Binary

“There are 10 types of people in the world… those that understand binary and those that don’t.”

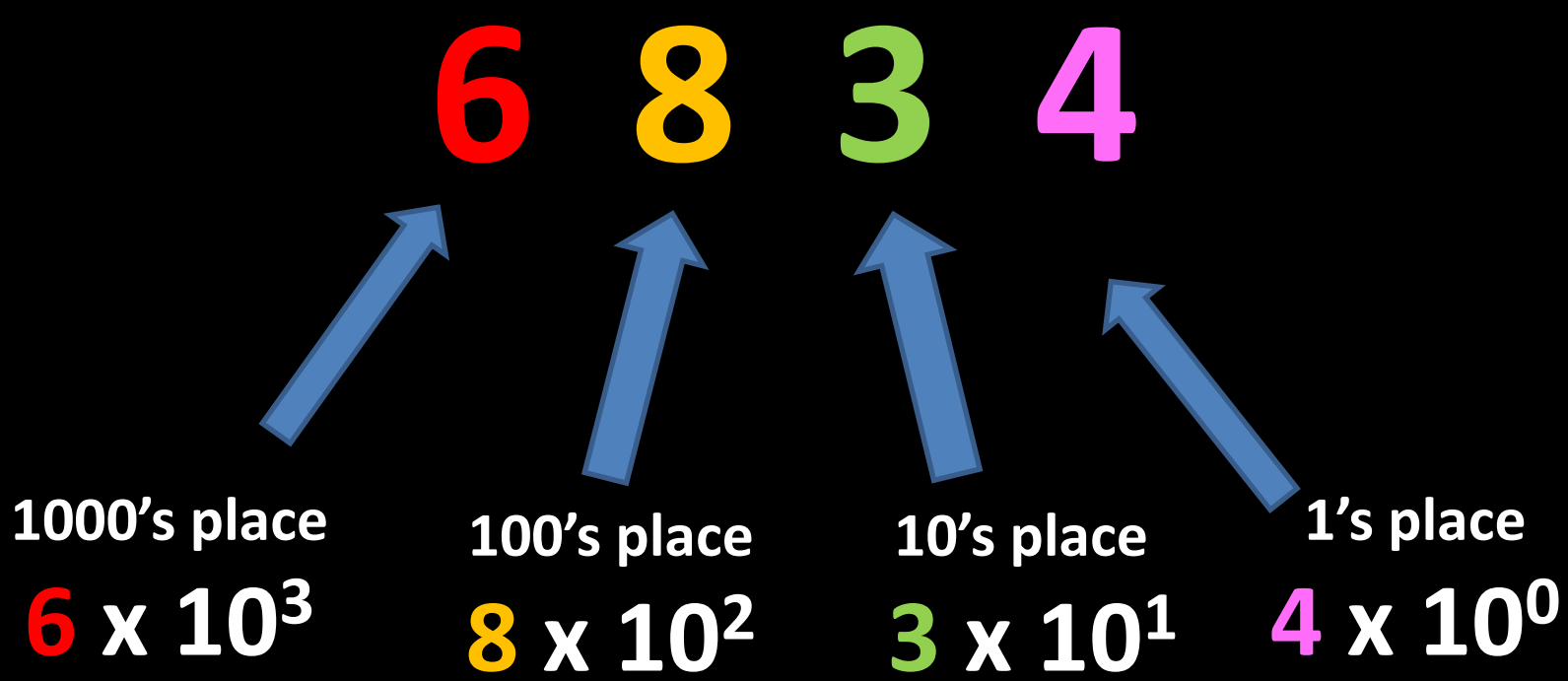
What is binary?

- You and I write numbers like this: twelve is 12, sixty eight is 68, and one hundred is 100
- Binary is a number system that computers use. That is, binary is the way that computers express numbers.
- It's good to know binary because it helps us understand how computers think

Base-10

- Our number system is made up of ten digits (0, 1, 2….9)….that's why it's called base-10.
- We use those ten digits to express any number we want!
- But how do we do this when there are only 10 of them?

Base-10 Example



So the number 6834 is made up of six 1000s, eight 100s, three 10s, and four 1s. *In other words…*

6834 = (**6** x **1000**) + (**8** x **100**) + (**3** x **10**) + (**4** x **1**)

Places

- What are the first few places in our number system?
  - Ones, tens, hundreds, thousands, ten thousands, hundred thousands, millions, etc…
- Do you notice any patterns here?
- Each one is ten times bigger than the one before it!

