1.2 Matrices

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

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 M = [[3,2],[5,4]].

(a) Find det(M). **(1)**

(b) Find M^{-1}. **(2)**

(c) Hence use matrices to solve the simultaneous equations $3x + 2y = 8$ and $5x + 4y = 14$. **(3)**

(Total for Question 1 is 6 marks)

2 R is the matrix representing a reflection in the line $y = x$. S is the matrix representing a rotation of 90 degrees anticlockwise about the origin O.

(a) Write down the matrix R. **(1)**

(b) Write down the matrix S. **(1)**

(c) Find the matrix RS, representing rotation by S followed by reflection by R. **(3)**

(d) Describe fully the single geometrical transformation represented by RS, and find the image of the point (3,-2) under this transformation. **(2)**

(Total for Question 2 is 7 marks)

3 The matrix A is given by A = ((3, -2, -2), (k, 0, 3), (1, 0, 3)), written row by row, where k is a constant.

(a) Show that det A = 6k - 6. **(3)**

(b) Find the value of k for which A is singular. **(2)**

(c) State the value of det A when k = 2, and hence state whether A is invertible when k = 2. **(2)**

(Total for Question 3 is 7 marks)

4 The matrices A and B are given by A = ((1, -4), (-3, 3)) and B = ((-2, 4), (1, -1)), where each matrix is written row by row.

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

(b) Find det A and, given that A is non-singular, find A^{-1}. **(4)**

(c) Use A^{-1} to solve the equations x - 4y = 11 and -3x + 3y = -15. **(3)**

(Total for Question 4 is 9 marks)

5 The matrix A is given by A = ((2, -1, 2), (2, 4, -2), (-2, k, 2)), written row by row, where k is a constant.

(a) Show that det A = 8k + 32. **(3)**

(b) Find the value of k for which A is singular. **(2)**

(c) State the value of det A when k = 3, and hence state whether A is invertible when k = 3. **(2)**

(Total for Question 5 is 7 marks)

6 The matrices A and B are given by A = ((-1, 3), (0, -1)) and B = ((2, -3), (3, 4)), where each matrix is written row by row.

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

(b) Find det A and, given that A is non-singular, find A^{-1}. **(4)**

(c) Use A^{-1} to solve the equations -x + 3y = 15 and -y = -4. **(3)**

(Total for Question 6 is 9 marks)

7 The matrix M is given by M = ((-5, 2), (0, 2)).

(a) Find the characteristic equation of M and hence find its eigenvalues. **(3)**

(b) Find an eigenvector corresponding to each eigenvalue, giving each as a vector with integer components in simplest form. **(3)**

(c) Find M^2. **(2)**

(Total for Question 7 is 8 marks)

8 The matrices A and B are given by A = ((1, 0), (3, 5)) and B = ((-3, 2), (-2, 1)), where each matrix is written row by row.

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

(b) Find det A and, given that A is non-singular, find A^{-1}. **(4)**

(c) Use A^{-1} to solve the equations x = -1 and 3x + 5y = -3. **(3)**

(Total for Question 8 is 9 marks)

9 The matrix M is given by M = ((4, -2), (5, -3)).

(a) Find the characteristic equation of M and hence find its eigenvalues. **(3)**

(b) Find an eigenvector corresponding to each eigenvalue, giving each as a vector with integer components in simplest form. **(3)**

(c) Find M^4. **(2)**

(Total for Question 9 is 8 marks)

10 The matrices A and B are given by A = ((5, 4), (0, 2)) and B = ((3, 1), (1, -1)), where each matrix is written row by row.

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

(b) Find det A and, given that A is non-singular, find A^{-1}. **(4)**

(c) Use A^{-1} to solve the equations $5x + 4y = 10$ and $2y = 0$. **(3)**

(Total for Question 10 is 9 marks)

11 The matrix M is given by M = ((2, -3), (-2, -3)).

(a) Find the characteristic equation of M and hence find its eigenvalues. **(3)**

(b) Find an eigenvector corresponding to each eigenvalue, giving each as a vector with integer components in simplest form. **(3)**

(c) Find M^3. **(2)**

(Total for Question 11 is 8 marks)

12 The transformation T_1 is an anticlockwise rotation through 180 degrees about the origin. The transformation T_2 is a reflection in the x axis.

