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HIGHER

IG.M5 Matrices and Matrix Transformations

EDEXCEL 4MA1 · Calculator allowed · about 60 minutes

Total Marks

Name: ________________________________ Date: ____ / ____ / ______

Questions 1 to 12 do not require full sentence answers. Questions 13 to 16 require full sentences when describing transformations. Allow 60 minutes.

1 In the context of matrix arithmetic for a plotting task, calculate the sum of the 2x2 matrices A = [[2, -1], [3, 4]] and B = [[1, 5], [-2, 0]].

(Total for Question 1 is 1 mark)

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2 For a transformation exercise, calculate A - B where A = [[7, 2], [0, -3]] and B = [[4, -1], [5, 2]].

(Total for Question 2 is 1 mark)

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3 A gardener uses a 2x1 column matrix to record a plant position. Calculate 4 times the column matrix v = [[2], [-1]] to scale coordinates for an enlargement.

(Total for Question 3 is 2 marks)

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4 In matrix transformations, calculate the product of 2x2 matrices C = [[1, 2], [3, 0]] and D = [[-1, 4], [2, 1]] to combine two linear maps.

(Total for Question 4 is 2 marks)

5 Apply a linear transformation to a point. Calculate the image of point P with position vector p = [[3], [2]] under the 2x2 matrix T = [[2, 0], [1, -1]].

(Total for Question 5 is 2 marks)

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6 For a 2x2 matrix used in area-scaling, calculate the determinant of M = [[5, 2], [1, 3]]. State the determinant value which indicates area scale factor.

(Total for Question 6 is 2 marks)

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7 Find the inverse of the non-singular 2x2 matrix N = [[4, 1], [3, 2]] to reverse a linear transformation used on coordinates.

(Total for Question 7 is 3 marks)

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8 Determine whether the 2x2 matrix S = [[2, 4], [1, 2]] is singular, for a coordinate transform used by Priya. If singular, give a brief reason.

(Total for Question 8 is 3 marks)

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9 Calculate the product of a 2x2 transformation matrix and a column vector. Let U = [[0, -1], [1, 0]] (a rotation by 90 degrees) and q = [[4], [1]]. Find U q, the image of q under this rotation.

(Total for Question 9 is 2 marks)

10 Calculate the 2x2 matrix that represents a combined transformation of first scaling by 3 in all directions, then reflecting in the x-axis. Use matrices S = [[3, 0], [0, 3]] for enlargement and R = [[1, 0], [0, -1]] for reflection. Find the matrix product R S which maps a point after both transformations.

(Total for Question 10 is 2 marks)

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11 Find the 2x2 matrix which represents a rotation of 180 degrees about the origin, and then use it to find the image of point with position vector r = [[-2], [5]].

(Total for Question 11 is 3 marks)

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12 Combine two 2x2 linear transformations. Let A = [[0, 1], [1, 0]] (reflection in the line y = x) and B = [[2, 0], [0, 1]] (horizontal stretch by factor 2). Calculate the single 2x2 matrix that is equivalent to doing B then A (i.e. compute A B).

(Total for Question 12 is 4 marks)

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13 Describe fully the single transformation that maps the square with vertices at (1,1), (2,1), (2,2), (1,2) to the square with vertices at (-2, -2), (-4, -2), (-4, -4), (-2, -4). Give the transformation as a combination of standard terms (scale factor, centre, rotation angle, reflection as appropriate) and any translation vector.

(Total for Question 13 is 4 marks)

14 Describe fully the single transformation that maps point A with position vector a = [[1], [0]] to A' with position vector [[0], [2]], and maps B with position vector b = [[0], [1]] to B' with position vector [[-2], [0]]. Use standard transformation language (rotation, reflection, enlargement, translation) and state centre or angle as needed.

(Total for Question 14 is 5 marks)

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15 Two transformations are combined: first reflect in the y-axis, then translate by vector t = [[3], [1]]. Describe fully the single transformation that maps an arbitrary point (x,y) to its final image. Give the type of transformation, and if it is not a pure single linear transformation explain it as 'reflection then translation' and give the net effect on coordinates.

(Total for Question 15 is 5 marks)

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16 A map on the plane is represented by the matrix P = [[-1, 0], [0, 1]] followed by the translation vector u = [[2], [0]]. Describe fully the single transformation performed, and give the image of point (3, -1).

