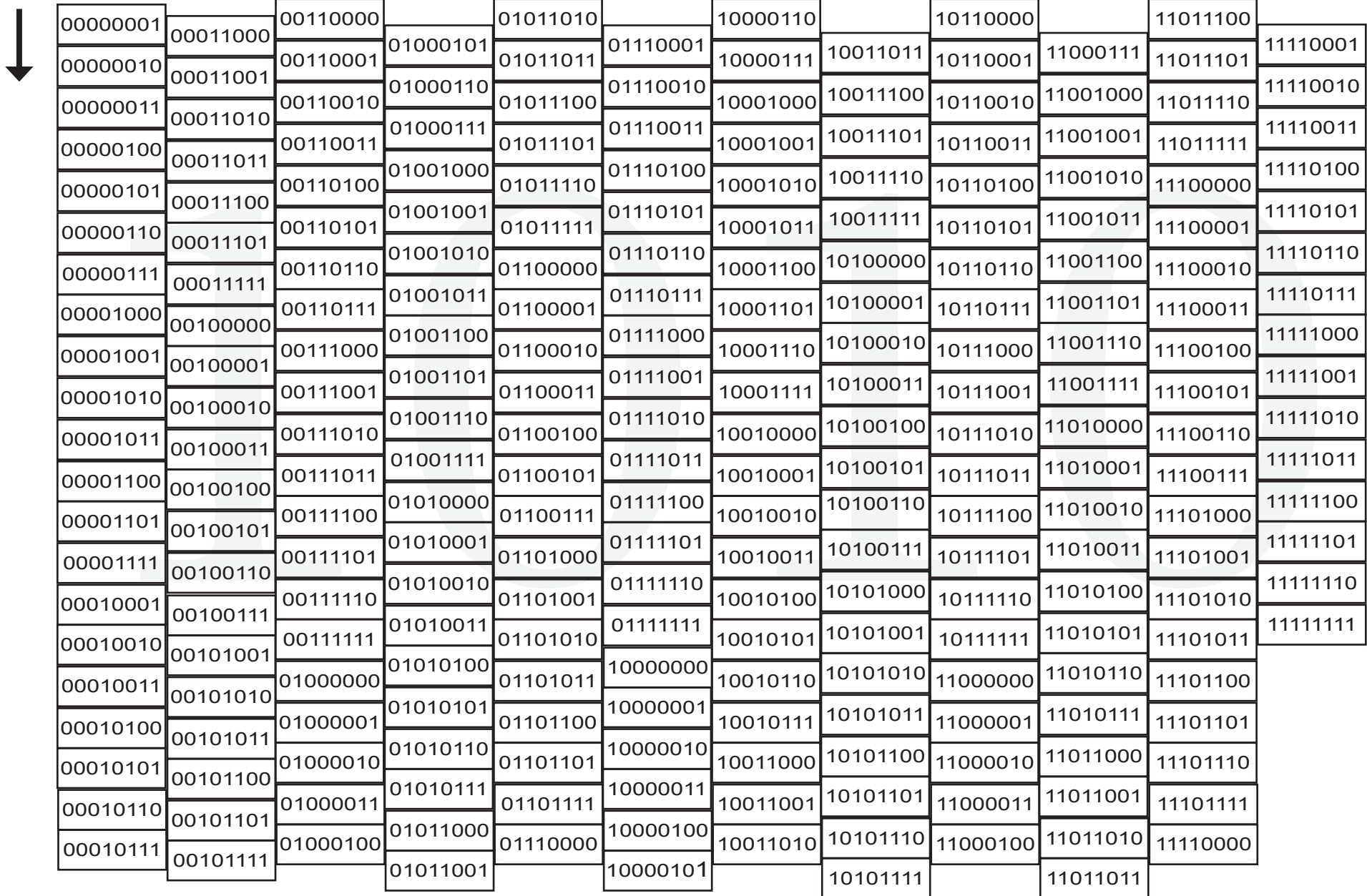


Count in the binary number system and convert to decimal numbers.

