# Introduction to Binary

The binary system is a way of representing data using 0s and 1s. This system is used by computers to represent all the data it works with.

1011110000011111
0010101000100101
0101010011111001
0100001001010100
0010010010101010
0011001011

Decimal System:

The number system we use in everyday life is called the decimal system, where we use the numbers 1,2,3,4,5,6,7,8,9 to represent all of our numbers. In this system, each digit is a power of 10.
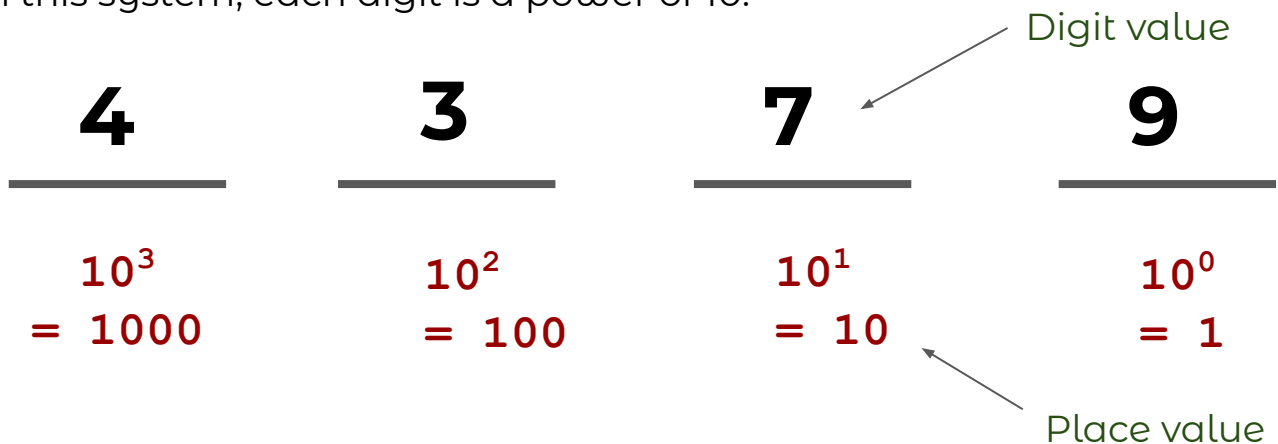
Digit value

4	**3**	**7**	**9**
10^3 = 1000	10^2 = 100	10^1 = 10	10^0 = 1

Place value

To compute a number in this system, you would multiply the digit value by the place value, then add them all together. So to represent the number 4379, you would have to compute :

(4*1000)+(3*100)+(7*10)+(9*1)=4379.

The binary system follows a similar structure, except for each digit, you only have 2 values, 0 and 1.

Digit value

0	0	0	0	1	0	0	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
= 128	= 64	= 32	= 16	= 8	= 4	= 2	= 1

Place value

To compute a number in this system, you would multiply the digit value by the place value, then add them all together. So to translate the binary number 1001, you would have to compute:

$$(1*8)+(0*4)+(0*2)+(1*1) = 9$$

To convert this number back to binary, find the largest power of 2 and subtract until your total is 0

$9 - (1 * 2^3) = 9 - 8 = 1$ so 4th digit is 1

$2^2 = 4 > 1$ so 3rd digit is 0

$2^1 = 2 > 1$ so 2nd digit is 0

$1 - (1 * 1^0) = 1 - 1 = 0$ so 1st digit is 1

So the resulting number is 1001.

Let's try a few!

Binary Practice Problems

Digit value

Clue!

If the decimal value is odd,

then the 1st digit must be a 1

2^7 = 128 2^6 = 64 2^5 = 32 2^4 = 16 2^3 = 8 2^2 = 4 2^1 = 2 2^0 = 1

Place value

Refer to this for help!

Convert the following decimal values into binary:

1) 8 _ _ _ _ _ _ _ _

2) 17 _ _ _ _ _ _ _ _

3) 11 _ _ _ _ _ _ _ _

4) 36 _ _ _ _ _ _ _ _

5) 70 _ _ _ _ _ _ _ _

6) 132 _ _ _ _ _ _ _ _

Binary Practice Problems

Digit value

Clue!

If the 1st digit is a 1, then the decimal value must be odd

2^7 = 128	2^6 = 64	2^5 = 32	2^4 = 16	2^3 = 8	2^2 = 4	2^1 = 2	2^0 = 1

Place value

Refer to this for help!

Convert the following binary values into decimal:

1) 0 0 1 0   _____

2) 1 1 1 0   _____

3) 1 0 1 1   _____

4) 0 0 1 0 0 0 0 1   _____

5) 0 0 0 1 1 0 1 0   _____

6) 1 0 1 0 1 0 1 0   _____

ANSWER KEY
Binary Practice Problems

Digit value

Clue!
If the decimal value is odd,
then the 1st digit must be a 1

2^7
= 128

2^6
= 64

2^5
= 32

2^4
= 16

2^3
= 8

2^2
= 4

2^1
= 2

2^0
= 1

Place value

Refer to this for help!

