

## Binary Numbers

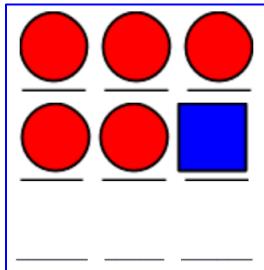
### Your Tasks (Mark these off as you go)

- Brainstorm: How many three place patterns can you make with a circle and square
- Watch the Circle-Triangle-Square to Binary video
- Get acquainted with the virtual Flippy-Do
- Use your Flippy-Do to determine all the possible combinations of a binary number for a given number of bits
- Determine the base 10 value of all the 8-bit binary numbers with exactly one 1
- Practice with conversions
- Complete the reflection questions
- Receive credit for this lab guide

#### Brainstorm: How many three place patterns can you make with a circle and square

In the previous lesson you created 27 different 3-place patterns out of circles, triangles and squares, and tried to define a system of rules to generate all of the patterns.

What if you only had a circle and square? With only a circle and square, how many 3-place patterns are there? A few are started below. How many are there total?



000	100
001	101
010	110
011	111

## □ Watch the Circle-Triangle-Square to Binary Video

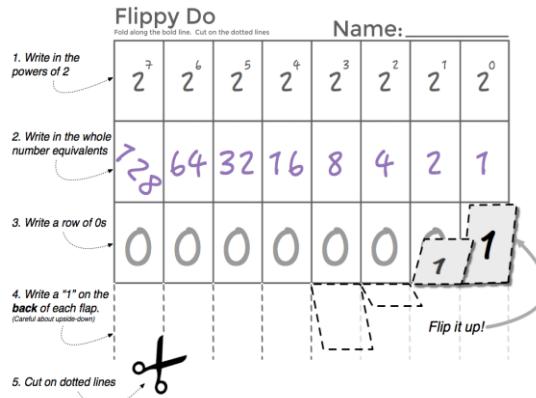
To help with the transition from circle-triangle-square to binary check out the following video,

<https://www.youtube.com/watch?v=91HLBUjCHbs>

## □ Get acquainted with the virtual Flippy-Do

A Flippy-Do is a useful tool for figuring out the decimal equivalent of a base 2 number. An example of a paper Flippy-Do is illustrated to the right.

In this lab we will be using a virtual Flippy-Do! This virtual Flippy Do will allow you to convert any number from base 2 thru 10 to its decimal equivalent. How to use the virtual Flippy Do is illustrated below,



To get started, type a base of the number you want to convert then click the button.

Welcome to the FlippyDo!

Enter a number base:

To determine the base 10 equivalent of each place value, multiply the number in the yellow box, by the number in the green box. The result should be entered in the gray box.

Click on the yellow buttons, until the number you want for a given place displays. For our binary number example, only 0 or 1 can display.

$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
128	64	32	16	8	4	2	1
0	0	0	0	0	1	0	1

Click on the yellow buttons to enter a value in a given base. Then, multiply the value of the yellow button by the value of the green button above it. Enter this value in the gray text box. The sum of the values in the gray text boxes is the corresponding value in base 10.

The numbers in the green boxes represent the place values the number system. In our base 10 system, we have the 1s, 10s, 100s places, etc. But, a binary system has the 1s, 2s, 4s, places, etc.

Finally, to determine the base 10 equivalent of the number, simply add the values in the gray boxes. In this example, the binary number 101 is equivalent to 5 in base 10

To play with the virtual Flippy-Do follow the link below,

<https://flippydo.hpluska.repl.co/>

**Use your Flippy-Do to determine all the possible combinations of a binary number for a given number of bits**

Navigate to the Flippy Do, type the number 2 for base-2 and click the button. You can enter binary numbers by clicking on the yellow buttons. If each yellow button represents a bit, or a binary number. How many possible combinations are there for each number of bits. Refer to the Flippy-Do to figure this out.

2 bits	3 bits	4 bits	5 bits
4	8	16	32

Write down all the possible combinations of 1s and 0s for a 3 bit system. For each combination, indicate the base-10 equivalent

Combination of 1s and 0s	Base 10 equivalent
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

**Determine the base 10 value of all the 8-bit binary numbers with exactly one 1**

The table below contains *every* 8-bit number that has exactly one 1 in it. Write down the decimal equivalent next to each one. Do you notice a pattern?

Binary: 8-bit number (with exactly one 1)	Decimal
0000 0001	1
0000 0010	2
0000 0100	4
0000 1000	8

Binary: 8-bit number (with exactly one 1)	Decimal
0001 0000	16
0010 0000	32
0100 0000	64
1000 0000	128

## Practice with conversions

Using your own binary skills (aided by the flippy do) fill in the decimal and binary equivalents below.

### What's the Decimal Number?

Binary	Decimal
100	4
101	5
1101	13
0001 1111	31
0010 0000	32
1010 1010	170
1111 1111	255

**NOTE:** a short binary number like **101** is assumed to have leading 0s for all the other bits, like: **00000101**. Typically large binary numbers are grouped in 4-bit chunks to improve readability, for example: 0110 0101 1010

### What's the Binary Number?

Binary	Decimal
101	5
10001	17
111111	63
1000000	64
1111111	127
100000000	256*
1000000001	513*

**\*NOTE:** **256** and **513** exceed the capacity of the flippy-do but you can work it logically following what you know about patterns with binary numbers.

## Complete the reflection questions

There is a simple pattern for determining if a binary number is odd. What is it and why does this pattern occur?

If the last number is a 1. This happens because it is the only odd number and an even plus an odd is the only way to get an odd.

How many bits would you need if you wanted to have the ability to count up to 1000?

10

How high could you count in binary if you used all 10 of your fingers as bits? (finger up means 1, finger down means 0)

1028

**Receive Credit for this lab guide**

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