(a) Write down the 2 x 2 matrices M_1 and M_2 representing T_1 and T_2. **(2)**

(b) Find the matrix representing the transformation T_1 followed by T_2. **(2)**

(c) Find the image of the point (2, 1) under T_1 followed by T_2. **(2)**

(d) A triangle of area 6 is transformed by T_1 followed by T_2. Find the area of its image. **(2)**

(Total for Question 12 is 8 marks)

13 The matrices A and B are given by A = ((-2, 1), (4, -1)) and B = ((2, 3), (1, 4)), where each matrix is written row by row.

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

(b) Find det A and, given that A is non-singular, find A^{-1}. **(4)**

(c) Use A^{-1} to solve the equations -2x + y = 1 and 4x - y = -3. **(3)**

(Total for Question 13 is 9 marks)

14 The transformation T_1 is a reflection in the line $y = -x$. The transformation T_2 is an enlargement with scale factor 2, centre the origin.

(a) Write down the 2 x 2 matrices M_1 and M_2 representing T_1 and T_2. **(2)**

(b) Find the matrix representing the transformation T_1 followed by T_2. **(2)**

(c) Find the image of the point (-4, 2) under T_1 followed by T_2. **(2)**

(d) A triangle of area 6 is transformed by T_1 followed by T_2. Find the area of its image. **(2)**

(Total for Question 14 is 8 marks)

15 A transformation of the plane is represented by the matrix M = [[5,-2],[4,-1]].

(a) Show that every point on the line y = 2x is an invariant point of the transformation represented by M. **(3)**

(b) Find the equation of the other invariant line of M through the origin (not consisting entirely of invariant points). **(4)**

(c) State the scale factor of enlargement associated with this second invariant line. **(1)**

(d) Verify your answer to part (b) by finding the image of the point (1,1) under M and confirming it lies on the same invariant line, stating the scale factor this confirms. **(2)**

(Total for Question 15 is 10 marks)

16 A transformation of the plane is represented by the matrix T = [[3,1],[1,2]]. Triangle ABC has vertices A(0,0), B(4,0), C(0,2) and is mapped to triangle A'B'C' by T.

(a) Find det(T). **(1)**

(b) State the area scale factor of the transformation, and hence find the area of triangle A'B'C'. **(2)**

(c) Find the coordinates of A', B' and C'. **(3)**

(d) Verify your answer to part (b) by calculating the area of A'B'C' directly, using the coordinates found in part (c). **(3)**

(Total for Question 16 is 9 marks)

17 A = [[4,1],[2,3]].

(a) Find A^2 by direct matrix multiplication. **(3)**

(b) Given that A satisfies its own characteristic equation, show that $A^2 = 7A - 10I$. **(2)**

(c) By multiplying the result in part (b) by A^{-1}, show that $A^{-1} = 0.7I - 0.1A$. **(3)**

(d) Hence write A^{-1} as a matrix with fractional entries. **(1)**

(Total for Question 17 is 9 marks)

18 V = [[1,-1],[1,1]].

(a) Show that V can be written as k*R(θ), where R(θ) = [[cos(θ),-sin(θ)], [sin(θ),cos(θ)]], stating the value of k and the value of θ (0 < θ < 90 degrees). **(4)**

(b) Describe fully the single geometrical transformation represented by V. **(2)**

(c) Find V^2 and describe the single geometrical transformation it represents. **(4)**

(d) Find the image of the point (3,1) under the transformation represented by V^2. **(2)**

(Total for Question 18 is 12 marks)

19 A system of equations is given by $x + 2y - z = 3$, $2x + y + z = 5$, $3x + 3y + (\lambda)z = \mu$, where λ and μ are real constants. The coefficient matrix is $A(\lambda) = [[1,2,-1],[2,1,1],[3,3,\lambda]]$.

(a) Show that $\det(A(\lambda)) = -3*\lambda$. **(3)**

(b) State the value of λ for which the system does not have a unique solution. **(1)**

(c) When $\lambda = 0$, find the value of μ for which the system is consistent. **(3)**

(d) Describe geometrically the configuration of the three planes when $\lambda = 0$, in the two cases (i) $\mu = 8$ and (ii) μ is not equal to 8. **(3)**

(Total for Question 19 is 10 marks)

20 A 3D design scaling transformation for a manufactured component is represented by the matrix $X = [[2,0,1],[0,1,0],[1,0,2]]$, applied to position vectors $(x,y,z)^T$ measured in cm.

