Teacher: McCoy
Grade Level/Class: 11th and 12th grade AP CS Principles

Unit of Study: Binary
Lesson Topic: Introduction to Binary Numbers

<table>
<tr><th colspan="2">SELECTING AND SETTING UP A MATHEMATICAL TASK</th></tr>
<tr><td colspan="2">Learning Objective: SWBAT: Convert numbers between Base 2 (binary) and Base 10 (decimal)</td></tr>
<tr><td>Learning Targets:

-Students will be able to explain that

● at the lowest level of abstraction, all information is coded through circuits that are on or off.
● ON/OFF is represented by 0 and 1
● All information can be converted to digital representation

-Students will be able to compute

● the decimal equivalent of a number in binary
● or the binary equivalent of a number in decimal</td><td>Success Criteria:

-Convert a number in decimal to a number in binary

-Convert a number in binary to a number in decimal</td></tr>
<tr><td>Computational Thinking Practices P3

Students learn about the abstraction (P3) hierarchy of computers of as three overarching domains: the software domain (with its own four layers of programmatic abstraction), the digital domain (which includes four levels of conceptual abstraction), and the analog domain.</td><td>Big Ideas 2

Students learn how software is an abstraction (Big Idea 2) over hardware: digital hardware (based on zeros and ones) is not a law of nature, but an abstraction over the physics of transistors, and requires engineering effort to make it work.</td></tr>
<tr><td colspan="2">Materials/Resources: Mind reading game sheets, whiteboard, computers, Google classroom, handouts from csunplugged.com, counting cards, big version of cards</td></tr>
<tr><td colspan="2">Prior Academic Learning and Prerequisite Skills:

Students should be familiar with powers of 2 and other bases. Fluency with arithmetic is assumed as well.</td></tr>
<tr><td colspan="2">Vocabulary:

Binary, decimal, base 2, base 10, digital, powers</td></tr>
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<tr><th>INSTRUCTIONAL AND LEARNING TASKS</th></tr>
<tr><td>Lesson Development (Investigation/Initial Activity/Mini-Lesson)</td></tr>
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1. **Motivation**: Mind Reading Trick…*(Student thinks of number 1-31. You show her the five cards. She tells you which cards her number appears on. Find the sum of the FIRST number on each card her number appears on (1, 2, 4, 8, and/or 16) to "read her mind". After doing trick a bunch of times, tell them today's lesson will help them understand how it works.* ***(5 minutes)***

https://drive.google.com/file/d/0B0y1Jg8Cks8YZGZaUjE3TFFQTUU/view?usp=sharing

2. Lesson Intro: When we program in Snap!, we are using a very high level of abstraction. All software, including programming languages, represent an abstraction of digital hardware, which is in itself an abstraction over the physics of transistors. Transistors either allow electricity to flow (a circuit that is on) or not flow (a circuit that is off). The physical states of off and on can be abstracted as 0 and 1. All data in computers, therefore, is stored and transmitted as a series of zeros and ones--that is, the data is stored in DIGITAL form. How can we represent words and numbers using just these two symbols? That is, what is behind the digital revolution? We shall explore this in today's activity. **(3 minutes)**

Write on board and give a brief explanation
Binary vs. Decimal
Base 2 vs. Base 10
0-1 0-9

3. **Introducing binary initial activity*:*** *Counting the Dots activity from csunplugged.com.*
Teacher directs a group of 5 kids, using big cards, following directions from page 4 of Counting the Dots activity…**(5 minutes)**
(http://csunplugged.org/wp-content/uploads/2014/12/unplugged-01-binary_numbers.pdf)

Medial Task (Group/Independent Practice/Activity):

Pairs work:

1. **Circulate to check for understanding as the students do # 1 and 2 on handout:**

https://docs.google.com/document/d/1C2hpDCSFQYT1lRrUok5vS-Wq8JSkvFPAqKZ9JChYFDs/edit?usp=sharing

(5 minutes)
Ask:
What is the biggest number you can create with these cards?
The smallest?
Is there more than one way to get any number? How do you know?
Are there any numbers you cannot represent?
What if you wanted to get higher than 31? What card would you add?
With the new card, what's the highest number you can represent?
Each of these cards represents 1 bit of information. So, you can represent 0-31, or 32 unique pieces of information using 5 bits. What if I added a 6th card? A seventh?

(Students should realize that every number has a unique representation in binary)
2. Assign the rest of handout **(10 minutes)**
https://docs.google.com/document/d/1C2hpDCSFQYT1lRrUok5vS-Wq8JSkvFPAqKZ9JChYFDs/edit?usp=sharing

Differentiation:

The number cards activity is accessible to everyone, as it is hands-on and simple (it only requires counting) When kids are ready, I will move to a more formal representation of binary using powers of 2,, which will lead to the ability to generalize to other bases and base 16.

Reflection/Assessment:

Back to the mind reading trick. Now that you have done this activity, take another look at the cards I used to "read your mind". Some of the cards were "on" and some were "off", based on the number you were thinking of. Can you figure out what the trick is? (Discuss)**(5 minutes)**

Exit Ticket (on classroom): (5 minutes)
Basic:
Convert 24 to binary
Convert 11001 to decimal

Harder:
Convert 78 to binary
Convert 1011101 to decimal

Challenge question:

Set up a chart to represent the powers used if we were converting to Base 5

Convert the base 5 number 4331 to decimal