Escape Room Challenges Using Cryptology

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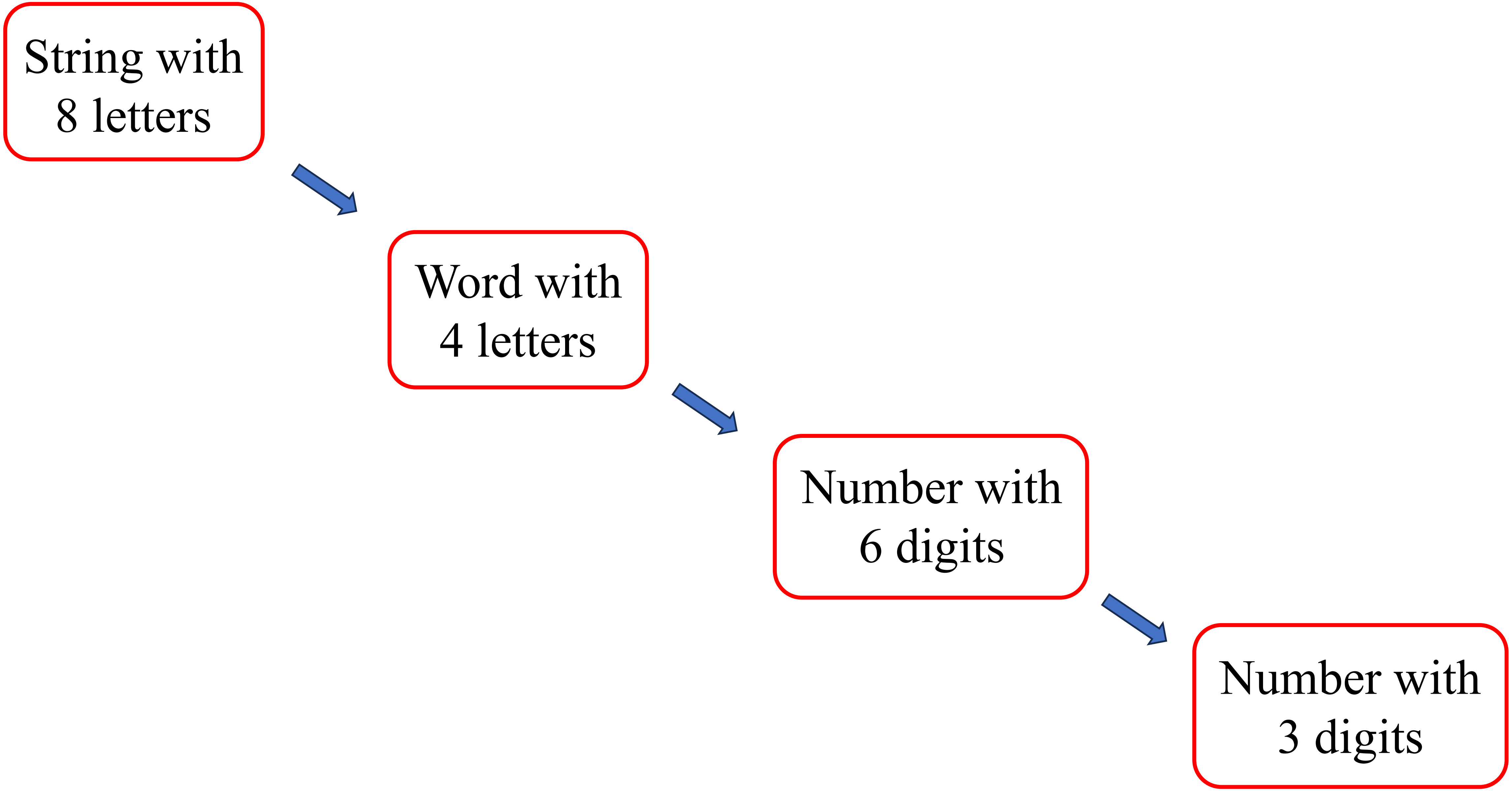
Topics for the Escape Room Challenges

- Affine Ciphers (Modular Arithmetic)
- Hill Cipher (Matrices)
- Base Twenty-Six Arithmetic (Addition and Subtraction)
- Euclidean Algorithm

Escape Room Instructions

- There are four locks that need to be opened.
- Each lock can be opened with a 3-digit number corresponding to a 6-digit number, which is derived from a base 26 number with 4 letters.
- Each word with 4 letters is derived from a set of 8 letters according to a particular encryption technique.



