

# The Code Breaker

## Encoder – Decoder

Math & Physics Explora-

3 x 9	1 25
5 x 21	3 23
7 x 15	5 21
11 x 19	7 19
17 x 23	9 17
25 x 25	11 15

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**The Math Magician**  
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Chelsea’s school was competing with another school to see which students could visit the most places without the competitor school discovering where they had gone and to determine what the final destination would be. Chelsea’s friend Amanda Smith, who was going to the competitive school, was taking a European route while Chelsea was taking a United States route. Each girl had to send a coded message back to the head mistress of both schools. Each side was given the same coding kit with each kit having the ability to generate 274 different coding schemes.

As the girls were leaving, Chelsea gave Amanda a model of a fishing boat and Amanda gave Chelsea a turkey sandwich, They had to figure out each others routes from the messages that the head mistresses would send along to their students. As Chelsea landed in the United states, she got Amanda’s first coded message. The message was as follows:

P DJESTDP R ZV QETCTQPO QEJKZSJ KR RUQJESDPDJ KR QJESZFPO. P DPQTSPO R OTLWJP. PL

Because Chelsea knew her friend well, she realized that the last two letters where Amanda’s initials. Since A is the 0th letter in the alphabet and P is the 15th she could figure out the coding scheme using modular arithmetic. L is the 11th letter and the S from Amanda’s last name is 18th letter. The coding formula is  $C=aL+b$ , where C is the coded letter and L is the letter to coded. Using the above information:

$$\begin{array}{rcl}
 P & A & L & S \\
 15=a \times 0 +b & & 11=18a+b \\
 15=b & & 11=18a+15 \\
 & & 18a=-4=22 & \text{in modulo 26 arithmetic} \\
 & & 9a=11 & \text{dividing by 2} \\
 & & 27a=33 & \text{multiplying by 3} \\
 & & a=7 & \text{since } 27=26+1 \quad 33=26+7
 \end{array}$$

The translation formula for Amanda is  $C=7L+15$

Now that Chelsea knows the coding formula, she can reverse it by first multiplying by 15 giving :

$$\begin{array}{l}
 15C=105L+225 \quad 105= 4 \times 26+1 \quad 225= 26 \times 8+17 \\
 15C=L+17 \\
 L=15C-17=15C+9 \quad 26-17=9
 \end{array}$$

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
9	24	13	2	17	6	21	10	25	14	3	18	7	22	11	0	15	4	19	8	23	12	1	16	5	20
J	Y	N	C	R	G	V	K	Z	O	D	S	H	W	L	A	P	E	T	I	X	M	B	Q	F	U

To translate Amanda’s code, Chelsea has to use the formula:  $L=15C+9$  Let us make a table: For each letter, Chelsea puts its number equivalent (row 2) in the formula  $L=15C+9$  to get a numerical value in row 3. Then she uses that number to translate back to a letter using the number convention applied to the first row. The Letter K has a value 11 which becomes a 3 using the formula. The 3 is the letter D. Thus a K will translate back to the original letter D.

Now Chelsea begins her translation:

P DJESTDP R ZV QETCTQPO QEJKZSJ KR RUQJESDPDJ KR QJESZFPO.  
A CORTICA E UM PRINIPAL PRODUTO DE EXPORTACAO DE PORTUGAL.

She recognizes that the last word is Portugal. Amanda was very clever, she had sent the message in Portugese. Chelsea translates the last sentence:

P DPQTSPO R OTLWJP.  
A CAPITAL E LISBOA.

Amanda's message translated to English is Cork is a chief export from Portugal. The Capital is Lisbon. Chelsea knows that Lisbon, Portugal was the first city that Amanda visited. Amanda did not use the formula to create her message. She used coding disk 7 and placed the P (15th letter) on the disk under the A. Chelsea did not have to create the table. The formula told her that she need to use disk 15 with the J on the disk under the A.

Chelsea's first message was:

A CM AP CKEHAP HOTCE 3C

The 3 meant that she used coding disk 3 and placed the C under the A. To decode the message Amanda must use disk 9 ( $3 \times 9 = 27 = 26 + 1$ ) and place the A under the C. Doing this she gets the following message:

I am in Austin, Texas



Amanda sent the following messages from the next 6 cities. Translate the messages and determine the reasoning behind Amanda's choice of cities and why she gave Chelsea a turkey sandwich.

Message 2:

YWLY QUVVSZY ZI NUVOE IL CYZVSZ, IEDYLY RWI EYLAVSILNU. 9Y

Message 3:

TW FEAP CIXXCT W ZWPIK, TW XPWJMC CKF IOZPCKKIEJJWJF. 21W

Message 4:

QEMHQHKEYE, YE AQTI NKX TEHQTEQ. TQ AQNEHQTK K XIYQ. 5Q

Message 5:

VZINK TBAVNK, TNDKN EANKZWN DK ONACDK. WXR CXKW DRI  
WNZIRFMCXKW. 17X

Message 6:

DJZBNZENIJKZBN WNUGJEVEN ZIFY KXUJI KX GINF UJHV. 3X

Message 7:

