Name ____ Period _________

Protecting Data

Your Tasks (Mark these off as you go)

- ☐ Decrypt a message
- ☐ Decrypt a message encrypted with a random substitution cipher
- ☐ Apply the XOR algorithm to encrypt and decrypt a message
- ☐ Watch: The Internet: Encryption and Public Keys
- ☐ Define key vocabulary
- ☐ Receive credit for this lab guide

☐ Decrypt a message

You have been provided a message which has been encrypted.
In the space below, write your encrypted message.
Take 5 minutes and work with your group and try to decode the message. In the space below, write your decoded message. If you were unable to decode your message, that is ok! Just indicate “I have no idea”
Describe the process or techniques your group used to try to decode the message. What information would have been useful for the decoding process?

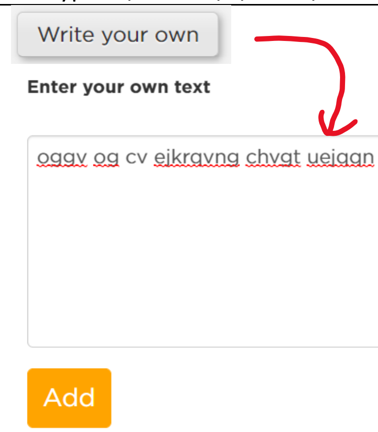
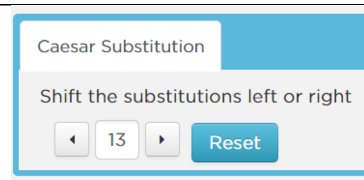
Throughout our daily lives, data is collected. Some data is more sensitive than other data and if not properly protected can be stolen and misused.

Many of the ideas we use to keep our data secret in the digital age are far older than the Internet. The process of encoding data in some secret way is called Encryption.

For example, in Roman times Julius Caesar is reported to have encrypted messages to his soldiers and generals by using a simple alphabetic shift - every character was encrypted by substituting it with a character that was some fixed number of letters away in the alphabet.

As a result, an alphabetic shift is often referred to as the Caesar Cipher. Below are some examples.

Encrypted Message	**Shift**	**Decrypted Message**
serr cvmmn va gur pnsrgrevn	13	free pizza in the cafeteria
ridiakzqxb qa lwxm	18	Javascript is dope
oggv og cv ejkrqvng chvgt uejqqn	24	meet me at chipotle after school

Now, navigate to the following link shown to the right	https://studio.code.org/s/hoc-encryption/lessons/1/levels/1
Click on the *Write your own* button, paste your encrypted message in the box, then click the *Add* button.	
Click on the left and right arrows in the Caesar Substitution tab until the message makes sense.	
What is your decoded message?	
What is the shift?	

☐ Decrypt a message encrypted with a random substitution cipher

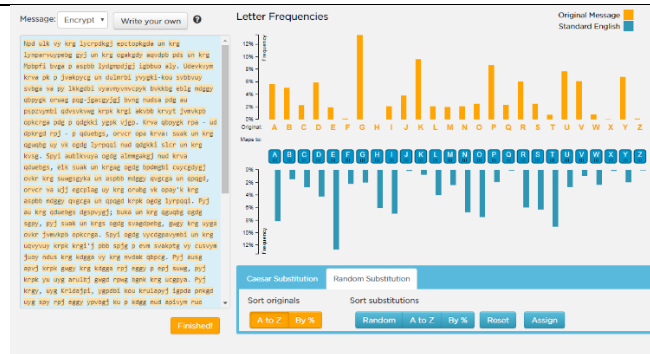
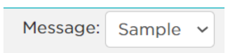
With the tool, cracking a Caesar Cipher is easy. Once you've done one, it only takes a matter of seconds to do others.

What if instead of shifting the whole alphabet, we matched every letter of the alphabet to a different random letter of the alphabet? This is called a random substitution cipher.