(a) Find det(X) and interpret its value in the context of the transformation. **(3)**

(b) A component originally has volume 5 cm^3 before the transformation is applied. Find the volume of the transformed component. **(1)**

(c) Find X^{-1}. **(5)**

(d) A transformed point has coordinates (5,2,4). Find its original coordinates before the transformation was applied. **(3)**

(Total for Question 20 is 12 marks)

Mark scheme · 1.2 Matrices

Question 1

(a) det(M) = 2 cao **B1**

(a) Answer: det(M) = 2

(b) correct adjugate [[4,-2],[-5,3]] with 1/det(M) used, ft their det(M) **M1**

(b) M^{-1} = [[2,-1],[-2.5,1.5]] oe cao **A1**

(b) Answer: M^{-1} = (1/2)[[4,-2],[-5,3]] = [[2,-1],[-2.5,1.5]]

(c) writing the system as $M[x,y]^T = [8,14]^T$ and using $[x,y]^T = M^{-1}[8,14]^T$ (ft their M^{-1}) **M1**

(c) x = 2 cao **A1**

(c) y = 1 cao **A1**

(c) Answer: x = 2, y = 1

Question 2

(a) R = [[0,1],[1,0]] cao **B1**

(a) Answer: R = [[0,1],[1,0]]

(b) S = [[0,-1],[1,0]] cao **B1**

(b) Answer: S = [[0,-1],[1,0]]

(c) attempt at product RS with at least one correct entry, ft their R, S **M1**

(c) two correct entries **A1**

(c) RS = [[1,0],[0,-1]] cao **A1**

(c) Answer: RS = [[1,0],[0,-1]]

(d) reflection in the x-axis (ft their RS if of the form [[1,0],[0,-1]]) **B1**

(d) image (3,2) cao **B1**

(d) Answer: RS represents a reflection in the x-axis; image of (3,-2) is (3,2).

Question 3

(a) expands the determinant along a row or column **M1**

(a) evaluates the 2 x 2 minors correctly **A1**

(a) det A = 6k - 6 (cso) **A1**

(a) Answer: det A = 6k - 6

(b) sets det A = 0 **M1**

(b) k = 1 **A1**

(b) Answer: k = 1

(c) det A = 6 **B1**

(c) invertible **B1**

(c) Answer: 6; invertible

Question 4

(a) multiplies rows of A by columns of B **M1**

(a) ((-6, 8), (9, -15)) **A1**

(a) Answer: ((-6, 8), (9, -15))

(b) det A = ad - bc **M1**

(b) det A = -9 **A1**

(b) uses the inverse formula (1/det)((d, -b), (-c, a)) **M1**

(b) A^{-1} = ((-1/3, -4/9), (-1/3, -1/9)) **A1**

(b) Answer: det A = -9, A^{-1} = ((-1/3, -4/9), (-1/3, -1/9))

(c) writes as a matrix equation A(x, y) = (b1, b2) and multiplies by A^{-1} **M1**

(c) x = 3 **A1**

(c) y = -2 **A1**

(c) Answer: x = 3, y = -2

Question 5

(a) expands the determinant along a row or column **M1**

(a) evaluates the 2 x 2 minors correctly **A1**

(a) det A = 8k + 32 (cso) **A1**

(a) Answer: det A = 8k + 32

(b) sets det A = 0 **M1**

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

(b) Answer: k = -4

(c) det A = 56 **B1**

(c) invertible **B1**

(c) Answer: 56; invertible

Question 6

(a) multiplies rows of A by columns of B **M1**

(a) ((7, 15), (-3, -4)) **A1**

(a) Answer: ((7, 15), (-3, -4))

(b) det A = ad - bc **M1**

(b) det A = 1 **A1**

(b) uses the inverse formula (1/det)((d, -b), (-c, a)) **M1**

(b) A^{-1} = ((-1, -3), (0, -1)) **A1**

(b) Answer: det A = 1, A^{-1} = ((-1, -3), (0, -1))

(c) writes as a matrix equation A(x, y) = (b1, b2) and multiplies by A^{-1} **M1**

