Codes 1

Materials

Rulers

Measuring cups & beverage containers

(per student) Set of 5 binary cards

Readings

Petzold, Ch. 1, 2, 3, 8 & 15

Handouts

Emoji Descriptions

Sample codes and keys

Fabric care key

Common Kitchen measures

Abacus and Tally Marks

Resources

History of binary codes https://www.csunplugged.org/en/topics/binary-numbers/integrations/biographies-and-binary-number-system-history/

Interactive binary cards https://www.csfieldguide.org.nz/en/interactives/binary-cards/?digits=4&start=WWWW

Evolution of sign language www.nytimes.com/interactive/2022/07/26/us/american-sign-language-changes.html

Abbott and Costello do the math https://www.youtube.com/watch?v=_HvGven4qJ0

Unicode-11 Full Emoji List https://unicode.org/emoji/charts-11.0/full-emoji-list.html

1) Symbols: What are they? Why do we use them? How do we use them?

   Individual activity: Scavenger hunt for symbols, where we find them, what they mean

2) Codes: A code is a system of symbols. To understand a code, there is often a key, which translates the symbols in a code into a familiar language. On a map, the key is called a legend. Examples of codes & keys: Subway map key, keys to Braille, ASL, football referee's signals, musical scale.

3) Emojis: Are they a code? What do you use them for? Where did they come from? "Emoji" means "picture-word" in Japanese, and were invented around 2000 in Japan, based on Manga characters.

   Individual activity: write down a few of your favorite emojis and create a key that explains each one.

Handout: duplicate pp. 23-24 and/or 74-78 from The Semiotics of Emoji

4) Positional number systems: Hindu (only 10 symbols) vs. Roman (new symbol for each column: X, C, M) Positional requires symbol for empty column. Roman numbers are not usable for computation – used abacus instead.

   Group Activity: Add 48 + 79 in decimal.

   Now try adding the Roman equivalents, XLVIII + LXXIX. What goes wrong?

   Individual Assignment: in your journal, discuss the advantage of using a positional number system.

   Historical Notes:

   - Transition from Roman to Hindu-Arabic took centuries; example of IV0II = 1502, which combines both.
   - Examples of Roman system still used today:
     Building cornerstones, movie production dates, Super Bowl numbering

5) Number bases other than 10

   Individual activity:
   Identify the number base or bases used in each of the following systems

   - Measurement of an angle
   - Roman numerals
   - Commonly used subdivisions of an inch: distribute rulers
   - Measurement of time
   - Subdivisions of a gallon: distribute beverage containers, measuring cups
   - The abacus
   - Tally marks
   - Dozen/gross
   - French word for 80

6) Place value: The meaning of each column in decimal and other positional number systems. In decimal, what is the place value of each column? What do you do when the result in each column exceeds 10?

7) Introduction to binary: each switch in a computer has only two possible states: ON or OFF. These states can be represented as the binary numbers 0 and 1.

   Whole Class Activity: Develop a chart showing the place value of each column in binary and decimal.

   How big a group does each column represent in the decimal system? The answer is called the place value of that column. For decimal, these are shown in the highlighted row below. An easy way to see it is to put a 1 in that column, and zeros in the others. Then read across that row and it will give you the place value of the only column with a 1 in it.

	Decimal place value of each column					Decimal number
100,000	10,000	1000	100	10	1	
0	0	0	0	0	1	1
0	0	0	0	1	0	10
0	0	0	1	0	0	100
0	0	1	0	0	0	1000
0	1	0	0	0	0	10,000
1	0	0	0	0	0	100,000

Class discussion: To get to the next place value to the left, what number do you multiply by?

Now let's look at the place values in binary. We've already seen that the first two columns count groups of 1 and 2, moving right to left. If we add one to two, we will get 11, which is equivalent to 3 in decimal. Now we've run out of symbols again, so we add another column, which represents 4. We run out again at 8 and 16. The first six columns are shown below.

	Binary place value of each column					Decimal equivalent
32	16	8	4	2	1	
0	0	0	0	0	1	1
0	0	0	0	1	0	2
0	0	0	1	0	0	4
0	0	1	0	0	0	8
0	1	0	0	0	0	16
1	0	0	0	0	0	32

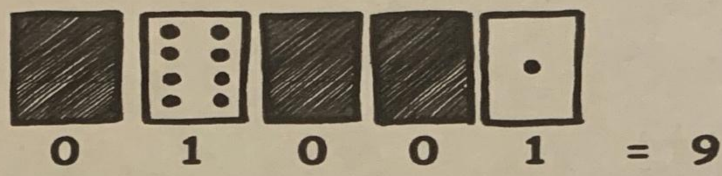
Class discussion: What do you have to multiply by to get from each place value to the next one to the left?

BREAK BETWEEN SESSIONS

8) Binary number cards: These show the place value of the first five binary columns:

You can use them to convert from binary to decimal or vice versa. Here is an example:

The binary system uses **zero** and **one** to represent whether a card is face up or not. **0** shows that a card is hidden, and **1** means that you can see the dots. For example:



Can you work out what **10101** is? What about **11111**?

9) Binary to decimal: List all the binary numbers from 0000 to 1111, by filling in the table below. The first four rows are shown. Fill in the remaining 12 rows, showing both the binary number and its decimal equivalent, which you can find by adding the place values of all the columns with 1's in them:

Place value of each binary column				Decimal equivalent
8	4	2	1	
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
?	?	?	?	4
				15

10) Decimal to binary

Individual activity: Use the binary cards to express your decimal birthdate in binary. Then let others convert from binary back to decimal to see if they can decode your birth date.

Class discussion:

Is there any birth date that cannot be translated to five binary digits (bits)?

Is there any five-bit binary that does not translate into a possible birthdate?

Individual activity: Express your birthdate using on and off LEDs.

11) Saving space on the birthday cake:

Class discussion:

What number base is used to represent someone's age on a birthday cake?

How could binary be used instead?

What would be the advantages and disadvantages of using binary to represent the birthday person's age on a cake?

How would you represent a binary zero on the cake?

12) Octal and Hex codes: These are closely related to binary code but much more compact. Binary numbers are often expressed in octal or hex to save space. We'll soon see codes for text and emojis that are expressed in octal or hex instead of binary.

a) Octal means base 8. Its symbols range from 0 to 7. In binary, these are represented by 000 to 111. Three bits of binary code can translate into one octal number. If there are more than three bits, translate each 3-bit group separately and combine them into one octal number. For example, 110010 is translated as 110 = 6 in octal, and 010 = 2 in octal, so 110010 = 62.

Individual activity:
i) Translate from binary to octal: 101, 011, 100111
ii) Translate from octal to binary: 37, 15, 24

b) Hex is short for hexadecimal, which is base 16. Since four binary bits can express any number from 0 to 15, hexadecimal translates four binary bits into one hexadecimal digit. One problem is that the decimal system has no individual symbol for 10, 11, 12, 13, 14 or 15, which should be represented by one symbol in hex, so by convention, these are represented by letters according to the following chart:

Decimal	**Binary**	**Octal**	**Hex**
O	0000	00	O
1	0001	01	1
2	0010	02	2
3	0011	03	3
4	0100	04	4
5	0101	05	5
6	0110	06	6
7	0111	07	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Individual activity

Select a Unicode-11 hexadecimal code and translate it into binary.