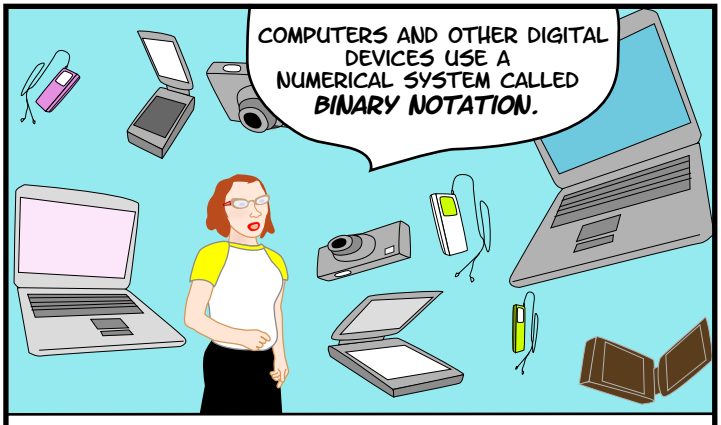
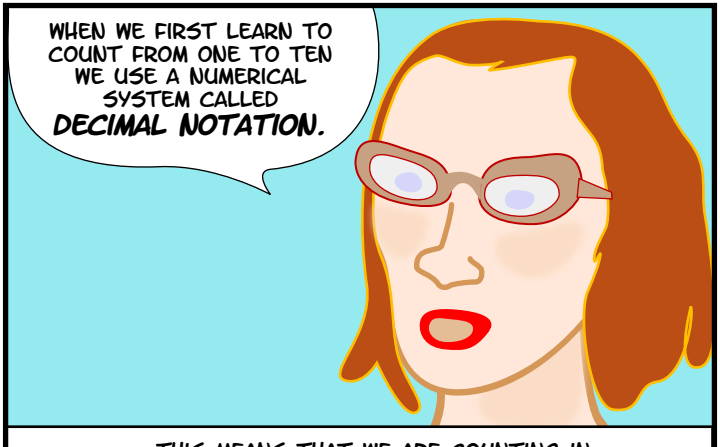
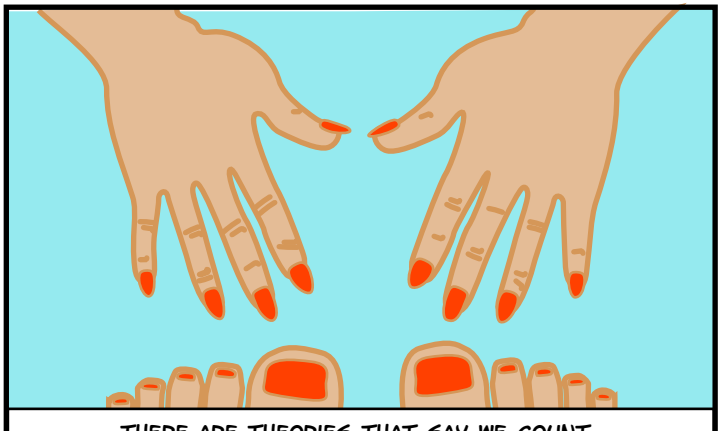
COUNTING in BINARY



SOME ELECTRONIC EQUIPMENT KEEPS TRACK OF INFORMATION BY USING TWO POSSIBLE STATES OF VOLTAGE– ON OR OFF, 1 OR 0.



THIS MEANS THAT WE ARE COUNTING IN A SYSTEM THAT IS BASED ON TEN SYMBOLS.



THERE ARE THEORIES THAT SAY WE COUNT IN MULTIPLES OF TEN BECAUSE HUMAN BEINGS HAVE TEN FINGERS AND TEN TOES.

0 1 2 3 4 5 6 7 8 9

TEN SYMBOLS IN BASE 10

DECIMAL NOTATION IS ALSO CALLED **BASE 10** BECAUSE THERE ARE TEN SYMBOLS.