(c) x = -3 **A1**

(c) y = 4 **A1**

(c) Answer: x = -3, y = 4

Question 7

(a) forms det(M - λ I) = 0 **M1**

(a) λ^2 + 3lambda - 10 = 0 **A1**

(a) λ = -5 and λ = 2 **A1**

(a) Answer: λ = -5, 2

(b) solves (M - λ I) v = 0 for the first eigenvalue **M1**

(b) for λ = -5: (1, 0) **A1**

(b) for λ = 2: (2, 7) **A1**

(b) Answer: λ = -5: (1, 0); λ = 2: (2, 7)

(c) multiplies M by itself 2 times (or uses the diagonalisation PD^2P^{-1}) **M1**

(c) ((25, -6), (0, 4)) **A1**

(c) Answer: ((25, -6), (0, 4))

Question 8

(a) multiplies rows of A by columns of B **M1**

(a) ((-3, 2), (-19, 11)) **A1**

(a) Answer: ((-3, 2), (-19, 11))

(b) det A = ad - bc **M1**

(b) det A = 5 **A1**

(b) uses the inverse formula (1/det)((d, -b), (-c, a)) **M1**

(b) A^{-1} = ((1, 0), (-3/5, 1/5)) **A1**

(b) Answer: det A = 5, A^{-1} = ((1, 0), (-3/5, 1/5))

(c) writes as a matrix equation A(x, y) = (b1, b2) and multiplies by A^{-1} **M1**

(c) x = -1 **A1**

(c) y = 0 **A1**

(c) Answer: x = -1, y = 0

Question 9

(a) forms det(M - λ I) = 0 **M1**

(a) λ^2 - λ - 2 = 0 **A1**

(a) λ = -1 and λ = 2 **A1**

(a) Answer: λ = -1, 2

(b) solves (M - λ I) v = 0 for the first eigenvalue **M1**

(b) for λ = -1: (2, 5) **A1**

(b) for λ = 2: (1, 1) **A1**

(b) Answer: λ = -1: (2, 5); λ = 2: (1, 1)

(c) multiplies M by itself 4 times (or uses the diagonalisation PD^4P^{-1}) **M1**

(c) ((26, -10), (25, -9)) **A1**

(c) Answer: ((26, -10), (25, -9))

Question 10

(a) multiplies rows of A by columns of B **M1**

(a) ((19, 1), (2, -2)) **A1**

(a) Answer: ((19, 1), (2, -2))

(b) det A = ad - bc **M1**

(b) det A = 10 **A1**

(b) uses the inverse formula (1/det)((d, -b), (-c, a)) **M1**

(b) A^{-1} = ((1/5, -2/5), (0, 1/2)) **A1**

(b) Answer: det A = 10, A^{-1} = ((1/5, -2/5), (0, 1/2))

(c) writes as a matrix equation A(x, y) = (b1, b2) and multiplies by A^{-1} **M1**

(c) x = 2 **A1**

(c) y = 0 **A1**

(c) Answer: x = 2, y = 0

Question 11

(a) forms det(M - λ I) = 0 **M1**

(a) λ^2 + λ - 12 = 0 **A1**

(a) λ = -4 and λ = 3 **A1**

(a) Answer: λ = -4, 3

(b) solves (M - λ I) v = 0 for the first eigenvalue **M1**

(b) for λ = -4: (1, 2) **A1**

(b) for λ = 3: (3, -1) **A1**

(b) Answer: λ = -4: (1, 2); λ = 3: (3, -1)

(c) multiplies M by itself 3 times (or uses the diagonalisation PD^3P^{-1}) **M1**

(c) ((14, -39), (-26, -51)) **A1**

(c) Answer: ((14, -39), (-26, -51))

Question 12

(a) M_1 = ((-1, 0), (0, -1)) **B1**

(a) M_2 = ((1, 0), (0, -1)) **B1**

(a) Answer: M_1 = ((-1, 0), (0, -1)), M_2 = ((1, 0), (0, -1))

(b) multiplies in the correct order: M_2 M_1 **M1**

(b) ((-1, 0), (0, 1)) **A1**

(b) Answer: ((-1, 0), (0, 1))

(c) multiplies the combined matrix by the position vector **M1**

(c) (-2, 1) **A1**

(c) Answer: (-2, 1)

(d) area scale factor = |det of the combined matrix| **M1**

(d) |-1| x 6 = 6 **A1**

(d) Answer: 6

Question 13

(a) multiplies rows of A by columns of B **M1**

(a) ((-3, -2), (7, 8)) **A1**

(a) Answer: ((-3, -2), (7, 8))

