Binary #MicDropMath – Build Your Own Cards

Find all related files to print and videos for this lesson here:
https://stemazing.org/binary-mic-drop-math-build-your-own-cards/

Recommended Order of Binary #MicDropMath Lessons:

While all these lessons can stand on their own, in a perfect world with eons of time to engage students, the following would be the recommended sequence:

- Binary #MicDropMath Patterns
- Binary #MicDropMath Build Your Own Cards
- Binary #MicDropMath Multiply This
- Human Computers – Creative Message Communication

These can all be found here: https://stemazing.org/binary-mic-drop-math-lessons/

This lesson will demonstrate to students how to make the binary #MicDropMath cards. A common question when engaging students with the Binary #MicDropMath is: "Why are those numbers on the cards?" In this lesson, they will start with blank cards and put the numbers on the cards so they understand the numbers are not random. The numbers on each card are the numbers which have that place value turned on to a 1 in the binary system.

NOTE: The terms "magic" and "trick" are purposely being avoided. This is not magic, it is beautiful mathematics. Using a term like "math magic" implies a mysticism or mystery related to math, which we want to avoid. Historically, math tricks represent numerous shortcuts which undermine student number sense and conceptual understanding. Everyone can learn and understand math. There is no magic to it! We are adopting the term "Mic Drop Math" in place of magic and trick, and we hope you will do the same.

Materials:
A set of blank cards, the Binary Numbers 0-31 worksheet, and the 0, 1 and 1, 2, 4, 8, 16 number lines for each student.
Marker
Scissors

Engage:
You may have already done the Binary #MicDropMath Patterns lesson, in which case, students should be ready to tackle the "why" behind how it works. You could also start with this lesson and then do the other. At any rate, you should remind students about the binary number system as well as positional notation. It might be helpful to watch the video explaining the binary system again. Show this video until 3:45 when it becomes an advertisement for the sponsor: https://bit.ly/BinaryNumbersFast

PIMA COUNTY
SCHOOL SUPERINTENDENT

Binary Numbers – a numeral base system which uses only two numbers – 1 and 0

Numeral Base Systems – systems which uses only the digits 0-9 or a subset of those digits to represent different values – examples are base 10 (which we use every day), base 2 or binary which uses just two values, but there are also base three, base four, and so on.

Explore:

You should have students cut out the blank set of cards along the dotted lines and set up the number lines as shown in the picture below. It helps to tape the 0, 1 and 1, 2, 4, 8, 16 number lines down to the table. The blank cards should be left free to move.
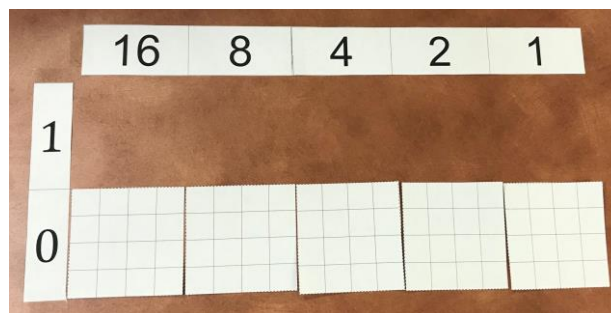
On the Binary Numbers 0-31 worksheet, students should write 00000 next to the 0 = indicating that 00000 is used to represent the value of zero in binary. Students can also be reminded about positional notation here. They should note that in our base ten system, the first five positions would the ones, tens, hundreds, thousands, and ten thousands. You can also note that it is called base 10 because each position is 10 to the next highest power – $10^0 = 1$, $10^1 = 10$, $10^2 = 100$, $10^3 = 1,000$, $10^4 = 10,000$, and so on. Shown below with ones place on the right and each new position to the left.