String with 8 letters
Word with 4 letters
Number with 6 digits
Number with 3 digits

Example

Find the four sets of 3-digit numbers associated with

KCVBG KTMOJ VZUJO GWFSC
CXFYL FTYHN KR

First, separate the 32 letters into four blocks of 8 letters, in order.

Example

Find the four sets of 3-digit numbers associated with

KCVBG KTM|OJ VZUJO G|WFSC
CXFY|L FTYHN KR

First, separate the 32 letters into four blocks of 8 letters, in order.

First Lock

KCVBGKTM → ?

An **affine cipher** is a formula of the form $y = ax + b \pmod{n}$, where a, b, and n are integers, used for enciphering messages.

We use $n = 26$ for enciphering a letter of the alphabet as another letter of the alphabet using $\pmod{26}$.

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
0	**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**

1. **Affine Cipher**

Block 1: KCVBGKTM

- Find the affine cipher (mod 26) where K enciphers as C, and V enciphers as B.
- Then find the decipherment formula.
- Use the decipherment formula to decipher GKTM mod 26.
- After deciphering, find the base-ten equivalent of the base twenty-six number.
- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

Suppose, in an affine cipher, K enciphers as C, and V enciphers as B.

Give the encipherment formula.

x			y
10	K	→ C	2
21	V	→ B	1

$$10a + b = 2$$
$$21a + b = 1$$

$$ax + b = y \pmod{26}$$

Solve for a and b.

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
0	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

Suppose, in an affine cipher, K enciphers as C, and V enciphers as B.

Give the encipherment formula.

x			y
10	K	→ C	2
21	V	→ B	1

$$10a + b = 2$$
$$21a + b = 1$$

$$\begin{array}{rl} & 21a + b = 1 \\ - & \underline{(10a + b = 2)} \\ & 11a \quad = -1 \end{array}$$

$$11^{-1} = 19 \bmod 26$$

$$\Rightarrow \quad a = -19 = -19 + 26 = 7$$

$$\boxed{a = 7}$$

Inverses (mod 26)

x	1	3	5	7	9	11	15	17	19	21	23	25
x^{-1} (mod 26)	1	9	21	15	3	19	7	23	11	5	17	25

Suppose, in an affine cipher, K enciphers as C, and V enciphers as B.

Give the encipherment formula.

x			y
10	K	→ C	2
21	V	→ B	1

$$10a + b = 2$$
$$21a + b = 1$$

$$\begin{aligned} & 21a + b = 1 \\ - & \underline{(10a + b = 2)} \\ & 11a \quad = -1 \end{aligned}$$

$$11^{-1} = 19 \bmod 26$$

$$\Rightarrow \quad a = -19 = -19 + 26 = 7$$

$$\boxed{a = 7}$$

$$10a + b = 2$$
$$10(7) + b = 2 \;\Rightarrow\; b = 2 - 70 = -68 = -68 + 78 = 10$$

$$\boxed{b = 10}$$

Encipherment:

$$\boxed{y = 7x + 10 \bmod 26}$$

1. **Affine Cipher**

Block 1: KCVBGKTM

- Find the affine cipher (mod 26) where K enciphers as C, and V enciphers as B.

$$\boxed{y = 7x + 10 \bmod 26}$$

- Then find the decipherment formula.
- Use the decipherment formula to decipher GKTM mod 26.
- After deciphering, find the base-ten equivalent of the base twenty-six number.
- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

Suppose, in an affine cipher, K enciphers as C, and V enciphers as B.

