain answer $6x + 4y - 7z = 36$, or equivalent	Substitute coordinates of a relevant point in $6x + 4y - 7z = d$ and evaluate d M1 Obtain answer $6x + 4y - 7z = 36$, or equivalent A1 Attempt to form 2-parameter equation with relevant vectors M1 State a correct equation, e.g. $\mathbf{r} = 2\mathbf{i} - \mathbf{j} - 4\mathbf{k} + \lambda(\mathbf{i} + 2\mathbf{j} + 2\mathbf{k}) + \mu(3\mathbf{i} - \mathbf{j} + 2\mathbf{k})$ A1 State three equations in x, y, z, λ, μ A1 Eliminate λ and μ M1

Q3.

3 (i) Obtain
$$\pm \begin{pmatrix} 3 \\ -4 \\ 6 \end{pmatrix}$$
 as normal to plane

Form equation of p as $3x - 4y + 6z = k$ or $-3x + 4y - 6z = k$ and use relevant point to find k

Obtain $3x - 4y + 6z = 80$ or $-3x + 4y - 6z = -80$

M1

Carry out correct process for finding scalar product of two relevant vectors

Use correct complete process with moduli and scalar product and evaluate \sin^{-1} or \cos^{-1}

of result

Obtain 30.8° or 0.538 radians

B1

B1

Carry out correct process with moduli and scalar product and evaluate \sin^{-1} or \cos^{-1}

of result

Obtain 30.8° or 0.538 radians

Q4.

10	(i)	EITHER:	Express general point of l or m in component form, e.g. $(2 + \lambda, -\lambda, 1 + 2\lambda)$ or		
			$(\mu, 2 + 2\mu, 6 - 2\mu)$	Bl	
			Equate at least two pairs of components and solve for λ or for μ	Ml	
			Obtain correct answer for λ or μ (possible answers for λ are -2, $\frac{1}{4}$, 7 and for		
			$\mu \text{ are } 0, 2\frac{1}{4}, -4\frac{1}{2})$	Al	
			Verify that all three component equations are not satisfied	Al	
		OR:	State a relevant scalar triple product, e.g.		
			$(2i-2j-5k) \cdot ((i-j+2k) \times (i+2j-2k))$	Bl	
			Attempt to use the correct method of evaluation	Ml	
			Obtain at least two correct simplified terms of the three terms of the expansion of the triple product or of the corresponding determinant,		
			e.g4, -8, -15	Al	
			Obtain correct non-zero value, e.g27, and state that the lines do not		
			intersect	A1	[4]
	(ii)		ne correct process for evaluating scalar product of direction vectors for l and m	M1	
			orrect process for the moduli, divide the scalar product by the product of the		
			evaluate the inverse cosine of the result	M1	***
		Obtain ansv	ver 47.1° or 0.822 radians	Al	[3]
	(iii)	EITHER:	Use scalar product to obtain $a - b + 2c = 0$	Bl	
			Obtain $a + 2b - 2c = 0$, or equivalent, from a scalar product, or by		
			subtracting two point equations obtained from points on m, and solve for one		
			ratio, e.g. a: b	M1*	
			Obtain $a:b:c=-2:4:3$, or equivalent	A1	
			Substitute coordinates of a point on m and values for a , b and c in general		
			equation and evaluate d	M1(d	lep*)
			Obtain answer $-2x + 4y + 3z = 26$, or equivalent	Al	
		OR1:	Attempt to calculate vector product of direction vectors of l and m	M1*	
			Obtain two correct components	Al	
			Obtain -2i + 4j + 3k, or equivalent	Al	
			Form a plane equation and use coordinates of a relevant point to evaluate d	M1(d	(ep+)
		OR2:	Obtain answer $-2x + 4y + 3z = 26$, or equivalent	Al Ml*	
		ORZ:	Form a two-parameter plane equation using relevant vectors State a correct equation a $(x_1 - 2) + 6(x_1 + 2) + 4(x_2 + 2) + 4(x_1 + 2) + 4(x_2 + 2$		
			State a correct equation e.g. $\mathbf{r} = 2\mathbf{j} + 6\mathbf{k} + \mathbf{s}(\mathbf{i} - \mathbf{j} + 2\mathbf{k}) + \mathbf{t}(\mathbf{i} + 2\mathbf{j} - 2\mathbf{k})$ State three correct equations in x, y, z, s and t	A1 A1	
			Eliminate s and t	M1(d	len*)
			Obtain answer $-2x + 4y + 3z = 26$, or equivalent	Al	[5]
			John disher 2x 1 4y 1 32 - 20, or equivalent	Ai	[2]

Q5.

	(2)		
8 (i) Eithe		B1	
	Use scalar product to find cosine of angle between PA and line	M1	
	Obtain $\frac{42}{\sqrt{14 \times 230}}$ or equivalent	Al	
	Use trigonometry to obtain $\sqrt{104}$ or 10.2 or equivalent $(2n+2)$	A1	
<u>Or 1</u>	Obtain $\pm \binom{n-1}{3n-15}$ for PN (where N is foot of perpendicular)	B1	
	Equate scalar product of PN and line direction to zero Or equate derivative of PN ² to zero		
	\underline{Or} use Pythagoras' theorem in triangle PNA to form equation in n	Ml	
	Solve equation and obtain $n = 3$	Al	
	Obtain $\sqrt{104}$ or 10.2 or equivalent	Al	
<u>Or 2</u>	Obtain $\pm \begin{pmatrix} 2 \\ -1 \\ -15 \end{pmatrix}$ for vector PA (where A is point on line)	B1	
	Evaluate vector product of PA and line direction (12)	MI	
	Obtain $\pm \begin{pmatrix} -36 \\ -4 \end{pmatrix}$	Al	
	Divide modulus of this by modulus of line direction and obtain $\sqrt{104}$ or 10.2 or		
	equivalent (2)	Al	
<u>Or 3</u>	Obtain $\pm \begin{pmatrix} 2 \\ -1 \\ -15 \end{pmatrix}$ for vector PA (where A is point on line)	B1	
	Evaluate scalar product of PA and line direction to obtain distance AN	M1	
	Obtain 3√14 or equivalent	Al	
	Use Pythagoras' theorem in triangle PNA and obtain $\sqrt{104}$ or 10.2 or equivalent	Al	
	(2)		
Or 4	Obtain $\pm \begin{bmatrix} -1 \\ -15 \end{bmatrix}$ for vector PA (where A is point on line)	Bl	
	Use a second point B on line and use cosine rule in triangle ABP to find angle A		
	or angle B or use vector product to find area of triangle	M1	
	Obtain correct answer (angle $A = 42.25$)	A1	
	Use trigonometry to obtain √104 or 10.2 or equivalent	Al	[4]

(ii)	Either	Use scalar product to obtain a relevant equation in a, b, c, e.g. $2a + b + 3c = 0$ or		
(-)		2a - b - 15c = 0	M1	
		State two correct equations in a, b and c	A1√	
		Solve simultaneous equations to obtain one ratio	M1	
		Obtain $a:b:c=-3:9:-1$ or equivalent	A1	
		Obtain equation $-3x + 9y - z = 28$ or equivalent	A1	
		(2) (2) (8)		
	<u>Or 1</u>	Calculate vector product of two of $\begin{pmatrix} 2 \\ 1 \\ 3 \end{pmatrix}$, $\begin{pmatrix} 2 \\ -1 \\ -15 \end{pmatrix}$ and $\begin{pmatrix} 8 \\ 2 \\ -6 \end{pmatrix}$ or equiv	M1	
		Obtain two correct components of the product	Al√	
		Obtain correct $\begin{pmatrix} -3\\9\\-1 \end{pmatrix}$ or equivalent	Al	
		Substitute in $-3x + 9y - z = d$ to find d or equivalent	M1	
		Obtain equation $-3x + 9y - z = 28$ or equivalent	A1	
	Or 2	Form a two-parameter equation of the plane	M1	
		() () () ()		
		Obtain $\mathbf{r} = \begin{pmatrix} 1 \\ 3 \\ -4 \end{pmatrix} + s \begin{pmatrix} 2 \\ 1 \\ 3 \end{pmatrix} + t \begin{pmatrix} 2 \\ -1 \\ -15 \end{pmatrix}$ or equivalent	A1√	
		State three equations in x, y, z, s, t	A1	
		Eliminate s and t	M1	
		Obtain equation $3x - 9y + z = -28$ or equivalent	A1	[5]

Q6.