ZGXALWIHWN , WN OSNXSU WTWI. 25A

While Amanda was traveling in Europe, Chelsea was traveling in the United States. These are the messages and pictures that Chelsea sent:

Message 2:

URXHGRJ XER YREN UPUTAXE LK XOAXKOX, BRPEBLX. 5X



Message 3:

XKKXUPALJ LJ OGR HXULOXA PW OGR JOXOR LK DGLHG FN BEXKMUX DXJ  
CPEK. 5X



Message 4:

XACXKN LJ OGR HXULOXA PW OGR JOXOR DGRER GR KPD ALYRJ. 5X



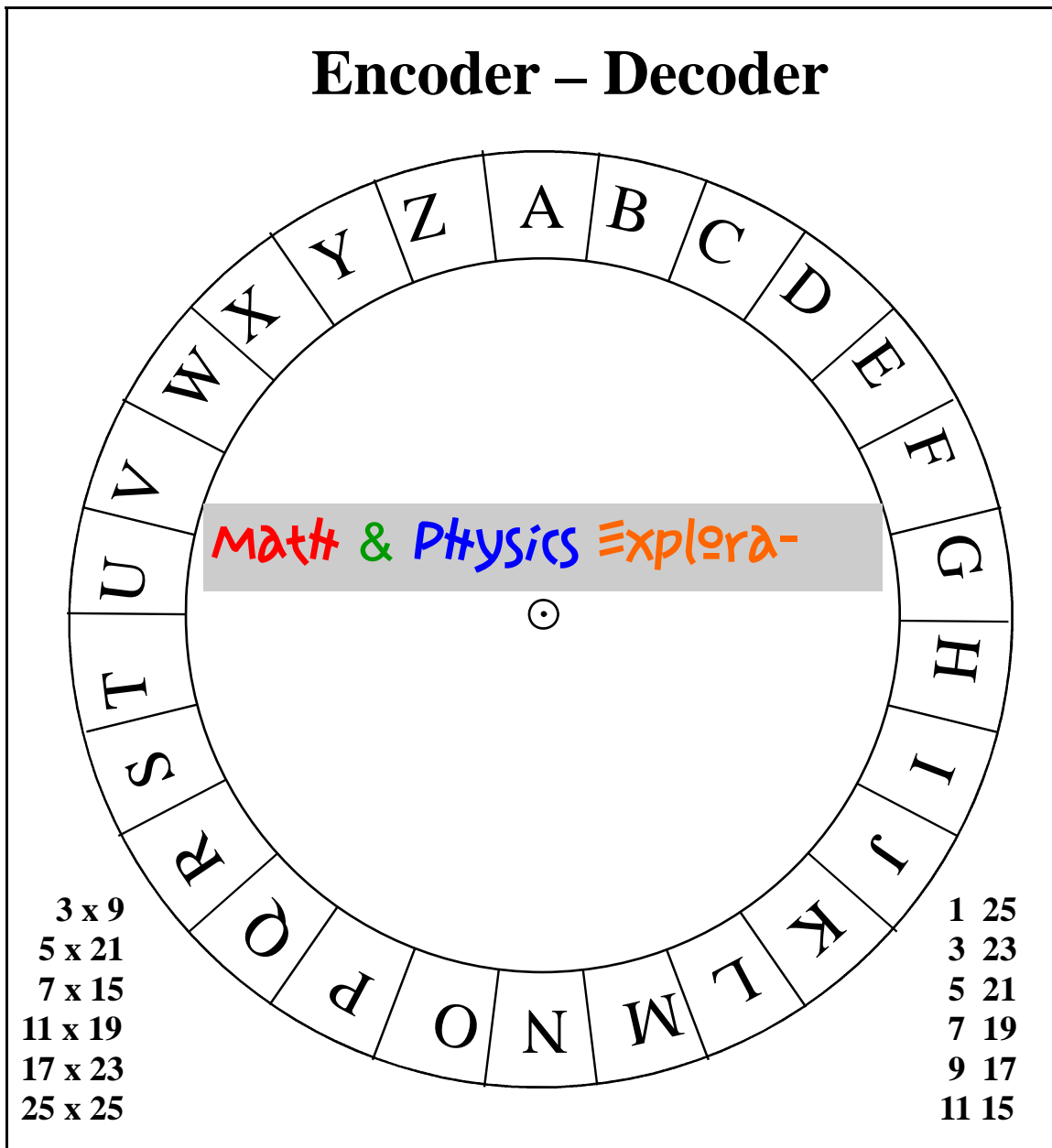
Message5:

L MLM KPO BLYR XFXKXMX X APCJORE, CRHXTJR L MLM KPO DXKO HRE OP  
BTRJJ XTBTJOX. 5X



Chelsea and Amanda would both like to thank you for translating their messages. They would like to know if you figured out their patterns of travel.

# Encoder – Decoder



For example 3x9 and 9x3 are complimentary encoders and decoders of one another. When encoding check the letter under the “A“. The decoder will put his disk so that the “A” is under the appropriate letter.

Using disk 3x9 place the “U” under the “A“. Encoding “NAME” you get “HUEG.” The decoder places the 9x3 disk so that the “A” is under the “U“. Decoding, he gets NAME.





