Machine Language

you are the computer!

Binary Numbers

- *In order to talk directly to a computer, instructions must be given in machine language, or binary language*
- *Binary language consists of 1s and 0s*
- *Example: 101 is 5 and 11001 is 25*
- *These are called binary numbers*

Regular Numbers

- *Example: The number 213 is made up of 2 in the hundreds place, 1 in the tens place, and 3 in the ones place.*
- *This is the same as saying:*

  213 = 2x100 + 1x10 + 3x1 *(try it out!)*
- *Remember exponents?* 10^2 = *10x10 = 100*
- *Another way to think of this is:*
- *213* = $2x10^2$ + $1x10^1$ + $3x10^0$

Binary Numbers

- *With binary numbers, instead of powers of 10 we use powers of 2*
- *Example: 101 = 1x2^2 + 0x2^1 + 1x2^0*
- *Remember that 2^0 = 1*
- *So 101 = 1x4 + 0x2 + 1x1*
- *Multiplying we get 4 + 0 + 1 = 5*
- *Try these out: a) 110 b) 111 c) 1011 d) 10101*
- *Remember 2^3 does NOT mean 2x3 it means 2x2x2. Similarly 2^4 does not mean 2x4.*

One Final Example

Convert the following binary number: 1101011

1	1	0	1	0	1	1
2^6	2^5	2^4	2^3	2^2	2^1	2^0
64	32	16	8	4	2	1

So, 1101011 = 1x64 + 1x32 + 0x16 + 1x8 + 0x4 + 1x2 + 1x1

= 64 + 32 + 0 + 8 + 0 + 2 + 1 = 107

Assignment

1) Which of the following are binary numbers?

a) 1 b) 12101 c) 57 d) 11101 e) 10

2) Convert the following binary numbers

a) 11001 b) 11111 c) 1001 d) 1110110

3) Convert the following to binary

a) 3 b) 17 c) 19 d) 12

4) Create (and solve) three binary conversions of your own

Adding In Binary

Addition

- *The key to adding in binary is to remember that 1 + 1 = 2 which is 10 in binary (that's one zero, not ten)*
- *So, adding 101 + 111 we get*

step 1)

```
 101
+111
----
```

=10, so we carry the 1

step 2)

```
  1
 101
+111
----
   0
```

step 3)

```
  1
 101
+111
----
   0
```

step 4)

```
 11
 101
+111
----
  00
```

- *But what do we do with 1 + 1 + 1 ?*
- *Remember that 1 + 1 + 1 = 3*
- *And 3 is equal to 11 in binary*
- *So we get:*

$$\begin{array}{r} 11 \\ 101 \\ +111 \\ \hline 1100 \end{array}$$

$$\begin{array}{r} 11 \\ 101 \\ +111 \\ \hline ?00 \end{array}$$

- *Check to confirm:*

$101 = 2^2 + 0 + 2^0 = 5$

$111 = 2^2 + 2^1 + 2^0 = 7$

$1100 = 2^3 + 2^2 + 0 + 0 = 12$

Does 5 + 7 = 12?

Assignment

1) Add the following sets of binary numbers

   a) 111 + 100 b) 1001 + 11011

   c) 101101 + 110011 d) 10100111 + 1101111

2) Confirm that your answers in number 1 are correct by converting the numbers to regular numbers

3) Create (and solve) 2 binary addition questions of your own