

# Activity One: Communication

## Educator Notes

### Learning Objectives

Students will

- Analyze and interpret patterns when converting an 8-bit RGB (red, green, and blue) color code to hexadecimal notation.
- Encode and decode a variety of data into and from binary or hexadecimal notation.
- Replicate binary notation using objects or symbols to encode a message.

### Challenge Overview

In this activity, students will simulate how astronauts, satellites, rovers, and other spacecraft are able to send data digitally to Earth from deep space. Students will learn to convert between binary, decimal, and hexadecimal notation to decode images, create encoded messages, and create a cipher. Finally, students will design a unique project using one of the skills they have learned during this activity.

### Suggested Pacing

120 to 150 minutes

### National STEM Standards

Computer Science (CSTA)
<p><i>Standards for Students</i></p> <ul style="list-style-type: none"> <li>• 2-DA-07: Represent data using multiple encoding schemes.</li> </ul>
Science and Engineering (NGSS)
<p><i>Engineering Practices</i></p> <ul style="list-style-type: none"> <li>• Developing and Using Models: Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed.</li> </ul>
Mathematics (CCSS)
<p><i>Mathematical Practices</i></p> <ul style="list-style-type: none"> <li>• CCSS.MATH.CONTENT.6.EE.B.6: Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or depending on the purpose at hand, any number in a specified set.</li> </ul>

### Challenge Preparation

- Read the introduction and background information to become familiar with the challenge. The Deep Space Network information will be of particular interest for this activity.
- Read the Educator Notes and Student Handout to become familiar with the activities.
- Read the sheet “Decimal, Hexadecimal, and Binary Number Systems Overview” (located at the end of the Educator Notes) to review how to express integers in bases other than 10 (decimal), specifically binary (base 2) and hexadecimal (base 16). This sheet also includes an overview on converting 8-bit RGB color codes to hexadecimal and binary notation.
  - At the discretion of the educator, students can use a calculator or internet-based converter to change numbers between the different bases (e.g., from decimal to binary, or from hexadecimal to decimal). In the **Elaborate** section, there are two optional advanced activities for students to learn to do the conversions by hand. Read the “Hexadecimal Conversions” and “Binary Conversions” activity sheets to learn more about converting 8-bit RGB color codes to hexadecimal and binary notation to determine if these advanced activities are appropriate for your students.
- Determine which of the 10 student activities listed in the **Elaborate** section will be available as choices for students. Decide how many activities each student must complete.

Download and review the student activity documents in the downloadable zipped file. <https://www.nasa.gov/sites/default/files/atoms/files/deepspacecommunications.zip>

- Make copies of the activities, if necessary, or ensure that computers and programs will be available.
- If putting students in groups, have the groups prearranged.
- Have a variety of miscellaneous craft materials available for the final project, or allow time for students to bring in materials found around the house.

## Materials

- Computer with internet access
- “Hello” name tags
- Pencils
- Student Handouts
- Printouts (Make copies for students as needed)
  - Decimal, Hexadecimal, and Binary Number Systems Overview
  - American Standard Code for Information Exchange (ASCII)
- Miscellaneous items for final project (e.g., safety pins and two different-color beads, two types of noodles, etc.—let students be creative)
- Calculators (optional)
- Coloring utensils (optional)
- Downloadable zipped file of documents for student activities  
<https://www.nasa.gov/sites/default/files/atoms/files/deepspacecommunications.zip>

## Safety

- Students should be aware of their surroundings and carefully move throughout the room when viewing other teams’ work.
- Before using sharp instruments, discuss safety issues surrounding proper use.

## Introduce the Challenge

- Introduce the activity by playing 15 seconds of fax machine “handshake” sounds. (Search the internet for “fax machine noise.”)
- Ask students if they can identify the noise.
  - Answer: That is the sound of two fax machines communicating to confirm they are ready to share information. The sending fax machine then scans the document and turns the image into binary numbers that are transmitted over the telephone line using sound. The receiving fax machine converts the sound back into binary numbers and translates them into an image.

