STEAM Subject: Computer Science
Lab: Coding-Binary Code

Grades: 2nd-8th

Learning Objective:
Students will be to:
- Identify the parts of a computer and its function.
- Describe and model how the computer communicates.
- Represent information using numbers.

ENGAGE:
Ask student the following questions:
- What are the different parts of a computer? Check out
  https://www.informationq.com/about-the-basic-parts-of-a-computer-with-devices/ for
  details about each part of a computer.

- What are some of the coding languages that you have heard of? *Examples: JavaScript, Java, C++, C, Python, HTML, CSS, etc.*

EXPLORE:
Activity: Binary Code Name Bracelet
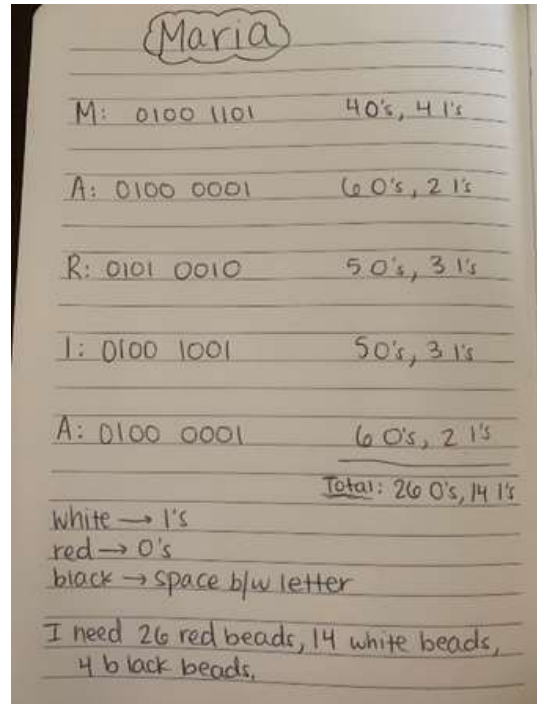
Materials needed per student:

- Piece of paper and a pencil/pen
- Three different colors of beads (Tri beads or pony beads work best). Note: number of beads will vary per student, see Steps 5-7 below.
- Some string (bracelet string, lanyard string, elastic cord, yarn, or any string that fits in the beads)

You will be writing your name in binary code! Every letter in the alphabet, number, and every symbol has an 8-number code, made of only 0's and 1's.

ASCII Code: Character to Binary

Char	Binary	Char	Binary	Char	Binary
0	0011 0000	O	0100 1111	m	0110 1101
1	0011 0001	P	0101 0000	n	0110 1110
2	0011 0010	Q	0101 0001	o	0110 1111
3	0011 0011	R	0101 0010	p	0111 0000
4	0011 0100	S	0101 0011	q	0111 0001
5	0011 0101	T	0101 0100	r	0111 0010
6	0011 0110	U	0101 0101	s	0111 0011
7	0011 0111	V	0101 0110	t	0111 0100
8	0011 1000	W	0101 0111	u	0111 0101
9	0011 1001	X	0101 1000	v	0111 0110
A	0100 0001	Y	0101 1001	w	0111 0111
B	0100 0010	Z	0101 1010	x	0111 1000
C	0100 0011	a	0110 0001	y	0111 1001
D	0100 0100	b	0110 0010	z	0111 1010
E	0100 0101	c	0110 0011	.	0010 1110
F	0100 0110	d	0110 0100	,	0010 0111
G	0100 0111	e	0110 0101	:	0011 1010
H	0100 1000	f	0110 0110	;	0011 1011
I	0100 1001	g	0110 0111	?	0011 1111
J	0100 1010	h	0110 1000	!	0010 0001
K	0100 1011	I	0110 1001	'	0010 1100
L	0100 1100	j	0110 1010	"	0010 0010
M	0100 1101	k	0110 1011	(	0010 1000
N	0100 1110	l	0110 1100	)	0010 1001
				space	0010 0000

1. Grab a piece of paper and something to write with. Write your name in big letters on the top of the page.
2. Then find the letters of your name in the ASCII Code table below. You can use either uppercase or lowercase letters. Also notice how uppercase and lowercase letters have a different 8-letter code.

3. Write the 8-letter binary code for each letter of your name on your piece of paper.

4. Count how many 0's and 1's are in your entire name. Write the number for each on the bottom of your paper. Check out EIS Coding Instructor Maria Morgan's example.
5. Assign one of your color beads to the number 0. The amount of 0's that are in your name is how many of those color beads you will need.
6. Assign another color bead to the number 1. The amount of 1's that are in your name is how many of those color beads you will need.
7. The last color bead is for the space between each letter. This is to help see the different beads for each letter. For example: if your name has 5 letters, you will need 4 of these color beads. If you name 7 letters, you will need 6 of these color beads. Don't place one of these beads before your first letter or after your last letter.