(i) Express general point of l or m in component form, i.e. $(3-\lambda, -2+2\lambda, 1+\lambda)$ or $(4+a\mu, 4+b\mu, 2-\mu)$ B₁ Equate components and eliminate either λ or μ from a pair of equations M1Eliminate the other parameter and obtain an equation in a and bM1 Obtain the given answer A1 [4] (ii) Using the correct process equate the scalar product of the direction vectors to zero M1* Obtain -a+2b-1=0, or equivalent A1 M1(dep*) Solve simultaneous equations for a or for b Obtain a = 3, b = 2A1 [4] (iii) Substitute found values in component equations and solve for λ or for μ M1Obtain answer $\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}$ from either $\lambda = 2$ or from $\mu = -1$ A1 [2]

Q7.

6 (i)		State or	B 1		
		State or	imply $\overline{QP} = 12\mathbf{i} + 6\mathbf{j} - 6\mathbf{k}$ or equivalent	B1	
		Use QF	as normal and A as mid-point to find equation of plane	M1	
	Obtain	A1	[4]		
	(ii)	Either	State equation of PB is $\mathbf{r} = 7\mathbf{i} + 7\mathbf{j} - 5\mathbf{k} + \lambda \mathbf{i}$	B1	
	. ,		Set up and solve a relevant equation for λ .	M1	
			Obtain $\lambda = -9$ and hence B is $(-2, 7, -5)$	A1	
			Use correct method to find distance between A and B.	M1	
			Obtain 5.20	A1	
		<u>Or</u>	Obtain 12 for result of scalar product of QP and i or equivalent Use correct method involving moduli, scalar product and cosine	B1	
			to find angle APB	M1	
			Obtain 35.26° or equivalent	A1	
			Use relevant trigonometry to find AB	M1	
			Obtain 5.20	A1	[5]

Q8.

10 (i) Equate scalar product of direction vector of
$$l$$
 and p to zero M1
Solve for a and obtain $a = -6$ A1 [2]

(ii) Express general point of
$$l$$
 correctly in parametric form, e.g. $3\mathbf{i} + 2\mathbf{j} + \mathbf{k} + \mu (2\mathbf{i} + \mathbf{j} + 2\mathbf{k})$
or $(1 - \mu)(3\mathbf{i} + 2\mathbf{j} + \mathbf{k}) + \mu (\mathbf{i} + \mathbf{j} - \mathbf{k})$

Equate at least two pairs of corresponding components of l and the second line and solve for λ or for μ M1

Obtain either
$$\lambda = \frac{2}{3}$$
 or $\mu = \frac{1}{3}$; or $\lambda = \frac{2}{a-1}$ or $\mu = \frac{1}{a-1}$; or reach $\lambda(a-4) = 0$ or $(1+\mu)(a-4) = 0$

Obtain a = 4 having ensured (if necessary) that all three component equations are satisfied A1 [4]

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(iii) Using the correct process for the moduli, divide scalar product of direction vector if l and normal to p by the product of their moduli and equate to the sine of the given angle, or form an equivalent horizontal equation $M1^*$ Use $\frac{2}{\sqrt{5}}$ as sine of the angle A1State equation in any form, e.g. $\frac{a+6}{\sqrt{(a^2+4+1)}\sqrt{(1+4+4)}} = \frac{2}{\sqrt{5}}$ All Solve for aMl (dep*)
Obtain answers for a=0 and $a=\frac{60}{31}$, or equivalent A1 [5]

[Allow use of the cosine of the angle to score M1M1.]

Q9.