Convert the following decimal values into binary:

1) 8   0 0 0 0 1 0 0 0

2) 17   0 0 0 1 0 0 0 1

3) 11   0 0 0 0 1 0 1 1

4) 36   0 0 1 0 0 1 0 0

5) 70   0 1 0 0 0 1 1 0

6) 132   1 0 0 0 0 1 0 0

ANSWER KEY

Binary Practice Problems

Digit value

Clue!

If the 1st digit is a 1, then the decimal value must be odd

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
= 128	= 64	= 32	= 16	= 8	= 4	= 2	= 1

Place value

Refer to this for help!

Convert the following binary values into decimal:

1) 0 0 1 0   2

2) 1 1 1 0   14

3) 1 0 1 1   11

4) 0 0 1 0 0 0 0 1   33

5) 0 0 0 1 1 0 1 0   26

6) 1 0 1 0 1 0 1 0   170

Activity: Encode and Decode your own message!

Using one of the ciphers we learned about along with the template below, encode your own message. Then decode it to see if your cipher worked!
(If you did it right, your message before encoding and after decoding will be the same!)

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
– –

– –

*Remember to pick a key, go down to encode, and up to decode!

Challenge: Make your own Cipher!

Try to make a new way to encode a message. Make sure your new cipher uses a small key, so that only the people with access to the key know how to use it. Encode and then decode your message to see if your new cipher works!

(If you did it right, your message before encoding and after decoding will be the same!)

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

_ _

_ _
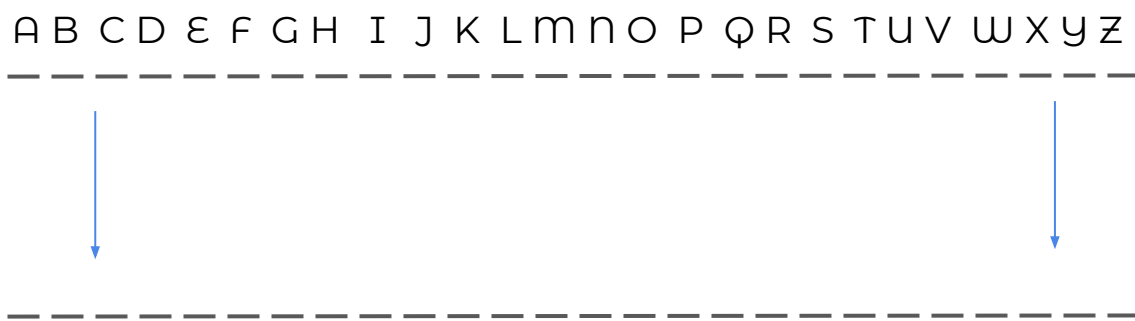
*Remember to pick a key, go down to encode, and up to decode!

Ciphers!

Ciphers are a way of writing a message in a secret way (sort of like a secret language!).

- To **encode** a message is to translate a normal message into a coded one.
- To **decode** a message is to translate a coded message back into normal language

Caesar Cipher:

Shifting the alphabet by a number of letters.

