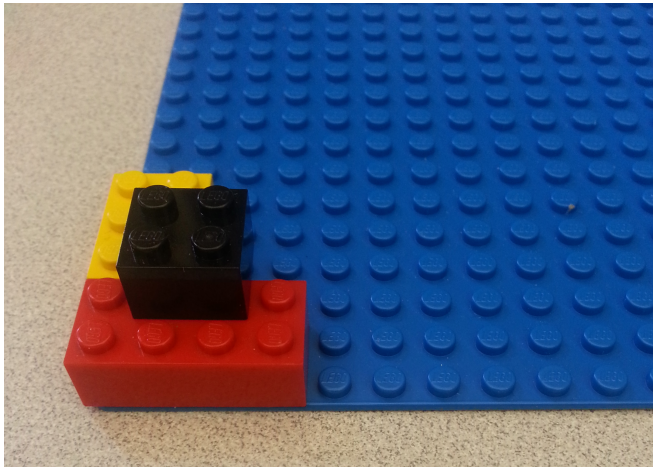
SOLUTIONS

Understanding Block Encoding and Decoding

In the space below, create a set of building instructions so that a friend can make the exact same LEGO tower shown in the picture.



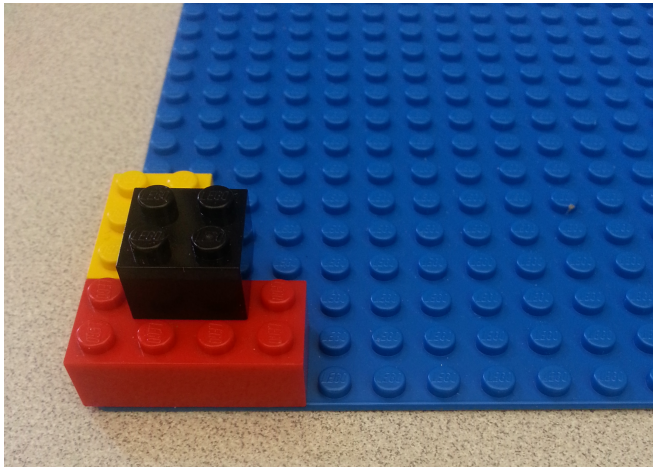
Answers will vary. They should describe a series of steps someone would be able to follow to reconstruct this tower.

Ambiguous or incorrect instructions warrant the necessity for a systematic way of describing LEGO blocks. This is a nice transition to the video in which the four attributes of LEGO blocks are described.

How clear were your instructions? How precise? Was a friend able to follow them to build the correct tower?

Now try describing the four attributes of each block to help you make instructions: color, size, position, and orientation.

Do these four attributes fully describe each LEGO block in the tower?

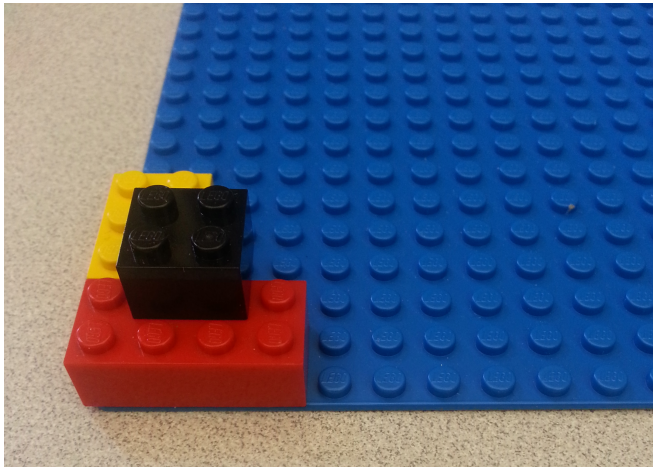


Color	**Size**	**Orientation**	**Position**
Red	2 x 4	Horizontal	Bottom left corner
Yellow	2 x 3	Vertical	2 units up from the bottom of the board, but along the left edge of the board.
Black	2 x 2	Doesn't matter	On top of the red block and yellow block. 1 unit in from each of the edges.