Base 10 – Decimal Number System

10^4	10^3	10^2	10^1	10^0
10,000s	1,000s	100s	10s	1s

In the binary number system, because we are only using two symbols, 0 and 1, and not all ten digits, the positions now represent the following values and increase in value from right to left, just as they do the in base 10 system we most frequently use. This time, because we are using base 2 (two symbols), the positional values can be determined by increasing the power of 2 like this – $2^0 = 1$, $2^1 = 2$, $2^2 = 4$, $2^3 = 8$, $2^4 = 16$, and so on. They are listed with the ones place on the right and each new position to the left like this:

Base 2 – Binary Number System

2^4	2^3	2^2	2^1	2^0
16	8	4	2	1

In order to represent a value of 1, we need to turn the first position in the binary number system on to a 1 so it counts. Students should shift the blank card on the right to the "on" or 1 location and write the number 1 in the first square on the blank card as shown below.
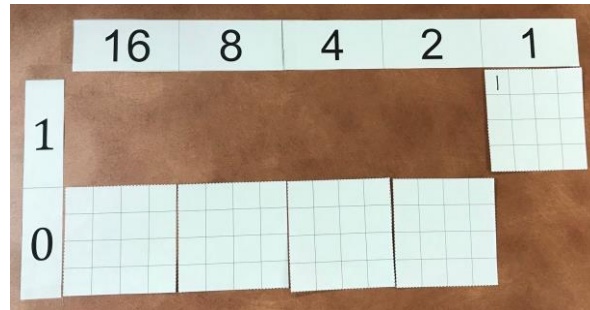

Students should also record the binary number 00001 on their Binary Numbers 0-31 worksheet.

To represent a value of 2, the card in position 1 needs to be turned "off" or moved back to the 0 location and the card in position 2 should be turned "on" or moved to the 1 location, as shown in the image below. The number 2 should be written in the first square on the blank card in position 2 as shown. Students should record the binary number 00010 on their Binary Numbers worksheet for 2 =.
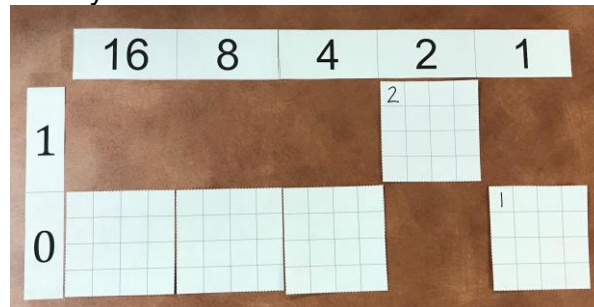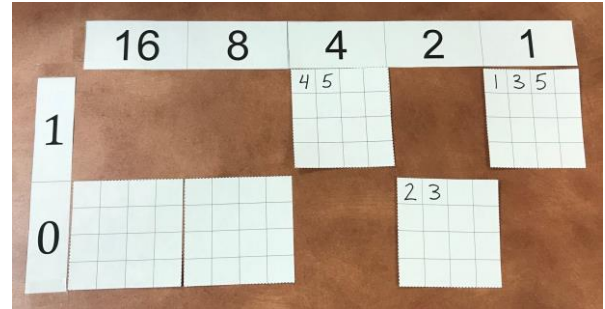

