

# Binary Coding

## Preparation

<b>Grade Level: K–5</b>	<b>Group Size: 20–30</b>
<b>Time: 50 Minutes</b>	<b>Presenters: 1–3</b>

This lesson can be adapted to the grade level by the presenter. Decide the level of content and activities as appropriate.

## Objectives

Students will be able to:

- Identify different uses and forms of coding information
- Use binary code to encode and decode written language

## Standards

This lesson aligns with the following National Science Content Standards:



- Unifying Concepts and Processes in Science, K–12
- Science and Technology, K–4

## Materials

- Jelly beans, red and white (20 each per student) (grades K–2) **OR**
- Two-color bean counters (40 per student)
- Samples of different “memory” devices (grades 3–5), e.g.:
  - Floppy disk
  - CD-ROM
  - DVD
  - Cassette tape
  - Flash Drive
  - Videocassette
  - MP3 Player
- Pictures of: Bicycle, Biplane, Binoculars
- Twenty cards large enough to be seen from the front of the class with **1** and **0** written on opposite sides
- Ten clear plastic bottles (20-oz soda), five of them filled with red water, five empty
- Memory chips
- “Simplified Binary Code” handout (Appendix A)
- “Write Your Name” activity sheet – jelly bean version grades K–2 (Appendix B)
- “Write Your Name” activity sheet – regular version grades 3–5 (Appendix C)
- “Send Secret Messages” activity sheet (Appendix D)
- “Counting in Binary” handout (for Middle Elementary) (Appendix E – 2 pages)

## Preparation

*Prepare copies of handouts and activity sheets for distribution to each student. For early elementary, prepare jelly beans for distribution: re-sealable plastic bags with 20 of each color, or 40 two-color plastic beans. Fill five of the plastic bottles with red water.*

## Introduction

*Introduce yourself. Pass out memory chips to the students. Tell the students that the items you have just passed out are what Micron Technology makes.*



Q: Does anyone know what I just passed out is called?

A: Answers will vary. Correct answer – Memory Devices, Semiconductors

Q: What are some everyday things memory devices are used in?

A: Answers will vary. *Write their answers on the board.*

They may include:

Cell phones	Cars	Greeting cards	Game Boy
Coffee makers	CD players	VCRs	Xbox
Fax machines	Toys	Cameras	MP3 Player
Clock radios	Printer	Refrigerators	DVD player
Microwave ovens	Airplanes	Stoves	Computer

Q: How do memory devices store the information we put into the computer?

A: Millions of microscopic storage spaces called capacitors. For example if one of these memory chips is a “512 Megabit chip”, that means it has 512 Million separate storage spaces on it. That’s enough memory to hold 40 *Harry Potter* books.

Each storage space on the memory device is called a capacitor. Each capacitor has a switch called a transistor, which is like a light switch that turns it “on” or “off”. That simple selection, whether the switch is “on” or “off,” is the basis for all the numbers, letters, colors, and pictures you see on a computer or phone screen. So for memory devices we call the switch that controls the electricity flowing through a circuit a “transistor.” The object that holds the electricity is a “capacitor.”

Computers talk in a language called “binary”. Let’s understand where that word comes from. Remember that the information a computer deals with is only in two states, “on” or “off”.

Q: How many fingers, or digits, do each of us have?

A: Ten. So we count in the decimal system, because “dec” means “ten”.

*Show the pictures of the bicycle, biplane, and binoculars or write the words on the board. Point out that each of these has two of something.*

Q: What is similar about each of these words?

A: They each begin with “bi”

Bicycle = 2 wheels.

Biplane = 2 wings

Binoculars = 2 eyepieces

Q: Then what does the word “bi” mean?

A: “Two”

So:

Binary = 2 numbers.

The Binary Code assigns a “1” or a “0” to each state that a switch on a memory chip happens to be in.

Q: Do you think a “1” means “on” or “off”?

A: ON

If the switch is “ON,” it is assigned a “1.” If it is “OFF,” it is assigned a “0.”