Positive number: Shift Right

Negative number: Shift Left

EXAMPLE 1: Encode, KEY = 3

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S

H E L L O ➝ K H O O R

EXAMPLE 2: Encode, KEY = -5

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K

H E L L O → C Z G G J
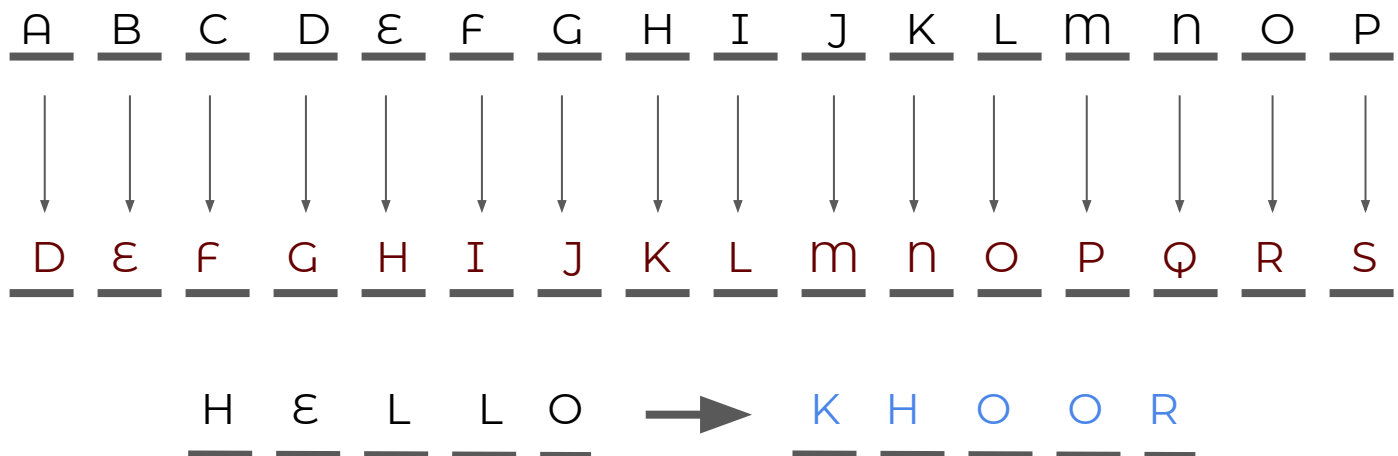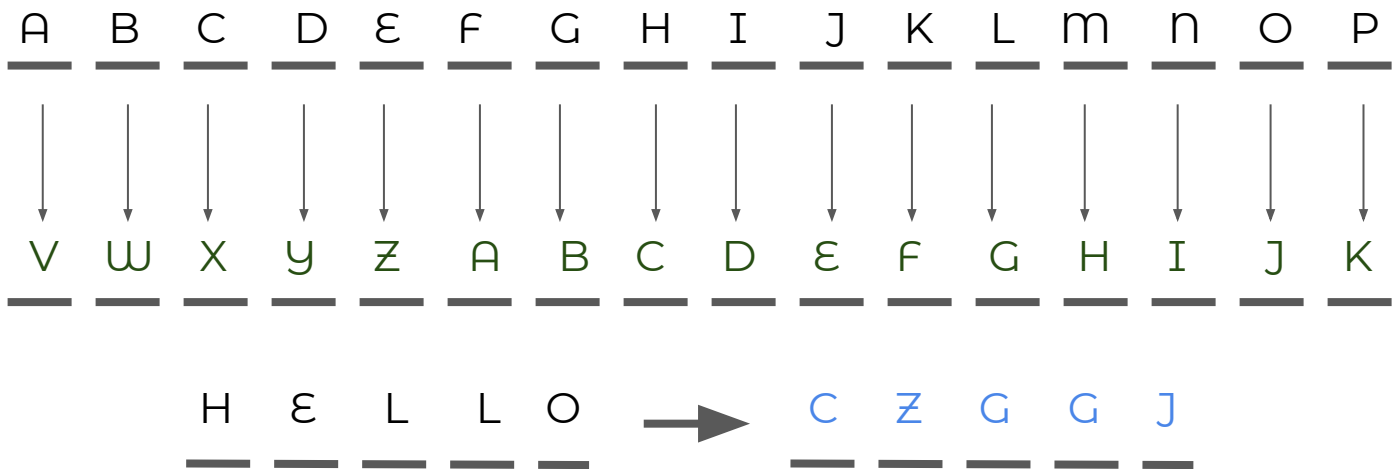
EXAMPLE 3: Decode, KEY = -5   *use chart from above

V K K G Z → A P P L E
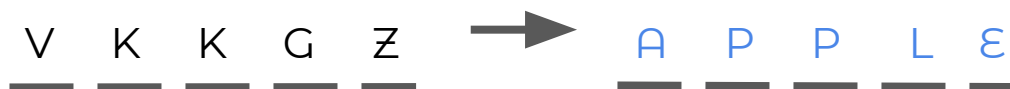
Simple Substitution Cipher:

Shifting the alphabet by setting the first few letters to a certain word, then setting the rest of the alphabet with the remaining letters after the word is removed (in alphabetical order).

