1.5 Further Vectors

EDEXCEL 9FM0 · Calculator allowed · about 225 minutes · Write-in edition

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Two coastal survey markers used by Jamal's team are at A(2, -1, 3) and B(5, 4, -2), with coordinates in kilometres relative to a harbour office. Jamal models the straight path between them as the line l1 through A and B.

(a) Find the vector AB. **(2)**

(b) Write down a vector equation for l1. **(2)**

(c) A third marker C has coordinates (11, 14, -12). Show that C lies on l1. **(3)**

(Total for Question 1 is 7 marks)

2 Two straight paths through a country park are modelled by the lines l1: r = (1, 2, -1) + s(2, -1, 2) and l2: r = (4, 0, 3) + t(1, 2, 2), where s and t are real parameters.

(a) Find the acute angle between l1 and l2, giving your answer in degrees to 1 decimal place. **(4)**

(b) State, with a reason, whether l1 and l2 are parallel, perpendicular or neither. **(2)**

(Total for Question 2 is 6 marks)

3 A triangular solar panel has corners at the points P(1, 0, 2), Q(3, 4, 1) and R(0, 2, 5), with coordinates measured in metres.

(a) Find the vectors PQ and PR. **(2)**

(b) Calculate the vector product PQ x PR. **(3)**

(c) Hence find the area of triangle PQR, giving your answer in m^2 to 3 significant figures. **(3)**

(Total for Question 3 is 8 marks)

4 A line l has equation r = (1, 0, 2) + t(2, 1, -2). A navigation beacon is located at E(5, 4, -1).

(a) Find the position vector of the foot of the perpendicular from E to l. **(5)**

(b) Hence find the position vector of the reflection of E in the line l. **(2)**

(Total for Question 4 is 7 marks)

5 The lines l_1 and l_2 have vector equations $\mathbf{r} = (-4\mathbf{i} - 5\mathbf{j} + 5\mathbf{k}) + \lambda(-2\mathbf{i} - \mathbf{j} + 2\mathbf{k})$ and $\mathbf{r} = (\mathbf{i} - 3\mathbf{j} + 3\mathbf{k}) + \mu(\mathbf{i} + 2\mathbf{k})$ respectively.

(a) Show that l_1 and l_2 intersect, and find the position vector of their point of intersection. **(5)**

(b) Find the acute angle between the lines, to 1 decimal place. **(3)**

(Total for Question 5 is 8 marks)

6 The lines l_1 and l_2 have vector equations $\mathbf{r} = (6\mathbf{i} + 9\mathbf{j} - 3\mathbf{k}) + \lambda(-\mathbf{i} - 2\mathbf{j})$ and $\mathbf{r} = (11\mathbf{j} - 9\mathbf{k}) + \mu(2\mathbf{i} - 3\mathbf{j} + 3\mathbf{k})$ respectively.

(a) Show that l_1 and l_2 intersect, and find the position vector of their point of intersection. **(5)**

(b) Find the acute angle between the lines, to 1 decimal place. **(3)**

(Total for Question 6 is 8 marks)

7 The points A, B and C have position vectors 3j + 3k, -2i + j + 2k and -3i + 2j respectively, relative to a fixed origin O.

(a) Find the vector products AB x AC, and hence a vector perpendicular to the plane ABC (simplified). **(4)**

(b) Find a Cartesian equation of the plane ABC in the form ax + by + cz = d. **(3)**

(c) Find the perpendicular distance from the point Q with position vector 5i + 6j + k to the plane ABC, to 3 significant figures. **(3)**

(d) The line with equation $r = (-3i - 3j - 3k) + t(-3i + 3j + 2k)$ meets the plane ABC at the point R. Find the position vector of R. **(3)**

(Total for Question 7 is 13 marks)

8 The line l has equation $r = (-3k) + t(-i + 2j + 3k)$ and the point Q has position vector $-i - j + 6k$.

(a) Find the value of t for which the point on l is closest to Q. **(3)**

(b) Hence find the position vector of the foot of the perpendicular from Q to l, and the shortest distance from Q to l, to 3 significant figures. **(4)**

(Total for Question 8 is 7 marks)

9 The line l has equation $\mathbf{r} = (4\mathbf{i} - \mathbf{j} + 2\mathbf{k}) + t(-3\mathbf{i} + 3\mathbf{j} - 2\mathbf{k})$ and the point Q has position vector $-2\mathbf{i} - 2\mathbf{j} + 4\mathbf{k}$.