Interesting note: Ask the students if they can remember, or even draw, the symbol that is on the on/off switch on a remote control, a phone, or other electronic device. Point out that the symbol, shown here, is a “1” superimposed on a “0”, the universal symbol for “on/off”.



*Ask students if they have heard of how many bits or bytes an electronic device may have. Answers will vary, but some may have prior knowledge.*

The word “bit” comes from “binary digit”, because in the system of digital electronics, only two digits are used. Each “1” or “0” is called a “bit.”

Every letter, every number, every color, everything you type on your keyboard is translated into a code consisting of a series of “1”s and “0”s by your computer. Each series of eight bits is called a “byte.”

*(Now ask them again about their knowledge about bytes – e.g. the capacity of an mp3 player – they will likely be able to relate to it now.)*

*Ask students if they have ever worked with secret codes.*

The code used with computers that translates letters, numbers and symbols to binary is called “ASCII” (pronounced “ask-ee”). For simplicity we’ll look at a code of only five bits.

*Illustrate the following on the board:*

If you type an “a” on your keyboard, the computer assigns it the series 00001. A “b” is 00010. A “j” is 01010 and so on through the whole alphabet.

*Pass out the “Simplified Binary” handout (Appendix A).*

Q: What does “0” mean in each of these letters?

A: Off

Q: What does “1” mean?

A: On

Likewise, numbers, punctuation, colors, pictures, everything that appears on your screen is merely a series of “0”s and “1”s.

That’s the Binary Code. And it’s the secret language of computers!

## Binary Code Water Bottle Example

*Use the plastic bottles to illustrate the binary code. Ask the students which bottle would represent “on” (full) and “off” (empty). Have the students select a letter. Have them tell you the five digit binary code for the letter, write it on the board. Then have them help set up the bottles in the proper order for the given letter. This illustrates the concept with a concrete example. You can also use the 1/0 cards in front of the bottles to further reinforce the concept.*



ASCII representation of the letter “M”

## Counting in Binary

(Middle Elementary students)

Today we are talking about the Binary Code, the language of computers. A short introduction into kinds of numbering systems is helpful. The number system we use most of the time is called the decimal system. We count by tens, but you could also count by "twenties" or "nines" or "threes." *Ask students to demonstrate.* Computers count by "twos," which is called a "binary system." A computer uses only "0" and "1" to do all the things a computer can do.

For the computer to do this, it changes what we give it—text, numbers, sounds, colors, and pictures—into *binary code* and then turns the code back into text, pictures or anything else that humans understand.

For example, we represent the number "forty-three" like this: **43**. The computer represents the number "forty-three" like this: **00101011**. *Write the numbers on the blackboard.*

The number 43 means it has 4 tens and 3 ones, using our base 10 system. In the binary, or base 2 system, we can figure out how "00101011" is equivalent to 43.

*Hand out the sheet "Counting in Binary" (Appendix E).*

*On the board write the following for your examples:*

Decimal	Binary
$10^2$ $10^1$ $10^0$	$2^5$ $2^4$ $2^3$ $2^2$ $2^1$ $2^0$
<u>100</u> <u>10</u> <u>1</u>	<u>32</u> <u>16</u> <u>8</u> <u>4</u> <u>2</u> <u>1</u>

*Write a number on the decimal side, pointing out the digit designations. Then figure out the same number in Binary, placing 1's or 0's where appropriate. Have the students complete their "Counting in Binary" activity sheet.*

## Jelly Bean Binary Activity

(Early Elementary, but fun for any age)

*Hand out "Write Your Name with Jelly Beans" activity sheet (Appendix B).*

Write the letters of your name down the spaces under the "Letter" column. Referring to the code in the box on the left, write the binary code for each letter of your name in the spaces to the right of each letter.

*As the students are completing the coding, pass out the bags of jelly beans.*

Put red jelly beans on the "1"s and white jelly beans on the "0"s.