These answers might also vary, but students should be getting closer to creating a good description of how to build this tower. These attributes should fully describe each block in the tower!

We want to be able to describe all the attributes in *binary* encoding. Let's start with **color** and **size**.

In the table below, make a *legend* that matches each color and size to its binary encoding.



Color	**Binary Color**	**Size**	**Binary Size**
Red	001	2 x 4	010100
Yellow	010	2 x 3	010011
Black	011	2 x 2	010010

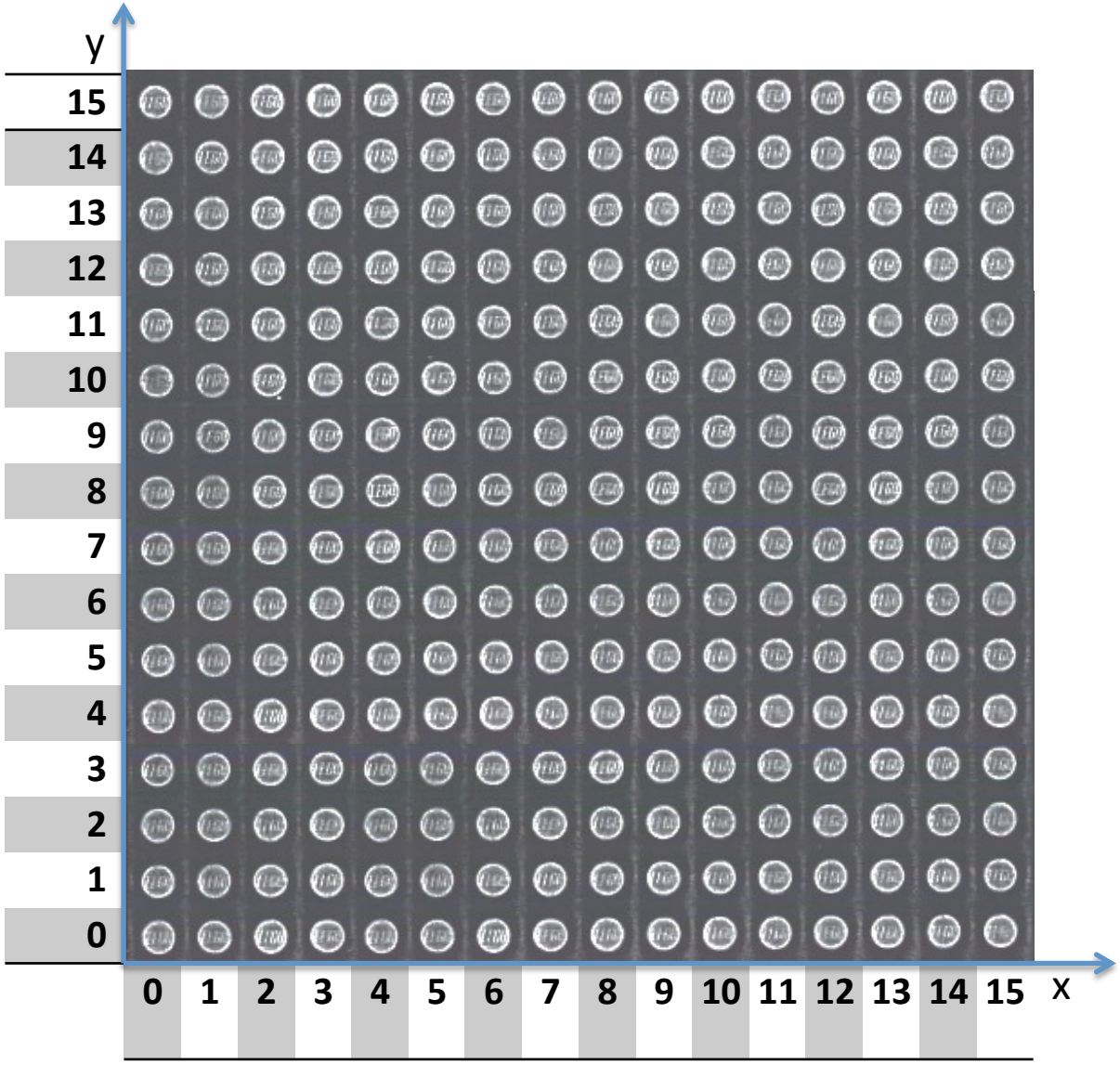
It would be helpful for the whole class to create a legend that matches this one.
The colors are not numerical, so the binary encoding is somewhat arbitrary.
The sizes of each block are numerical, so we can encode them simply by converting the dimensions of each block into binary.
Note that 2 is 010 and 4 is 100, so a 2 x 4 block has the size encoding 010100