(a) Find the value of t for which the point on l is closest to Q. **(3)**

(b) Hence find the position vector of the foot of the perpendicular from Q to l, and the shortest distance from Q to l, to 3 significant figures. **(4)**

(Total for Question 9 is 7 marks)

10 The points A, B and C have position vectors 4j - 2k, -i + 3j - k and -i + 3j - 4k respectively, relative to a fixed origin O.

(a) Find the vector products AB x AC, and hence a vector perpendicular to the plane ABC (simplified). **(4)**

(b) Find a Cartesian equation of the plane ABC in the form ax + by + cz = d. **(3)**

(c) Find the perpendicular distance from the point Q with position vector -4i + 5j - 6k to the plane ABC, to 3 significant figures. **(3)**

(d) The line with equation $\mathbf{r} = (-2\mathbf{i} - 3\mathbf{j} - 2\mathbf{k}) + t(3\mathbf{i} - \mathbf{j} - 2\mathbf{k})$ meets the plane ABC at the point R. Find the position vector of R. **(3)**

(Total for Question 10 is 13 marks)

11 The lines l_1 and l_2 have vector equations $\mathbf{r} = (-5\mathbf{i} + 3\mathbf{j} - \mathbf{k}) + \lambda(2\mathbf{i} + \mathbf{j} - 2\mathbf{k})$ and $\mathbf{r} = (-7\mathbf{i} - 7\mathbf{j} - 11\mathbf{k}) + \mu(2\mathbf{i} + 4\mathbf{j} + 2\mathbf{k})$ respectively.

(a) Show that l_1 and l_2 intersect, and find the position vector of their point of intersection. **(5)**

(b) Find the acute angle between the lines, to 1 decimal place. **(3)**

(Total for Question 11 is 8 marks)

12 The points A, B and C have position vectors -i - j, 2i + k and 2i - 2j + k respectively, relative to a fixed origin O.

(a) Find the vector products AB x AC, and hence a vector perpendicular to the plane ABC (simplified). **(4)**

(b) Find a Cartesian equation of the plane ABC in the form ax + by + cz = d. **(3)**

(c) Find the perpendicular distance from the point Q with position vector 3i + 5j + 7k to the plane ABC, to 3 significant figures. **(3)**

(d) The line with equation $\mathbf{r} = (-3\mathbf{i} + 5\mathbf{j} + 3\mathbf{k}) + t(3\mathbf{i} - 2\mathbf{j} - \mathbf{k})$ meets the plane ABC at the point R. Find the position vector of R. **(3)**

(Total for Question 12 is 13 marks)

13 The lines l_1 and l_2 have vector equations $\mathbf{r} = (7\mathbf{i} - 6\mathbf{j} + 3\mathbf{k}) + \lambda(-3\mathbf{i} + \mathbf{j} + 3\mathbf{k})$ and $\mathbf{r} = (8\mathbf{i} - 9\mathbf{j} + 12\mathbf{k}) + \mu(2\mathbf{i} - 2\mathbf{j} + 3\mathbf{k})$ respectively.

(a) Show that l_1 and l_2 intersect, and find the position vector of their point of intersection. **(5)**

(b) Find the acute angle between the lines, to 1 decimal place. **(3)**

(Total for Question 13 is 8 marks)

14 The lines l_1 and l_2 have vector equations $\mathbf{r} = (-6\mathbf{i} - 4\mathbf{k}) + \lambda(3\mathbf{i} - \mathbf{j})$ and $\mathbf{r} = (\mathbf{j} - 2\mathbf{k}) + \mu(3\mathbf{i} + 2\mathbf{j} + 2\mathbf{k})$ respectively.

(a) Show that l_1 and l_2 intersect, and find the position vector of their point of intersection. **(5)**

(b) Find the acute angle between the lines, to 1 decimal place. **(3)**

(Total for Question 14 is 8 marks)

15 The line l has equation $\mathbf{r} = (2\mathbf{i} - \mathbf{j} - 3\mathbf{k}) + t(3\mathbf{i} - \mathbf{j} - 3\mathbf{k})$ and the point Q has position vector $\mathbf{i} - \mathbf{j} + 4\mathbf{k}$.