Give the decipherment formula.

$$y = 7x + 10 \bmod 26$$ **encipherment formula**

$$\Rightarrow y - 10 = 7x$$

$$\Rightarrow \quad 7x = y - 10$$

+ 26

$$\Rightarrow \quad x = 15(y - 10)$$ $$7^{-1} = 15 \bmod 26$$

$$\Rightarrow \quad x = 15(y + 16)$$

Decipherment formula:

$$x = 15(y + 16) \bmod 26$$

1. **Affine Cipher**

Block 1: KCVBGKTM

- Find the affine cipher (mod 26) where K enciphers as C, and V enciphers as B.

$y = 7x + 10 \bmod 26$

$x = 15(y + 16) \bmod 26$

- Then find the decipherment formula.
- Use the decipherment formula to decipher GKTM mod 26.
- After deciphering, find the base-ten equivalent of the base twenty-six number.
- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

Decipherment Formula: $x = 15(y+16) \bmod 26$

6 10 19 12

Decipher GKTM.

G (6) $15(6+16) = 15 \cdot 22 = 330 \equiv 18 \bmod 26$ **S (18)**

K (10) $15(10+16) = 15 \cdot 26 \equiv 15 \cdot 0 = 0 \bmod 26$ **A (0)**

T (19) $15(19+16) = 15 \cdot 35 = 525 \equiv 5 \bmod 26$ **F (5)**

M (12) $15(12+16) = 15 \cdot 28 = 420 \equiv 4 \bmod 26$ **E (4)**

GKTM deciphers as **SAFE**

1. **Affine Cipher**

Block 1: KCVBGKTM

- Find the affine cipher (mod 26) where K enciphers as C, and V enciphers as B.

$y = 7x + 10 \bmod 26$

- Then find the decipherment formula.

$x = 15(y + 16) \bmod 26$

- Use the decipherment formula to decipher GKTM mod 26.

SAFE

- After deciphering, find the base-ten equivalent of the base twenty-six number.
- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

Find the base-ten equivalent of the base-26 number SAFE.

18 0 5 4

$$\text{SAFE} = \underline{18} \cdot 26^3 + \underline{0} \cdot 26^2 + \underline{5} \cdot 26 + \underline{4}$$

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
0	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

Find the base-ten equivalent of the base-26 number SAFE.

$$\overset{18\ \ 0\ \ 5\ \ 4}{\text{SAFE}} = \underline{18} \cdot 26^3 + \underline{0} \cdot 26^2 + \underline{5} \cdot 26 + \underline{4}$$

$$= (18)(17576) + (5)(26) + 4$$

$$= 316502$$

$$\boxed{\text{SAFE} = 316502}$$

1. **Affine Cipher**

Block 1: KCVBGKTM

- Find the affine cipher (mod 26) where K enciphers as C, and V enciphers as B.

$y = 7x + 10 \bmod 26$

- Then find the decipherment formula.

$x = 15(y + 16) \bmod 26$

- Use the decipherment formula to decipher GKTM mod 26.

SAFE

- After deciphering, find the base-ten equivalent of the base twenty-six number.

SAFE = 316502

- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

3 6 0

Second Lock

OJVZUJOG → ?

Hill Cipher

The **determinant** of a 2×2 matrix $A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$

is the number $ad - bc$.

Notation: $\det(A) = ad - bc$

Theorem

A 2×2 matrix $A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$ is invertible modulo 26

if and only if $\det(A)$ is relatively prime to 26.

Then $A^{-1} = (\det A)^{-1} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix} \bmod 26.$

2. **Hill Cipher**

Block 2: OJVZUJOG

- Given that O $= 14$, J$= 9$, V$= 21$, Z$= 25$,

  consider the matrix $A = \begin{bmatrix} 14 & 9 \\ 21 & 25 \end{bmatrix}$.

- Find A^{-1} mod 26.