OCTAL:
BASE 8

EIGHT SYMBOLS:
01234567

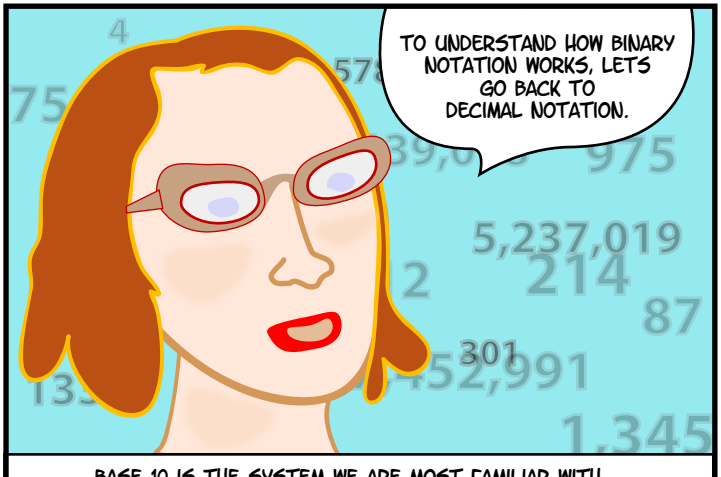
HEXADECIMAL:
BASE 16

SIXTEEN SYMBOLS:
0123456789ABCDEF

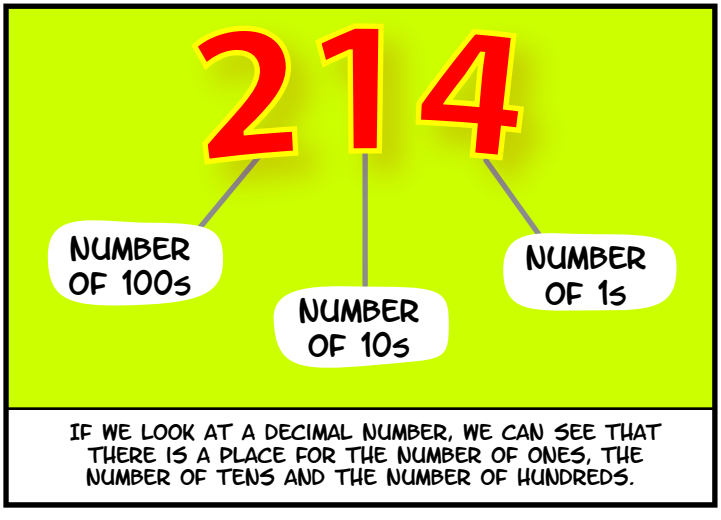
THERE ARE OTHER WAYS OF COUNTING THAT ARE COMMONLY USED IN COMPUTING- **OCTAL** & **HEXADECIMAL**.

0 1

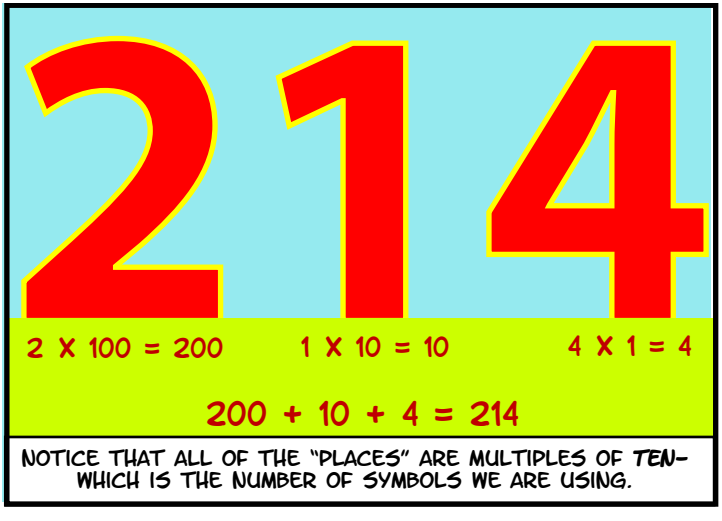
BINARY NOTATION (ALSO CALLED **BASE 2**) USES TWO SYMBOLS - **0** AND **1** - TO REPRESENT ALL POSSIBLE NUMBERS



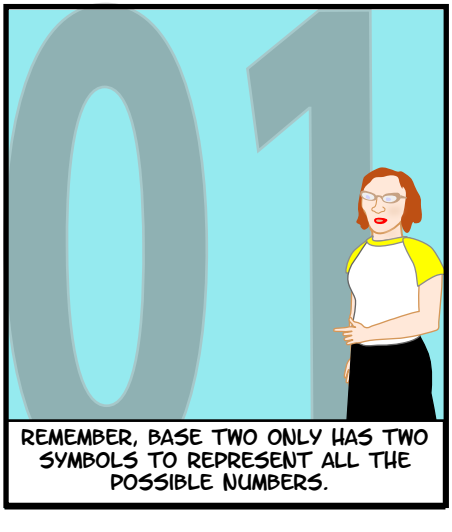
BASE 10 IS THE SYSTEM WE ARE MOST FAMILIAR WITH.