Carry out a correct method for finding the position vector of N MI Obtain answer $31-2j+k$, or equivalent $A1$ Obtain answer $31-2j+k$, or equivalent $A1$ Obtain vector equation of MN in any correct form, e.g. $r=2i+j-2k+\lambda(i-3j+3k)$ Al OR: State that the position vector of MN in any correct form $A1$ Obtain answer, $e, i=1-3j+3k$, or equivalent $A1$ Obtain answer $e, i=1-3j+3k$, or equivalent $A1$ Obtain vector equation of MN in any correct form, e.g. $r=2i+j-2k+\lambda(i-3j+3k)$ Al [4] [4] State equation of BC in any correct form, e.g. $r=3i+2j-3k+\mu(i-5j+5k)$ Bl Solve for λ or for μ Obtain correct value of λ , or μ , e.g. $\lambda=3$, or $\mu=2$ Al Obtain position vector $S1-8j+7k$ Al [4] Obtain position vector $S1-8j+7k$ Al [4] [4] Obtain position vector $S1-8j+7k$ Al Obtain position vector $S1-8j+7k$ Al Obtain any form, e.g. $r=i+2j+2k+\lambda(2i+2j-2k)$ Bl [1] (ii) EITHER: Equate a relevant scalar product to zero and form an equation in λ MI OR: Equate derivative of OP^2 (or OP_1) to zero and form an equation in λ MI OR: Equate derivative of OP^2 or OP_1 to zero and form an equation in λ MI State a correct equation in any form Solve and obtain $\lambda=-\frac{1}{2}$ or equivalent Al Obtain final answer $OP^2=\frac{1}{2}$ i $+\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain final answer $OP^2=\frac{1}{2}$ i $+\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain final answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equivalent Al Obtain answer $OP^2=\frac{1}{2}$ j $+\frac{1}{2}$ k, or equ	6	6	i) <i>E</i>	ITHER:	State that the position vector of M is $2\mathbf{i} + \mathbf{j} - 2\mathbf{k}$, or equivalent	B 1	
Obtain answer $3\mathbf{i} - 2\mathbf{j} + \mathbf{k}$, or equivalent Obtain vector equation of MN in any correct form, e.g. $r = 2\mathbf{i} + \mathbf{j} - 2\mathbf{k} + \lambda(\mathbf{i} - 3\mathbf{j} + 3\mathbf{k})$ Al OR: State that the position vector of M is $2\mathbf{i} + \mathbf{j} - 2\mathbf{k}$, or equivalent Obtain vector equation of MN in any correct form, e.g. $r = 2\mathbf{i} + \mathbf{j} - 2\mathbf{k} + \lambda(\mathbf{i} - 3\mathbf{j} + 3\mathbf{k})$ (Obtain answer, e.g. $\mathbf{i} - 3\mathbf{j} + 3\mathbf{k}$), or equivalent Obtain vector equation of MN in any correct form, e.g. $r = 2\mathbf{i} + \mathbf{j} - 2\mathbf{k} + \lambda(\mathbf{i} - 3\mathbf{j} + 3\mathbf{k})$ [SR: The use of $AN = AC/3$ can earn $M1A0$, but $AN = AC/2$ gets $M0A0$.] (ii) State equation of BC in any correct form, e.g. $r = 3\mathbf{i} + 2\mathbf{j} - 3\mathbf{k} + \mu(\mathbf{i} - 5\mathbf{j} + 5\mathbf{k})$ B1 Solve for λ or for μ Obtain orrect value of λ , or μ , e.g. $\lambda = 3$, or $\mu = 2$ Al Obtain position vector $5\mathbf{i} - 8\mathbf{j} + 7\mathbf{k}$ (ii) EITHER: Equate a relevant scalar product to zero and form an equation in λ OR: Equate derivative of OP^2 (or OP_2) to zero and form an equation in λ MI OR: Use Pythagons in OAP or OBP and form an equation in λ MI State a correct equation in any form Solve and obtain $\lambda = -\frac{1}{6}$ or equivalent Obtain final answer $OP^2 = \frac{1}{2}\mathbf{i} + \frac{1}{2}\mathbf{j} + \frac{1}{3}\mathbf{k}$, or equivalent Al OB: EITHER: State or imply OP^2 is a normal to the required plane State normal vector $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Obtain answer $2x + 5y + 7z = 26$, or equivalent OB and evector normal to plane AOB and calculate its vector product with a direction vector for the line AB Obtain answer $2x + 5y + 7z = 26$, or equivalent OB 2: Set up and solve simultaneous equations in a, b, c derived from zero scalar products of $A^2 + b^2 +$		(.	.,				
Obtain vector equation of MN in any correct form, e.g. $r = 2i + j - 2k$, $k + (2i - 3j + 3k)$ OR: State that the position vector of M is $2i + j - 2k$, or equivalent Carry out a correct method for finding a direction vector for MN Obtain answer, e.g. $i - 3j + 3k$, or equivalent Obtain vector equation of MN in any correct form, e.g. $r = 2i + j - 2k + k + (2i - 3j + 3k)$ [SR: The use of $AN = AC/3$ can earn M1A0, but $AN = AC/2$ gets M0A0.] (ii) State equation of BC in any correct form, e.g. $r = 3i + 2j - 3k + \mu(i - 5j + 5k)$ B1 Solve for λ or for μ Obtain position vector $Si = 8j + 7k$ Obtain position vector $Si = 8j + 7k$ O10. 7 (i) State correct equation in any form, e.g. $r = i + 2j + 2k + \lambda(2i + 2j - 2k)$ B1 [1] (ii) EITHER: Equate a relevant scalar product to zero and form an equation in λ OR: Equate derivative of OP (or OP) to zero and form an equation in λ M1 OR: Equate derivative of OP (or OP) to zero and form an equation in λ M1 OR: Equate derivative of OP (or OP) to zero and form an equation in λ M1 State a correct equation in any form Solve and obtain $\lambda = -\frac{1}{2}$ or equivalent Obtain final answer $OP = \frac{1}{2}i + \frac{1}{3}j + \frac{2}{3}k$, or equivalent OBtain final answer of $PP = \frac{1}{2}i + \frac{1}{3}j + \frac{2}{3}k$, or equivalent OBtain answer $PP = \frac{1}{2}i + \frac{1}{3}j + \frac{2}{3}k$, or equivalent OBtain answer $PP = \frac{1}{2}i + \frac{1}{3}j + \frac{2}{3}k$, or equivalent OBtain answer $PP = \frac{1}{2}i + \frac{1}{3}j + \frac{1}{3}k$, or equivalent OBtain answer $PP = \frac{1}{3}i + \frac{1}{3}i + \frac{1}{3}k$, or equivalent OBtain answer $PP = \frac{1}{3}i + \frac{1}{3}i + \frac{1}{3}k$, or equivalent OBtain answer $PP = \frac{1}{3}i + \frac{1}{3}i + \frac{1}{3}k$, or equivalent OBtain answer $PP = \frac{1}{3}i + \frac$						A1	
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Obtain correct value of λ_i , or μ , e.g. $\lambda = 3$, or $\mu = 2$ Obtain position vector $5\mathbf{i} - 8\mathbf{j} + 7\mathbf{k}$ A1 [4] Q10. 7 (i) State correct equation in any form, e.g. $\mathbf{r} = \mathbf{i} + 2\mathbf{j} + 2\mathbf{k} + \lambda(2\mathbf{i} + 2\mathbf{j} - 2\mathbf{k})$ B1 [1] (ii) EITHER: Equate a relevant scalar product to zero and form an equation in λ M1 OR 1: Equate derivative of OP^2 (or OP) to zero and form an equation in λ M1 State a correct equation in any form Solve and obtain $\lambda = -\frac{1}{2}$ or equivalent Obtain final answer $\overline{OP} = \frac{2}{3}\mathbf{i} + \frac{1}{3}\mathbf{j} + \frac{1}{3}\mathbf{k}$, or equivalent A1 Obtain final answer $\overline{OP} = \frac{2}{3}\mathbf{i} + \frac{1}{3}\mathbf{j} + \frac{1}{3}\mathbf{k}$, or equivalent M1 State normal vector $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d M1 Obtain answer $2x + 5y + 7z = 20$, or equivalent A1 OB 1: Find a vector normal to plane AOB and calculate its vector product with a direction vector for the line AB Obtain answer $2x + 5y + 7z = 20$, or equivalent A1 OR 2: Set up and solve simultaneous equations in a , b , c derived from zero scalar products of $a^{\dagger} + b^{\dagger} + c^{\dagger} + c^$		-					
Q10. 7 (i) State correct equation in any form, e.g. $\mathbf{r} = \mathbf{i} + 2\mathbf{j} + 2\mathbf{k} + \lambda(2\mathbf{i} + 2\mathbf{j} - 2\mathbf{k})$ B1 [1] (ii) EITHER: Equate a relevant scalar product to zero and form an equation in λ M1 OR 1: Equate derivative of OP^2 (or OP_1 to zero and form an equation in λ M1 OR 2: Use Pythagoras in OAP or OBP and form an equation in λ M1 State a correct equation in any form Solve and obtain $\lambda = -\frac{1}{6}$ or equivalent Obtain final answer $\overline{OP} = \frac{2}{3}\mathbf{i} + \frac{5}{3}\mathbf{j} + \frac{7}{3}\mathbf{k}$, or equivalent A1 Obtain final answer $\overline{OP} = \frac{2}{3}\mathbf{i} + \frac{5}{3}\mathbf{j} + \frac{7}{3}\mathbf{k}$, or equivalent Substitute coordinates of a relevant point in $2\mathbf{k} + 5\mathbf{y} + 7\mathbf{z} = d$ and evaluate d M1 Obtain answer $2\mathbf{k} + 5\mathbf{y} + 7\mathbf{z} = 26$, or equivalent Obtain answer $2\mathbf{k} + 5\mathbf{y} + 7\mathbf{z} = 26$, or equivalent Obtain answer $2\mathbf{k} + 5\mathbf{y} + 7\mathbf{z} = 26$, or equivalent Obtain answer $2\mathbf{k} + 5\mathbf{y} + 7\mathbf{z} = 26$, or equivalent Obtain answer $2\mathbf{k} + 5\mathbf{y} + 7\mathbf{z} = 26$, or equivalent Obtain answer $2\mathbf{k} + 5\mathbf{y} + 7\mathbf{z} = 26$, or equivalent Obtain answer $2\mathbf{k} + 5\mathbf{y} + 7\mathbf{z} = 26$, or equivalent Obtain answer $2\mathbf{k} + 5\mathbf{y} + 7\mathbf{k} = 26$, or equivalent Obtain $a\mathbf{k} + b\mathbf{j} + c\mathbf{k}$ with (i) a direction vector for line $a\mathbf{k}\mathbf{k}$, (ii) a normal to plane $a\mathbf{k}\mathbf{k}$ and $a\mathbf{k}\mathbf{k}$ by $a\mathbf{k}\mathbf{k}$ and $a\mathbf{k}\mathbf{k}$ by $a\mathbf{k}\mathbf{k}$ and $a\mathbf{k}\mathbf{k}$ by $a\mathbf{k}\mathbf{k}$ and $a\mathbf{k}\mathbf{k}$ by $a\mathbf{k}\mathbf{k}$ by $a\mathbf{k}\mathbf{k}$ by $a\mathbf{k}\mathbf{k}$ and $a\mathbf{k}\mathbf{k}$ by $a\mathbf{k}\mathbf{k}$ b						A1	