To represent a value of 3, the cards in positions 1 + 2 need to be turned "on" or moved to the 1 location and the number 3 should be written in the next blank square on BOTH cards as shown below. Students should record the binary number 00011 on their Binary Numbers worksheet for 3 =.
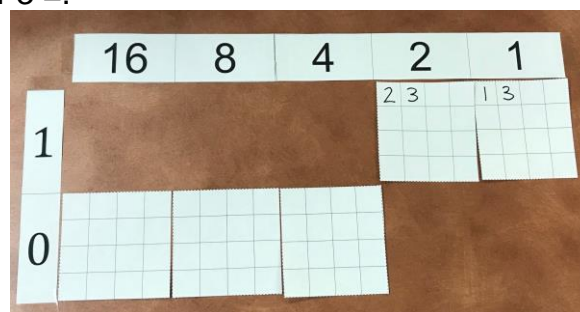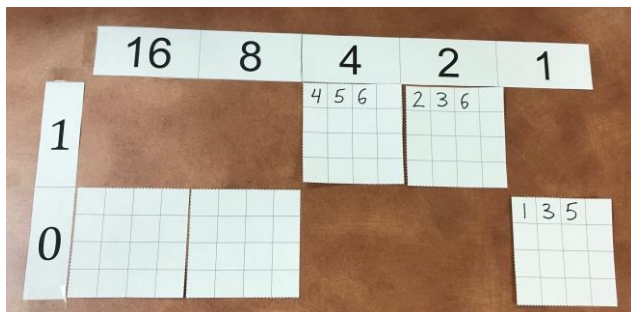
And so it should continue with students working their way through the values 0-31 until the cards are completely filled. Examples up to the value of 10 are shown below along with the Binary Numbers worksheet filled out for the first 10 numbers.
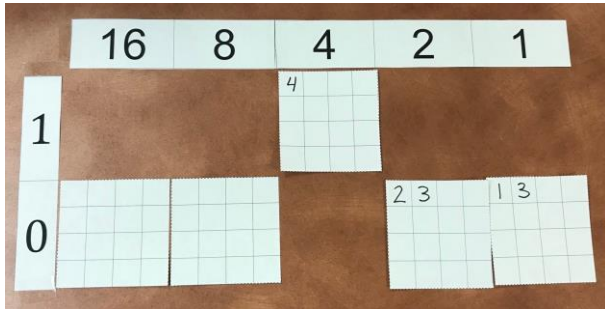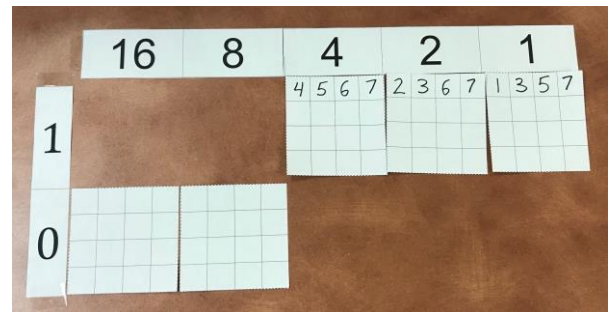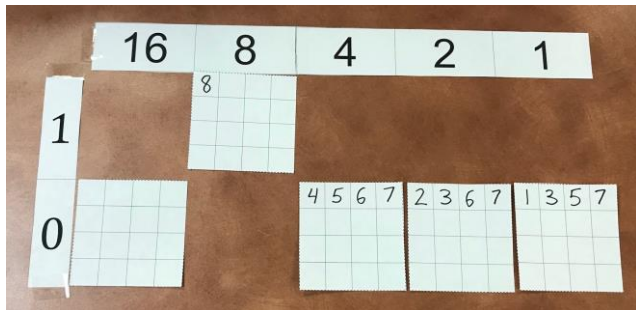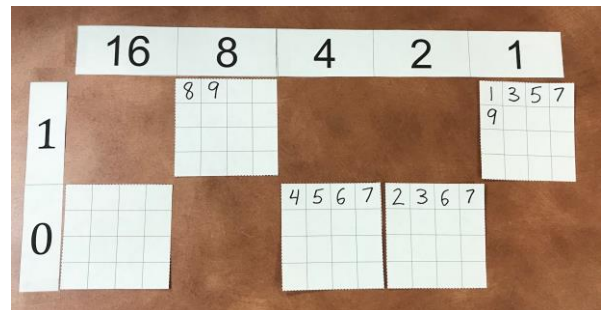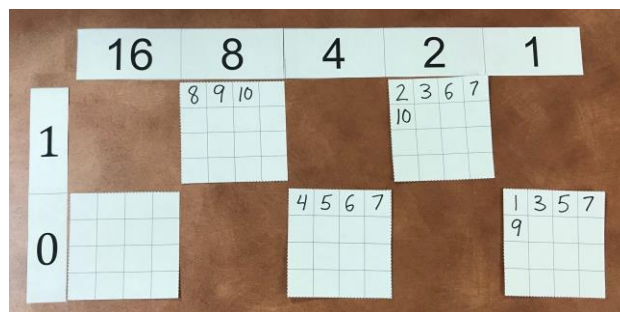

