

MARKING KEY 3

TOTAL 40

1. Encode "MORE AMMO URGENT" by following these steps: (12 marks)

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

13	15	18	5	27	1	13	13	15	27	21	18	7	5	14	20
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b) Write these as a series of matrices. (4 marks)

$$\begin{bmatrix} 13 & 15 \\ 18 & 5 \end{bmatrix} \quad \begin{bmatrix} 27 & 1 \\ 13 & 13 \end{bmatrix} \quad \begin{bmatrix} 15 & 27 \\ 21 & 18 \end{bmatrix} \quad \begin{bmatrix} 7 & 5 \\ 14 & 20 \end{bmatrix}$$

c) Multiply these matrices by the encoding matrix, which is $\begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix}$ (4 marks)

$$\begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 13 & 15 \\ 18 & 5 \end{bmatrix} = \begin{bmatrix} 44 & 35 \\ 31 & 20 \end{bmatrix} \quad \begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 27 & 1 \\ 13 & 13 \end{bmatrix} = \begin{bmatrix} 67 & 15 \\ 40 & 14 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 15 & 27 \\ 21 & 18 \end{bmatrix} = \begin{bmatrix} 51 & 72 \\ 36 & 45 \end{bmatrix} \quad \begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 7 & 5 \\ 14 & 20 \end{bmatrix} = \begin{bmatrix} 28 & 30 \\ 21 & 25 \end{bmatrix}$$

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)	44	35	31	20	67	15	40	14	51	72	36	45	28	30	21	25
e)	17	8	4	20	13	15	13	14	24	18	9	18	1	3	21	25
f)	Q	H	D	T	M	O	M	N	X	R	I	R	A	C	U	Y

FT a) - f)

2. Decode the following message, using the **encoding** matrix $\begin{bmatrix} 2 & 1 \\ 3 & 2 \end{bmatrix}$ (14 marks)

a) Convert to numbers

(1 mark)

R	X	H	E	S	R	K	-	R	P	P	X	Q	E	E	V
18	24	8	5	19	18	11	27	18	16	16	24	17	5	5	22

b) What is the **decoding** matrix to be used?

(2 marks)

$$\begin{bmatrix} 2 & -1 \\ -3 & 2 \end{bmatrix} \quad \checkmark \checkmark \quad \text{r/w any error } \times$$

c) Apply the decoding matrix.

(8 marks)

$$\begin{bmatrix} 2 & -1 \\ -3 & 2 \end{bmatrix} \begin{bmatrix} 18 & 24 \\ 8 & 5 \end{bmatrix} = \begin{bmatrix} 28 & 43 \\ -38 & -62 \end{bmatrix} \quad \checkmark \checkmark$$

$$\begin{bmatrix} 2 & -1 \\ -3 & 2 \end{bmatrix} \begin{bmatrix} 19 & 18 \\ 11 & 27 \end{bmatrix} = \begin{bmatrix} 27 & 9 \\ -35 & 0 \end{bmatrix} \quad \checkmark \checkmark$$

$$\begin{bmatrix} 2 & -1 \\ -3 & 2 \end{bmatrix} \begin{bmatrix} 18 & 16 \\ 16 & 24 \end{bmatrix} = \begin{bmatrix} 20 & 8 \\ -22 & 0 \end{bmatrix} \quad \checkmark \checkmark$$

$$\begin{bmatrix} 2 & -1 \\ -3 & 2 \end{bmatrix} \begin{bmatrix} 17 & 5 \\ 5 & 22 \end{bmatrix} = \begin{bmatrix} 29 & -12 \\ -41 & 29 \end{bmatrix} \quad \checkmark \checkmark$$

(3 marks)

d)	28	43	-38	-62	27	9	-35	0	20	8	-22	0	29	-12	-41	29
e)	1	16	16	19	27	9	19	27	20	8	5	27	2	15	13	2
f)	A	P	P	S	-	I	S	-	T	H	E	-	B	O	M	B

-1 errors F.T. errors from d) \rightarrow 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)

$\begin{matrix} \text{O} & \text{N} & \text{E} & - & \text{B} & \text{E} & \text{E} & \text{R} & - & \text{N} & \text{O} & \text{W} \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 15 & 14 & 5 & 27 & 2 & 5 & 5 & 18 & 27 & 14 & 15 & 23 \end{matrix}$ ✓

b) Set up 2 x 2 matrices for these. (1 mark)

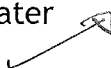
$\begin{bmatrix} 15 & 14 \\ 5 & 27 \end{bmatrix}$
 $\begin{bmatrix} 2 & 5 \\ 5 & 18 \end{bmatrix}$
 $\begin{bmatrix} 27 & 14 \\ 15 & 23 \end{bmatrix}$

c) Use the **encoding** 2 x 2 matrix $\begin{bmatrix} 2 & 7 \\ 13 & 5 \end{bmatrix}$ to encode the message. (2 marks)

$$\begin{bmatrix} 15 & 14 \\ 5 & 27 \end{bmatrix} + \begin{bmatrix} 2 & 7 \\ 13 & 5 \end{bmatrix} = \begin{bmatrix} 17 & 21 \\ 18 & 32 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 5 \\ 5 & 18 \end{bmatrix} + \begin{bmatrix} 2 & 7 \\ 13 & 5 \end{bmatrix} = \begin{bmatrix} 4 & 12 \\ 18 & 23 \end{bmatrix} \checkmark$$

$$\begin{bmatrix} 27 & 14 \\ 15 & 23 \end{bmatrix} + \begin{bmatrix} 2 & 7 \\ 13 & 5 \end{bmatrix} = \begin{bmatrix} 29 & 21 \\ 28 & 28 \end{bmatrix} \checkmark$$

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

$\begin{matrix} 17 & 21 & 18 & 32 & 4 & 12 & 18 & 23 & (29) & 21 & (21) & (28) & (28) \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ \text{Q} & \text{U} & \text{R} & \text{E} & \text{D} & \text{L} & \text{R} & \text{W} & \text{B} & \text{U} & \text{A} & \text{A} \end{matrix}$

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

$$\begin{bmatrix} -2 & -7 \\ -13 & -5 \end{bmatrix}$$

Use this decoding matrix to decode the message below.

(8 marks)

V O N Y U G V Y
 ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
 22 15 14 25 21 7 22 25 ✓

$$\begin{bmatrix} 22 & 15 \\ 14 & 25 \end{bmatrix} + \begin{bmatrix} -2 & -7 \\ -13 & -5 \end{bmatrix} = \begin{bmatrix} 20 & 8 \\ 1 & 20 \end{bmatrix} \checkmark$$

*
 -5 marks if
 multiply

$$\begin{bmatrix} 21 & 7 \\ 22 & 25 \end{bmatrix} + \begin{bmatrix} -2 & -7 \\ -13 & -5 \end{bmatrix} = \begin{bmatrix} 19 & 0 \\ 9 & 20 \end{bmatrix} \checkmark$$

20 8 1 20 19 0 9 20 ✓
 ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
 T H A T S - I T ✓

END OF INVESTIGATION