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|  | EASTERN GOLDFIELDS COLLEGE  Year 11 MATHEMATICS APPLICATIONS 2019  Unit 1 - Investigation 2    ALPHABET CODES – MATRICES Weighting 5%  Time Allowed: 55 mins Marks: 40  Name: |

**INFORMATION SHEET**

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 etc

  Now let’s look at the first word “SEND”

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

**Note**: The encoding matrix must be the **left** matrix when multiplying, as shown above.

90 24 71 19 are the corresponding numbers for the word “SEND”

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

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

So the word “SEND” would be written as “IXQS”

Decoding

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.)



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

-8 5 41 4

19 5 14 4

S E N D

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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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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

**(14 marks)**



1. Convert to numbers (1 mark)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **R** | **X** | **H** | **E** | **S** | **R** | **K** | **-** | **R** | **P** | **P** | **X** | **Q** | **E** | **E** | **V** |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

1. What is the **decoding** matrix **to be** used? (2 marks)
2. Apply the decoding matrix as shown on the previous page (8 marks)

(3 marks)

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

3. Messages can also be sent in code by **ADDING** matrices together. Consider the following message: **(6 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. (1 marks)

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

+ = Complete for the other two words

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. **(7 marks)**

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

END OF INVESTIGATION