(Total for Question 16 is 5 marks)

Mark scheme · IG.M5 Matrices and Matrix Transformations

Question 1

- **B1** A + B = [[3, 4], [1, 4]] cao
- **Answer: [[3, 4], [1, 4]]**

Question 2

- **B1** A - B = [[3, 3], [-5, -5]] cao
- **Answer: [[3, 3], [-5, -5]]**

Question 3

- **M1** multiplies both entries by 4
- **A1** 4v = [[8], [-4]] cao
- **Answer: [[8], [-4]]**

Question 4

- **M1** multiplies rows of C by columns of D to form product entries
- **A1** CD = [[3, 6], [-3, 12]] cao
- **Answer: [[3, 6], [-3, 12]]**

Question 5

- **M1** performs matrix multiplication T p
- **A1** T p = [[6], [1]] cao
- **Answer: [[6], [1]]**

Question 6

- **M1** uses ad - bc method correctly
- **A1** determinant = 13 cao
- **Answer: 13**

Question 7

- **M1** calculates determinant correctly as 5
- **M1** forms adjugate matrix by swapping diagonal entries and negating off-diagonal entries
- **A1** N^{-1} = (1/5)[[2, -1], [-3, 4]] cao
- **Answer: (1/5)[[2, -1], [-3, 4]]**

Question 8

- **M1** calculates determinant correctly using ad - bc
- **M1** states determinant = 0 or shows rows are proportional
- **A1** concludes S is singular with correct reason, e.g. det = 0 so no inverse exists
- **Answer: Singular, because determinant = 2*2 - 4*1 = 4 - 4 = 0**

Question 9

- **M1** performs correct multiplication of U and q
- **A1** U q = [[-1], [4]] cao
- **Answer: [[-1], [4]]**

Question 10

- **M1** multiplies R and S in correct order R S
- **A1** R S = [[3, 0], [0, -3]] cao
- **Answer: [[3, 0], [0, -3]]**

Question 11

- **M1** states or writes rotation by 180 degrees matrix as [[-1, 0], [0, -1]]
- **M1** multiplies matrix by the column vector r
- **A1** image = [[2], [-5]] cao
- **Answer: [[2], [-5]]**

Question 12

- **M1** multiplies A and B in the correct order A B
- **M1** computes entries correctly for first row
- **M1** computes entries correctly for second row
- **A1** A B = [[0, 1], [2, 0]] cao
- **Answer: [[0, 1], [2, 0]]**

Question 13

- **M1** identifies change in size: scale factor 2 or 2x enlargement or reduction
- **M1** identifies orientation change: rotation by 180 degrees or reflection equivalent
- **M1** gives correct centre or translation vector, e.g. maps centre (1.5,1.5) to centre (-3, -3) so translation vector is (-4.5, -4.5) or states combined as enlargement with negative scale about origin
- **A1** fully correct description, for example: enlargement by scale factor 2 with centre at the origin combined with a reflection through the origin, equivalent to a rotation by 180 degrees and then scale factor 2, which maps the small square to the large one; or concise equivalent description with correct translation vector

Question 14

- **M1** identifies mapping of basis vectors implies linear map corresponding to matrix [[0, -2], [2, 0]] or recognises rotation and scale
- **M1** shows that a maps to (0,2) and b maps to (-2,0) consistent with a 90 degree rotation combined with scale factor 2
- **M1** states the centre is the origin and gives angle and scale factor, e.g. rotation by 90 degrees anticlockwise and enlargement by factor 2 about the origin
- **M1** explains that this is equivalent to multiplying by matrix [[0, -2], [2, 0]] or alternatively enlargement by 2 then rotation by 90 degrees
- **A1** full correct description, e.g. 'enlargement by factor 2 with centre at the origin combined with a rotation of 90 degrees anticlockwise about the origin' or equivalent wording

Question 15

- **M1** describes reflection in y-axis as mapping (x,y) to (-x,y)
- **M1** applies translation to give (-x + 3, y + 1)
- **M1** states that the combined map is not a single linear transformation but an isometry composed of reflection then translation
- **M1** gives final coordinate rule correctly as (x,y) -> (3 - x, y + 1)
- **A1** full clear description that the mapping is: reflect in the y-axis, then translate by vector (3,1), equivalently (x,y) maps to (3 - x, y + 1)

Question 16

- **M1** identifies P as reflection in the y-axis
- **M1** applies reflection to point (3, -1) to get (-3, -1)
- **M1** applies translation vector u to give final image (-1, -1)
- **M1** states combined transformation fully as reflection in the y-axis then translation by (2,0) and notes it is not a single 2x2 linear map
- **A1** final image given and description complete, e.g. image of (3, -1) is (-1, -1) and the transformation is reflect in the y-axis then translate by (2,0)