(a) Find the value of t for which the point on l is closest to Q. **(3)**

(b) Hence find the position vector of the foot of the perpendicular from Q to l, and the shortest distance from Q to l, to 3 significant figures. **(4)**

(Total for Question 15 is 7 marks)

16 The line l has equation $\mathbf{r} = (-4\mathbf{i} + 3\mathbf{j} - 4\mathbf{k}) + t(-\mathbf{i} + 3\mathbf{j} - \mathbf{k})$ and the point Q has position vector $-4\mathbf{i} - 6\mathbf{j} - 6\mathbf{k}$.

(a) Find the value of t for which the point on l is closest to Q. **(3)**

(b) Hence find the position vector of the foot of the perpendicular from Q to l, and the shortest distance from Q to l, to 3 significant figures. **(4)**

(Total for Question 16 is 7 marks)

17 A plane Pi has equation $2x - y + 2z = 5$. A sensor is positioned at D(4, 3, -1), with coordinates in metres.

(a) Show that D does not lie in the plane Pi. **(1)**

(b) Find the shortest distance from D to Pi, giving your answer as an exact fraction. **(3)**

(c) Find the coordinates of the foot of the perpendicular from D to Pi. **(4)**

(Total for Question 17 is 8 marks)

18 A line l has equation r = (3, -1, 2) + t(1, 2, -2). A plane Pi has equation 3x - 4y + z = 6.

(a) Find the angle between l and Pi, giving your answer in degrees to 1 decimal place. **(4)**

(b) Show that l intersects Pi, and find the coordinates of the point of intersection. **(4)**

(Total for Question 18 is 8 marks)

19 Two planes are given by Pi1: x + 2y - 2z = 4 and Pi2: 3x + 4z = 10.

(a) Find the acute angle between Pi1 and Pi2, giving your answer in degrees to 1 decimal place. **(4)**

(b) Find a vector equation for the line of intersection of Pi1 and Pi2. **(5)**

(Total for Question 19 is 9 marks)

20 A line l has equation r = (2, -1, 3) + t(1, 2, -1). A point F has coordinates (0, 4, 1).

(a) Show that F does not lie on l. **(2)**

(b) Find the cartesian equation of the plane containing l and F, giving your answer in the form ax + by + cz = d. **(5)**

(Total for Question 20 is 7 marks)

21 A plane Pi has equation $2x - y + kz = 8$, where k is a constant. A line l has equation $r = (1, 3, -2) + t(4, 1, -3)$.

(a) Given that l is parallel to Pi, find the value of k. **(3)**

(b) Show that, for every value of k, the line l does not lie in the plane Pi. **(4)**

(Total for Question 21 is 7 marks)

Mark scheme · 1.5 Further Vectors

Question 1

(a) attempts B - A **M1**

(a) AB = (3, 5, -5), cao **A1**

(a) Answer: AB = (3, 5, -5)

(b) uses point A (or B) as the position vector **B1**

(b) r = (2, -1, 3) + t(3, 5, -5), oe (e.g. using B and/or a scalar multiple of AB) **B1**

(b) Answer: r = (2, -1, 3) + t(3, 5, -5)

(c) forms two equations from components, e.g. 2+3t=11 and -1+5t=14 **M1**

(c) solves to get t=3 from both equations **A1**

(c) checks third component 3-5t = 3-15 = -12, consistent, so C lies on l1, cso **A1**

(c) Answer: C lies on l1 (t = 3 is consistent for all three components)

Question 2

(a) finds the dot product of the direction vectors, (2,-1,2). (1,2,2) = 4 **M1**

(a) finds both magnitudes, $\sqrt{4+1+4}=3$ and $\sqrt{1+4+4}=3$ **M1**

(a) uses cos(θ) = (d1.d2)/(|d1||d2|) **M1**

(a) θ = awrt 63.6 degrees **A1**

(a) Answer: 63.6 degrees (1 dp)

(b) neither **B1**

(b) valid reason, e.g. dot product = 4 not equal to 0 so not perpendicular, and (2,-1,2) is not a scalar multiple of (1,2,2) so not parallel **B1**

(b) Answer: Neither parallel nor perpendicular

Question 3

(a) attempts Q-P and R-P **M1**

(a) PQ = (2,4,-1) and PR = (-1,2,3), both cao **A1**

(a) Answer: PQ = (2, 4, -1), PR = (-1, 2, 3)

(b) sets up the determinant/component method for the vector product **M1**

(b) at least two components correct **A1**

(b) PQ x PR = (14, -5, 8), fully correct, cao **A1**

(b) Answer: PQ x PR = (14, -5, 8)