Maria

M:	0100 1101	4 0's, 4 1's
A:	0100 0001	6 0's, 2 1's
R:	0101 0010	5 0's, 3 1's
I:	0100 1001	5 0's, 3 1's
A:	0100 0001	6 0's, 2 1's

Total: 26 0's, 14 1's

white → 1's
red → 0's
black → space b/w letter

I need 26 red beads, 14 white beads, 4 black beads.

8. Once you have collected all the beads, grab your piece of string and get ready to make your bracelet!
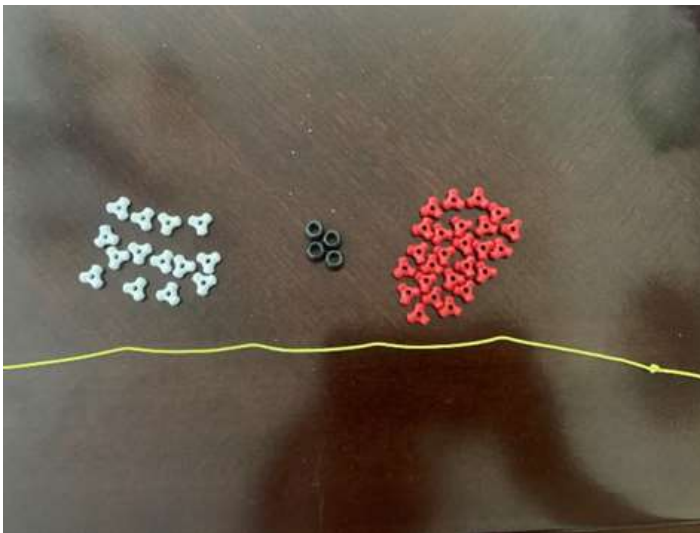
9. Before you start placing beads on your string, make a knot on one side of your string so your beads don't fall out.
10. Start with the first letter of your name and put your beads on the string. Don't forget to place the space bead in between each letter.
    a. Note: each letter should have 8 beads.

11. Once you have finished putting all your beads on the string, tie a knot on the other side of the string (where you just placed your last bead).
12. You are now ready to tie the two ends together to make your bracelet!
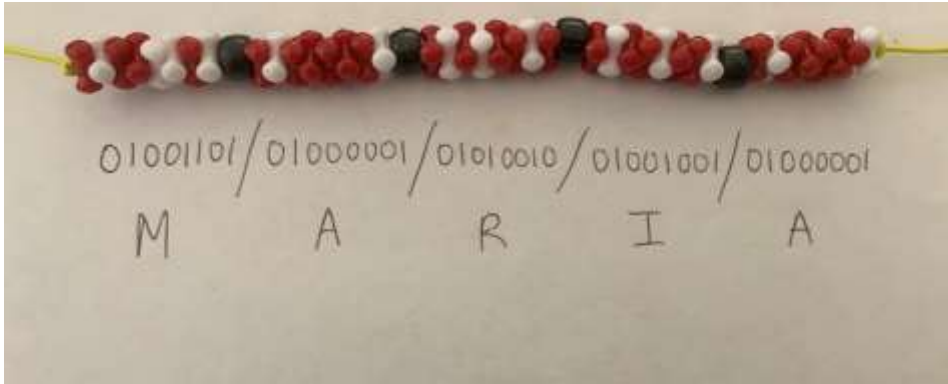
Make sure to send a picture of your finished bracelet to EIS!!

Optional Activity 1: Writing in Binary Code
Write a quick note to a friend or family member in binary code. Give them the key and see if they can translate it!