4 = 00100

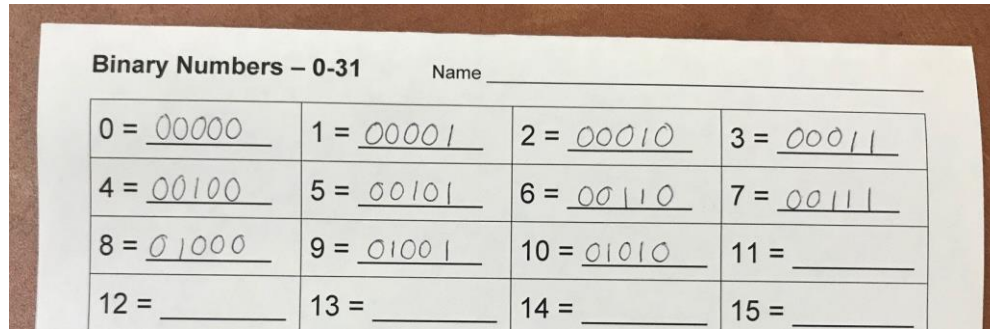4 + 1 = 5 = 00101

4 + 2 = 6 = 00110

4 + 2 + 1 = 7 = 00101

8 = 01000

8 + 1 = 9 = 01001

8 + 2 = 10 = 01010

Binary Numbers – 0-31   Name _____

0 = 00000	1 = 00001	2 = 00010	3 = 00011
4 = 00100	5 = 00101	6 = 00110	7 = 00111
8 = 01000	9 = 01001	10 = 01010	11 = _____
12 = _____	13 = _____	14 = _____	15 = _____

Students should continue filling out the cards until they are all full of numbers. The last number to go in the bottom right square of each blank card should be 31.

After they have this complete set of cards filled out, you can share with them a pattern they may have overlooked. This pattern can make building future card sets that include more numbers much more efficient.

Write down the following numbers on the board and ask students to write them in their journals:

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

For the first card, ask students to cross out numbers which do not appear on the first card in the first row. Cross out the numbers which do not appear on the second card in the second row. Third card, third row and fourth card, fourth row – same directions.

This is what they should see:

1   ~~0~~ 1 ~~2~~ 3 ~~4~~ 5 ~~6~~ 7 ~~8~~ 9 ~~10~~ 11 ~~12~~ 13 ~~14~~ 15 ~~16~~

2   ~~0~~ ~~1~~ 2 3 ~~4~~ ~~5~~ 6 7 ~~8~~ ~~9~~ 10 11 ~~12~~ ~~13~~ 14 15 ~~16~~

4   ~~0~~ ~~1~~ ~~2~~ ~~3~~ 4 5 6 7 ~~8~~ ~~9~~ ~~10~~ ~~11~~ 12 13 14 15 ~~16~~

8   ~~0~~ ~~1~~ ~~2~~ ~~3~~ ~~4~~ ~~5~~ ~~6~~ ~~7~~ 8 9 10 11 12 13 14 15 ~~16~~

Ask students if they can describe in one or two sentences, the pattern established above? How could you generalize the rule to each new card you might want to add to your set? Does this pattern hold true for the six-card 0-63 version of this #MicDropMath? (You will find a PowerPoint version of the above pattern at the end of the presentation for this lesson found here: https://stemazing.org/binary-mic-drop-math-build-your-own-cards/)

Explain:
The students should now be able to explain why all the numbers are on each card. In a nutshell, those are the numbers for which that position in the binary number system is turned "on" or a 1 to make that value. For instance, 13 shows up on the 8, 4, and 1 position cards because 8 + 4 + 1 = 13. This leads directly into the how the #MicDropMath works.

Use the Binary #MicDropMath lesson to have students notice and wonder about the patterns they see on the cards. Then, show them how to do the #MicDropMath to determine a number someone is thinking of between 1-31 using the 0-31 cards they built or printing out the ready-made cards.

Explore:
For further exploration, you can challenge students to come up with a simple rule about how to increase a binary number by 1. There is a simple rule, which can be expressed in one sentence, to explain what you would do to increase the number by 1. This involves looking at patterns to figure out what this simple rule might be.

SPOILER ALERT: The rule is this – To increase a binary by one, simply start at the first position on the right and switch cards from 0 to 1 and 1 to 0 until you reach a position which was initially at 0 and you moved it up to 1. At that point, STOP. You now have the next highest integer.