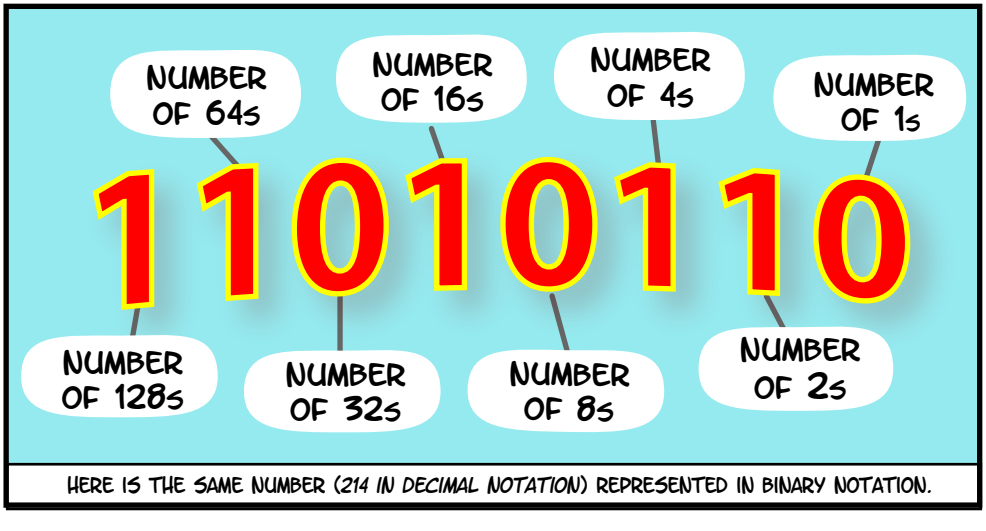
IF WE LOOK AT A DECIMAL NUMBER, WE CAN SEE THAT THERE IS A PLACE FOR THE NUMBER OF ONES, THE NUMBER OF TENS AND THE NUMBER OF HUNDREDS.



NOTICE THAT ALL OF THE "PLACES" ARE MULTIPLES OF *TEN*- WHICH IS THE NUMBER OF SYMBOLS WE ARE USING.



REMEMBER, BASE TWO ONLY HAS TWO SYMBOLS TO REPRESENT ALL THE POSSIBLE NUMBERS.



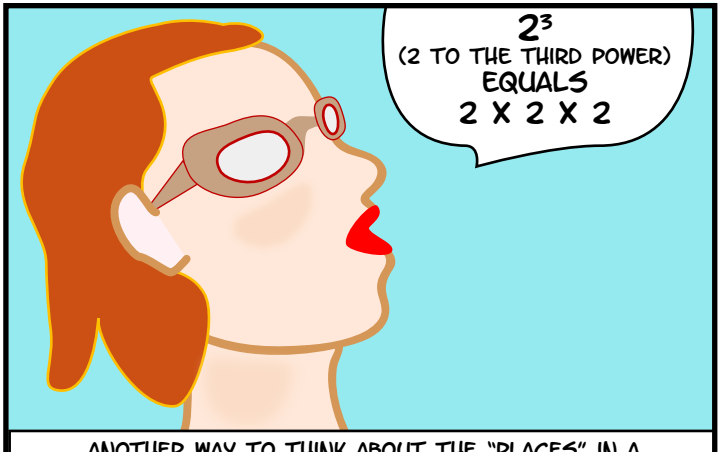
HERE IS THE SAME NUMBER (*214 IN DECIMAL NOTATION*) REPRESENTED IN BINARY NOTATION.