- Use A^{-1} to decipher UJOG mod 26.

- After deciphering, find the base-ten equivalent of the base twenty-six number.

- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

$$A = \begin{bmatrix} 14 & 9 \\ 21 & 25 \end{bmatrix}$$

Find A^{-1}.

$$\det(A) = 14 \cdot 25 - 21 \cdot 9 = 350 - 189 = 161 \equiv 5 \bmod 26$$

$$A^{-1} = 5^{-1} \begin{bmatrix} 25 & -9 \\ \underset{+26}{-21} & 14 \end{bmatrix} = 21 \begin{bmatrix} 25 & -9 \\ 5 & 14 \end{bmatrix} = \begin{bmatrix} 525 & -189 \\ 105 & 294 \end{bmatrix} = \begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix} \mod 26$$

x	1	3	5	7	9	11	15	17	19	21	23	25
x^{-1} (mod 26)	1	9	21	15	3	19	7	23	11	5	17	25

$$A = \begin{bmatrix} 14 & 9 \\ 21 & 25 \end{bmatrix}$$

Find A^{-1}.

$$\det(A) = 14 \cdot 25 - 21 \cdot 9 = 350 - 189 = 161 \equiv 5 \bmod 26$$

$$A^{-1} = 5^{-1} \begin{bmatrix} 25 & -9 \\ \underset{+26}{-21} & 14 \end{bmatrix} = 21 \begin{bmatrix} 25 & -9 \\ 5 & 14 \end{bmatrix} = \begin{bmatrix} 525 & -189 \\ 105 & 294 \end{bmatrix} = \begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix} \mod 26$$

$$\boxed{A^{-1} = \begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix}}$$

2. **Hill Cipher**

Block 2: OJVZUJOG

- Given that O = 14, J= 9, V= 21, Z= 25,

  consider the matrix $A = \begin{bmatrix} 14 & 9 \\ 21 & 25 \end{bmatrix}$.

- Find A^{-1} mod 26.

- Use A^{-1} to decipher UJOG mod 26.

- After deciphering, find the base-ten equivalent of the base twenty-six number.

- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

$$A^{-1} = \begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix}$$

Use A^{-1} to decipher UJOG.

Letters encipher (or decipher) as pairs in a 2×1 matrix.

Use A^{-1} to decipher UJOG.

$$A^{-1} = \begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix}$$

U (20)

J (9)

$$\begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix} \begin{bmatrix} 20 \\ 9 \end{bmatrix} = \begin{bmatrix} 271 \\ 92 \end{bmatrix} = \begin{bmatrix} 11 \\ 14 \end{bmatrix}$$

L (11)

O (14)

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
0	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

Use A^{-1} to decipher UJOG.

$$A^{-1} = \begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix}$$

U (20)
J (9)

$$\begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix} \begin{bmatrix} 20 \\ 9 \end{bmatrix} = \begin{bmatrix} 271 \\ 92 \end{bmatrix} = \begin{bmatrix} 11 \\ 14 \end{bmatrix}$$

L (11)
O (14)

O (14)
G (6)

$$\begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix} \begin{bmatrix} 14 \\ 6 \end{bmatrix} = \begin{bmatrix} 184 \\ 62 \end{bmatrix} = \begin{bmatrix} 2 \\ 10 \end{bmatrix}$$

C (2)
K (10)

UJOG deciphers as **LOCK**

2. **Hill Cipher**

Block 2: OJVZUJOG

- Given that O $= 14$, J$= 9$, V$= 21$, Z$= 25$,

  consider the matrix $A = \begin{bmatrix} 14 & 9 \\ 21 & 25 \end{bmatrix}$.

- Find A^{-1} mod 26.

- Use A^{-1} to decipher UJOG mod 26.

- After deciphering, find the base-ten equivalent of the base twenty-six number.

- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

$$A^{-1} = \begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix}$$

LOCK

Find the base-ten equivalent of the base-26 number LOCK.

