



Subject: Math	Grade: 3-5	Lesson Duration: 45 minutes
Title of Lesson: Secret Coders Lesson 2: Binary Code		
Objective: Students will <ul style="list-style-type: none"><li>● Learn that computers understand language in a different way</li><li>● Learn computers store information using 0s and 1s</li><li>● Encode numbers 1-15 into binary code</li><li>● Decode binary into numbers 1-15</li></ul>		
Common Core Standards in Mathematics in Grades 3-5:  <b>3<sup>rd</sup> Grade: Solve problems involving the four operations, and identify and explain patterns in arithmetic.</b> CCSS.MATH.CONTENT.3.OA.D.9 Identify arithmetic patterns (including patterns in the addition table or multiplication table), and explain them using properties of operations. <b>4<sup>th</sup> Grade: Generate and analyze patterns.</b> CCSS.MATH.CONTENT.4.OA.C.5 Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself. <b>5<sup>th</sup> Grade: Analyze patterns and relationships.</b> CCSS.MATH.CONTENT.5.OA.B.3 Generate two numerical patterns using two given rules. Identify apparent relationships between corresponding terms. Form ordered pairs consisting of corresponding terms from the two patterns, and graph the ordered pairs on a coordinate plane.		
Teacher Resources: <a href="http://www.secret-coders.com/watch-videos/">http://www.secret-coders.com/watch-videos/</a>		
Materials: <ul style="list-style-type: none"><li>● Secret Coders Worksheet (1 per student)</li><li>● Binary Code Recording Sheet (1 per student)</li><li>● 15 Pennies per student (or 15 small sized manipulatives)</li><li>● Back to Numbers Worksheet (1 per student as extension work)</li></ul>		
Introduction (5 minutes) <ul style="list-style-type: none"><li>● Begin the lesson by explaining how computers use a different language, called binary. Computers do not communicate like humans do with their different languages, for example English, Spanish or Sign Language.</li><li>● Computers will convert all its data into binary code before storing the information internally</li><li>● Binary Code is the sequence of 0s and 1s. It's the language the computer uses to store the information.</li></ul>		
Instruction (10 minutes) <ul style="list-style-type: none"><li>● Tell students that they will be learning how binary code works. They will be working with numbers 1-15.</li><li>● Display the 4 columns. Ask students what they notice about each of the columns. Have</li></ul>		

students notice how many boxes are in each column. Point out that each column is doubled.

- Explain to the students that each they will figure out the binary code for the number 7. Show your 7 pennies (or other 7 manipulatives). Ask students how the 7 pennies can fit into the boxes following 1 rule. Every column of boxes has to be completely filled or completely empty. Explain that no column can have partially filled boxes.
- When all 7 pennies are placed in the boxes, write a zero on the line beneath each empty column. Then write a one on the line beneath each filled column. The result of 0111, is seven as a binary number.
- Explain that the computer stores the number seven as 0111.
- Allow students to create their own binary code. While the computer stores information using the numbers 0s and 1s, they can use 2 other symbols to code numbers. For example, they can use triangles and squares to represent numbers.

#### Independent Working Time (20 minutes)

- Provide each student with the Secret Coders worksheet, Binary Code Recording Sheet and 15 pennies (or small manipulatives).
- Have students use the columns and pennies to record the Binary Code for each number on the Recording Sheet.
- When students complete the Recording Sheet, have them create their own Binary Code and record the numbers 1-15 using their code.

#### Differentiation

- For students who need an extra challenge, have them work on Back to Numbers Worksheet
- Explain that they will see Binary Numbers on this worksheet and they are to convert those back to numbers between 1-15.

#### Closure (10 minutes)

- Gather students back to the large group to share their Binary Code.
- Choose various students to show their codes. Invite comments.
- Connect how computers use these sequences of 0s and 1s to store all the information into the computer.
- As a review, show the code 0111, and ask the students what number would the computer have stored? Say other codes to review the Binary Code.
- Extend the lesson by asking how the computer would store numbers that are greater than 15? What additional columns would we need? Do they notice a pattern in the columns?

# SECRET CODERS

Learn how binary numbers work by playing the same game Hopper and Eni play in **Secret Coders Book 1!**

1. Start with seven pennies.
2. Fit all seven pennies into the boxes, but there's a catch! Every column of boxes has to be either completely full or completely empty. No half-filled columns.
3. When you're done, write a zero on the line beneath each empty column. Write a one on the line beneath each empty column.
4. The result is seven as a binary number! (Turn this page upside down to see the answer.)

5. Try it with other numbers too! This game will work with any number that's fifteen or smaller.

If you want to use numbers bigger than fifteen, you'll need to add more columns to the left. (And you'll need bigger paper!) The next column will have 16 boxes, the one after that 32, and so on. Each column will have twice as many boxes as the column to its right.




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## Binary Code Recording Sheet

Use the skills you practiced on the Binary Code worksheet to convert the numbers below into binary code. Once you've finished, create your own code using shapes or symbols and convert the numbers to your code.

Number	Binary Code	Your Own Code
7	_____	_____
1	_____	_____
5	_____	_____
4	_____	_____
8	_____	_____
2	_____	_____
10	_____	_____
3	_____	_____
12	_____	_____
6	_____	_____
14	_____	_____
9	_____	_____
15	_____	_____
13	_____	_____
11	_____	_____



## Back to Numbers Worksheet

Practice converting binary code back into numbers. The pieces of binary code you see below are actually numbers between 1-15. Can you convert them back?

1010	
0001	
0111	
0101	
1000	
0110	
1000	
1100	
0100	
1111	
0101	
1001	
0011	
0010	