1.1 - Bits and Bytes

Lesson Description	Learning Objective/Skills
Computers fundamentally operate on the basis of electrical switches. These switches can be either on (representing a 1) or off (representing a 0). Binary, with its two-state system, perfectly aligns with this physical reality. By using 0s and 1s, computers can store data, perform calculations, and execute instructions. Every piece of information you see on your screen, every program you run, is ultimately a combination of 0s and 1s manipulated by the computer's internal circuitry. Understanding binary conversions will give you a deeper appreciation for how computers work at their core. In this lesson we look at the conversion of binary, a number system that uses just two digits, 0 and 1 to the decimal system, a number system we all know (with digits 0-9).	**Learning Objective:** Explain how computer systems are able to translate numbers into binary (base 2) numbers. **Skills:** ● Conversion of numbers between binary and decimals as needed ● Determination of the number of bits needed to store information ● Bit is shorthand for binary digit and is either 0 or 1. ● A byte is 8 bits.

Lesson Duration and Materials
This lesson is planned for 45 minutes: - 5 minute Monkey Business (Bell Ringer) - 10 minute lesson on what is binary and binary conversions - 5-10 minute practice of binary conversions - 5-10 minute discussion on relationship between the number of bits and the number of items that can be represented - 15 minutes War with Binary Cards - Assessment (Homework) Materials: - Binary Worksheet - Binary Play Cards

Assessment

Formative	Summative
Worksheet Game of War	CodeMonkey Problems

Monkey Business - Peel the Problem

Imagine you're stranded on a deserted island with a group of monkeys and a plentiful banana supply. How can you use the monkeys and bananas to send a message for help?

- Consider things like the number of bananas, how the monkeys are positioned, or any actions they might perform.

After discussing the different ideas for sending a message, acknowledge the challenges of relying solely on physical objects like monkeys and bananas.

Pose a follow-up question:

> What if we could use a simpler system, like just two things, to represent different messages?

Can you think of any examples where two things are used to send information?

Explore Examples:

> Briefly mention traffic lights (red/green) or light switches (on/off) as examples of two-state systems used for communication.

Introduce Binary using CodeMonkey Unit 1 The Language of Computers

The Binary Number System

DIRECT INSTRUCTION or VIDEO ON CODEMONKEY on Conversion from Decimal to Binary. Please reference Lesson 1: The Binary Number System with students. Additionally, here is an alternative way to convert decimal to binary.

Conversion to Decimal to Binary (Division):
Step 1: Divide the given decimal number by 2 and note down the remainder.
Step 2: Now, divide the obtained quotient by 2, and note the remainder again.
Step 3: Repeat the above steps until you get 0 as the quotient.
Step 4: Now, write the remainders in the reverse order.

Example:

42_{10}
Decimal

Division	Remainder
24	0
12	0
6	0
3	0
1	1
1	1

Binary
110000_2

Binary Conversions

Have students complete binary worksheet or binary review problems on CodeMonkey. Remind students they will not be able to use a calculator or utilize any tools on the AP CSP exam.

How many bits do you need?

Looking at a byte, which is a fundamental unit of digital information, what is the largest number you can make? We can determine this by adding all 8 bits together …. 128+64+32+16+8+4+2+1, giving us 255. The smallest number we can make is 0. Therefore with 8 bits we can have 256 possible values. Let's look at this in a different manner. The number of different values that can be represented with n bits is calculated as 2 raised to the power of n (2^n). So, with 8 bits (1 byte), you have 2^8 (2 to the power of 8), which equals 256 possible values. If given a certain number of values needed we can determine the minimum number of bits:

1. **Find the highest power of 2 less than or equal to the number:** Continuously double the value of 1 (2^0, 2^1, 2^2, etc.) until you reach a value that's greater than or equal to your number. For instance, to represent the number 10, the next highest power of 2 is 8 (2^3).

Here's an example:

- How many bits are needed to represent the number 127?

Following the steps above:

- The highest power of 2 less than or equal to 127 is 128 (2^7).
- In binary, 128 is represented as 10000000.

Therefore, 7 bits are required to represent the number 127.

Go Bananas Actvity: Binary War

Intro to War and Card Games:
We just learned that data in computers is stored as a series of zeros and ones. We just discussed how many bits are needed to represent various numbers of items. Now we are going to practice utilizing binary to play a fun game of war.

This activity will reinforce student's ability to convert between binary and decimal values by playing War. We will be using a special deck of playing cards where each number is represented in binary form instead of decimal notation. Thus, the card that would normally say "8" now reads "1000."

Share with students the rules of War.

The rules of War are below:

1. Decks are 20 cards for each pair of students. Shuffle the deck of binary playing cards.
2. Each student should be dealt half of the deck of cards. Students should not look at their cards.
3. Students will each flip over a card from their deck and then determine who has the higher value. That student gets both cards and places them on the bottom of their deck.
4. If the values are equal then students will turn over the next card to determine who wins.
5. Students continue game play until one student has the whole deck of cards.

Note:
The binary playing cards could also be used as flash cards. The flash cards could be used to help students who are still struggling with converting from binary to decimal.

Assessment

Have students complete the assessment at the end of the unit on CodeMonkey.