Next, let's think about **position**. Look at the table you made on page 2. Did you define position the same way that your classmates did?

Probably not.

Look at this coordinate system. If I told you the bottom left corner of the block was at x=4 and y=2, would you know exactly where the block is?

Yes



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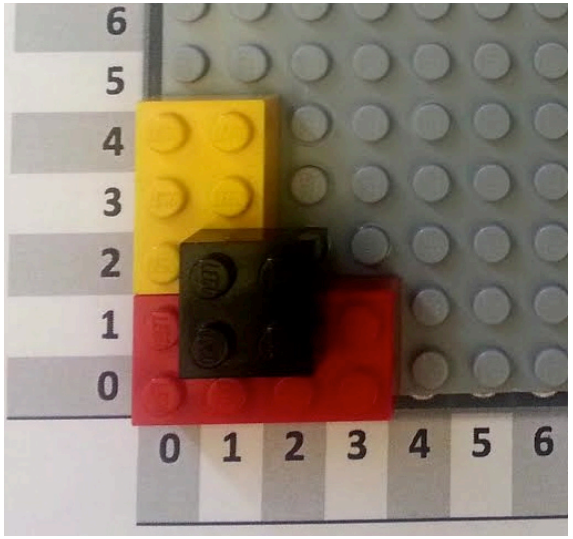
Using the coordinate system on the last page, give the position of each block in base-10 (regular counting numbers like 1, 2, 3, 4, 5…) and in binary (1, 10, 11, 100, 101…).

For consistency, give the position of the *bottom left corner* of each block.

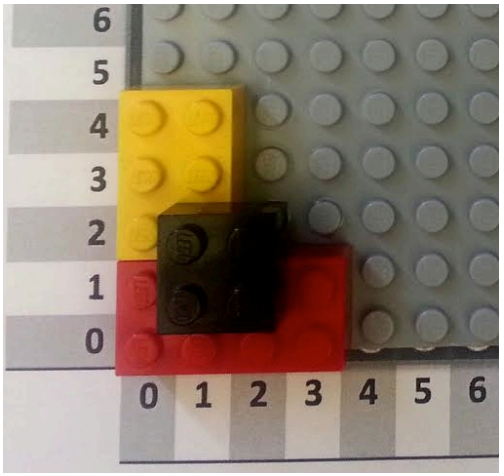


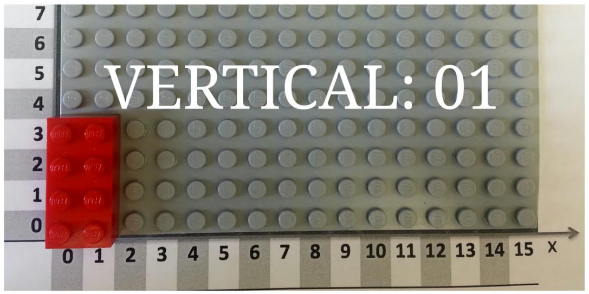
Block	X Coordinate (base 10)	X Coordinate (binary)	Y Coordinate (base 10)	Y Coordinate (binary)
Red 2 x 4	0	000	0	000
Yellow 2 x 3	0	000	2	010
Black 2 x 2	1	001	1	001

The binary numbers all have 3 digits even if the binary numbers don't need to be

Now let's encode the **orientation** of each block into binary.