(ii) State correct equation in any form, e.g. $\mathbf{r} = \mathbf{i} + 2\mathbf{j} + 2\mathbf{k} + \lambda(2\mathbf{i} + 2\mathbf{j} - 2\mathbf{k})$ B1 [1] (ii) EITHER: Equate a relevant scalar product to zero and form an equation in λ OR 1: Equate derivative of OP^2 (or OP) to zero and form an equation in λ M1 OR 2: Use Pythagoras in OAP or OBP and form an equation in λ M1 State a correct equation in any form Solve and obtain $\lambda = -\frac{1}{4}$ or equivalent Obtain final answer $\overrightarrow{OP} = \frac{2}{3}\mathbf{i} + \frac{5}{3}\mathbf{j} + \frac{7}{3}\mathbf{k}$, or equivalent Obtain final answer $\overrightarrow{OP} = \frac{2}{3}\mathbf{i} + \frac{5}{3}\mathbf{j} + \frac{7}{3}\mathbf{k}$, or equivalent State normal vector $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent OR 1: Find a vector normal to plane AOB and calculate its vector product with a direction vector for the line AB Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Substitute coordinates of a relevant point in $2\mathbf{i} + 5\mathbf{y} + 7\mathbf{z} = d$ and evaluate d M1* OR 2: Set up and solve simultaneous equations in a , b , c derived from zero scalar products of $a\mathbf{i} + b\mathbf{j} + c\mathbf{k}$ with (i) a direction vector for line AB , (ii) a normal to plane AOB Obtain $a : b : c = 2 : 5 : 7$, or equivalent Substitute coordinates of a relevant point in $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{i} = d$ and evaluate d M1* Obtain $a : b : c = 2 : 5 : 7$, or equivalent Substitute coordinates of a relevant point in $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{i} = d$ and evaluate d M1* Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k} = 2b$, or equivalent Substitute coordinates of a relevant point in $a = a + b = a + a + a + a + a + a + a + a + a + a$			O	btain posi	tion vector $5\mathbf{i} - 8\mathbf{j} + 7\mathbf{k}$	A1	[4]
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OR 1: Equate derivative of OP^2 (or OP) to zero and form an equation in λ MI State a correct equation in any form Al Solve and obtain $\lambda = -\frac{1}{6}$ or equivalent Al Obtain final answer $OP^2 = \frac{2}{3}\mathbf{i} + \frac{3}{3}\mathbf{j} + \frac{7}{3}\mathbf{k}$, or equivalent Al [4] (iii) EITHER: State or imply OP is a normal to the required plane State normal vector $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Al Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Al Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Al Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Al Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Al Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Al Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Substitute coordinates of a relevant point in $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{j} = d$ and evaluate d MI Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Substitute coordinates of a relevant point in $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{j} = d$ and evaluate d M1(dep*) Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Al OB and calculate its vector product with a direction vector for the line dB MI (dep*) Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Al OB dB MI (dep*) Obtain answer dB with (i) a direction vector for line dB , (ii) a normal to plane dAB Obtain $a : b : c = 2 : 5 : 7$, or equivalent Al Substitute coordinates of a relevant point in $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{j} = d$ and evaluate d M1(dep*) Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{j} = 26$, or equivalent Al OB and form a equation in $\mathbf{i} \times \mathbf{j} \times \mathbf{j} + 7\mathbf{j} = 2\mathbf{j} \times \mathbf{j} \times \mathbf{j} = 2\mathbf{j} \times \mathbf{j} \times \mathbf{j} \times \mathbf{j} = 2\mathbf{j} \times \mathbf{j} \times j$			(ii)	EITHER-	Fquate a relevant scalar product to zero and form an equation in 2	MI	
OR 2: Use Pythagoras in OAP or OBP and form an equation in λ MI State a correct equation in any form Solve and obtain $\lambda = -\frac{1}{6}$ or equivalent Obtain final answer $\overrightarrow{OP} = \frac{2}{3}\mathbf{i} + \frac{5}{3}\mathbf{j} + \frac{7}{3}\mathbf{k}$, or equivalent A1 Obtain final answer $\overrightarrow{OP} = \frac{2}{3}\mathbf{i} + \frac{5}{3}\mathbf{j} + \frac{7}{3}\mathbf{k}$, or equivalent MI State normal vector $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d Obtain answer $2x + 5y + 7z = 26$, or equivalent OR 1: Find a vector normal to plane AOB and calculate its vector product with a direction vector for the line AB Obtain answer $2x + 5y + 7z = 26$, or equivalent Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d Obtain answer $2x + 5y + 7z = 26$, or equivalent OR 2: Set up and solve simultaneous equations in a , b , c derived from zero scalar products of $a\mathbf{i} + b\mathbf{j} + c\mathbf{k}$ with (i) a direction vector for line AB , (ii) a normal to plane OAB Obtain $a : b : c = 2 : 5 : 7$, or equivalent Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d Obtain answer $2x + 5y + 7z = 26$, or equivalent Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d Obtain answer $2x + 5y + 7z = 26$, or equivalent Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d Obtain answer $2x + 5y + 7z = 26$, or equivalent OBTAIN All (dep*) Obtain answer $2x + 5y + 7z = 26$, or equivalent OR 3: With $Q(x, y, z)$ on plane, use Pythagoras in OPQ to form an equation in x , y and z Form a correct equation Reduce to linear form Obtain answer $2x + 5y + 7z = 26$, or equivalent OR 4: Find a vector normal to plane AOB and form a 2-parameter equation with relevant vectors, e.g., $\mathbf{r} = \mathbf{i} + 2\mathbf{j} + 2\mathbf{k} + \lambda(2\mathbf{i} - 2\mathbf{j} + 2\mathbf{k}) + \mu(8\mathbf{i} - 6\mathbf{j} + 2\mathbf{k})$ A1 Eliminate λ and μ M1(dep*)			(11)				
State a correct equation in any form Solve and obtain $\lambda = -\frac{1}{6}$ or equivalent Obtain final answer $\overrightarrow{OP} = \frac{2}{3}\mathbf{i} + \frac{5}{3}\mathbf{j} + \frac{2}{3}\mathbf{k}$, or equivalent A1 (iii) EITHER: State or imply \overrightarrow{OP} is a normal to the required plane State normal vector $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d Obtain answer $2x + 5y + 7z = 26$, or equivalent OR 1: Find a vector for the line AB Obtain answer $2x + 5y + 7z = 26$, or equivalent OR 2: Set up and solve simultaneous equations in a, b, c derived from zero scalar products of $a^{\dagger} + b\mathbf{j} + c\mathbf{k}$ with (i) a direction vector for line AB , (ii) a normal to plane AOB and calculate the substitute coordinates of a relevant point in $a^{\dagger} + b^{\dagger} + c\mathbf{k}$ with (i) a direction vector for line $a^{\dagger} + b^{\dagger} + c\mathbf{k}$ with (i) a direction vector for line $a^{\dagger} + b^{\dagger} + c\mathbf{k}$ with (i) a direction vector for line $a^{\dagger} + b^{\dagger} + c\mathbf{k}$ with (i) a direction vector for line $a^{\dagger} + b^{\dagger} + c\mathbf{k}$ with (ii) a direction vector for line $a^{\dagger} + b^{\dagger} + c\mathbf{k}$ with (ii) a direction vector for line $a^{\dagger} + b^{\dagger} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a direction vector for line $a^{\dagger} + b\mathbf{k} + c\mathbf{k}$ with (iii) a normal to plane $a^{\dagger} + b\mathbf{k} + c\mathbf{k} $							
Solve and obtain $\lambda = -\frac{1}{6}$ or equivalent Obtain final answer $\overrightarrow{OP} = \frac{2}{3}\mathbf{i} + \frac{5}{3}\mathbf{j} + \frac{7}{3}\mathbf{k}$, or equivalent A1 A1 [4] (iii) EITHER: State or imply \overrightarrow{OP} is a normal to the required plane State normal vector $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d M1 Obtain answer $2x + 5y + 7z = 26$, or equivalent A1 OR 1: Find a vector normal to plane AOB and calculate its vector product with a direction vector for the line AB Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent A1 Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d M1(dep*) Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent OR 2: Set up and solve simultaneous equations in a , b , c derived from zero scalar products of $a\mathbf{i} + b\mathbf{j} + c\mathbf{k}$ with (i) a direction vector for line AB , (ii) a normal to plane OAB Obtain $a: b: c = 2: 5: 7$, or equivalent A1 OR 3: With $Q(x, y, z)$ on plane, use Pythagoras in OPQ to form an equation in x , y and z Form a correct equation Reduce to linear form Obtain answer $2x + 5y + 7z = 26$, or equivalent OR 4: Find a vector normal to plane AOB and form a 2-parameter equation with relevant vectors, e , e , e i e i e e e quivalent A1 OR 4: Find a vector normal to plane AOB and form a 2-parameter equation with relevant vectors, e , e , e i e							
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State three correct equations in x , y , z , λ and μ A1 Eliminate λ and μ M1(dep*)				OR 4:			
Eliminate λ and μ M1(dep*)							
Obtain answer $2x + 5y + 7z = 26$, or equivalent A1 [4]						The state of the s	543
					Obtain answer $2x + 5y + 7z = 20$, or equivalent	AI	[4]