*Student will enjoy looking at the patterns that their names made, and then can enjoy a few jelly beans!*

## Writing in Binary Activity

(Middle Elementary)

*Hand out "Write Your Name" activity sheet (Appendix C).*

Write the letters of your names down the spaces in the middle column. Referring to the code on the left, write the binary code for each letter of your name in the spaces of the far right column.

*(Optional) Hand out the "Secret Message" activity sheet (Appendix D) and make sure students have the simplified binary "decoder."*

Think of answers to the questions on the sheet. Write your answers in our secret code—binary. *Give them about five minutes to write their answers. Have the students exchange their "Secret Message" activity sheets and decode the answers.*

It took us a long time to encode and decode the binary code compared to a computer. In fact, some of you may not have finished all the questions. What took you several minutes to do, the computer can encode faster than you can blink your eye. It could do all of our work sheets together at once that fast!

Did you make a mistake or translate wrong? Was it a little boring after awhile? Computers never get bored. They can do the same thing over and over and over and over and never make mistakes.

## The Bits and Bytes Game

(all ages – with variations as age-appropriate)

So how can computers, using only 0s and 1s, do all of the things they do? Computers string the 1s and 0s, called bits, into units of eight, called bytes. For this lesson, we will use 5-digit simplified bytes, as the entire upper-case alphabet can be shortened to 5 binary digits, or bits.

*Distribute the “Simplified Binary Code” handout (Appendix A). Call five students to the front of the class. Give each student a card with 0 on one side, 1 on the other side. Each of these students represents a bit. When lined in a row, the five students together represent a (modified) byte. This activity has a number of variations:*

- 1. Assign a letter to the group of five students. Have them arrange their cards in the proper binary sequence and show it to the class. Have the class determine the letter. Call up students five at a time to do this activity.*
- 2. Invite 10 or 15 students to the front of the class and have them spell out a two or three letter word. Have the rest of the class determine the word.*



*Come up with other variations as deemed appropriate. There are many ways to play the “Bits & Bytes” game!*

## Conclusion

Now you know the language of computers. You can now teach your brothers or sisters or one of your parents the secret code.

Q: What is the language of computers called?

A: Binary Code.

Q: What are the two digits used in binary code?

A: 0 and 1.

Q: What does the “0” mean?

A: The bit is turned OFF.

Q: What does the “1” mean?

A: The bit is turned ON.

*If you haven't already done so, pass around the memory chips and discuss how many bits each one holds. For older students, have the class figure out how many eight-bit bytes are in a 256 Megabit DRAM, defining Mega as million. How many in a 512Meg DRAM?*

## Simplified Binary Code

●	↔	00000	●	↔	01110
<b>A</b>	↔	00001	●	↔	01111
<b>B</b>	↔	00010	●	↔	10000
<b>C</b>	↔	00011	●	↔	10001
<b>D</b>	↔	00100	●	↔	10010
<b>E</b>	↔	00101	●	↔	10011
<b>F</b>	↔	00110	●	↔	10100
<b>G</b>	↔	00111	●	↔	10101
<b>H</b>	↔	01000	●	↔	10110
<b>I</b>	↔	01001	●	↔	10111
<b>J</b>	↔	01010	●	↔	11000
<b>K</b>	↔	01011	●	↔	11001
<b>L</b>	↔	01100	●	↔	11010
<b>M</b>	↔	01101			

## Write Your Name in Binary Code with Jelly Beans

Write each letter of your first name—going down rather than across. Then look up the binary code for each letter and write it with jelly beans or bean counters on the lines across from the letter. White jelly beans are 0 and red jelly beans equal 1. You will have written the language of computers.