1010

Count in the binary number system and convert to decimal numbers.



0000001	00011000	00110000	01000101	01011010	10000110	10110000	11011100				
0000010	00011001	00110001	01000110	01011011	10000111	10011011	11011101				11110001
0000011	00011010	00110010	01000111	01011100	10001000	10011100	11011110				11110010
0000100	00011011	00110011	01001000	01011101	10001001	10011101	11011111				11110011
0000101	00011100	00110100	01001001	01011110	10001010	10011110	11001010				11110100
0000110	00011101	00110101	01001010	01011111	10001011	10011111	11001011				11110101
0000111	00011111	00110110	01001011	01100000	10001100	10100000	11001100				11110110
00001000	00100000	00110111	01001100	01100001	10001101	10100001	11001101				11110111
00001001	00100001	00111000	01001101	01100010	10001110	10100010	11001110				11111000
00001010	00100010	00111001	01001110	01100011	10001111	10100011	11001111				11111001
00001011	00100011	00111010	01001111	01100100	10010000	10100100	11010000				11111010
00001100	00100100	00111011	01010000	01100101	10010001	10100101	11010001				11111011
00001101	00100101	00111100	01010001	01100111	10010010	10100110	11010010				11111100
00001111	00100110	00111101	01010010	01101000	10010011	10100111	11010011				11111101
00010001	00100111	00111110	01010011	01101001	10010100	10101000	11010100				11111110
00010010	00101001	00111111	01010100	01101010	10010101	10101001	11010101				11111111
00010011	00101010	01000000	01010101	01101011	10000000	10101010	11000000				11101100
00010100	00101011	01000001	01010110	01101100	10000001	10101011	11000001				11101101
00010101	00101100	01000010	01010111	01101101	10000010	10101100	11000010				11101110
00010110	00101101	01000011	01010111	01101111	10000011	10101101	11000011				11101111
00010111	00101111	01000100	01011000	01110000	10000100	10101110	11000100				11110000
			01011001		10000101		11011011				

A Number Fairy Tale

This story is fiction. Any resemblance to any real number, historical or modern, is coincidental.

Once upon a time there was a king with ten very talented, very beautiful, and highly intelligent princesses. The first princess was named “One,” the second princess was named “Two,” the next was named “Three.” Then came “Four,” followed by “Five,” and after her came Princess “Six.” It may not surprise you to hear that “Six” was followed by “Seven,” and then of course came “Eight,” who was followed by “Nine.” And then came....Hold it....Stop. You see, the next daughter was the favorite of the royal father who decreed that no one was ever allowed to say her name. Nor were they allowed to write it. So whenever anyone in the kingdom was counting and they would get to “Nine,” they couldn’t go on. So they just decided they would start over again whenever they got past “Nine.” So after 9 comes 10. And after 99 comes 100. And after 999 comes 1000, because the people did not want to go to jail for saying or writing the tenth daughter’s name. Oops - I just said it.

Okay, enough fiction. This is NOT how we got our decimal system which, in fact, was a brilliant advancement from the Middle East which allowed the average person to calculate numbers far faster than an accountant using the old Roman Numeral system.

A Note About Number Systems

“Deci” means “ten” in Latin and may very well have been the name of the tenth princess in our story. The take home point is that the numbers repeat. We use a Base Ten number system, possibly because of ten fingers on the human hand. It seems so common and so obvious that it is hard to imagine any other number system. But for this lesson you will learn about two others.

Base Four

If we aren’t allowed to say or write the secret number following number 9 in the Base Ten system, then we can’t say or write the 4 in the Base Four system. We would count:

1,2,3,10, 11, 12, 13, 20, 21, 22, 23, 30, 31, 32, 33, 100, 101, 102, 103, 110, 111, 112, 113, 120, 121, 122, 123, etc.