Q11.

6	(i)	−5 i + 3 j + Substitute	ral vector for point on line, e.g. $6\mathbf{k} + s(10\mathbf{i} + 5\mathbf{j} - 5\mathbf{k})$ or $5\mathbf{i} + 8\mathbf{j} + \mathbf{k} + t(10\mathbf{i} + 5\mathbf{j} - 5\mathbf{k})$ or equivalent their line into equation of plane and solve for parameter rect value, $s = \frac{2}{5}$ or $t = -\frac{3}{5}$ or equivalent $5, 5, 4$ o.e.	B1 M1 A1	
	(ii)	Carry out p Using correvaluate an	aply normal vector to p is $2\mathbf{i} - \mathbf{j} + 4\mathbf{k}$ process for evaluating scalar product of two relevant vectors vect process for moduli, divide scalar product by the product of the moduli and resin() or $\arccos()$ of the result.	B1 M1 d M1 A1	
Q12					
7	(i)		ect method to express \overrightarrow{OP} in terms of λ given answer	M1 A1	[2]
	(ii)	OR1:	Use correct method to express scalar product of \overrightarrow{OA} and \overrightarrow{OP} , or \overrightarrow{OB} and \overrightarrow{OP} in terms of λ Using the correct method for the moduli, divide scalar products by products of moduli and express $\cos AOP = \cos BOP$ in terms of λ , or in terms of λ and OP Use correct method to express $OA^2 + OP^2 - AP^2$, or $OB^2 + OP^2 - BP^2$ in terms of λ Using the correct method for the moduli, divide each expression by twice the product of the relevant moduli and express $\cos AOP = \cos BOP$ in terms of λ , or λ and OP orrect equation in any form, e.g. $\frac{9+2\lambda}{3\sqrt{(9+4\lambda+12\lambda^2)}} = \frac{11+14\lambda}{5\sqrt{(9+4\lambda+12\lambda^2)}}$	M1 M1* M1 M1 A1	
		Solve for A Obtain $\lambda = [SR: The]$ cos $\frac{1}{2}$ AO but accept spurious n [SR: Allow	M1(dep*) A1	[5]
	(iii)	Verify the	given statement correctly	В1	[1]

Q13.

	8.831	Application of the control of the state of the control of the cont	92.30	1
9	(i)	Calculate scalar product of direction of l and normal to p	MI	
		Obtain $4 \times 2 + 3 \times (-2) + (-2) \times 1 = 0$ and conclude accordingly	A1	[2]
	(ii)	Substitute $(a, 1, 4)$ in equation of p and solve for a	MI	
		Obtain $a = 4$	A1	[2]
	(iii)	Either Attempt use of formula for perpendicular distance using (a, 1, 4)	MI	
		Obtain at least $\frac{2a-2+4-10}{\sqrt{4+4+1}} = 6$	Al	
		Obtain $a = 13$	A1	
		Attempt solution of $\frac{2a-8}{3} = -6$	MI	
		Obtain $a = -5$	Al	
		Or Form equation of parallel plane and substitute (a, 1, 4)	MI	
		Obtain $\frac{2a+2}{3} - \frac{10}{3} = 6$	Al	
		Obtain $a = 13$	Al	
		Solve $\frac{2a+2}{3} - \frac{10}{3} = -6$	MI	
		Obtain $a = -5$	Al	
1 1			1	ı

Or State a vector from a pt on the plane to $(a, 1, 4)$ e.g. $\begin{pmatrix} a-5\\1\\4 \end{pmatrix} \text{ or } \begin{pmatrix} a\\1\\-6 \end{pmatrix}$	ВІ	
Calculate the component of this vector in the direction of the unit normal and equate to 6: $\frac{1}{3} \begin{pmatrix} a-5 \\ 1 \\ 4 \end{pmatrix} \cdot \begin{pmatrix} 2 \\ -2 \\ 1 \end{pmatrix} = 6$	Mi	
Obtain $a = 13$	Al	
Solve $\frac{1}{3} \begin{pmatrix} a-5 \\ 1 \\ 4 \end{pmatrix} \cdot \begin{pmatrix} 2 \\ -2 \\ 1 \end{pmatrix} = -6$	MI	
Obtain $a = -5$	A1	

State or imply perpendicular line $\mathbf{r} = \begin{pmatrix} a \\ 1 \\ 4 \end{pmatrix} + \mu \begin{pmatrix} 2 \\ -2 \\ 1 \end{pmatrix}$ B1

Substitute components for p and solve for μ Obtain $\mu = \frac{8-2a}{9}$ Equate distance between (a, 1, 4) and foot of perpendicular to ± 6 M1

Obtain $\frac{3(8-2a)}{9} = \pm 6$ or equivalent and hence -5 and 13

A1

[5]

Q14.