(c) finds $|PQ \times PR| = \sqrt{14^2+(-5)^2+8^2}$ **M1**

(c) uses area = (1/2)|PQ x PR| **M1**

(c) awrt 8.44 m^2 **A1**

(c) Answer: 8.44 m^2 (3 sf)

Question 4

(a) writes a general point on l as (1+2t, t, 2-2t) **M1**

(a) forms the vector from this point to E **M1**

(a) sets this vector's dot product with (2,1,-2) equal to zero **M1**

(a) solves to get t = 2 **M1**

(a) foot of perpendicular = (5, 2, -2), cao **A1**

(a) Answer: (5, 2, -2)

(b) uses E' = 2F - E where F is the foot of the perpendicular found in (a) **M1**

(b) E' = (5, 0, -3), ft from (a) **A1**

(b) Answer: (5, 0, -3)

Question 5

(a) equates the i, j and k components to form simultaneous equations in λ and μ **M1**

(a) solves two of the equations **M1**

(a) λ = -2 and μ = -1 **A1**

(a) checks the third equation is satisfied, so the lines intersect **B1**

(a) position vector -3j + k **A1**

(a) Answer: -3j + k

(b) uses cos θ = |d1 . d2|/(|d1||d2|) **M1**

(b) d1 . d2 = 2 **A1**

(b) θ = 72.7 degrees **A1**

(b) Answer: 72.7 degrees

Question 6

(a) equates the i, j and k components to form simultaneous equations in λ and μ **M1**

(a) solves two of the equations **M1**

(a) λ = 2 and μ = 2 **A1**

(a) checks the third equation is satisfied, so the lines intersect **B1**

(a) position vector 4i + 5j - 3k **A1**

(a) Answer: 4i + 5j - 3k

(b) uses cos θ = |d1 . d2|/(|d1||d2|) **M1**

(b) d1 . d2 = 4 **A1**

(b) θ = 67.6 degrees **A1**

(b) Answer: 67.6 degrees

Question 7

(a) finds AB and AC **M1**

(a) AB = -2i - 2j - k, AC = -3i - j - 3k **A1**

(a) evaluates the vector product with the determinant method **M1**

(a) AB x AC = 5i - 3j - 4k, so a normal is 5i - 3j - 4k **A1**

(a) Answer: normal 5i - 3j - 4k

(b) uses n . r = n . a **M1**

(b) d = -21 **A1**

(b) 5x - 3y - 4z = -21 **A1**

(b) Answer: 5x - 3y - 4z = -21

(c) uses |n . q - d|/|n| **M1**

(c) $|3 - (-21)|/(5\sqrt{2})$ **A1**

(c) 3.39 **A1**

(c) Answer: 3.39

(d) substitutes the parametric form of the line into the plane equation **M1**

(d) t = 27/32 **A1**

(d) -(177/32)i - (15/32)j - (21/16)k **A1**

(d) Answer: -(177/32)i - (15/32)j - (21/16)k

Question 8

(a) the vector from the point on the line to Q must be perpendicular to the direction vector of l **M1**

(a) sets (Q - A - t d) . d = 0 **M1**

(a) t = 26/14 = 13/7 **A1**

(a) Answer: t = 13/7

(b) substitutes t into the equation of l **M1**

(b) -(13/7)i + (26/7)j + (18/7)k **A1**

(b) distance = |Q - F| **M1**

(b) 5.89 **A1**

(b) Answer: -(13/7)i + (26/7)j + (18/7)k; 5.89

Question 9

(a) the vector from the point on the line to Q must be perpendicular to the direction vector of l **M1**

(a) sets (Q - A - t d) . d = 0 **M1**

(a) t = 11/22 = 1/2 **A1**

(a) Answer: t = 1/2

(b) substitutes t into the equation of l **M1**

(b) (5/2)i + (1/2)j + k **A1**

(b) distance = |Q - F| **M1**

(b) 5.96 **A1**

(b) Answer: (5/2)i + (1/2)j + k; 5.96

Question 10

(a) finds AB and AC **M1**

(a) AB = -i - j + k, AC = -i - j - 2k **A1**

(a) evaluates the vector product with the determinant method **M1**

(a) AB x AC = 3i - 3j, so a normal is i - j **A1**

(a) Answer: normal i - j

(b) uses n . r = n . a **M1**

(b) d = -4 **A1**

(b) x - y = -4 **A1**

(b) Answer: x - y = -4

(c) uses |n . q - d|/|n| **M1**

(c) $|-9 - (-4)|/\sqrt{2}$ **A1**

(c) 3.54 **A1**

(c) Answer: 3.54

(d) substitutes the parametric form of the line into the plane equation **M1**

(d) t = -5/4 **A1**

(d) -(23/4)i - (7/4)j + (1/2)k **A1**

(d) Answer: -(23/4)i - (7/4)j + (1/2)k

Question 11

(a) equates the i, j and k components to form simultaneous equations in λ and μ **M1**