The point is that you never reach the mysterious “four” but have to add another place value. Base Four doesn’t have a whole lot of practical value to the average person except that:

- Hypothetically recognize that Base Ten is not the only number system that can be used
- Makes it much faster if your mom sends you to your room to count to 1000 (you didn’t hear me say that.)
- Makes the binary number system a little more comprehensible. And the Binary System is VERY important. (Hint: computers use it.)

Counting In Base Four

Give a pile of small objects (like miniature M&M’s) and have them count outloud as fast as they can in Base Four. If they say “four” they are out. Then Mom gets the rest of the M&M’s.

Have Some More with Base Four

Your young math whizzes might like to have a little fun adding and subtracting in the Base Four system. Your super whizzes might even want to try their hand at multiplying and dividing. Now THAT takes commitment.

Introducing the Binary Number System

The binary system is Base Two. You can’t say or write the number that comes after number 1. Whoa, that doesn’t give you a whole lot of numbers now, does it? In fact all you have are two: the zero and the one. (In case you didn’t notice it, Base Ten has ten numbers counting zero, and Base Four has four numbers counting zero.)

So how do you count in Base Two

1
10
11
100
101
111

Let the student dictate as you write the numbers to one million. (Don’t worry, it doesn’t take too long. You might even stop at 100,000 if you get bored.)

Binary Number Information Pieces

Cut apart the Information Pieces for MatchCard #5 with the different binary numbers. Students place them in the correct order on the MatchCard or on a table top. The numbers are in order going down the page, not across. For students in 3rd & 4th grade you might just use one row of numbers. Use two or three rows for students in 5th or 6th grade. For younger students you may also cut off the leading zeros.

Binary Number Flash Cards

This next activity will indicate how a computer "reads" a binary number. You will use the eight flashcards included or you can make your own. Fold the cards so one side has a "0" and one side has a "1."

Give the student one of the numbers on the information piece. They have to lay out their card with the 0 or the 1 side facing up.

For instance the number 1011 would look like this:



On & Off

One can also think of the "1" as an "on" switch and a "0" as an off switch. The figure above would be:

On - Off - On - On

Counting in the Binary System

You will need the small counting objects like pennies or M&M's for this activity as well as the MatchCard Information Pieces. As an alternative to counting objects one could also use tally marks if the student is familiar with them.

Put one object on the table and the Information Piece that says "1."

Put two objects in a pile with the next number which is "10." This ten represents two objects in the binary system just as the digit 2 represent it in the decimal system.

Now put three objects in a pile with the "11." Eleven is the same as the quantity 3 in the decimal system.

Continue making piles of counters and identifying those numbers with the binary numerals on the Information Pieces.

From Bits to Bytes

In computer language a "bit" is one stroke - either the one or the zero. Each 1 is a bit and each 0 is a bit. The number to the left is composed of four bits.

A byte is a series of eight bits. The byte would be written as:

00001011

So what does that byte mean? It refers to the quantity of 11 in the decimal system. In the next activity we will learn how to convert between the two different systems.

Converting from Binary to Decimal

Use the other flashcards in the information pieces that have these numbers below the "1":

- 1
- 2
- 4
- 8
- 16
- 32
- 64
- 128

The index cards for 00101011 would look like:

0	0	1	0	1	0	1	1
		32		8		2	1

The binary number is the large number and the decimal number is the small number below. Make sure the decimal numbers are lined up largest to smallest with the largest numbers to the left or it won't work.

So what does this mean?

The binary number 101,011 is the same quantity as the decimal number 43 (32+8+2+1).

Decimal to Binary Game

You will need a set of ten-sided dice to play this game. Alternative: two sets of cards from one to ten. Taking two of each of the cards Ace to 9 from a standard deck of playing cards will work, though you won't have a zero.

Roll the two dice (or draw two cards.)

Write the number as a decimal number. Then use the binary cards you made (with the small decimal numbers beneath the one) and find what the number would be in the binary system.

For instance, the number 85 would be:

0	1	0	1	0	1	0	1
	64		16		4		1

How do you find 85 (or any other number?)