## Engage

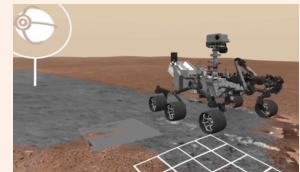
- Post the word “communication” where students can view it. Hand out a blank sheet of paper and have students express the concept of communication in one or more of the following ways:
  - Draw a picture of what communication looks like to them.
  - Draw a concept map of communication.
  - Write a list of related words.
  - Come up with their own definition of communication.
- Share the student papers.
- Come to a consensus on the meaning of “communication.” Explain that communication comes in many forms. There are times that the transmitter (the one sending the message) does not always speak the same language as the receiver (the one receiving the message).

## Share With Students



### Brain Booster

When NASA scientists want to follow the path of the Curiosity rover on Mars, they use special technology to virtually explore the Martian landscape. A free immersive experience called Access Mars lets anyone with an internet connection take a guided tour of the Red Planet! Access Mars offers a visceral impression of what it would be like to walk alongside Curiosity, wandering through the lonely red desert.



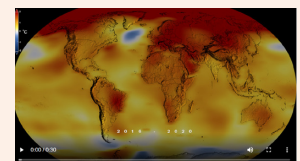
Learn more:

<https://www.nasa.gov/feature/jpl/take-a-walk-on-mars-in-your-own-living-room>



### On Location

The Scientific Visualization Studio (SVS) works closely with NASA scientists in the creation of thousands of visualizations, animations, and images to promote a greater understanding of Earth and space science research activities. Visualizations and multimedia products are accessible to everyone and free to download!



Learn more:

<https://svs.gsfc.nasa.gov/>

## Deep Space Communications

### Facilitate the Challenge

#### Explore

- Instruct students to fill out the “Hello” name tag to communicate who they are—without using the letters of the alphabet to spell out their names. Options might include using emoji, sign language, pictures or numbers that look like a letter, and so forth.
- Collect the name tags and pass them back out at random. Have the receiving students try to decode or interpret the name that is supposed to be on the name tag.
- Ask students the following questions:
  - What strategies did you use to decode the name you were given?
  - How did you decide on the type of communication you used to write your name?
  - What happens if two people do not speak the same language but want to communicate? What could they do?
    - Answer: They must have an interpreter or some other way to translate the language to allow the other person to understand it.



#### Explain

- Explain to students that communication is not limited to communication between people. Communication can take place between machines and between people and machines—even though people do not speak the same language as machines or computers.
- Have students examine some of the data that satellites in deep space have sent back to Earth. These brief video clips show amazing pictures sent to Earth from deep space satellites:
  - Deep Space Network: A Discussion on NASA's Vital Lifeline to Spacecraft. (Watch from time stamp 1:49 to 2:10.) <https://youtu.be/NGgzq8eXZQQ?t=108>
  - NASA | Magnificent Eruption in Full HD. (Watch from time stamp 0:15 to 0:55.) <https://youtu.be/GmGi-q6iWc?t=15>
- In small groups, have students create a foldable or graphic organizer of the three types of encoded data—binary, RGB, and hexadecimal—from the following references:
  - How Does a Spacecraft Take a Picture? (Total time of video is 3:02.) <https://solarsystem.nasa.gov/resources/10757/how-does-a-spacecraft-take-a-picture/>
  - How Do We Talk to Machines? <https://spaceplace.nasa.gov/binary-code2/en/>
  - Why Is Sixteen so Sweet? <https://spaceplace.nasa.gov/binary-code3/en/>
- Once the graphic organizers are completed and students have shared, it is time to have fun with the numbers. Locate a converter on the internet by searching “convert decimal to binary.” There may be a converter that converts a decimal number to binary and hexadecimal formats simultaneously. It is recommended that the instructor chooses a converter and shares the link with students, so everyone is using the same converter.
- Have students use the following table to practice using the converter. If given a binary or hexadecimal number, convert it back to decimal. For the blank rows in the Decimal column, students will add their own numbers to convert.


Decimal	Binary	Hexadecimal
99	01100011	63
14		
107		
156		
250		
		F
	00010011	

- After students have completed the task, ask if they can recall how a satellite captures an image and uses the RGB value to transmit a picture back to Earth.
  - Answer: As light passes through the satellite’s camera filter to a computer chip, the color and brightness are recorded using RGB (red, green, and blue) color codes for every pixel of data. Those color codes are converted to binary numbers and transmitted to a computer on Earth. The computer converts the binary numbers back into RGB color codes and reassembles the picture pixel by pixel.