Students can also be challenged with creating the cards 0-63 and 0-127. Templates for the setup and blank cards for these sets are included below. These represent the first six positions in binary and the first seven positions in binary.

Other ways to engage students with binary numbers include:

- Can you figure out how to add two binary numbers together?
- Can you figure out how to subtract two binary numbers?
- What happens when you multiply two binary numbers? Is there a simple way to explain how to get the product?
- What happens when you divide two binary numbers? Is there a simple way to explain how to get the quotient?
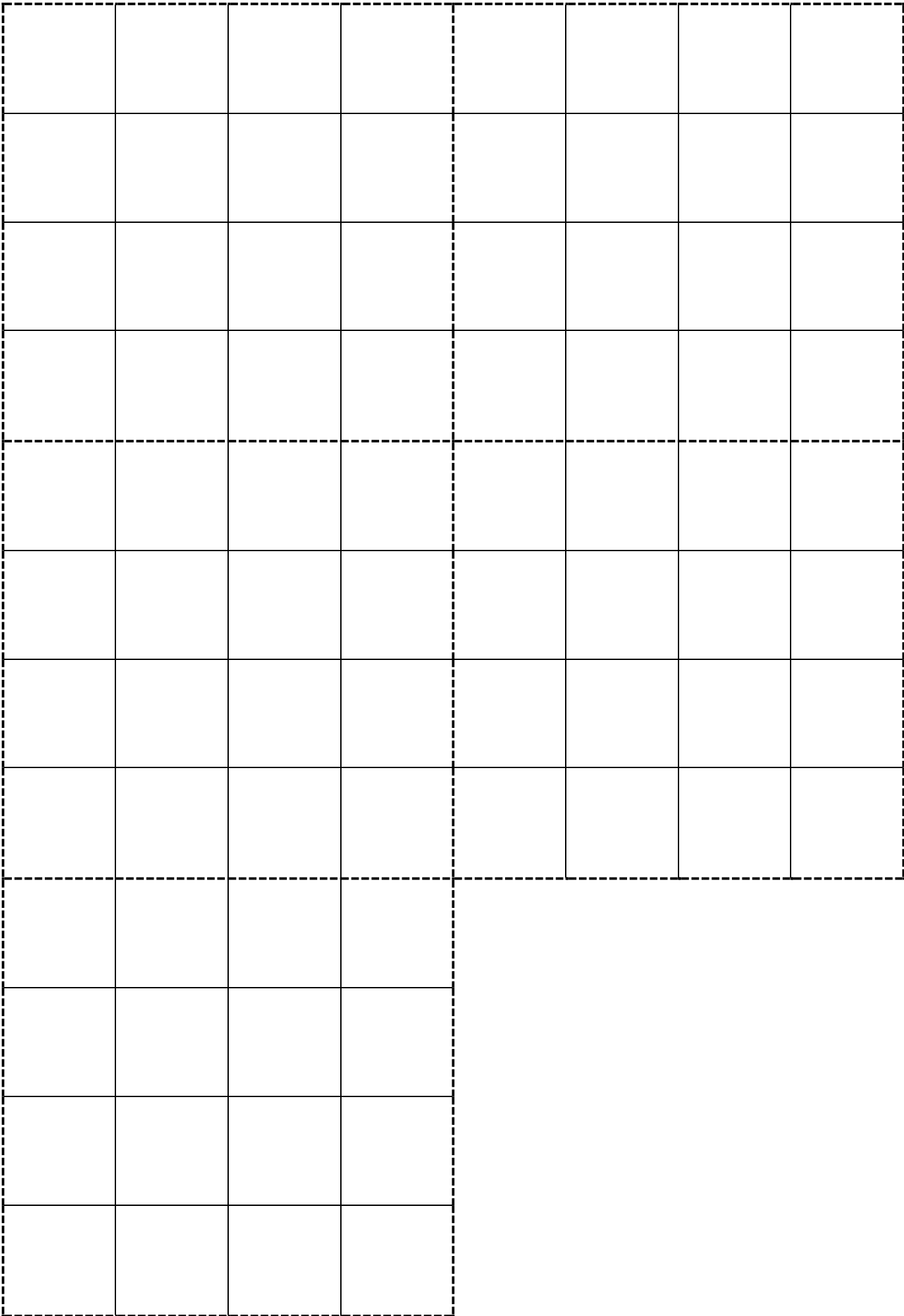
Here is a good resource for the binary arithmetic above: https://ryanstutorials.net/binary-tutorial/binary-arithmetic.php

