MAKE
SCHOOL

# BIT MANIPULATION

*Twiddling, Fiddling, Befuddling Bits*

# BITWISE OPERATIONS

| | | | |
|---|---|---|---|
| AND | & | NOT | ~ |
| OR | \| | LEFT SHIFT | << |
| XOR | ^ | RIGHT SHIFT | >> |

# AND

Only true if both input bits are true

```
0 & 0 = 0
1 & 0 = 0
0 & 1 = 0
1 & 1 = 1
```

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```
  10010110
&
  00110010
----------
  00010010
```

# OR

True if any input bit is true (either or both)

```
0 | 0 = 0
1 | 0 = 1
0 | 1 = 1
1 | 1 = 1
```

```
  10010110
|
  00110010
----------
  10110110
```

# XOR

True if one and only one input bit is true

$$0 \mid 0 = 0$$
$$1 \mid 0 = 1$$
$$0 \mid 1 = 1$$
$$1 \mid 1 = 0$$

```
  10010110
^
  00110010
----------
  10100100
```

# NOT

Ones' complement operator

Flips the input bit

$$\sim 0 = 1$$

$$\sim 1 = 0$$

~

```
  00110010
--------
  11001101
```

# LEFT SHIFT

Shift the binary digits by n, pad 0's on the right

Each shift is a multiply by 2 (unless there's overflow)

```
  00010110
<<
  00000010
----------
  01011000
```

# RIGHT SHIFT

Shift the binary digits by n, pad 0's on the right

Each shift is a divide by 2 with round towards negative infinity

```
  00010110
>>
  00000010
----------
  00000101
```

# BIT MANIPULATION BASICS

*Bit Manipulation Basics*

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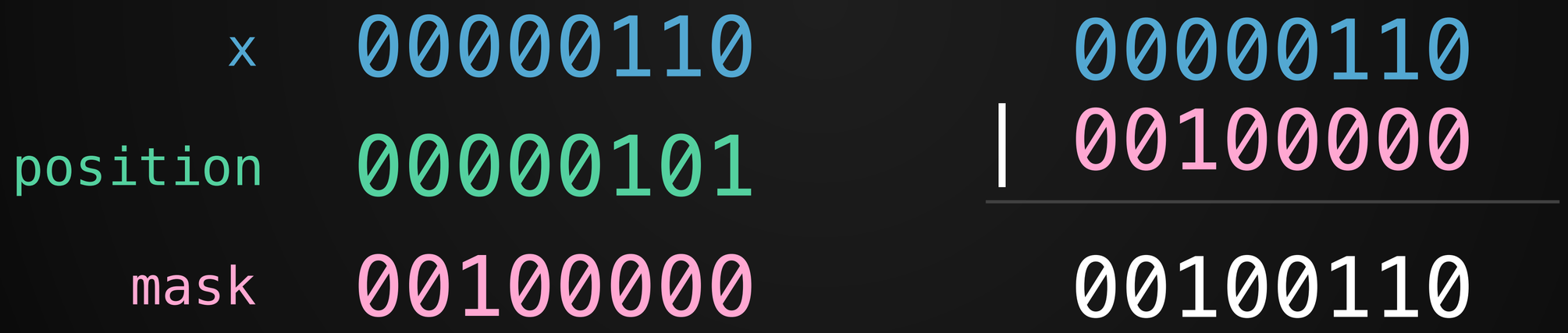
# SET BIT

```
int setBit(int x, unsigned char position) {
  int mask = 1 << position;
  return x | mask;
}
```



# CLEAR BIT

```
int clearBit(int x, unsigned char position) {
  int mask = 1 << position;
  return x & ~mask;
}
```

| | |
|---|---|
| x | 00000110 |
| position | 00000010 |
| mask | 00000100 |
| ~mask | 11111011 |

```
  00000110   x
& 11111011   ~mask
------------
  00000010
```

# FLIP BIT

```
int flipBit(int x, unsigned char position) {
  int mask = 1 << position;
  return x ^ mask;
}
```

# IS BIT SET

```
bool isBitSet(int x, unsigned char position) {
  int shifted = x >> position
  return shifted & 1
}
```

| | | | |
|---|---|---|---|
| x | 01100110 | 00000011 | shifted |
| position | 00000101 | & 00000001 | 1 |
| shifted | 00000011 | 00000001 | |

# MODIFY BIT

*SET*

```
int modifyBit(int x, unsigned char position, int state) {
  int mask = 1 << position;
  return (x & ~mask) | (-state & mask);
}
```

| | |
|---|---|
| x | 00000110 |
| position | 00000101 |
| state | 00000001 |
| mask | 00100000 |

| | |
|---|---|
| ~mask | 11011111 |
| -state | 11111111 |
| x & ~mask | 00000110 |
| -state & mask | 00100000 |

```
  00000110   x & ~mask
| 00100000   -state & mask
----------
  00100110
```

*Bit Manipulation Basics*

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# MODIFY BIT

*CLEAR*

```
int modifyBit(int x, unsigned char position, int state) {
  int mask = 1 << position;
  return (x & ~mask) | (-state & mask);
}
```

| | |
|---|---|
| x | 00000110 |
| position | 00000010 |
| state | 00000000 |
| mask | 00000100 |

| | |
|---|---|
| ~mask | 11111011 |
| -state | 00000000 |
| x & ~mask | 00000010 |
| -state & mask | 00000000 |

```
  00000010   x & ~mask
| 00000000   -state & mask
----------
  00000010
```

*Bit Manipulation Basics*

# BIT TRICKS

# CHECK IF EVEN

```
((x & 1) == 0)
```

```
  0110
&
  0001
------
  0000
```

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# CHECK IF POWER OF TWO

```
((x & (x-1)) == 0)
```

```
  1000
&
  0111
------
  0000
```

*Power of Two*

# EXERCISE

Write a function to count the number of bits that are different between two numbers