1 1 0 1 0 1 1 0

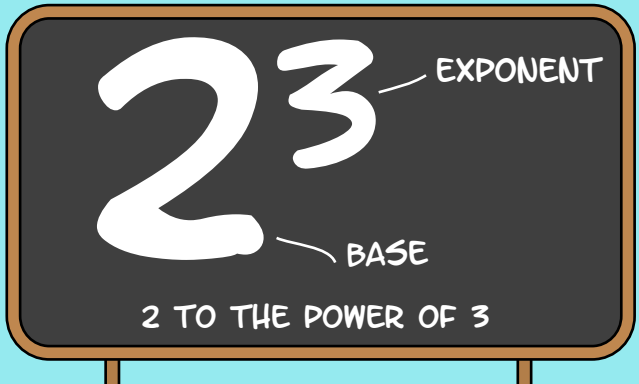
128 X 1 = 128 64 X 1 = 64 32 X 0 = 0 16 X 1 = 16 8 X 0 = 0 4 X 1 = 4 2 X 1 = 2 0 X 1 = 0

128 + 64 + 0 + 16 + 0 + 4 + 2 + 0 = 214

IN THIS CASE, ALL OF THE "PLACES" ARE MULTIPLES OF ***TWO*** – THE NUMBER OF SYMBOLS WE USE IN ***BINARY NOTATION***.



ANOTHER WAY TO THINK ABOUT THE "PLACES" IN A NUMERICAL SYSTEM IS TO USE ***EXPONENTS***.



THE ***BASE*** IS THE ***NUMBER*** THAT WILL BE MULTIPLIED BY ITSELF, THE ***EXPONENT*** IS THE NUMBER OF ***TIMES*** IT WILL BE MULTIPLIED.

1 1 0 1 0 1 1 0

$2^7 \times 1$ $2^6 \times 1$ $2^5 \times 0$ $2^4 \times 1$ $2^3 \times 0$ $2^2 \times 1$ $2^1 \times 1$ $2^0 \times 0$

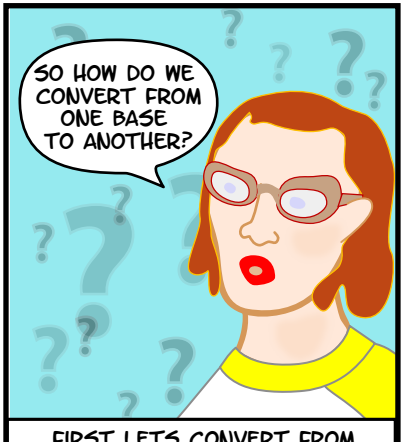
128 64 0 16 0 4 2 0

2 1 4

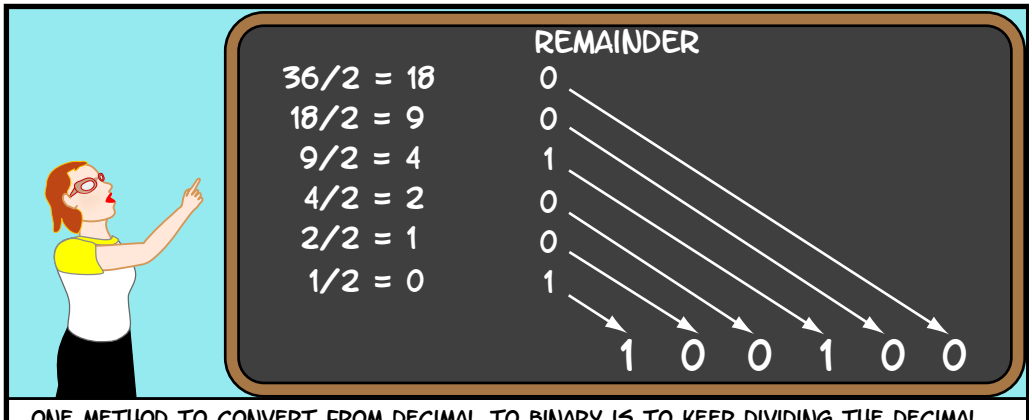
$10^2 \times 2$ $10^1 \times 1$ $10^0 \times 4$

200 10 4

HERE IS THE NUMBER IN BOTH BINARY AND DECIMAL, WITH THE EXPONENT VALUE AT EACH OF THE "***PLACES***".



FIRST LETS CONVERT FROM DECIMAL TO BINARY- WE'LL START WITH **36**.



