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| EGC_Black | EASTERN GOLDFIELDS COLLGE  Year 11 MATHEMATICS APPLICATIONS 2015 Investigation 2    ALPHABET CODES – MATRICES  Name: |

Part A – Due Thursday 30th April

Marks: \_\_\_\_\_\_\_\_\_\_/5

A security sensitive message (e.g. war time intelligence or email message) may be disguised by sending it in code.

An alphabet code may be disguised by representing the letters of each word by numbers and then scrambling the numbers using an encoding matrix. The message is later interpreted by the receiver and by applying a decoding matrix we are able to return the numbers to their original value. The message can then be deciphered.

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| **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** | **O** | **P** | **Q** | **R** | **S** | **T** | **U** | **V** | **W** | **X** | **Y** | **Z** | **-** |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |

The numbers 1 to 26 are chosen to represent the letters A to Z.

To send the message: **“SEND IN THE SUBS”**

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| **S** | **E** | **N** | **D** | **-** | **I** | **N** | **-** | **T** | **H** | **E** | **-** | **S** | **U** | **B** | **S** |
| 19 | 5 | 14 | 4 | 27 | 9 | 14 | 27 | 20 | 8 | 5 | 27 | 19 | 21 | 2 | 19 |

the numbers are grouped in fours and expressed in square matrix form.

 

a b c d a b c d

19 5 14 4 27 9 14 27

 

The message is coded by using an encoding matrix such as 

Each matrix is multiplied by this matrix: **** = ****

(4 x 19) + (1 x 14) = 90 (4 x 5) + (1 x 4) = 24

(3 x 19) + (1 x 14) = 71 (3 x 5) + (1 x 4) = 19

Encoding

1. Code the rest of the message.

Note: The encoding matrix must be the left matrix when multiplying, as shown on the

previous page.

2. The message now comprises the following set of numbers:

90 24 71 19 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Numbers greater than 27 are reduced by repeatedly **subtracting 27** until a number between

1 and 27 is obtained.

90 **– 27 – 27 – 27** = 9

24

71 **– 27 – 27** = 17

19

Therefore the message starts now as:

9 24 17 19\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Complete the message.

4. The numbers are then changed to letters by looking at the original alphabet and the message sent.

9 24 17 19

I X Q S

Complete the message to be sent.

I X Q S\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Decoding

5. To decode the message the receiver needs to know the encoding matrix i.e. 

The decoding matrix is the **inverse** of the encoding matrix 

(Swap the diagonal values (a and d) around and multiply the others (b and c) by -1.)

Now each letter from the coded message can be decoded.

(The decoding matrix must be first.)



The message is then written as:

-8 5 41 4 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

These numbers are finally adjusted by adding or subtracting 27 if necessary. Complete the decoding.

-8 5 41 4

19 5 14 4

S E N D

[-8 + 27 = 19] [41-27 = 14]

END OF PART A

|  |  |
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| EGC_Black | EASTERN GOLDFIELDS COLLEGE  Year 11 MATHEMATICS APPLICATIONS 2015  Investigation 2  ALPHABET CODES – MATRICES  Marks: \_\_\_\_\_\_\_/55  Name: |

**Part A – 5 marks**

Write your answers to part A here:



1.

2.

|  |  |  |  |  |  |  |  |  |  |  |  |
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3.

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4.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
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5.

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**PART B - 51 marks**

1. **Encode** “MORE AMMO URGENT”, following these steps: **(12 marks)**

a) Write the message in numbers. (1 marks)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

b) Write these as a series of matrices. (4 marks)

c) Multiply these matrices by the encoding matrix, which is

(4 marks)

= =

= =

Complete the table below by following these steps: (3 marks)

d) Write the resulting code.

e) Rewrite the code after subtracting 27 from the values where necessary.

f) Change back into letters, ready to send.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| d) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

2. **Decode** the following message, using the **encoding** matrix

**(13 marks)**



(1 mark)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Z | A | P | B | M | W | F | N | J | E | S | Q |
|  |  |  |  |  |  |  |  |  |  |  |  |

a) What is the **decoding** matrix to be used? (2 marks)

b) Apply the decoding matrix. (6 marks)

(4 marks)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| c) |  |  |  |  |  |  |  |  |  |  |  |  |
| d) |  |  |  |  |  |  |  |  |  |  |  |  |
| e) |  |  |  |  |  |  |  |  |  |  |  |  |

3. Messages can also be sent in code by **adding** matrices together. Consider the following

message: **(7 marks)**

**ONE BEER NOW**

a) Assign a number to each letter. (1 mark)

**O N E − B E E R − N O W**

15 14 5 27

b) Set up 2 x 2 matrices for these. (2 marks)

c) Use the **encoding** 2 x 2 matrix to encode the message. (2 marks)

+ =

d) Reassign letters to complete the message. Remember to take 27 from those numbers greater

than 27.

(2 marks)

17 21 18 32

**Q U R E**

4. To decode the message a **decoding** matrix is needed. The decoding matrix is  

Use this decoding matrix to decode the message below. **(8 marks)**

**V O N Y U G V Y**

5. Using your calculator, save these matrices and perform the following calculations or state if

they cannot be determined. **(10 marks)**

A = B = C = D =

a) A + D

b) 3A – D

c) C x 2B

d) – D²

e) B x C

END OF PART B