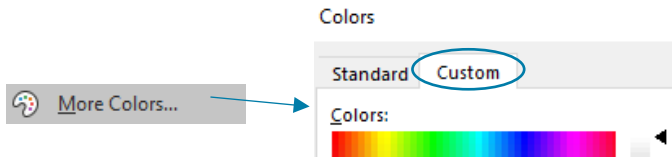
**Practice With RGB Color Codes**

Students should have individual devices (computers or tablets), or the instructor can do this as a demonstration.

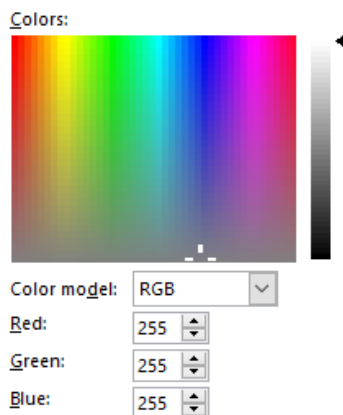
- On a blank document, insert a 2 × 2 table.


- Click inside a cell to fill or shade. 

- Navigate to where the color schemes and RGB numbers are shown (fill or shading>more colors>custom).



- In the custom colors window, click on different colors to observe how the RGB values change according to the colors.



Have students write down RGB color codes for various colors and brightness. Have them write the RGB color codes on the right as the color gets darker. If they are doing this on a device (computer or tablet), they can also fill in the colors in the cells on the left. If students do not have the chart available on a device or in the Student Handout, have them write it on a sheet of paper.

## Deep Space Communications

Color	RGB
Light red ↓	
Red	
Dark red	

Color	RGB
Light blue ↓	
Blue	
Dark blue	

Color	RGB
Light green ↓	
Green	
Dark green	

- Let students explain what is happening to the RGB color code as each color gets darker.

### Convert the RGB Color Code to Hexadecimal and Binary Notation

Students will practice converting RGB color codes to hexadecimal and binary notation. Students can use a calculator or internet-based converter or learn to convert by hand. (In the **Elaborate** section, there are two optional advanced activities for students to learn to do the conversions by hand. Refer to the “Hexadecimal Conversions” and “Binary Conversions” activity sheets to determine if these advanced activities are appropriate for your students.)

- Students will find the RGB triplet for the given colors, then convert the decimal RGB color code to hexadecimal and binary notation. For the blanks in the Color column, students will choose their own color and fill in the chart accordingly.

Color	8-Bit RGB Triplet		
	Decimal Color Code	Hexadecimal Color Code	Binary Color Code
White	255, 255, 255	#FFFFFF	111111111111111111111111 FF
Bright yellow	247, 252, 32	#F7FC20	111101111111110000100000 F7 FC 20
Black			
Light blue			
Dark blue			

### Elaborate

- Divide students into teams.
- Present the pool of activities students may choose from and explain how many activities they will need to complete.
- If activities will be set up in stations, be sure students are aware of the location of each assignment.

### Activities

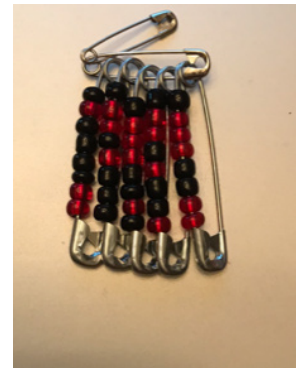
Follow the link to access the downloadable zipped file of student activity documents for the first five activities. <https://www.nasa.gov/sites/default/files/atoms/files/deepspacecommunications.zip>.