(a) solves two of the equations **M1**

(a) λ = 2 and μ = 3 **A1**

(a) checks the third equation is satisfied, so the lines intersect **B1**

(a) position vector -i + 5j - 5k **A1**

(a) Answer: -i + 5j - 5k

(b) uses cos θ = |d1 . d2|/(|d1||d2|) **M1**

(b) d1 . d2 = 4 **A1**

(b) θ = 74.2 degrees **A1**

(b) Answer: 74.2 degrees

Question 12

(a) finds AB and AC **M1**

(a) AB = 3i + j + k, AC = 3i - j + k **A1**

(a) evaluates the vector product with the determinant method **M1**

(a) AB x AC = 2i - 6k, so a normal is i - 3k **A1**

(a) Answer: normal i - 3k

(b) uses n . r = n . a **M1**

(b) d = -1 **A1**

(b) x - 3z = -1 **A1**

(b) Answer: x - 3z = -1

(c) uses |n . q - d|/|n| **M1**

(c) $|-18 - (-1)|/\sqrt{10}$ **A1**

(c) 5.38 **A1**

(c) Answer: 5.38

(d) substitutes the parametric form of the line into the plane equation **M1**

(d) t = 11/6 **A1**

(d) (5/2)i + (4/3)j + (7/6)k **A1**

(d) Answer: (5/2)i + (4/3)j + (7/6)k

Question 13

(a) equates the i, j and k components to form simultaneous equations in λ and μ **M1**

(a) solves two of the equations **M1**

(a) λ = 1 and μ = -2 **A1**

(a) checks the third equation is satisfied, so the lines intersect **B1**

(a) position vector 4i - 5j + 6k **A1**

(a) Answer: 4i - 5j + 6k

(b) uses cos θ = |d1 . d2|/(|d1||d2|) **M1**

(b) d1 . d2 = 1 **A1**

(b) θ = 86.8 degrees **A1**

(b) Answer: 86.8 degrees

Question 14

(a) equates the i, j and k components to form simultaneous equations in λ and μ **M1**

(a) solves two of the equations **M1**

(a) λ = 1 and μ = -1 **A1**

(a) checks the third equation is satisfied, so the lines intersect **B1**

(a) position vector -3i - j - 4k **A1**

(a) Answer: -3i - j - 4k

(b) uses cos θ = |d1 . d2|/(|d1||d2|) **M1**

(b) d1 . d2 = 7 **A1**

(b) θ = 57.5 degrees **A1**

(b) Answer: 57.5 degrees

Question 15

(a) the vector from the point on the line to Q must be perpendicular to the direction vector of l **M1**

(a) sets (Q - A - t d) . d = 0 **M1**

(a) t = -24/19 **A1**

(a) Answer: t = -24/19

(b) substitutes t into the equation of l **M1**

(b) -(34/19)i + (5/19)j + (15/19)k **A1**

(b) distance = |Q - F| **M1**

(b) 4.44 **A1**

(b) Answer: -(34/19)i + (5/19)j + (15/19)k; 4.44

Question 16

(a) the vector from the point on the line to Q must be perpendicular to the direction vector of l **M1**

(a) sets (Q - A - t d) . d = 0 **M1**

(a) t = -25/11 **A1**

(a) Answer: t = -25/11

(b) substitutes t into the equation of l **M1**

(b) -(19/11)i - (42/11)j - (19/11)k **A1**

(b) distance = |Q - F| **M1**

(b) 5.31 **A1**

(b) Answer: -(19/11)i - (42/11)j - (19/11)k; 5.31

Question 17

(a) substitutes D into 2x-y+2z to get 3, and states 3 is not equal to 5 so D is not on Pi, cso **B1**