Each block can either be *horizontal* or *vertical*. We can let 00 represent horizontal, and let 01 represent vertical, as shown in the picture below. Now encode the orientation of the blocks in the tower!





Block	Orientation	Binary Orientation
Red 2 x 4	Horizontal	00
Yellow 2 x 3	Vertical	01
Black 2 x 2	Horizontal or Vertical	00 or 01

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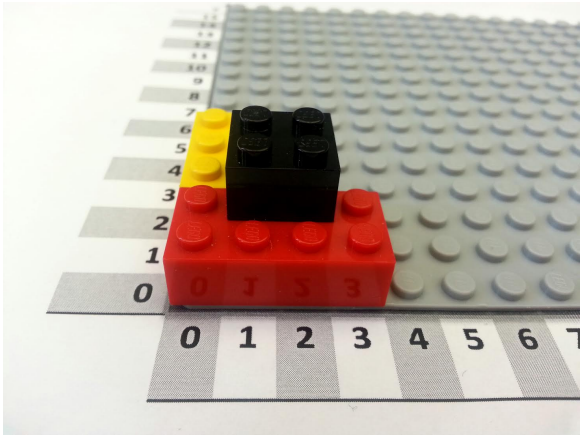
When we give instructions, the *order* of the steps can matter! If you crack an egg and then cook it, you have a poached egg. If you cook an egg and then crack it, you have a hard-boiled egg.

We can represent each step as the addition of another block. Look at the instruction tables below. Do they produce the same LEGO tower? In other words, does order matter?



Block	Color	Size	Orientation	X	Y
0	Red	2 x 4	Horizontal	0	0
1	Yellow	2 x 3	Vertical	0	2
2	Black	2 x 2	Horizontal	1	1

Block	Color	Size	Orientation	X	Y
0	Black	2 x 2	Horizontal	1	1
1	Yellow	2 x 3	Vertical	0	2
2	Red	2 x 4	Horizontal	0	0

Color	
Red	001
Yellow	010
Black	011

Size	
2 x 2	010010
2 x 3	010011
2 x 4	010100

Orientation	
Horizontal	00
Vertical	01

Numbers	
1	001
2	010
3	011
4	100
5	101
6	110

Here's a legend for the encoding we've been using to convert our regular instruction table to a *binary* instruction table.

You've already converted the color, size, orientation, and position. Now convert the block number from base 10 to binary.

Block	Color	Size	Orientation	X	Y
0	Red	2 x 4	Horizontal	0	0
1	Yellow	2 x 3	Vertical	0	2
2	Black	2 x 2	Horizontal	1	1

Block	Color	Size	Orientation	X	Y
000	001	010100	00	000	000
001	010	010011	01	000	010
010	011	010010	00	001	001

Now you have a complete binary instruction table!

Activity: Building the Encoding

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Color	
Red	001
Yellow	010
Black	011

Size	
2 x 2	010010
2 x 3	010011
2 x 4	010100

Orientation	
Horizontal	00
Vertical	01

Numbers	
1	001
2	010
3	011
4	100
5	101
6	110

Here's an encoded instruction table for a small LEGO tower. Can you figure out what this tower is supposed to look like?
Hint: first, *decode* the instruction table using the legend on the left, and then follow the instructions to recreate the tower.

Block	Color	Size	Orientation	X	Y
0000	010	010010	01	000	000
0001	001	010010	01	011	000
0010	001	010011	00	001	000
0011	010	010011	00	001	000

Block	Color	Size	Orientation	X	Y
0	Yellow	010010	01	000	000
1	Red	010010	01	011	000
2	Red	010011	00	001	000
3	Yellow	010011	00	001	000