Binary Numbers – 0-31

Name _____

0 = _____	1 = _____	2 = _____	3 = _____
4 = _____	5 = _____	6 = _____	7 = _____
8 = _____	9 = _____	10 = _____	11 = _____
12 = _____	13 = _____	14 = _____	15 = _____
16 = _____	17 = _____	18 = _____	19 = _____
20 = _____	21 = _____	22 = _____	23 = _____
24 = _____	25 = _____	26 = _____	27 = _____
28 = _____	29 = _____	30 = _____	31 = _____

Binary Numbers – 0-31

Name _____

0 = _____	1 = _____	2 = _____	3 = _____
4 = _____	5 = _____	6 = _____	7 = _____
8 = _____	9 = _____	10 = _____	11 = _____
12 = _____	13 = _____	14 = _____	15 = _____
16 = _____	17 = _____	18 = _____	19 = _____
20 = _____	21 = _____	22 = _____	23 = _____
24 = _____	25 = _____	26 = _____	27 = _____
28 = _____	29 = _____	30 = _____	31 = _____

4	2	1
16	8	
1	0	

Binary Numbers: 0-63

Name _____

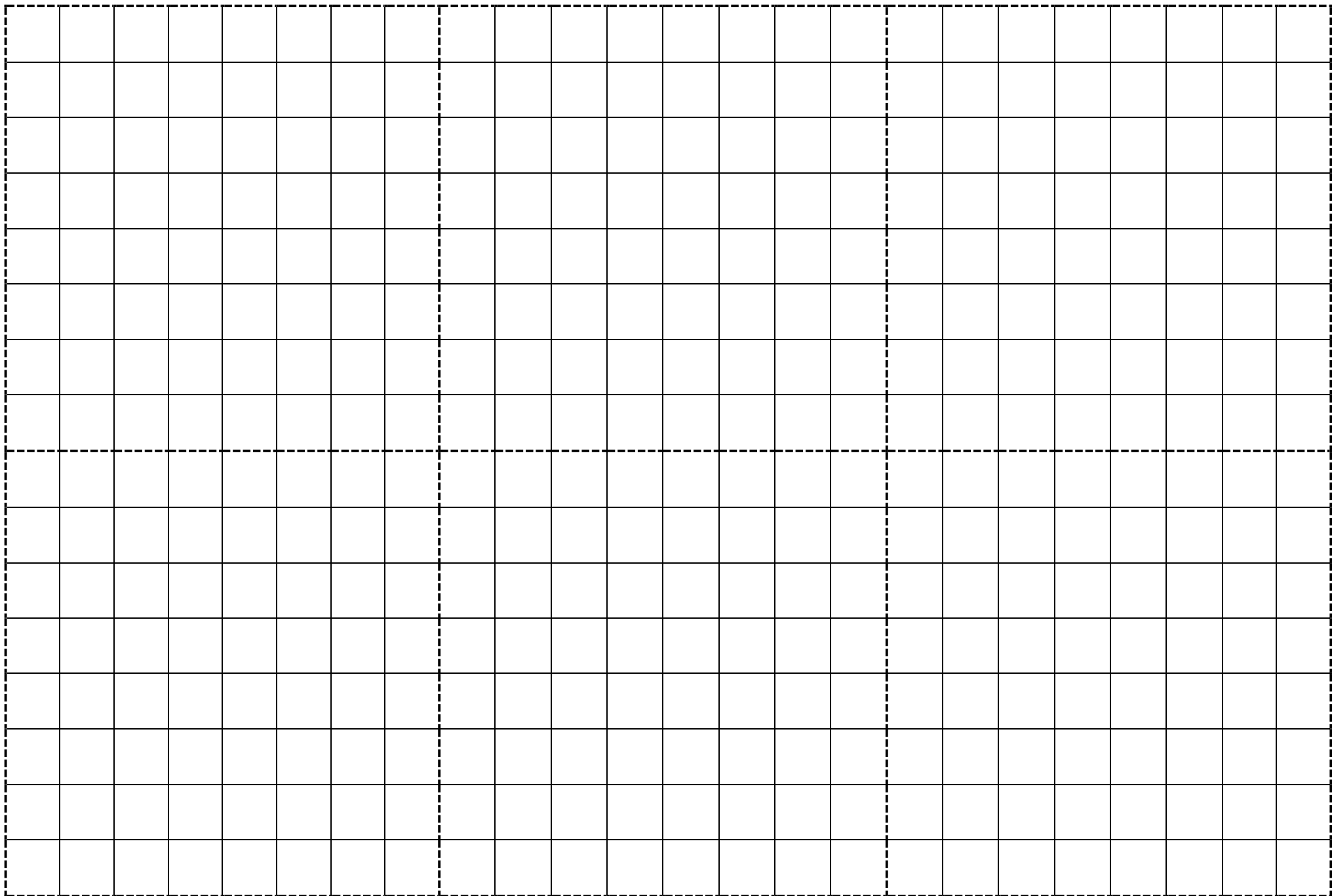| 0 = _____	1 = _____	2 = _____	3 = _____	4 = _____
5 = _____	6 = _____	7 = _____	8 = _____	9 = _____
10 = _____	11 = _____	12 = _____	13 = _____	14 = _____
15 = _____	16 = _____	17 = _____	18 = _____	19 = _____
20 = _____	21 = _____	22 = _____	23 = _____	24 = _____
25 = _____	26 = _____	27 = _____	28 = _____	29 = _____
30 = _____	31 = _____	32 = _____	33 = _____	34 = _____
35 = _____	36 = _____	37 = _____	38 = _____	39 = _____
40 = _____	41 = _____	42 = _____	43 = _____	44 = _____
45 = _____	46 = _____	47 = _____	48 = _____	49 = _____
50 = _____	51 = _____	52 = _____	53 = _____	54 = _____
55 = _____	56 = _____	57 = _____	58 = _____	59 = _____
60 = _____	61 = _____	62 = _____	63 = _____	64 = _____