11 14 2 10

$$\text{LOCK} = \underline{11} \cdot 26^3 + \underline{14} \cdot 26^2 + \underline{2} \cdot 26 + \underline{10}$$

$$= (11)(17576) + (14)(676) + 52 + 10$$

$$= 193336 + 9464 + 52 + 10$$

$$= 202862$$

$$\boxed{\text{LOCK} = 202862}$$

2. **Hill Cipher**

Block 2: OJVZUJOG

- Given that O $= 14$, J$= 9$, V$= 21$, Z$= 25$,

  consider the matrix $A = \begin{bmatrix} 14 & 9 \\ 21 & 25 \end{bmatrix}$.

- Find A^{-1} mod 26.

- Use A^{-1} to decipher UJOG mod 26.

- After deciphering, find the base-ten equivalent of the base twenty-six number.

- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

$$A^{-1} = \begin{bmatrix} 5 & 19 \\ 1 & 8 \end{bmatrix}$$

LOCK

LOCK $= \underline{2}0\underline{2}8\underline{6}2$

2 2 6

Third Lock

WFSCCXFY → ?

ADDITION IN BASE TEN

In base ten addition, we need to carry a 1 if the sum of two digits is greater than 9.

For example,

$$\begin{array}{r} {\color{red}1}\ {\color{red}1} \\ 3\ 4\ 7 \\ +\ 2\ 6\ 8 \\ \hline {\color{red}6}\ {\color{red}1}\ {\color{red}5} \end{array}$$

$7 + 8 = 15$

$1 + 4 + 6 = 11$

$1 + 3 + 2 = 6$

ADDITION IN BASE TWENTY-SIX

Similarly, in base twenty-six addition, we need to carry a term if the sum of the terms is greater than 25.

Find the following sum in base twenty-six.

```
   T E N
 + T W O
 -------
```

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
0	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

ADDITION IN BASE TWENTY-SIX

Similarly, in base twenty-six addition, we need to carry a term if the sum of the terms is greater than 25.

Find the following sum in base twenty-six.

```
     B   B  1  13
     T   E  4  N
            22 14
  +  T   W     O
  -----------------
  B  N   B     B
```

$$13 + 14 = 27$$

$$1 + 4 + 22 = 27$$

$$1 + 19 + 19 = 39$$

B B

$$27 = \underline{1} \times 26 + \underline{1}$$

$$= \mathrm{BB}$$

B N

$$39 = \underline{1} \times 26 + \underline{13}$$

T E N + T W O = B N B B

SUBTRACTION IN BASE TEN

In base ten subtraction, if the top term is smaller than the bottom term, then we need to borrow from the previous term (reduce by 1) and add 10 to the smaller term.

For example,

$$\begin{array}{rcc} & 4 & 13 = 3 + 10 \\ & \not{5} & \not{3} \\ - & 1 & 7 \\ \hline & 3 & 6 \end{array}$$

SUBTRACTION IN BASE TWENTY-SIX

Similarly, in base twenty-six subtraction, if the top letter is smaller than the bottom letter, then we borrow from the letter to the left (reduce to the previous letter) and add 26 (the base) to the value of the smaller letter.

For example,

17 45 = 19 + 26

R

~~S~~ T ~~19~~

− D [3] W [22]

O [14] X [23]

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
0	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

SUBTRACTION IN BASE TWENTY-SIX

Similarly, in base twenty-six subtraction, if the top letter is smaller than the bottom letter, then we borrow from the letter to the left (reduce to the previous letter) and add 26 (the base) to the value of the smaller letter.