1. Mystery Pictures (Convert RGB to hexadecimal). *Can be completed on computer or printed handout.*
2. Fill in the Picture (Convert RGB to hexadecimal). *Computer only.*
3. Paint by Number (Convert binary to decimal). *Printed handout.*
4. Binary Conversions (Advanced activity—Solve without a converter tool using mathematics, either manually or using a calculator). *Printed handout.*
5. Hexadecimal Conversions (Advanced activity—Solve without a converter tool using mathematics, either manually or using a calculator). *Printed handout.*
6. Learn more about NASA's Deep Space Network (DSN).
  - Research and write about the different parts of the DSN and how it works.
7. Create a poem. The poem should explain how NASA receives data from deep space.
8. Write an uplifting message. Write a message to someone in your group using hexadecimal or binary notation.
  - Search online for a positive quotation if needed. Do not use a predictable one. Trade quotes and decode the messages.
  - Use the American Standard Code for Information Exchange (ASCII) table to convert letters to binary or hexadecimal notation.
9. Create your own cipher. A cipher is a protocol meant specifically to hide or encrypt messages from others. Create the cipher as a group, then encode your own individual messages. Swap encoded messages with team members and then decode.
  - Using your cipher, write a nice note to your favorite educator. Send that educator a copy of your cipher and your encoded message.
10. Draw a diagram illustrating the data being transferred from one computer to another.

### ✓ Evaluate

Each student will create a physical project of their choice using any encoding process learned about in this activity. To convert letters to binary or hexadecimal, have students use the American Standard Code for Information Interchange (ASCII) table found at the end of the Educator Notes. Encourage creativity within the project. Here are just a few possible project ideas:

- Encode your name, initials, or a message in binary notation.
  - Put it on a necklace or bracelet using two different beads to represent the 0s and 1s.
  - Try using two different-color ultraviolet (UV) beads to create an encoded message that only appears in the sunlight or under UV light.
  - Put the different-color beads on safety pins to string them together, as shown in the picture.
- Using different types of noodles, create a message on paper. Be sure to have a key.
- Create your own cipher with color. (Tip: There are 16 digits in hexadecimal and 16 colors in a box of crayons.)



The name "Chris" in beads using a binary encoding of the ASCII values for each letter in the name.

### Extensions

Two advanced activities are suggested in the **Elaborate** section. Students will practice changing numbers between the different bases (e.g., from decimal to binary or from hexadecimal to decimal) without an internet-based converter. Read the "Binary Conversions" and "Hexadecimal Conversions" activity sheets to determine if these advanced activities are appropriate for your students.

### References

Binary Nametag. <https://chandra.si.edu/binary/nametag.html#nametag>

Binary Pins. <https://chandra.si.edu/binary/pin.html#pin>

# Decimal, Hexadecimal, and Binary Number Systems Overview

## Decimal or Base 10 Number System

The decimal or base 10 number system has 10 digits (numerals 0 to 9) and the position of each digit indicates its place value. These place values are based on powers of 10 (i.e., ones, tens, hundreds, thousands, etc.).

$$10^0 = 1 \text{ (one)}$$

$$10^1 = 10 \text{ (ten)}$$

$$10^2 = 100 \text{ (hundred)}$$

$$10^3 = 1,000 \text{ (thousand)}$$

In base 10, the number 247 has three digits. Reading from right to left, 7 is in the ones ( $10^0$ ) place, 4 is in the tens ( $10^1$ ) place, and 2 is in the hundreds ( $10^2$ ) place, so 247 is equivalent to:  $(2 \times 100) + (4 \times 10) + (7 \times 1) = 200 + 40 + 7 = 247$ .

## Hexadecimal or Base 16 Number System

The hexadecimal or base 16 number system uses 16 digits (numerals 0 to 9 and letters A to F, where A = 10, B = 11, C = 12, D = 13, E = 14, and F = 15). The position of each digit indicates its place value, but these place values are based on powers of 16.

$$16^0 = 1 \text{ (one)}$$

$$16^1 = 16 \text{ (sixteen)}$$

$$16^2 = 256 \text{ (two hundred fifty-six)}$$

$$16^3 = 4,096 \text{ (four thousand ninety-six)}$$

In base 16, the number F7 has two digits. Reading from right to left, 7 is in the ones ( $16^0$ ) place and F, which is equal to decimal number 15, is in the sixteens ( $16^1$ ) place, so F7 is equivalent to:  $(15 \times 16) + (7 \times 1) = 240 + 7 = 247$ .