(b) det A = ad - bc **M1**

(b) det A = -2 **A1**

(b) uses the inverse formula (1/det)((d, -b), (-c, a)) **M1**

(b) A^{-1} = ((1/2, 1/2), (2, 1)) **A1**

(b) Answer: det A = -2, A^{-1} = ((1/2, 1/2), (2, 1))

(c) writes as a matrix equation A(x, y) = (b1, b2) and multiplies by A^{-1} **M1**

(c) x = -1 **A1**

(c) y = -1 **A1**

(c) Answer: x = -1, y = -1

Question 14

(a) M_1 = ((0, -1), (-1, 0)) **B1**

(a) M_2 = ((2, 0), (0, 2)) **B1**

(a) Answer: M_1 = ((0, -1), (-1, 0)), M_2 = ((2, 0), (0, 2))

(b) multiplies in the correct order: M_2 M_1 **M1**

(b) ((0, -2), (-2, 0)) **A1**

(b) Answer: ((0, -2), (-2, 0))

(c) multiplies the combined matrix by the position vector **M1**

(c) (-4, 8) **A1**

(c) Answer: (-4, 8)

(d) area scale factor = |det of the combined matrix| **M1**

(d) |-4| x 6 = 24 **A1**

(d) Answer: 24

Question 15

(a) taking a general point (x, 2x) on the line and forming $M(x,2x)^T$ **M1**

(a) correctly computing both components: 5x - 2(2x) = x and 4x - 1(2x) = 2x **M1**

(a) cso: image (x,2x) equals original point, so every point on y=2x is invariant **A1**

(a) Answer: Shown: $M(x,2x)^T = (x,2x)^T$ for all x, so y = 2x is a line of invariant points.

(b) considering a general point (x,mx) on line y=mx and forming $M(x,mx)^T$ = (x(5-2m), x(4-m)) **M1**

(b) setting 4-m = m(5-2m) to require the image to lie on y=mx **M1**

(b) forming and solving the quadratic $2m^2$ - 6m + 4 = 0 oe, i.e. m^2-3m+2=0 **M1**

(b) m = 2 (already found in (a)) or m = 1; other invariant line is y = x cao **A1**

(b) Answer: y = x

(c) scale factor 3 (ft their line if consistent), oe **B1**

(c) Answer: Scale factor 3

(d) $M(1,1)^T$ = (3,3) found correctly (ft their M) **M1**

(d) (3,3) lies on y=x, and (3,3) = 3*(1,1), confirming scale factor 3 cao **A1**

(d) Answer: M(1,1) = (3,3), which lies on y=x, confirming scale factor 3.

Question 16

(a) det(T) = 5 cao **B1**

(a) Answer: det(T) = 5

(b) area scale factor = |det(T)| = 5, ft their det(T) **B1**

(b) area of A'B'C' = 20 cao (using area ABC = 4) **B1**

(b) Answer: Area scale factor = 5; area of A'B'C' = 20

(c) attempt at T applied to at least one vertex, ft their T **M1**

(c) A' = (0,0) and B' = (12,4) both correct **A1**

(c) C' = (2,4) cao **A1**

(c) Answer: A' = (0,0), B' = (12,4), C' = (2,4)

(d) correct use of the shoelace (or equivalent) area formula with their coordinates **M1**

(d) correct substitution: 0.5|0(4-4)+12(4-0)+2(0-4)| **A1**

(d) area = 20 cao, matching part (b) **A1**

(d) Answer: Area = 20, confirming part (b)

Question 17

(a) attempt at A*A with at least one correct entry **M1**

(a) two correct entries **A1**

(a) A^2 = [[18,7],[14,11]] cao **A1**

(a) Answer: A^2 = [[18,7],[14,11]]

(b) finding trace(A)=7 and det(A)=10 and forming λ^2-7lambda+10=0 (Cayley-Hamilton), or direct substitution using part (a) **M1**

(b) cso: 7A - 10I = [[18,7],[14,11]], matching A^2 from part (a) **A1**

(b) Answer: A^2 = 7A - 10I confirmed

(c) multiplying both sides of A^2=7A-10I by A^{-1} to obtain A = 7I - 10A^{-1} **M1**