For example,

17 45 = 19 + 26

R

~~S~~ T ~~19~~

− D 3 W 22

O 14 X 23

S T – D W = O X

3. **Base Twenty-Six Subtraction**

Block 3: WFSCCXFY

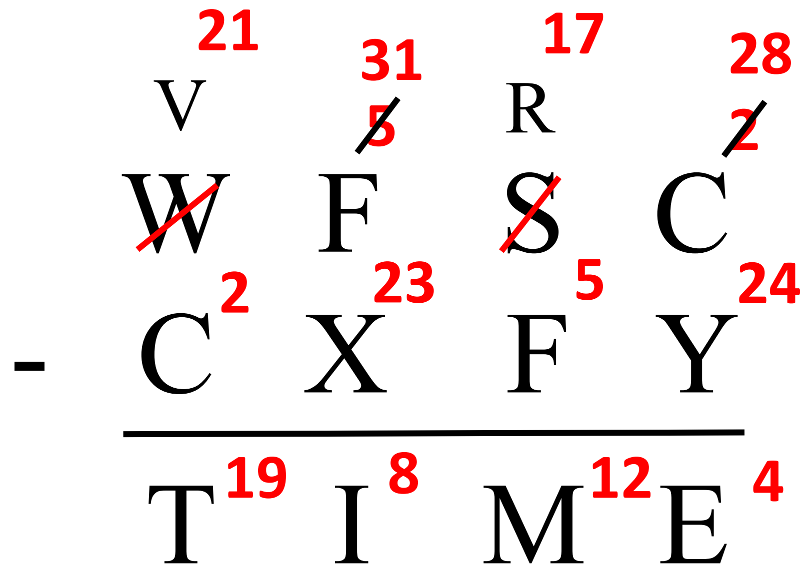
- Find WFSC − CXFY in base twenty-six.
- Find the base-ten equivalent of this base twenty-six number.
- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

Find WFSC − CXFY in base twenty-six.

	W	F	S	C
-	C	X	F	Y

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
0	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

Find WFSC − CXFY in base twenty-six.



WFSC – CSFY = **TIME**

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
0	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

3. **Base Twenty-Six Subtraction**

Block 3: WFSCCXFY

TIME

- Find WFSC − CXFY in base twenty-six.
- Find the base-ten equivalent of this base twenty-six number.
- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

Find the base-ten equivalent of the base-26 number TIME.

19 8 12 4

$$\text{TIME} = \underline{19} \cdot 26^3 + \underline{8} \cdot 26^2 + \underline{12} \cdot 26 + \underline{4}$$

$$= (19)(17576) + (8)(676) + 312 + 4$$

$$= 333944 + 5408 + 312 + 4$$

$$= 339668$$

$$\boxed{\text{TIME} = 339668}$$

3. Base Twenty-Six Subtraction

Block 3: WFSCCXFY

- Find WFSC − CXFY in base twenty-six.
- Find the base-ten equivalent of this base twenty-six number.
- Use the first, third, and fifth digits of this 6-digit number (in order) to open a lock. (You must determine which lock.)

TIME

TIME = 339668

3 9 6

Fourth Lock

LFTYHNKR → ?

4. **Base Twenty-Six Addition and the Euclidean Algorithm**

Block 4: LFTYHNKR

- Find LFTY + HNKR in base twenty-six.
- Find the base-ten equivalent of this base twenty-six number.
- The result is a 6-digit number in base-ten, which can be interpreted as a 3-digit number (the first 3 digits) followed by another 3-digit number (the last 3 digits). Use the Euclidean Algorithm to find the multiplicative inverse of the first 3-digit number in the modulus of the second 3-digit number.
- Use the 3 digits of the multiplicative inverse (in order) to open a lock. (You must determine which lock.)

Find LFTY + HNKR in base twenty-six.

$$\begin{array}{r} L\ F\ T\ Y \\ +\ H\ N\ K\ R \\ \hline \end{array}$$

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
0	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

Find LFTY + HNKR in base twenty-six.