## Binary or Base 2 Number System

The binary or base 2 number system has only two digits (numerals 0 and 1), and the position or place value of each digit is based on powers of 2.

$$2^0 = 1 \text{ (one)}$$

$$2^4 = 16 \text{ (sixteen)}$$

$$2^1 = 2 \text{ (two)}$$

$$2^5 = 32 \text{ (thirty-two)}$$

$$2^2 = 4 \text{ (four)}$$

$$2^6 = 64 \text{ (sixty-four)}$$

$$2^3 = 8 \text{ (eight)}$$

$$2^7 = 128 \text{ (one hundred twenty-eight)}$$

With only two digits, binary numbers require a long string of digits to express large numbers. In base 2, the number 11110111 has eight digits. Reading from right to left, the first three digits (111) are in the ones ( $2^0$ ), twos ( $2^1$ ), and fours ( $2^2$ ) places, respectively. The zero is in the eights ( $2^3$ ) place, and the last four digits (1111) are in the sixteens ( $2^4$ ), thirty-twos ( $2^5$ ), sixty-fours ( $2^6$ ), and one hundred twenty-eights ( $2^7$ ) places. The number 11110111 is equivalent to:  $(1 \times 128) + (1 \times 64) + (1 \times 32) + (1 \times 16) + (0 \times 8) + (1 \times 4) + (1 \times 2) + (1 \times 1) = 128 + 64 + 32 + 16 + 0 + 4 + 2 + 1 = 247$ .

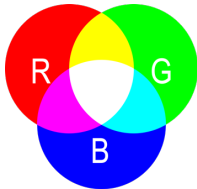
Another option is to segment long strings of binary numbers into sets of four and convert each group (0000 to 1111) into the decimal equivalent (0 to 15), where each set of four equates to one hexadecimal place value. Since binary is based on powers of 2 and hexadecimal is based on powers of 16 or  $2^4$ , four binary digits or four bits (also called a nybble) are equivalent to a single hexadecimal

digit (0 to F). Using the same example 11110111, the first nybble starting from the right (0111) is in the ones place ( $16^0$ ), and the second nybble (1111) is in the sixteens place ( $16^1$ ). After calculating the value of each nybble below, 11110111 is equivalent to hexadecimal number F7 =  $(15 \times 16) + (7 \times 1) = 240 + 7 = 247$ .

$$1111 = (1 \times 8) + (1 \times 4) + (1 \times 2) + (1 \times 1) = 8 + 4 + 2 + 1 = 15 \text{ (F in hexadecimal)}$$

$$0111 = (0 \times 8) + (1 \times 4) + (1 \times 2) + (1 \times 1) = 0 + 4 + 2 + 1 = 7$$

## Converting 8-Bit RGB Color Codes to Hexadecimal and Binary Notation



Decimal, hexadecimal, and binary numbers can be used to express 8-bit RGB color codes.

Each value in an 8-bit RGB triplet represents an integer number from 0 to 255 and defines a recipe for the amount of each primary color (red, green, and blue) that would be combined to make different shades of color in the visible spectrum. Hexadecimal color codes start with a pound or hashtag (#). Red is displayed in the first two places on the left (after the # symbol), then green, and finally blue (#RRGGBB). If any of the colors are converted into a 1-digit number, use a zero as a placeholder in front of the number. Binary color codes start with the 8-bit binary number for red, followed by the 8-bit binary number for green, followed by the 8-bit binary number for blue. Again, use place-holding zeros in front of any number that is smaller than 8 bits.

Color	RGB 8-Bit Triplet		
	Decimal Color Code	Hexadecimal Color Code	Binary Color Code
White	(255, 255, 255)	#FFFFFF	$11111111$ $11111111$ $11111111$ FF FF FF
Bright yellow	(247, 252, 32)	#F7FC20	$11110111$ $11111100$ $00010000$ F7 FC 20

Hexadecimal numbers require fewer digits than decimal or binary numbers to convey large values and are often used for expressing color codes in computer programming. While computers work in binary, hexadecimal is commonly used by programmers because it is easier to read and easily converts to decimal and binary number systems. All decimal integers from 0 to 255 can be expressed with a combination of just two hexadecimal digits (00 to FF), whereas the binary number equivalent would require up to eight digits, or eight bits (00000000 to 11111111). The RGB color code for white (255, 255, 255) would require only six hexadecimal digits (#FFFFFF) but twenty-four binary digits (111111111111111111111111).