Optional Activity 2: Book Challenge
Find a book at home and choose a page to translate to binary code. See how far you can go through the page. Your paper will have a lot of zeros and ones!
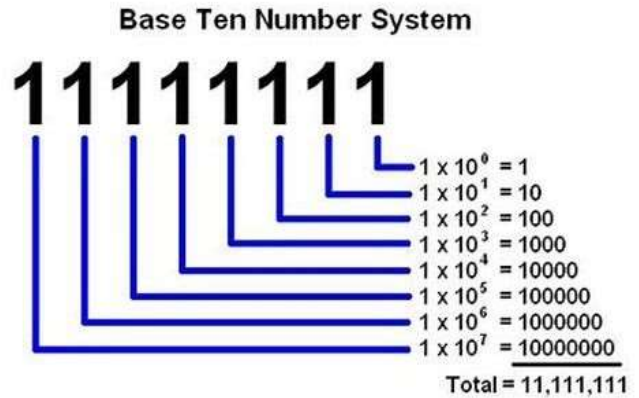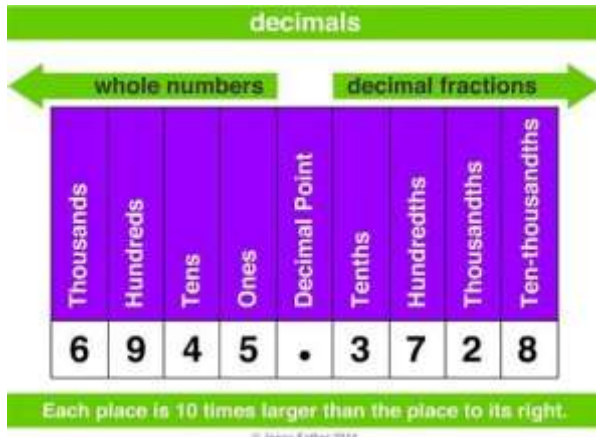
EXPLAIN:
Watch a video from Khan Academy and Code.org | Binary & Data explaining the workings of a computer and binary code: https://www.youtube.com/watch?v=ewokFOSxabs
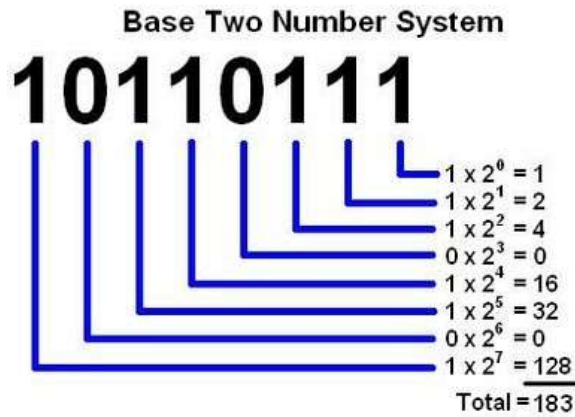
Basics of Binary Code
Binary code is how the computer communicates and stores information only using 0's and 1's. This is because a computer is made up of many electrical circuits. As you learned in the video, a 1 means turn on and a 0 means turn off. These 1's and 0's turn on and turn off switches in the circuits in the computer.

Number Systems
There are two different number systems that are used: the base-2 system and the base-10 system. The base-10 system is the standard system for writing integer and non-integer numbers. Examples of base-10 numbers are 15, 280, 5700, 34, 67304, and more.

decimals

whole numbers | decimal fractions

Thousands	Hundreds	Tens	Ones	Decimal Point	Tenths	Hundredths	Thousandths	Ten-thousandths
6	9	4	5	.	3	7	2	8

Each place is 10 times larger than the place to its right.

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Base Ten Number System

11111111

$1 \times 10^0 = 1$
$1 \times 10^1 = 10$
$1 \times 10^2 = 100$
$1 \times 10^3 = 1000$
$1 \times 10^4 = 10000$
$1 \times 10^5 = 100000$
$1 \times 10^6 = 1000000$
$1 \times 10^7 = \underline{10000000}$

Total = 11,111,111

The base-2 system is used for numbers that are only expressed with two symbols. They are called binary numbers because binary means something having two parts. Examples of base-2 numbers are 10011, 110110, 1011, 10010, and more.

Base Two Number System

10110111

$1 \times 2^0 = 1$
$1 \times 2^1 = 2$
$1 \times 2^2 = 4$
$0 \times 2^3 = 0$
$1 \times 2^4 = 16$
$1 \times 2^5 = 32$
$0 \times 2^6 = 0$
$1 \times 2^7 = \underline{128}$

Total = 183

Binary Base = 2

	Column 8	Column 7	Column 6	Column 5	Column 4	Column 3	Column 2	Column 1
Base	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Weight	128	64	32	16	8	4	2	1

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

There is a way to convert a base-2 system number to a base-10 system number. This is called a binary to decimal conversion. Here is an example of how to do it.

$$128 \quad 64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1$$
$$1 \quad 0 \quad 0 \quad 1 \quad 1 \quad 0 \quad 1 \quad 1$$
$$128 + 0 + 0 + 16 + 8 + 0 + 2 + 1$$
$$= 155$$

Here are some examples that you can try yourself! Convert the binary number into a decimal number.

1. 1001
2. 10110
3. 101010

Answers:

1. $2^3 + 0 + 0 + 2^0 = 8 + 1 = 9$
2. $2^4 + 0 + 2^2 + 2^1 + 0 = 16 + 4 + 2 = 22$
3. $2^5 + 0 + 2^3 + 0 + 2^1 + 0 = 32 + 8 + 2 = 42$

EVALUATE:

How the computer reads and stores any instructions or data that are entered?

The next step is to learn how to code so you can communicate with the computer.

Check out https://code.org/ to learn how to code!

If you have an account, you can also work in your coding skills with the Building Something Different (BSD) website: https://bsd.education/

Follow EIS on Facebook and Instagram and share a picture of you and your binary bracelet! Be sure to tag us @eissandiego!