		B (1)	B (1)	
	L (11)	F (5)	T (19)	Y (24)
+	H (7)	N (13)	K (10)	R (17)
	S (18)	T (19)	E	P

$$41 = \underline{1} \times 26 + \underline{15} = \text{BP}$$

$$30 = \underline{1} \times 26 + \underline{4} = \text{BE}$$

LFTY + HNKR = **STEP**

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
0	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

4. **Base Twenty-Six Addition and the Euclidean Algorithm**

Block 4: LFTYHNKR

STEP

- Find LFTY + HNKR in base twenty-six.
- Find the base-ten equivalent of this base twenty-six number.
- The result is a 6-digit number in base-ten, which can be interpreted as a 3-digit number (the first 3 digits) followed by another 3-digit number (the last 3 digits). Use the Euclidean Algorithm to find the multiplicative inverse of the first 3-digit number in the modulus of the second 3-digit number.
- Use the 3 digits of the multiplicative inverse (in order) to open a lock. (You must determine which lock.)

Find the base-ten equivalent of the base-26 number STEP.

18 19 4 15

$$\text{STEP} = \underline{18} \cdot 26^3 + \underline{19} \cdot 26^2 + \underline{4} \cdot 26 + \underline{15}$$

$$= (18)(17576) + (19)(676) + 104 + 15$$

$$= 316368 + 12844 + 104 + 15$$

$$= 329331$$

$$\boxed{\text{STEP} = 329331}$$

4. **Base Twenty-Six Addition and the Euclidean Algorithm**

Block 4: LFTYHNKR

- Find LFTY + HNKR in base twenty-six.
- Find the base-ten equivalent of this base twenty-six number.
- The result is a 6-digit number in base-ten, which can be interpreted as a 3-digit number (the first 3 digits) followed by another 3-digit number (the last 3 digits). Use the Euclidean Algorithm to find the multiplicative inverse of the first 3-digit number in the modulus of the second 3-digit number.
- Use the 3 digits of the multiplicative inverse (in order) to open a lock. (You must determine which lock.)

STEP

STEP = 329331

Find $329^{-1} \bmod 331$.

Find $329^{-1} \bmod 331$.

$$331 = \underline{329} + \underline{2}$$
$$329 = 164(\underline{2}) + \boxed{1}$$

$$\begin{aligned} 1 &= \underline{329} - 164(\underline{2}) \\ &= \underline{329} - 164[\underline{331} - \underline{329}] \\ &= \underline{329} - 164(\underline{331}) + 164(\underline{329}) \\ &= 165(\underline{329}) - 164(\underline{331}) \end{aligned}$$

Now backtrack to find the linear combination.

Check!

$$1 = 165(\underline{329}) - \underbrace{164(\underline{331})}_{\equiv 0} \bmod 331$$

$$\boxed{\text{so } 329^{-1} = 165 \bmod 331}$$

4. **Base Twenty-Six Addition and the Euclidean Algorithm**

Block 4: LFTYHNKR

- Find LFTY + HNKR in base twenty-six.
- Find the base-ten equivalent of this base twenty-six number.
- The result is a 6-digit number in base-ten, which can be interpreted as a 3-digit number (the first 3 digits) followed by another 3-digit number (the last 3 digits). Use the Euclidean Algorithm to find the multiplicative inverse of the first 3-digit number in the modulus of the second 3-digit number.
- Use the 3 digits of the multiplicative inverse (in order) to open a lock. (You must determine which lock.)

STEP

STEP = 329331

Find $329^{-1} \bmod 331$.

$329^{-1} = 165 \bmod 331$

1 6 5

Escape Room
Exercise

There are four locks that need to be opened. Each lock can be opened with a 3-digit number derived from a 6-digit number, which is derived from a base twenty-six number with 4 letters. Apply the same encryption techniques used in the example above, in the same order, to find the four sets of 3-digit numbers associated with the four sets of 8 letters in the encipherment below. You must determine which lock corresponds to each encryption technique.

Find the four sets of 3-digit numbers associated with

LFGCT AZSKL FHQHI KTNQD
GMUFL WKZGR DX

The four words decipher as

RUBY

LIME

NAVY

SNOW

The four locks are labeled red, green, blue, and white.

Reference

Invitation to Crytology. Thomas H. Barr.