Students can use a calculator or internet-based converter or learn to convert by hand. Converting with a calculator or by hand requires division. Divide the decimal number by the appropriate base number (16 for hexadecimal and 2 for binary) repeatedly until the quotient is zero. The remainder for each step of the division process provides the digit for each successive place value of the number system (hexadecimal or binary). Review the “Hexadecimal Conversions” and “Binary Conversions” activity sheets for examples of converting RGB triplets from decimal to hexadecimal and binary notation without an online conversion tool.



# American Standard Code for Information Interchange (ASCII)

Use this chart to encode letters and symbols in hexadecimal or binary notation.

ASCII character	Hex value	Binary value
A	41	01000001
B	42	01000010
C	43	01000011
D	44	01000100
E	45	01000101
F	46	01000110
G	47	01000111
H	48	01001000
I	49	01001001
J	4A	01001010
K	4B	01001011
L	4C	01001100
M	4D	01001101
N	4E	01001110
O	4F	01001111
P	50	01010000
Q	51	01010001
R	52	01010010
S	53	01010011
T	54	01010100

ASCII character	Hex value	Binary value
U	55	01010101
V	56	01010110
W	57	01010111
X	58	01011000
Y	59	01011001
Z	5A	01011010
[	5B	01011011
\	5C	01011100
]	5D	01011101
^	5E	01011110
_	5F	01011111
`	60	01100000
a	61	01100001
b	62	01100010
c	63	01100011
d	64	01100100
e	65	01100101
f	66	01100110
g	67	01100111
h	68	01101000

ASCII character	Hex value	Binary value
i	69	01101001
j	6A	01101010
k	6B	01101011
l	6C	01101100
m	6D	01101101
n	6E	01101110
o	6F	01101111
p	70	01110000
q	71	01110001
r	72	01110010
s	73	01110011
t	74	01110100
u	75	01110101
v	76	01110110
w	77	01110111
x	78	01111000
y	79	01111001
z	7A	01111010

# Activity One: Communication

## Student Handout

### Your Challenge

In this activity, you will be able to simulate how astronauts, satellites, rovers, and other spacecraft are able to send data digitally to Earth from deep space. You will learn to convert between binary, decimal, and hexadecimal notation to decode images, create encoded messages, and create a cipher. Finally, you will design a unique project using one of the skills learned during this activity.

### Engage

On a sheet of paper, express what the concept of “communication” means to you in one or more of the following ways:

- Draw a picture of what communication looks like to you.
- Draw a concept map of communication.
- Write a list of related words.
- Come up with your own definition of communication.

### Explore

- On a “Hello” name tag, create a way to communicate your name without using letters of the alphabet. You may want to practice on scrap paper first.
- Next, you will receive a “Hello” name tag completed by someone else. Try to decode the name you have been given.
  - What strategies did you use to decode the name you were given?
  - How did you decide on the type of communication you used to write your own name?
  - What happens if two people do not speak the same language, but they want to communicate? What could they do?

### Explain

In a small group, use the resources below to

- Create a foldable or a graphic organizer of the three types of encoded data: binary, RGB (red, green, and blue), and hexadecimal.
- Explain how data is sent from deep space to Earth.

### Resources

How Does a Spacecraft Take a Picture? (Total time of video is 3:02.)

<https://www.youtube.com/watch?v=5ueMGZTzefY>

How Do We Talk to Machines?

<https://spaceplace.nasa.gov/binary-code2/en/>

Why Is Sixteen so Sweet?

<https://spaceplace.nasa.gov/binary-code3/en/>

### Fun Fact

NASA Visualization Explorer is your portal to the coolest stories about NASA’s exploration of Earth, the Sun, the Moon, planets, and the universe. A new story is released every other Monday. Download the app and get stories delivered to your iOS and Android devices.

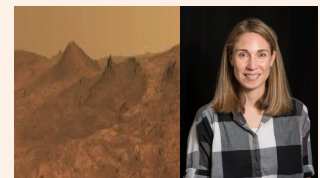


Learn more:

<https://nasaviz.gsfc.nasa.gov/>

### Career Corner

Elizabeth Rampe is a planetary geologist on the Astromaterials Research and Exploration Science (ARES) team at NASA’s Johnson Space Center. Rampe and other ARES scientists work to understand and decipher the properties of Martian surface materials that can inform us about past and present conditions on Mars. The secrets hiding within Martian geology and mineralogy may one day help astronauts navigate the perils of the Red Planet.