(a) Answer: 2(4) - 3 + 2(-1) = 3, and 3 ≠ 5, so D does not lie in Pi

(b) uses distance = $|2x0-y0+2z0-5| / \sqrt{2^2+(-1)^2+2^2}$ **M1**

(b) substitutes D correctly to get |3-5|/3 **M1**

(b) distance = 2/3, cao **A1**

(b) Answer: 2/3 m

(c) sets up point on the normal line through D: (4+2t, 3-t, -1+2t) **M1**

(c) substitutes into the plane equation to form a linear equation in t **M1**

(c) solves to get t = 2/9 **M1**

(c) coordinates (40/9, 25/9, -5/9), oe (equivalent decimals awrt (4.44, 2.78, -0.56) accepted), ft **A1**

(c) Answer: (40/9, 25/9, -5/9), i.e. awrt (4.44, 2.78, -0.56)

Question 18

(a) finds d.n = (1,2,-2).(3,-4,1) = -7 **M1**

(a) finds |d|=3 and $|n|=\sqrt{26}$ **M1**

(a) uses sin(θ) = |d.n|/(|d||n|) **M1**

(a) θ = awrt 27.2 degrees **A1**

(a) Answer: 27.2 degrees (1 dp)

(b) since d.n = -7 is not equal to 0, l is not parallel to Pi so a unique intersection point exists **B1**

(b) substitutes parametric coordinates (3+t, -1+2t, 2-2t) into the plane equation **M1**

(b) solves the resulting equation to get t = 9/7 **M1**

(b) point (30/7, 11/7, -4/7), oe (equivalent decimals awrt (4.29, 1.57, -0.57) accepted) **A1**

(b) Answer: (30/7, 11/7, -4/7), i.e. awrt (4.29, 1.57, -0.57)

Question 19

(a) finds n1.n2 = (1,2,-2).(3,0,4) = -5 **M1**

(a) finds |n1|=3 and |n2|=5 **M1**

(a) uses cos(θ) = |n1.n2|/(|n1||n2|) (taking the modulus for the acute angle) **M1**

(a) θ = awrt 70.5 degrees **A1**

(a) Answer: 70.5 degrees (1 dp)

(b) attempts n1 x n2 to find the direction of the line **M1**

(b) direction vector (8,-10,-6), oe (simplified form (4,-5,-3) accepted) **A1**

(b) sets y=0 (or another suitable substitution) and solves Pi1 and Pi2 simultaneously for a point **M1**

(b) point (3.6, 0, -0.2), oe (equivalent fraction (18/5, 0, -1/5) accepted) **A1**

(b) fully correct vector equation stated, e.g. r = (3.6,0,-0.2)+t(4,-5,-3), ft **B1**

(b) Answer: r = (3.6, 0, -0.2) + t(4, -5, -3)

Question 20

(a) attempts to find t from two components, e.g. 2+t=0 giving t=-2, and -1+2t=4 giving t=2.5 **M1**

(a) shows the two values of t are inconsistent, hence F does not lie on l, cso **A1**

(a) Answer: F does not lie on l (x gives t=-2, y gives t=2.5, inconsistent)

(b) finds the vector AF from a point on l (e.g. A=(2,-1,3)) to F, AF=(-2,5,-2) **M1**

(b) attempts d x AF where d is the direction of l, as the normal to the plane **M1**

(b) normal (1,4,9), oe **A1**

(b) forms the plane equation using the normal and a point on the plane **M1**

(b) x + 4y + 9z = 25, cao **A1**

(b) Answer: x + 4y + 9z = 25

Question 21

(a) sets the direction vector dotted with the normal equal to zero: (4,1,-3).(2,-1,k)=0 **M1**

(a) forms and rearranges 7-3k=0 **M1**

(a) k = 7/3, oe (awrt 2.33 accepted) **A1**

(a) Answer: k = 7/3

(b) recognises that for l to lie in Pi, the point (1,3,-2) on l must also satisfy the plane equation **M1**

(b) substitutes the point into the plane equation to get -1-2k=8, giving k=-9/2 **A1**

(b) compares this with k=7/3 from part (a) and notes the two required values of k are different **B1**

(b) concludes that l cannot lie in Pi for any single value of k, cso **B1**

(b) Answer: l cannot lie in Pi for any value of k, since containment would require k=7/3 (for the direction to be perpendicular to the normal) and k=-9/2 (for the point (1,3,-2) to satisfy the plane), which cannot both hold