Starting on the left side find the first number that is smaller or equal to the decimal number you want to represent. Turn that number up. Go to the next number just to the right of the first number you turned up. If you add those two digits will the sum be larger than the decimal number you are trying to make? If no, turn it up. If yes, keep it at zero and go to the next number. Keep passing or turning up cards until you have the correct decimal number. The zero's and one's will give you your binary number.

Binary to Decimal Game

Randomly pull one of the binary information pieces and convert it into the decimal number. You can do it as a contest with two or more players. They each have ten cards, and whoever can correctly convert all ten cards to decimal the first wins.

Binary War

You will need both sets of the binary numbers cut apart. Each player will have one set. Put them in an envelope or bowl and mix them up. Each player shows one of their cards. Whoever has the largest number keeps both cards. You can play a designated number of rounds (for instance - 20 rounds.)

Binary Hot Potato

It helps to have four or more players for this game, though you can play it with only three. Use a small object for the "potato." Start by counting from one in the binary system and keep going as fast as you can. If you have a timer that goes off, the person holding the potato loses that round.

Binary Jump Rope

Just for fun, count in the binary system while jumping rope.

Binary MatchCard Review

So how do you do the weekly review with the binary cards? There are a few choices:

- You could have the student write numbers from 1 to 10,000 on a separate sheet of paper.
- You could have the information pieces cut into strips (instead of individual numbers) and place the strips in order.
- You could have the individual numbers cut apart, have the student randomly draw five of the numbers and write on a separate sheet of paper:

- 1: What number will come after it
- 2: Convert to decimal.



0000001 T-5	00011000	00110000 T-5	01000101	01011010 T-5	10000110 T-5	10110000 T-5	11011100 T-5	11110001 T-5
0000010 T-5	00011001	00110001 T-5	01000110	01011011 T-5	10000111 T-5	10011011 T-5	11011101 T-5	11110010 T-5
0000011 T-5	00011010	00110010 T-5	01000111	01011100 T-5	10001000 T-5	10011100 T-5	11011110 T-5	11110011 T-5
00000100 T-5	00011011	00110011 T-5	01001000	01011101 T-5	10001001 T-5	10011101 T-5	11011111 T-5	11110100 T-5
00000101 T-5	00011100	00110100 T-5	01001001	01011110 T-5	10001010 T-5	10011110 T-5	11011000 T-5	11110101 T-5
00000110 T-5	00011101	00110101 T-5	01001010	01011111 T-5	10001011 T-5	10011111 T-5	11011011 T-5	11110110 T-5
00000111 T-5	00011110	00110110 T-5	01001011	01100000 T-5	10001100 T-5	10100000 T-5	11011010 T-5	11110111 T-5
00001000 T-5	00011111	00110111 T-5	01001100	01100001 T-5	10001101 T-5	10100001 T-5	11011011 T-5	11110100 T-5
00001001 T-5	00100000	00111000 T-5	01001101	01100010 T-5	10001110 T-5	10100010 T-5	11011100 T-5	11110101 T-5
00001010 T-5	00100001	00111001 T-5	01001110	01100011 T-5	10001111 T-5	10100011 T-5	11011101 T-5	11110110 T-5
00001011 T-5	00100010	00111010 T-5	01001111	01100100 T-5	10010000 T-5	10100100 T-5	11010000 T-5	11110111 T-5
00001100 T-5	00100011	00111011 T-5	01010000	01100101 T-5	10010001 T-5	10100101 T-5	11010001 T-5	11111000 T-5
00001101 T-5	00100100	00111100 T-5	01010001	01100110 T-5	10010010 T-5	10100110 T-5	11010010 T-5	11111001 T-5
00001110 T-5	00100101	00111101 T-5	01010010	01101000 T-5	10010011 T-5	10100111 T-5	11010011 T-5	11111010 T-5
00001111 T-5	00100110	00111110 T-5	01010011	01101001 T-5	10010100 T-5	10101000 T-5	11010100 T-5	11111011 T-5
00010000 T-5	00100111	00111111 T-5	01010100	01101010 T-5	10010101 T-5	10101001 T-5	11010101 T-5	11111100 T-5
00010001 T-5	00101000	01000000 T-5	01010101	01101011 T-5	10000000 T-5	10101010 T-5	11010110 T-5	11111101 T-5
00010010 T-5	00101001	01000001 T-5	01010110	01101100 T-5	10000001 T-5	10101011 T-5	11010111 T-5	11111110 T-5
00010011 T-5	00101010	01000010 T-5	01010111	01101101 T-5	10000010 T-5	10101100 T-5	11011000 T-5	11111111 T-5
00010100 T-5	00101011	01000011 T-5	01011000	01101110 T-5	10000011 T-5	10101101 T-5	11011001 T-5	
00010101 T-5	00101100	01000100 T-5	01011001	01110000 T-5	10000100 T-5	10101110 T-5	11011010 T-5	
00010110 T-5	00101101		01011010		10000101 T-5			
00010111 T-5	00101111							