ONE METHOD TO CONVERT FROM DECIMAL TO BINARY IS TO KEEP DIVIDING THE DECIMAL NUMBER BY **2**, KEEPING TRACK OF THE ***REMAINDER*** OF THE DIVISION. THE REMAINDER (ALWAYS A **0** OR **1**) MOVES FROM RIGHT TO LEFT, TO THE LEAST SIGNIFICANT PLACE AVAILABLE.

THERE'S A 1 AT THE "PLACE" FOR 32 AND A 1 AT THE "PLACE" FOR 4.

POWERS OF 2:	2^5	2^4	2^3	2^2	2^1	2^0
DECIMAL VALUE:	32	16	8	4	2	1
BINARY VALUE OF DECIMAL 36:	1	0	0	1	0	0

LET'S LOOK AT THE RELATIONSHIPS OF THE *POWERS OF 2* TO THE *DECIMAL VALUES* & SEE HOW THEY RELATE TO OUR NUMBER.

(SUBTRACT 2^5 FROM 36)	36−32 = 4	1
(CAN'T SUBTRACT 2^4 FROM 4)	4−16	0
(CAN'T SUBTRACT 2^3 FROM 4)	4−8	0
(SUBTRACT 2^2 FROM 4)	4−4 = 0	1
(CAN'T SUBTRACT 2^1 FROM 0)	0−2	0
(CAN'T SUBTRACT 2^0 FROM 0)	0−1	0

ANOTHER METHOD CONTINUALLY SUBTRACTS THE NEXT LARGEST POWER OF 2 FROM OUR DECIMAL NUMBER. ,

POWERS OF 2:	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
DECIMAL VALUE:	128	64	32	16	8	4	2	1
BINARY VALUE:	1	0	1	0	0	1	1	0
DECIMAL VALUE IN NUMBER:	128 + 0 + 32 + 0 + 0 + 4 + 2 + 0							= 166

NOW LET'S CONVERT THE BINARY NUMBER 10100110 TO BASE 10. WE USE A GRID TO DETERMINE THE DECIMAL VALUES AT EACH OF THE BINARY "*PLACES*".

TO TEST YOUR KNOWLEDGE, CLICK ANYWHERE ON THE PANEL BELOW AND FOLLOW THE INSTRUCTIONS.

YOU WILL NEED TO HAVE VERSION 9 OF THE FLASH PLAYER INSTALLED.
HTTP://WWW.ADOBE.COM/GO/BONRN

TYPE IN THE *BINARY VALUES* (1 OR 0) TO CREATE THE NUMBER TO THE RIGHT.

512

POWERS OF 2:	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
DECIMAL VALUE:	256	128	64	32	16	8	4	2	1
BINARY VALUE:	0	0	0	0	0	0	0	0	0
DECIMAL VALUE IN NUMBER:		+	+	+	+	+	+	+	+

= 269

TOTAL

AS YOU ENTER IN THE BINARY VALUES, YOU CAN CHECK THE DECIMAL VALUES BELOW, AND THE RUNNING TOTAL.

CLICK THE RESET BUTTON TO TRY AGAIN.

RESET

NOW TRY CONVERTING FROM BINARY TO DECIMAL. FOLLOW THE INSTRUCTIONS TO GET STARTED.

MAKE SURE YOU'VE GOT FLASH PLAYER V. 9 INSTALLED! HTTP://WWW.ADOBE.COM/GO/BONRN

BINARY NUMBERS USE TWO AS THEIR BASE. EACH NUMBER IS A DIFFERENT **POWER OF TWO**, AS YOU CAN SEE IN THE TOP ROW. TO GET SET UP TO **CONVERT A BINARY NUMBER** TO A **DECIMAL NUMBER**, FIRST ENTER THE **DECIMAL VALUES** OF THE POWERS OF TWO.

POWERS OF 2:	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
DECIMAL VALUE:									1
BINARY VALUE:									
DECIMAL VALUE IN NUMBER:									

2^0 IS ALWAYS ONE AND HAS BEEN ENTERED ALREADY. IF THE NUMBER IS WHITE, IT IS CORRECT, IF IT IS RED IT IS WRONG. (HINT: AS YOU MOVE TO THE LEFT EACH NUMBER IS DOUBLE THE NUMBER BEFORE IT).

NEXT