EXAMPLE 4: Encode, KEY = CODE
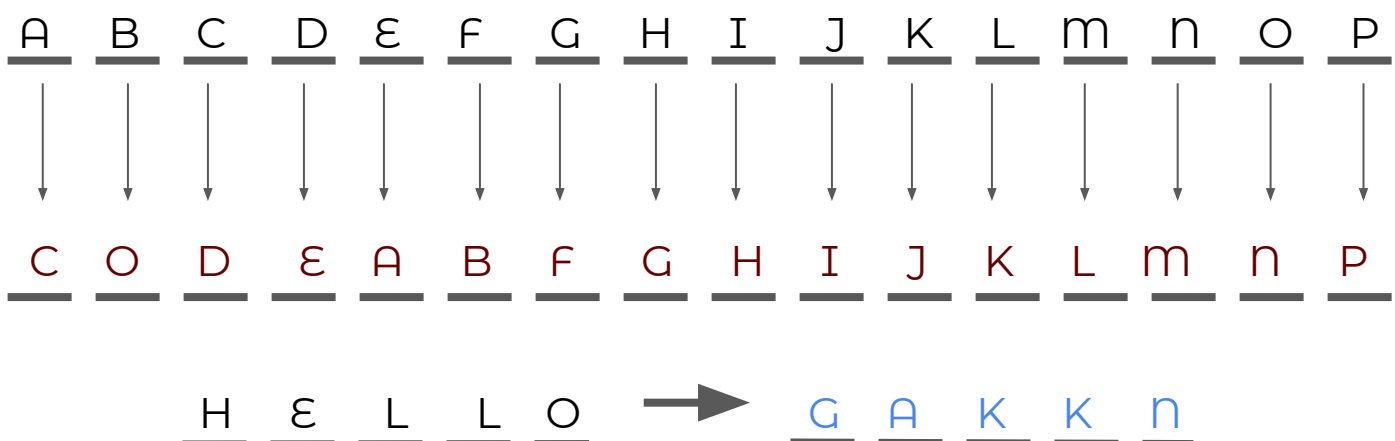
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
C	O	D	E	A	B	F	G	H	I	J	K	L	M	N	P

H E L L O → G A K K N

Ciphers Practice Problems

1) Use the Caesar Cipher to encode this message:

"CIPHERS ARE COOL!"

*Try filling out this chart with the shift before encoding the message.

KEY = 7

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
_ _

_ _

_ _ _ _ _ _ _   _ _ _   _ _ _ _ !

2) Use the same key as question 1 to decode the message:

"P AVAHSSF HNYLL!"   (using Caesar Cipher)

_   _ _ _ _ _ _ _   _ _ _ _ _ _ !

Ciphers Practice Problems

3) Use the Simple Substitution Cipher to encode this message:

"CAN YOU CRACK THE CODE?"

KEY = "SHIFT"

*Try filling out this chart with the shift before encoding the message.

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

‾ ‾

‾ ‾

‾ ‾ ‾   ‾ ‾ ‾   ‾ ‾ ‾ ‾ ‾   ‾ ‾ ‾   ‾ ‾ ‾ ‾ ?

4) Use the same key as question 1 to decode the message:

"UQT NSQQWMPFQ RM QRSY QSAT!"

‾   ‾ ‾ ‾ ‾ ‾ ‾ ‾   ‾ ‾ ‾ ‾ ‾ !

ANSWER KEY

Ciphers Practice Problems

1) Use the Caesar Cipher to encode this message:

"CIPHERS ARE COOL!"

*Try filling out this chart with the shift before encoding the message.

KEY = 7

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

H I J K L M N O P Q R S T U V W X Y Z A B C D E F G

J P W O L Y Z   H Y L   J V V S !

2) Use the same key as question 1 to decode the message:

"P AVAHSSF HNYLL!"   (using Caesar Cipher)

I   T O T A L L Y   A G R E E !

Ciphers Practice Problems

3)   Use the Simple Substitution Cipher to encode this message:

   "CAN YOU CRACK THE CODE?"

   KEY = "SHIFT"

   *Try filling out this chart with the shift before encoding the message.

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

S H I F T A B C D E G J K L M N O P Q R U V W X Y Z

I S L   Y M U   I P S I G   R C T   I M F T ?

4)   Use the same key as question 1 to decode the message:

   "UQT NSQQWMPFQ RM QRSY QSAT!"

U S E   P A S S W O R D S   T O

           S T A Y   S A F E !

The Protocol System

The protocol system is a set of steps used to send information over the internet.

Match the layer name to the descriptions below. Then number the layers from 1 to 4, with 1 being the top layer connected to the computer and 4 being the bottom layer connected to the internet.

Layers: IP, Application, Hardware, TCP

Layer Order	Layer Name	Layer Description
		Splits information into packets and numbers them.
		Routes packets over internet.
		Assigns IP addresses of start and end to packets.
		Converts user's command into a message to be sent over the internet.

ANSWER KEY

The Protocol System

The protocol system is a set of steps used to send information over the internet.

Match the layer name to the descriptions below. Then number the layers from 1 to 4, with 1 being the top layer connected to the computer and 4 being the bottom layer connected to the internet.

Layers: IP, Application, Hardware, TCP

Layer Order	Layer Name	Layer Description
2	TCP	Splits information into packets and numbers them.
4	Hardware	Routes packets over internet.
3	IP	Assigns IP addresses of start and end to packets.
1	Application	Converts user's command into a message to be sent over the internet.

Here are some links to activities and information related to the topics discussed in the module. Have fun!

- https://learningcontent.cisco.com/games/binary/index.html

- https://www.cmu.edu/iso/aware/protect-what-you-connect/malware.html

- https://howsecureismypassword.net/

- https://www.cryptoclub.org/#vIntro

- http://www.carnegiecyberacademy.com/

- https://myshadow.org/