An example of such random mapping is shown below,

Using the mapping above results in the following encrypted/decrypted pairs,

Encrypted Message	**Decrypted Message**
rtee nqggo qk fye uorefetqo	free pizza in the cafeteria
pomosutqnf qs vbne	javascript is dope
ceef ce of uyqnbfxe orfet suybbx	meet me at chipotle after school

<table>
<tr><td>Now, navigate to the following link shown to the right</td><td>https://studio.code.org/s/frequency_analysis/lessons/1/levels/1</td></tr>
<tr><td>Experiment with the tool: click things, poke around, figure out what it's doing</td><td>
</td></tr>
<tr><td colspan="2">How does the widget work? What steps would you take to crack the code?</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Select Sample Message (easy) from the Message dropdown,


Then, crack the message using the tips we just talked about

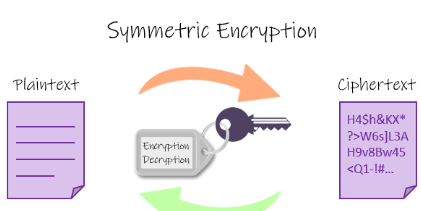
Find the short words and "crack" them first. How many one-letter words do you know? ("a"). A very common 3-letter word is "the".
Once you've done that, you have substitutes for some of the most common letters. You should be able to use intuition to look at other words with these partial substitutions and make good guesses.
After finding only a handful of hard-fought letters, the rest will tumble quickly.
Comparing the frequencies of letters gives good insight for making sensible guesses.

Copy and paste a portion of the decrypted message below.</td></tr>
<tr><td colspan="2"></td></tr>
</table>

☐ Apply the XOR algorithm to encrypt and decrypt a message

The XOR Encryption algorithm is a very effective yet easy-to-implement method of symmetric encryption. Due to its effectiveness and simplicity, XOR Encryption is an extremely common component used in more complex encryption algorithms used nowadays.

The XOR encryption algorithm is an example of *symmetric encryption* where the same key is used to both encrypt and decrypt a message.



To apply XOR Encryption requires that we first convert the text to be encrypted to binary. Recall, that each character in our alphabet has an ASCII decimal equivalent, which can, in turn, be converted to binary. Below, are the ASCII and binary equivalents of all the letters in our alphabet.

Letter	ASCII	Binary	Letter	ASCII	Binary
A	065	01000001	N	078	01001110
B	066	01000010	O	079	01001111
C	067	01000011	P	080	01010000
D	068	01000100	Q	081	01010001
E	069	01000101	R	082	01010010
F	070	01000110	S	083	01010011
G	071	01000111	T	084	01010100
H	072	01001000	U	085	01010101
I	073	01001001	V	086	01010110
J	074	01001010	W	087	01010111
K	075	01001011	X	088	01011000
L	076	01001100	Y	089	01011001
M	077	01001101	Z	090	01011010

The XOR Encryption algorithm is based on applying an XOR mask using plaintext and a key. Consider the following encrypted message which has been encrypted with the following key: 11001100

01000110010100100100010101000101001000000101000001001001010110100101101001000001

To decrypt the message, we need to do the following:

- First map each digit in the key to every digit in the message. Our key is only 8 digits long, so we need to repeat the key over and over until we reach the end of the encrypted message.
- For each bit in the encrypted message, if the bit in the key is the same, we decrypt the bit as a 1, if they are different we decrypt the bit as a 0.
- Each byte (8 bits) represents a letter. Map each by in the decrypted message to the corresponding letter

Below illustrates how to decrypt the first 24 bits of the message

Encrypted message	0	1	1	1	0	1	0	1	0	1	1	0	0	0	0	1	0	1	1	1	0	1	1	0
Key	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
Decrypted message	0	1	0	0	0	1	1	0	0	1	0	1	0	0	1	0	0	1	0	0	0	1	0	1
	F								R								E							

Consider the encrypted 5-letter word below,

00000101 00011100 00001111 00001111 00010100

Using the key below, decrypt the message.

10101010

Encrypted 5 letter word	00000101 00011100 00001111 00001111 00010100
8-digit key repeated	10101010 10101010 10101010 10101010 10101010
Decrypted binary word	
5-letter word	

Think of a five-letter word. Create an 8-bit key and encrypt your word.

5-letter word	
5-letter binary word	
8-digit key	
Encrypted message	

In the above examples of XOR encryption, we used an 8-bit key. What is a security concern associated with using an 8-bit repeatable key? How could we make our encryption more secure?

Consider the 8-bit keys we used in the previous examples, how many different values can be represented with 8 bits?

Now consider a 128-bit key which was the basis for encryption in 1999. How many values can be represented with 128 bits?

Most protocols today used 256-bit encryption. How many values can be represented with 256 bits?

☐ Watch: The Internet: Encryption and Public Keys

https://youtu.be/ZghMPWGXexs

☐ Define key vocabulary

Encryption

Decryption

Cipher

Caesar's Cipher

Symmetric Encryption

Asymmetric Encryption

☐ Receive Credit for this lab guide

Submit this portion of the lab to Pluska to receive credit for the lab guide.