1	1	1	1	1	1	1	1
fold →							
0	0	0	0	0	0	0	0
T-5	T-5	T-5	T-5	T-5	T-5	T-5	T-5

1	1	1	1	1	1	1	1
128	64	32	16	8	4	2	1
fold →							
0	0	0	0	0	0	0	0
T-5	T-5	T-5	T-5	T-5	T-5	T-5	T-5



00000001	00011000	00110000	01000101	01011010	01110001	10000110	10011011	10110000	11000111	11011100	11110001
00000010	00011001	00110001	01000110	01011011	01110010	10000111	10011100	10110001	11001000	11011101	11110010
00000011	00011010	00110010	01000111	01011100	01110011	10001000	10011101	10110010	11001001	11011110	11110011
00000100	00011011	00110011	01001000	01011101	01110100	10001001	10011110	10110011	11001010	11011111	11110100
00000101	00011100	00110100	01001001	01011110	01110101	10001010	10011111	10110100	11001011	11100000	11110101
00000110	00011101	00110101	01001010	01011111	01110110	10001011	10011111	10110101	11001011	11100001	11110110
00000111	00011111	00110110	01001011	01100000	01110111	10001100	10100000	10110110	11001100	11100010	11110111
00001000	00100000	00110111	01001100	01100001	01110111	10001101	10100001	10110111	11001101	11100011	11111000
00001001	00100001	00111000	01001101	01100010	01111000	10001110	10100010	10111000	11001110	11100100	11111001
00001010	00100010	00111001	01001110	01100011	01111001	10001111	10100011	10111001	11001111	11100101	11111010
00001011	00100011	00111010	01001111	01100100	01111010	10010000	10100100	10111010	11010000	11100110	11111011
00001100	00100100	00111011	01001000	01100101	01111011	10010001	10100101	10111011	11010001	11100111	11111100
00001101	00100101	00111100	01010000	01100111	01111100	10010010	10100110	10111100	11010010	11101000	11111101
00001111	00100110	00111101	01010001	01101000	01111101	10010011	10100111	10111101	11010011	11101001	11111110
00010001	00100111	00111110	01010010	01101001	01111110	10010100	10101000	10111110	11010100	11101010	11111111
00010010	00101001	00111111	01010011	01101010	01111111	10010101	10101001	10111111	11010101	11101011	
00010011	00101010	01000000	01010100	01101011	10000000	10010110	10101010	11000000	11010110	11101100	
00010100	00101011	01000001	01010101	01101100	10000001	10010111	10101011	11000001	11010111	11101101	
00010101	00101100	01000010	01010110	01101101	10000010	10011000	10101100	11000010	11011000	11101110	
00010110	00101101	01000011	01010111	01101111	10000011	10011001	10101101	11000011	11011001	11101111	
00010111	00101111	01000100	01011000	01110000	10000100	10011010	10101110	11000100	11011010	11110000	
			01011001		10000101		10101111		11011011		