Learn more about ARES:

<http://www.nasa.gov/centers/johnson/astromaterials>

## Deep Space Communications

### Practice converting decimals

Your teacher will instruct you on how to convert between decimal, binary, and hexadecimal.

- If given a binary or hexadecimal number, convert it back to decimal. For the blank rows in the Decimal column, choose your own numbers to convert.

Decimal	Binary	Hexadecimal
99	01100011	63
14		
107		
156		
250		
		F
	00010011	

### RGB Color Codes

What does an RGB triplet indicate?

- Use a computer to find the RGB triplets for each of the colors (red, green, and blue) in the tables below. Then write the RGB triplets (#, #, #) in the right column as the color gets lighter and darker.

Color	RGB
Light red ↓	
Red	
Dark red	

Color	RGB
Light blue ↓	
Blue	
Dark blue	

Color	RGB
Light green ↓	
Green	
Dark green	

What do you notice about the RGB values in the

- Red table?
- Blue table?
- Green table?

Now, use the following chart to practice converting RGB color codes to hexadecimal and binary notation. Refer to the sheet "Converting 8-Bit RGB Color Codes to Hexadecimal and Binary Notation."

- Review the examples, then practice with the given colors. You will find the RGB triplet for the given colors, then convert the decimal RGB color code to hexadecimal and binary notation.
- For the blank rows in the Color column, choose your own colors and fill in the chart accordingly.

Color	8-Bit RGB Triplet		
	Decimal Color Code	Hexadecimal Color Code	Binary Color Code
White	255, 255, 255	#FFFFFF	11111111 11111111 11111111 FF
Bright yellow	247, 252, 32	#F7FC20	11110111 11111100 00100000 F7 FC 20
Black			
Light blue			
Dark blue			

 **Elaborate**

Activities are listed below. Your teacher will tell you which of the activities you are able to choose from and how many you need to complete.

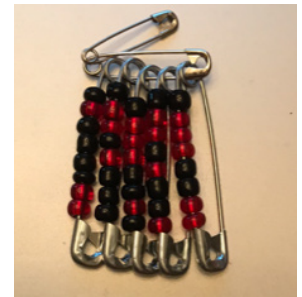
1. Mystery Pictures (Convert RGB to hexadecimal).
2. Fill in the Picture (Convert RGB to hexadecimal).
3. Paint by Number (Convert binary to decimal).
4. Binary Conversions (Solve without a converter tool using mathematics, either manually or using a calculator).
5. Hexadecimal Conversions (Solve without a converter tool using mathematics, either manually or using a calculator).
6. Learn more about NASA's Deep Space Network (DSN).
  - Research and write about the different parts of the DSN and how it works.
7. Create a poem. The poem should explain how NASA receives data from deep space.
8. Write an uplifting message. Write a message to someone in your group using hexadecimal or binary notation.
  - Search online for a positive quotation if needed. Do not use a predictable one. Trade quotes and decode the messages.
  - Use the “American Standard Code for Information Interchange (ASCII)” table to convert letters to binary or hexadecimal notation.
9. Create your own cipher. A cipher is a protocol meant specifically to hide or encrypt messages from others. Create the cipher as a group, then encode your own individual messages. Swap encoded messages with team members and then decode.
  - Using your cipher, write a nice note to your favorite educator. Send that educator a copy of your cipher and your encoded message.
10. Draw a diagram illustrating data being transferred from one computer to another.

## Deep Space Communications

### ✓ Evaluate

Create a physical project of your choice using any encoding process you learned about in this activity. To convert letters to binary or hexadecimal, use the “American Standard Code for Information Interchange (ASCII)” table. Be creative! Here are just a few possible project ideas:

- Encode your name, initials, or a message in binary notation.
  - Put it on a necklace or bracelet using two different beads to represent the 0s and 1s.
  - Try using two different-color ultraviolet (UV) beads to create an encoded message that only appears in the sunlight or under UV light.
  - Put the different-color beads on safety pins to string them together, as shown in the picture.
- Using different types of noodles, create a message on paper. Be sure to have a key.
- Create your own cipher with color. (Tip: there are 16 digits in hexadecimal and 16 colors in a box of crayons.)



The name “Chris” in beads using a binary encoding of the ASCII values for each letter in the name.