Can you guess 64?
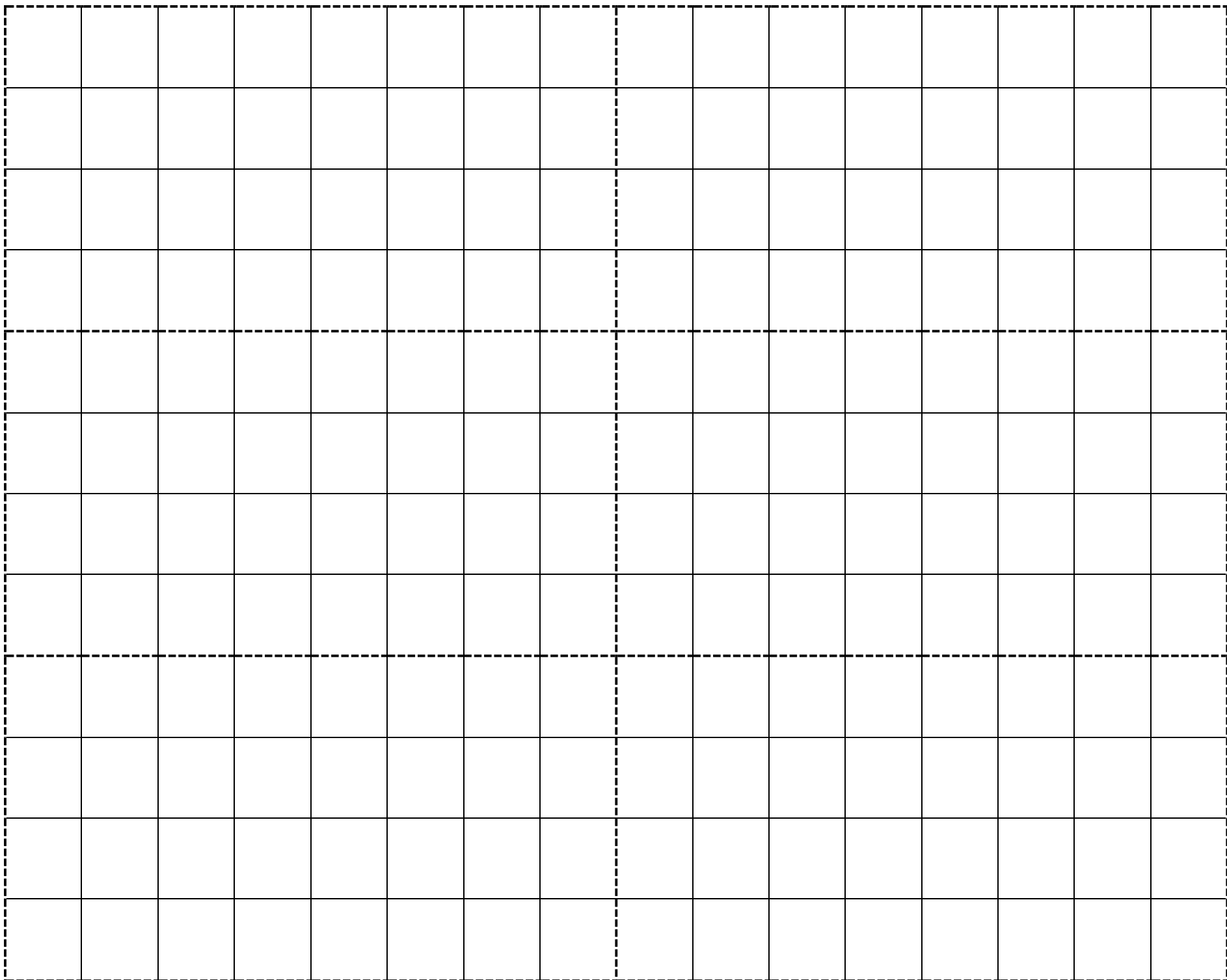
2	1
8	4
32	16

1	0

Binary Numbers: 0-127

Name _____

0 = _____	1= _____	2 = _____	3 = _____	4 = _____	5 = _____	6 = _____
7 = _____	8 = _____	9 = _____	10 = _____	11 = _____	12 = _____	13 = _____
14 = _____	15 = _____	16 = _____	17 = _____	18 = _____	19 = _____	20 = _____
21 = _____	22 = _____	23 = _____	24 = _____	25 = _____	26 = _____	27 = _____
28 = _____	29 = _____	30 = _____	31 = _____	32 = _____	33 = _____	34 = _____
35 = _____	36 = _____	37 = _____	38 = _____	39 = _____	40 = _____	41 = _____
42 = _____	43 = _____	44 = _____	45 = _____	46 = _____	47 = _____	48 = _____
49 = _____	50 = _____	51 = _____	52 = _____	53 = _____	54 = _____	55 = _____
56 = _____	57 = _____	58 = _____	59 = _____	60 = _____	61 = _____	62 = _____
63 = _____	64 = _____	65 = _____	66 = _____	67 = _____	68 = _____	69 = _____
70 = _____	71 = _____	72 = _____	73 = _____	74 = _____	75 = _____	76 = _____
77 = _____	78 = _____	79 = _____	80 = _____	81 = _____	82 = _____	83 = _____
84 = _____	85 = _____	86 = _____	87 = _____	88 = _____	89 = _____	90 = _____
91 = _____	92 = _____	93 = _____	94 = _____	95 = _____	96 = _____	97 = _____
98 = _____	99 = _____	100 = _____	101 = _____	102 = _____	103 = _____	104 = _____
105 = _____	106 = _____	107 = _____	108 = _____	109 = _____	110 = _____	111 = _____
112 = _____	113 = _____	114 = _____	115 = _____	116 = _____	117 = _____	118 = _____
119 = _____	120 = _____	121 = _____	122 = _____	123 = _____	124 = _____	125 = _____
126 = _____	127 = _____	128 = _____				

Can you guess 128?

4	2	1
32	16	8

64

1	0