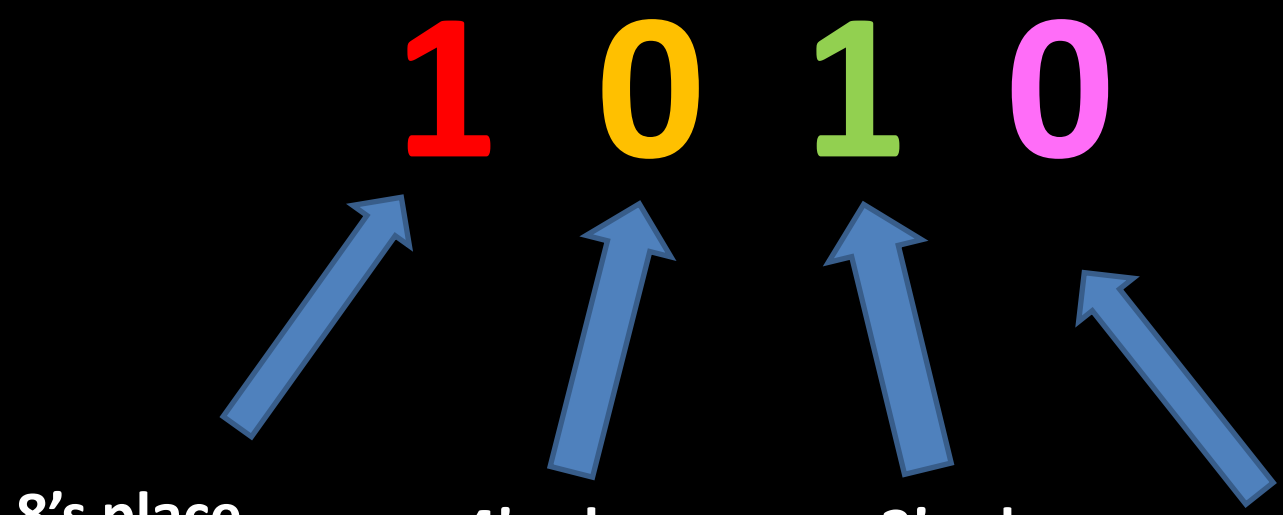
What is binary?

- Binary is just like our number system….
- Except it only uses two digits!
- The only digits in binary are 0 and 1
- In base-10 (the normal number system), any number bigger than 9 needs more than one digit.
- In binary, any number bigger than 1 needs more than one digit.

Exponents in Binary

- There are ten possible digits in the Base-10 number system (0 to 9).
- Powers of 10 are used to decide the places values.
- If binary only has two possible digits, what do you think is used to decide the values of its places?
- Powers of 2! ☺

Binary Example System



What is 1010 equal to in the base-10 number system?

8's place
1×2^3

4's place
0×2^2

2's place
1×2^1

1's place
0×2^0

So the number 1010 in BINARY is made up of
one 8, zero 4s, one 2, and zero 1s.

1010 is <u>binary</u> for (**1** x **8**) + (**0** x **4**) + (**1** x **2**) + (**0** x **1**)

Let's Count!

…in Base-10	…in Binary
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

Are there any patterns that you notice?

Converting Base-10 to Binary!

- Let's convert the number 25 to binary!
- First we need to find the largest binary digit that has a value less than 25.
  - In this case it is 2^4: 16
  - 2^5 wouldn't work because it is 32, which is bigger than 25.
- So now we know that the largest binary digit for this number will be the 16's place.

Converting Base-10 to Binary!

1				
16's place	8's place	4's place	2's place	1's place
2^4	2^3	2^2	2^1	2^0

- We chose the 16's place to be our first digit because 16 is the largest number that can fit inside 25.
- So we put a 1 in the 16's place, indicating that 16 is part of our number.

Converting Base-10 to Binary!

16's place	8's place	4's place	2's place	1's place
1	1			

- So, now 16 out of our total 25 is accounted for. Let's take care of the remainder.
- 25 – 16 = 9
- Now we go to the next digit, the 8's place. Does an 8 fit inside 9 – our remainder?
- Yes it does!!

Converting Base-10 to Binary!