10 (i) EITHER Use scalar product of relevant vectors, or subtract point equations to form two equations in a,b,c, e.g. a - 5b - 3c = 0 and a - b - 3c = 0M1* State two correct equations in a,b,c A1 Solve simultaneous equations and find one ratio, e.g. a:c, or b=0M1 (dep*) Obtain a:b:c=3:0:1, or equivalent A1Substitute a relevant point in 3x + z = d and evaluate d M1 (dep*) Obtain equation 3x + z = 13, or equivalent Al OR 1 Attempt to calculate vector product of relevant vectors, e.g. $(i - 5j - 3k) \times (i - j - 3k)$ M2* Obtain 2 correct components of the product A1 Obtain correct product, e.g. 12i + 4k A1 Substitute a relevant point in 12x + 4z = d and evaluate d M1 (dep*) Obtain 3x + z = 13, or equivalent A1 OR 2 Attempt to form 2-parameter equation for the plane with relevant vectors M2* State a correct equation e.g. $\mathbf{r} = 3\mathbf{i} - 2\mathbf{j} + 4\mathbf{k} + \lambda(\mathbf{i} - 5\mathbf{j} - 3\mathbf{k}) + \mu(\mathbf{i} - \mathbf{j} - 3\mathbf{k})$ A1 State 3 equations in x, y, z, λ and μ Al Eliminate λ and μ M1 (dep*) Obtain equation 3x + z = 13, or equivalent Al [6] (ii) EITHER Find \overline{CP} for a point P on AB with a parameter t, e.g. $2\mathbf{i} + 3\mathbf{j} + 7\mathbf{k} + t(-\mathbf{i} + \mathbf{j} + 3\mathbf{k})$ B1 $\sqrt{}$ Either: Equate scalar product $\overline{CP}, \overline{AB}$ to zero and form an equation in t Or 1: Equate derivative for CP^2 (or CP) to zero and form an equation in t Or 2: Use Pythagoras in triangle CPA (or CPB) and form an equation in t M1 Solve and obtain correct value of t, e.g. t = -2Al Carry out a complete method for finding the length of CP MI Obtain answer 3 12 (4.24), or equivalent A1

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State \overline{AC} (or \overline{BC}) and \overline{AB} in component form
OR I
                                                                                                             B1 √
             Using a relevant scalar product find the cosine of CAB (or CBA)
                                                                                                             MI
             Obtain cost CAB = -\sqrt{11.\sqrt{52}}, or \cos CBA = \sqrt{11.\sqrt{117}}, or equivalent
                                                                                                             A1
             Use trig to find the length of the perpendicular
                                                                                                             M1
             Obtain answer 3\sqrt{2} (4.24), or equivalent
                                                                                                             A1
             State AC (or BC) and AB in component form
                                                                                                             B1 √
OR 2
             Using a relevant scalar product find the length of the projection AC (or BC)
                                                                                                             M1
             Obtain answer 2\sqrt{11} (or), 3\sqrt{11} or equivalent
                                                                                                             Al
             Use Pythagoras to find the length of the perpendicular
                                                                                                             MI
             Obtain answer 3√2 (4.24), or equivalent
                                                                                                             A1
             State AC (or BC) and AB in component form
OR 3
                                                                                                             B1 √
             Calculate their vector product, e.g. (-2\mathbf{i} - 3\mathbf{j} - 7\mathbf{k}) \times (-\mathbf{i} + \mathbf{j} + 3\mathbf{k})
                                                                                                             M1
             Obtain correct product, e.g. -2i + 13j - 5k
                                                                                                             A1
             Divide modulus of the product by the modulus of \overline{AB}
                                                                                                             M1
             Obtain answer 3\sqrt{2} (4.24), or equivalent
                                                                                                             A1
             State two of \overline{AB}, \overline{BC}) and \overline{AC} in component form
OR 4
                                                                                                             B1 √
             Use cosine formula in triangle ABC to find cos A or cos B
                                                                                                             M1
             Obtain \cos A = -\frac{2\sqrt{11} \cdot \sqrt{62}}{\sqrt{11} \cdot \sqrt{117}}, or \cos B = 2\sqrt{11} \cdot \sqrt{117}
                                                                                                             A1
             Use trig to find the length of the perpendicular
                                                                                                             MI
    Obtain answer \sqrt[3]{2} (4.24), or equivalent
                                                                                                             [5]
                                                                                                       A1
    [The f.t is on \overline{AB}]
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Q15.

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State or imply general point of either line has coordinates (5+s, 1-s, -4+3s) or
                                                                                                                   B1
       (p+2t, 4+5t, -2-4t)
       Solve simultaneous equations and find s and t
                                                                                                                  M1
       Obtain s = 2 and t = -1 or equivalent in terms of p
                                                                                                                  A1
       Substitute in third equation to find p = 9
                                                                                                                  A1
       State point of intersection is (7, -1, 2)
                                                                                                                  A1
                                                                                                                           [5]
                  Use scalar product to obtain a relevant equation in a, b, c
(ii) Either
                  e.g. a-b+3c=0 or 2a+5b-4c=0
                                                                                                                  M1
                  State two correct equations in a, b, c
                                                                                                                  A1
                  Solve simultaneous equations to obtain at least one ratio
                                                                                                                DM1
                  Obtain a : b : c = -11 : 10 : 7 or equivalent
                                                                                                                  A1
                  Obtain equation -11x + 10y + 7z = -73 or equivalent with integer coefficients
                                                                                                                  A1
                  Calculate vector product of \begin{pmatrix} 1 \\ -1 \\ 3 \end{pmatrix} and \begin{pmatrix} 2 \\ 5 \\ -4 \end{pmatrix}
       Or 1
                                                                                                                  M1
                  Obtain two correct components of the product
                                                                                                                  A1
                  Obtain correct 10 or equivalent
                                                                                                                  A1
                  Substitute coordinates of a relevant point in \mathbf{r}.\mathbf{n} = d to find d
                                                                                                                DM1
                  Obtain equation -11x + 10y + 7z = -73 or equivalent with integer coefficients
                                                                                                                  A1
       Or 2
                  Using relevant vectors, form correctly a two-parameter equation for the plane
                                                                                                                  M1
                  Obtain \mathbf{r} = \begin{pmatrix} 5 \\ 1 \\ -4 \end{pmatrix} + \lambda \begin{pmatrix} 1 \\ -1 \\ 3 \end{pmatrix} + \mu \begin{pmatrix} 2 \\ 5 \\ -4 \end{pmatrix} or equivalent
                                                                                                                  A1
                  State three equations in x, y, z, \lambda, \mu
                                                                                                                   A1
                                                                                                                DM1
                  Eliminate \lambda and \mu
                  Obtain 11x - 10y - 7z = 73 or equivalent with integer coefficients
                                                                                                                  A1
                                                                                                                           [5]
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Q16.