<b>(space)</b>	→	00000
<b>A</b>	→	00001
<b>B</b>	→	00010
<b>C</b>	→	00011
<b>D</b>	→	00100
<b>E</b>	→	00101
<b>F</b>	→	00110
<b>G</b>	→	00111
<b>H</b>	→	01000
<b>I</b>	→	01001
<b>J</b>	→	01010
<b>K</b>	→	01011
<b>L</b>	→	01100
<b>M</b>	→	01101
<b>N</b>	→	01110
<b>O</b>	→	01111
<b>P</b>	→	10000
<b>Q</b>	→	10001
<b>R</b>	→	10010
<b>S</b>	→	10011
<b>T</b>	→	10100
<b>U</b>	→	10101
<b>V</b>	→	10110
<b>W</b>	→	10111
<b>X</b>	→	11000
<b>Y</b>	→	11001
<b>Z</b>	→	11010

Letter		→	Binary code				
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____
_____		→	_____	_____	_____	_____	_____

## Write Your Name in Binary Code

Write each letter of your name going down under the "Letter" column. Then look up the binary code for each letter and write it on the lines across from the letter. Don't forget the space between your first and last names. You will have written the language of computers!

A	→	00001	Letter	→	Binary code
B	→	00010	-----	→	-----
C	→	00011	-----	→	-----
D	→	00100	-----	→	-----
E	→	00101	-----	→	-----
F	→	00110	-----	→	-----
G	→	00111	-----	→	-----
H	→	01000	-----	→	-----
I	→	01001	-----	→	-----
J	→	01010	-----	→	-----
K	→	01011	-----	→	-----
L	→	01100	-----	→	-----
M	→	01101	-----	→	-----
N	→	01110	-----	→	-----
O	→	01111	-----	→	-----
P	→	10000	-----	→	-----
Q	→	10001	-----	→	-----
R	→	10010	-----	→	-----
S	→	10011	-----	→	-----
T	→	10100	-----	→	-----
U	→	10101	-----	→	-----
V	→	10110	-----	→	-----
W	→	10111	-----	→	-----
X	→	11000	-----	→	-----
Y	→	11001	-----	→	-----
Z	→	11010	-----	→	-----
Space	→	00000			

## Send Secret Messages

On a separate piece of paper, write down your secret answers to the following questions (shhhh, it's a secret). Using the binary code system on the “Binary Code” page, change your answers from the alphabet to binary code. Write your code in the spaces provided.

1. If I were an animal, I would be a(n)

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2. My favorite sport is

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3. My favorite cartoon character is

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## Counting in Binary

Complete the table to count in binary.

$2^3$	$2^2$	$2^1$	$2^0$	Decimal Count	Decimal Value
8	4	2	1		
0	0	0	0	0+0+0+0	0
0	0	0	1	0+0+0+1	1
0	0	1	0	0+0+2+0	2
0	0	1	1	0+0+2+1	3
0	1	0	0	0+4+0+0	4
0	1	0	1	0+4+0+1	
0	1	1	0	0+4+2+0	
0	1	1	1	0+4+2+1	
1	0	0	0	8+0+0+0	
1	0	0	1	8+0+0+1	
1	0	1	0	8+0+2+0	
1	0	1	1	8+0+2+1	
1	1	0	0	8+4+0+0	
1	1	0	1	8+4+0+1	
1	1	1	0	8+4+2+0	
1	1	1	1	8+4+2+1	

## Counting in Binary

Completed table

$2^3$	$2^2$	$2^1$	$2^0$	Decimal	Decimal
8	4	2	1	Count	Value
0	0	0	0	0+0+0+0	0
0	0	0	1	0+0+0+1	1
0	0	1	0	0+0+2+0	2
0	0	1	1	0+0+2+1	3
0	1	0	0	0+4+0+0	4
0	1	0	1	0+4+0+1	5
0	1	1	0	0+4+2+0	6
0	1	1	1	0+4+2+1	7
1	0	0	0	8+0+0+0	8
1	0	0	1	8+0+0+1	9
1	0	1	0	8+0+2+0	10
1	0	1	1	8+0+2+1	11
1	1	0	0	8+4+0+0	12
1	1	0	1	8+4+0+1	13
1	1	1	0	8+4+2+0	14
1	1	1	1	8+4+2+1	15