16's place	8's place	4's place	2's place	1's place
1	1	0		

- Now 8 out of the remainder 9 is taken care of.
- 9 – 8 = 1
- Does the next digit – the 4's place – fit inside this remainder?
- Nope! So, we have to put a 0 at the 4's place because 1 is smaller than 4.

Converting Base-10 to Binary!

1	1	0	0	
16's place	8's place	4's place	2's place	1's place

- Let's see if the next digit can take care of our remainder (which is still 1).
- The next digit is the 2's place. Can this digit fit inside our remainder?
- No, it can't either, because 1 is smaller than 2. We have to put a 0 here too.

Converting Base-10 to Binary!

1	1	0	0	1
16's place	8's place	4's place	2's place	1's place

- One last try to get rid of our remainder (still 1)!
- The last thing we have is the 1's place. Can a 1 fit inside our remainder?
- Yes! 1 is equal to 1!
- We have no remainder left now, because 1 – 1 = 0!
- We're done!

Converting Binary into Base-10!

1	1	0	0	1
16's place	8's place	4's place	2's place	1's place

- Now let's convert our number back!
- All we have to do is take each binary digit, and figure out how much it is worth in base-10.
- 0 means that the digit doesn't add anything to our number
- 1 means it adds the value of the place it's in
- This way is easier!

Converting Binary into Base-10!

1	1	0	0	1
16's place	8's place	4's place	2's place	1's place

- 1 in the 16's place. Add 16.
- 1 in the 8's place. Add 8.
- 0 in the 4's place. Nothing added
- 0 in the 2's place. Nothing added
- 1 in the 1's place. Add 1.

16
8
0
0
+1

TOTAL: **25** 

Practice!

1. *Is the following number written in binary form?* 121011
   - No! Binary only has 1s and 0s.

Practice!

2. *What is this binary number in the base-10 system?* 111
   - It is (4 x 1) + (2 x 1) + (1 x 1), which is 7!

Practice!

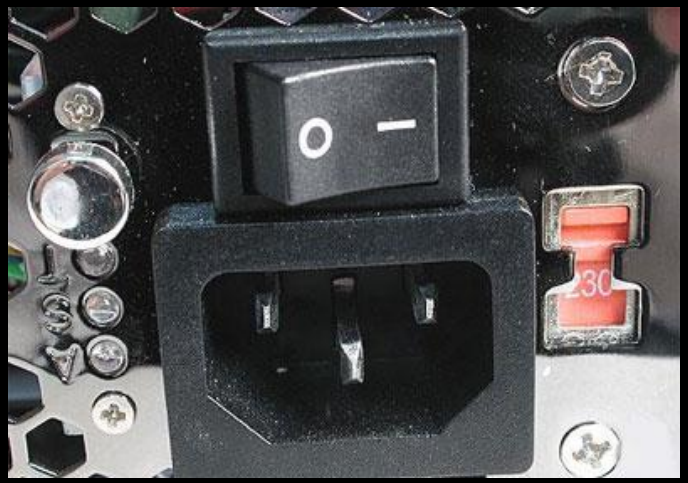
3. *What is this base-10 number in binary?* 14
   - 14 has 1 eight, 1 four, 1 two, and 0 ones. So it's 1110!

Practice!

3. *What is this base-10 number in binary?* 11
   - 11 has 1 eight, 0 fours, 1 two, and 1 one. So it's 1011!

Why does binary matter?

A computer has many switches inside it that tell it what to do.



The computer will do different things, depending on which ones are switched ON and which are OFF.

To a computer, an ON switch is represented by 1 and an OFF switch is represented by 0.

Why does anyone use binary?

Because computers only understand things in terms of ON and OFF, a system with only two options for digit values makes a lot sense (OFF = 0, ON = 1).

This makes it very easy for computers to express everything happening inside them as a bunch of 0s and 1s.

Why does anyone use binary?

There is a particular assortment of ON and OFF switches for everything you do on a computer.

ANYTHING you do on computer can be represented as a very long string of binary.

It sounds crazy until you realize there are a huge amount of switches in your computer – and SO many ways the whole system can be arranged. Actually, it still sounds pretty amazing!


0010101010100110001010101
0101010010010101001010100
1010010010111101011110010
0000011010100101011111100
0101010111100101010100010
0010101111010101001010100
0001010010100001001111100
1010101010101010101010101

So remember… there are 10 types of people in this world: those that understand binary, and those that don’t! ☺

Any questions?