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(i) EITHER: Obtain a vector parallel to the plane, e.g. \overrightarrow{AB} = -2\mathbf{i} + 4\mathbf{j} - \mathbf{k}
9
                                                                                                                B1
                          Use scalar product to obtain an equation in a, b, c, e.g. -2a+4b-c=0,
                          3a-3b+3c=0, or a+b+2c=0
                                                                                                               M1
                          Obtain two correct equations in a, b, c
                                                                                                                A1
                          Solve to obtain ratio a:b:c
                                                                                                               M1
                          Obtain a:b:c=3:1:-2, or equivalent
                                                                                                                A1
                          Obtain equation 3x + y - 2z = 1, or equivalent
                                                                                                                Al
               OR1:
                          Substitute for two points, e.g. A and B, and obtain 2a-b+2c=d
                          and 3b+c=d
                                                                                                                B1
                          Substitute for another point, e.g. C, to obtain a third equation and eliminate
                          one unknown entirely from the three equations
                                                                                                               M1
                          Obtain two correct equations in three unknowns, e.g. in a, b, c
                                                                                                                A1
                          Solve to obtain their ratio, e.g. a:b:c
                                                                                                                M1
                          Obtain a:b:c=3:1:-2, a:c:d=3:-2:1, a:b:d=3:1:1
                          b:c:d=-1:-2:1
                                                                                                                A1
                          Obtain equation 3x + y - 2z = 1, or equivalent
                                                                                                                Al
                          Obtain a vector parallel to the plane, e.g. \overrightarrow{BC} = 3\mathbf{i} - 3\mathbf{j} + 3\mathbf{k}
               OR2:
                                                                                                                B1
                          Obtain a second such vector and calculate their vector product
                          e.g. (-2i+4j-k)\times(3i-3j+3k)
                                                                                                               M1
                          Obtain two correct components of the product
                                                                                                                Al
                          Obtain correct answer, e.g. 9i + 3j - 6k
                                                                                                                A1
                          Substitute in 9x + 3y - 6z = d to find d
                                                                                                               M1
                          Obtain equation 9x + 3y - 6z = 3, or equivalent
                                                                                                                Al
               OR3:
                          Obtain a vector parallel to the plane, e.g. \overrightarrow{AC} = \mathbf{i} + \mathbf{j} + 2\mathbf{k}
                                                                                                                BI
                          Obtain a second such vector and form correctly a 2-parameter equation for
                                                                                                               M1
                          Obtain a correct equation, e.g. \mathbf{r} = 3\mathbf{i} + 4\mathbf{k} + \lambda(-2\mathbf{i} + 4\mathbf{j} - \mathbf{k}) + \mu(\mathbf{i} + \mathbf{j} + 2\mathbf{k})
                                                                                                                A1
                          State three correct equations in x, y, z, \lambda, \mu
                                                                                                                A1
                          Eliminate \lambda and \mu
                                                                                                               M1
                          Obtain equation 3x + y - 2z = 1, or equivalent
                                                                                                                Al
                                                                                                                       [6]
         (ii) Obtain answer i + 2j + 2k, or equivalent
                                                                                                                B1
                                                                                                                       [1]
```

(iii)	EITHER	2: Use $\frac{\overrightarrow{OA}.\overrightarrow{OD}}{ \overrightarrow{OD} }$ to find projection ON of OA onto OD	Ml	
		Obtain $ON = \frac{4}{3}$	Al	
		Use Pythagoras in triangle <i>OAN</i> to find <i>AN</i> Obtain the given answer	M1 A1	
	OR1:	Calculate the vector product of \overrightarrow{OA} and \overrightarrow{OD} Obtain answer $6\mathbf{i} + 2\mathbf{j} - 5\mathbf{k}$	MI Al	
	OR2:	Divide the modulus of the vector product by the modulus of \overrightarrow{OD} Obtain the given answer Taking general point P of OD to have position vector $\lambda(\mathbf{i} + 2\mathbf{j} + 2\mathbf{k})$, form	M1 A1	
	Onz.	an equation in λ by either equating the scalar product of \overrightarrow{AP} and \overrightarrow{OP} to		
		zero, or using Pythagoras in triangle OPA , or setting the derivative of \overrightarrow{AP}		
		to zero	Ml	
		Solve and obtain $\lambda = \frac{4}{9}$	Al	
		Carry out method to calculate AP when $\lambda = \frac{4}{9}$	Ml	
		Obtain the given answer	Al	
	OR3:	Use a relevant scalar product to find the cosine of AOD or ADO	MI	
		Obtain $\cos AOD = \frac{4}{9}$ or $\cos ADO = \frac{5}{3\sqrt{10}}$, or equivalent	Al	
		Use trig to find the length of the perpendicular	Ml	
	0.247	Obtain the given answer	Al	
	OR4:	Use cosine formula in triangle AOD to find cos AOD or cos ADO	M1	
		Obtain $\cos AOD = \frac{8}{18}$ or $\cos ADO = \frac{10}{6\sqrt{10}}$, or equivalent	Al	
		Use trig to find the length of the perpendicular	Ml	
		Obtain the given answer	A1	[4]

Q17.