(c) rearranging to 10A^{-1} = 7I - A **M1**

(c) cso: A^{-1} = 0.7I - 0.1A (answer printed) **A1**

(c) Answer: A^{-1} = 0.7I - 0.1A

(d) A^{-1} = [[0.3,-0.1],[-0.2,0.4]] oe cao, ft their part (c) **B1**

(d) Answer: A^{-1} = [[0.3,-0.1],[-0.2,0.4]] = (1/10)[[3,-1],[-2,4]]

Question 18

(a) recognising k = √entries squared and summed, e.g. k = $\sqrt{1^2+1^2}$ **M1**

(a) k = $\sqrt{2}$ **A1**

(a) using cos(θ) = 1/$\sqrt{2}$ or sin(θ) = 1/$\sqrt{2}$ to find θ **M1**

(a) cso: θ = 45 degrees, with $\sqrt{2}$ *[[cos45,-sin45], [sin45,cos45]] = [[1,-1],[1,1]] confirmed **A1**

(a) Answer: k = $\sqrt{2}$, θ = 45 degrees

(b) enlargement, scale factor $\sqrt{2}$, centre O (ft their k) **B1**

(b) combined with rotation of 45 degrees anticlockwise about O (ft their θ) **B1**

(b) Answer: V represents an enlargement of scale factor $\sqrt{2}$ centre O, combined with a rotation of 45 degrees anticlockwise about O.

(c) attempt at V*V with at least one correct entry **M1**

(c) V^2 = [[0,-2],[2,0]] cao **A1**

(c) enlargement scale factor 2, ft their V^2 **B1**

(c) combined with rotation of 90 degrees anticlockwise about O, ft their V^2 **B1**

(c) Answer: V^2 = [[0,-2],[2,0]]; represents enlargement scale factor 2 combined with rotation 90 degrees anticlockwise about O.

(d) attempt at V^2 applied to (3,1), ft their V^2 **M1**

(d) (-2,6) cao **A1**

(d) Answer: (-2,6)

Question 19

(a) correct expansion of det(A(λ)) along a row or column **M1**

(a) correct simplification of all three terms **A1**

(a) cso: det(A(λ)) = -3*λ (answer printed) **A1**

(a) Answer: det(A(λ)) = -3*λ

(b) λ = 0, ft their part (a) **B1**

(b) Answer: λ = 0

(c) adding equation 1 and equation 2 to eliminate z: 3x + 3y = 8 **M1**

(c) comparing with equation 3 at λ = 0: 3x + 3y = μ **M1**

(c) μ = 8 cao **A1**

(c) Answer: μ = 8

(d) (i) the three planes meet in a common line (a sheaf of planes), giving infinitely many solutions **B1**

(d) (ii) the planes have no common point **B1**

(d) (ii) they form a triangular prism, each pair of planes meeting in a line, with the three lines parallel and distinct oe **B1**

(d) Answer: (i) μ = 8: planes meet in a common line, infinitely many solutions. (ii) μ ≠ 8: planes form a triangular prism, no common point, system inconsistent.

Question 20

(a) correct expansion of det(X), e.g. along row 2 **M1**

(a) det(X) = 3 cao **A1**

(a) interpretation: the transformation multiplies the volume of any shape by a factor of 3 (ft their det(X)) **B1**

(a) Answer: det(X) = 3; the transformation scales volume by a factor of 3.

(b) 15 cm^3, ft their det(X) **B1**

(b) Answer: 15 cm^3

(c) attempt at the cofactor matrix of X, ft their X **M1**

(c) correct adjugate (transpose of cofactor matrix; X is symmetric so adjugate = cofactor matrix here) **M1**

(c) adjugate = [[2,0,-1],[0,3,0],[-1,0,2]] with at least 6 entries correct **A1**

(c) fully correct adjugate **A1**

(c) X^{-1} = (1/3)[[2,0,-1],[0,3,0],[-1,0,2]] cao, ft their det(X) **A1**

(c) Answer: X^{-1} = (1/3)[[2,0,-1],[0,3,0],[-1,0,2]]

(d) computing X^{-1}*$(5,2,4)^T$, ft their X^{-1} **M1**

(d) two of the three coordinates correct **A1**

(d) original coordinates (2,2,1) cao **A1**

(d) Answer: (2,2,1)