(i) Find scalar product of the normals to the planes MI Using the correct process for the moduli, divide the scalar product by the product of the moduli and find cos-1 of the result. MI Obtain 67.8° (or 1.18 radians) Al [3] (ii) EITHER Carry out complete method for finding point on line MI Obtain one such point, e.g. (2,-3,0) or $(\frac{17}{7},0,\frac{6}{7})$ or (0,-17,-4) or ... A1... Either State 3a - b + 2c = 0 and a + b - 4c = 0 or equivalent BI Attempt to solve for one ratio, e.g. a:b MI Obtain a:b:c=1:7:2 or equivalent Al State a correct final answer, e.g. $r = [2, -3, 0] + \lambda[1, 7, 2]$ A1√ Obtain a second point on the line AI Subtract position vectors to obtain direction vector MI Obtain [1, 7, 2] or equivalent Al State a correct final answer, e.g. $r = [2, -3, 0] + \lambda[1, 7, 2]$ AI√ Use correct method to calculate vector product of two normals Ml Obtain two correct components Al Obtain [2, 14, 4] or equivalent AI State a correct final answer, e.g. $r = [2, -3, 0] + \lambda[1, 7, 2]$ A1√ [is dependent on both M marks in all three cases] OR 3 Express one variable in terms of a second variable MI Obtain a correct simplified expression, e.g. $x = \frac{1}{2}(4+z)$ AI Express the first variable in terms of third variable MI Obtain a correct simplified expression, e.g. $x = \frac{1}{7}(17 + y)$ ΑI Form a vector equation for the line MI State a correct final answer, e.g. $r = [0, -17, -4] + \lambda[1, 7, 2]$ AI OR 4 Express one variable in terms of a second variable MI Obtain a correct simplified expression, e.g. z = 2x - 4AI Express third variable in terms of the second variable MI Obtain a correct simplified expression, e.g. y = 7x - 17AI Form a vector equation for the line MI State a correct final answer, e.g. $r = [0, -17, -4] + \lambda[1, 7, 2]$ [6] Al Q18. Obtain 2x - 3y + 6z for LHS of equation B₁ Obtain 2x - 3y + 6z = 23B₁ [2] Use correct formula to find perpendicular distance (ii) Either M1Obtain unsimplified value $\frac{\pm 23}{\sqrt{2^2 + (-3)^2 + 6^2}}$, following answer to (i) A1√

A1

[3]

Obtain $\frac{23}{7}$ or equivalent

	OR 1	Use scalar product of $(4, -1, 2)$ and a vector normal to the plane	M1	
		Use unit normal to plane to obtain $\pm \frac{(8+3+12)}{\sqrt{49}}$	A1	
		Obtain $\frac{23}{7}$ or equivalent	A1	[3]
	OR 2	Find parameter intersection of p and $\mathbf{r} = \mu (2\mathbf{i} - 3\mathbf{j} + 6\mathbf{k})$	M1	
		Obtain $\mu = \frac{23}{49}$ [and $\left(\frac{46}{49}, -\frac{69}{49}, \frac{138}{49}\right)$ as foot of perpendicular]	A1	
		Obtain distance $\frac{23}{7}$ or equivalent	A1	[3]
(iii)	Either	Recognise that plane is $2x - 3y + 6z = k$ and attempt use of formula for perpendicular distance to plane at least once	M1	
		Obtain $\frac{ 23-k }{7} = 14$ or equivalent	A1	
	OB	Obtain $2x - 3y + 6z = 121$ and $2x - 3y + 6z = -75$	A1	[3]
	<u>OR</u>	Recognise that plane is $2x - 3y + 6z = k$ and attempt to find at least one point on q using l with $\lambda = \pm 2$	M1	
		Obtain 2x - 3y + 6z = 121	A1	
		Obtain 2x - 3y + 6z = -75	A1	[3]

Q19.

10	(i)	Express g	eneral point of <i>l</i> in component form, e.g. $(1+3\lambda, 2-2\lambda, -1+2\lambda)$	B1	
		Substitute	in given equation of p and solve for λ	M1	
			nal answer $-\frac{1}{2}\mathbf{i} + 3\mathbf{j} - 2\mathbf{k}$, or equivalent, from $\lambda = -\frac{1}{2}$	A1	3
	(ii)	State or in	nply a vector normal to the plane, e.g. $2i + 3j - 5k$	B1	
		normal for	•	M1	
			correct process for the moduli, divide the scalar product by the product of the		
			ad find the inverse sine or cosine of the result	M1	
		Obtain an	swer 23.2° (or 0.404 radians)	A1	4
	(iii)	EITHER:	State $2a + 3b - 5c = 0$ or $3a - 2b + 2c = 0$	B1	
			Obtain two relevant equations and solve for one ratio, e.g. a: b	M1	
			Obtain $a:b:c=4:19:13$, or equivalent	A1	
			Substitute coordinates of a relevant point in $4x + 19y + 13z = d$, and evaluate d	M1	
			Obtain answer $4x + 19y + 13z = 29$, or equivalent	A1	
		OR1:	Attempt to calculate vector product of relevant vectors, e.g.		
			$(2\mathbf{i} + 3\mathbf{j} - 5\mathbf{k}) \times (3\mathbf{i} - 2\mathbf{j} + 2\mathbf{k})$	MI	
			Obtain two correct components of the product	A1	
			Obtain correct product, e.g. $-4\mathbf{i} - 19\mathbf{j} - 13\mathbf{k}$	A1	
			Substitute coordinates of a relevant point in $4x + 19y + 13z = d$	M1	
			Obtain answer $4x + 19y + 13z = 29$, or equivalent	A1	
		OR2:	Attempt to form a 2-parameter equation with relevant vectors	M1	
			State a correct equation, e.g. $\mathbf{r} = \mathbf{i} + 2\mathbf{j} - \mathbf{k} + \lambda(2\mathbf{i} + 3\mathbf{j} - 5\mathbf{k}) + \mu(3\mathbf{i} - 2\mathbf{j} + 2\mathbf{k})$	A1	
			State 3 equations in x , y , z , λ and μ	A1	
			Eliminate λ and μ	M1	
			Obtain answer $4x + 19y + 13z = 29$, or equivalent	A1	
		OR3:	Using a relevant point and relevant direction vectors, form a determinant equation for the plane	M1	
			State a correct equation, e.g. $\begin{vmatrix} x-1 & y-2 & z+1 \\ 2 & 3 & -5 \\ 3 & -2 & 2 \end{vmatrix} = 0$	A1	
			3 -2 2		
			Attempt to expand the determinant	M1	
			Obtain correct values of two cofactors	A1	
			Obtain answer $4x + 19y + 13z = 29$, or equivalent	A1	5

Q20.

10	(i)	EITHER:	Find \overrightarrow{AP} (or \overrightarrow{PA}) for a point P on I with parameter λ , e.g. $\mathbf{i} - 17\mathbf{j} + 4\mathbf{k} + \lambda(-2\mathbf{i} + \mathbf{j} - 2\mathbf{k})$	В1
			Calculate scalar product of \overrightarrow{AP} and a direction vector for l and equate to zero	Ml
			Solve and obtain $\lambda = 3$	Al
			Carry out a complete method for finding the length of AP	M1
			Obtain the given answer 15 correctly	Al
		OR1:	Calling $(4, -9, 9) B$, state \overrightarrow{BA} (or \overrightarrow{AB}) in component form, e.g. $-\mathbf{i} + 17\mathbf{j} - 4\mathbf{k}$	Bl
			Calculate vector product of \overline{BA} and a direction vector for l ,	
			e.g. $(-\mathbf{i} + 17\mathbf{j} - 4\mathbf{k}) \times (-2\mathbf{i} + \mathbf{j} - 2\mathbf{k})$	Ml
			Obtain correct answer, e.g. $-30\mathbf{i} + 6\mathbf{j} + 33\mathbf{k}$	A1
			Divide the modulus of the product by that of the direction vector	M1
			Obtain the given answer correctly	Al
		OR2:	State BA (or AB) in component form	Bl
			Use a scalar product to find the projection of BA (or AB) on l	M1
			Obtain correct answer in any form, e.g. $\frac{27}{\sqrt{9}}$	Al
			Use Pythagoras to find the perpendicular	Ml

	Obtain the given answer correctly	Al	
OR3:	State \overline{BA} (or \overline{AB}) in component form	B1	
	Use a scalar product to find the cosine of ABP	M1	
	Obtain correct answer in any form, e.g. $\frac{27}{\sqrt{9.\sqrt{306}}}$	A1	
	Use trig. to find the perpendicular	M1	
	Obtain the given answer correctly	A1	
OR4:	State BA (or AB) in component form	B1	
	Find a second point C on I and use the cosine rule in triangle ABC to find cosine of angle A , B , or C , or use a vector product to find the area of ABC		
	Obtain correct answer in any form	A1	
	Use trig, or area formula to find the perpendicular	M1	
	Obtain the given answer correctly	A1	
OR5:	State correct AP (or PA) for a point P on I with parameter λ in any form	B1	
	Use correct method to express AP^2 (or AP) in terms of λ Obtain a correct expression in any form,	M1	
	e.g. $(1-2\lambda)^2 + (-17+\lambda)^2 + (4-2\lambda)^2$	A1	
	Carry out a method for finding its minimum (using calculus, algebra	3757	
	or Pythagoras)	M1	
	Obtain the given answer correctly	A1	[5]
(ii) EIT OR:	THER: Substitute coordinates of a general point of l in equation of plane and equate constant terms or equate the coefficient of λ to zero, obtaining a equation in a and b Obtain a correct equation, e.g. $4a-9b-27+1=0$ Obtain a second correct equation, e.g. $-2a+b+6=0$ Solve for a or for b Obtain $a=2$ and $b=-2$ Substitute coordinates of a point of l and obtain a correct equation, e.g. $4a-9b=26$ EITHER: Find a second point on l and obtain an equation in a and b Obtain a correct equation OR: Calculate scalar product of a direction vector for l and a vec normal to the plane and equate to zero Obtain a correct equation, e.g. $-2a+b+6=0$ Solve for a or for b Obtain $a=2$ and $b=-2$	M1* A1 A1 M1(dep*) A1 B1 M1* A1	[5]
Q21.			
7 (i)	State at least two of the equations $1 + \lambda = a + \mu$, $4 = 2 + 2\mu$, $-2 + 3\lambda = -2 + 3a\mu$	B1	
	Solve for λ or for μ	M1	
	Obtain $\lambda = a$ (or $\lambda = a + \mu - 1$) and $\mu = 1$	A1	
	Confirm values satisfy third equation	A1	[4]
(ii)	State or imply point of intersection is $(a+1, 4, 3a-2)$	B1	
	Use correct method for the modulus of the position vector and equate to 9, followin	g their	
	point of intersection	M*1	
	Solve a three-term quadratic equation in a $\left(a^2 - a - 6 = 0\right)$	DM*1	
	Obtain –2 and 3	A1	[4]