An Introduction to STEM Programming with Python 3 – Chapter 2
Binary Addition and Subtraction

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In this video we will cover:

- Binary Addition
- Calculating the Two's compliment
- Subtraction by adding the Two's compliment

Adding Binary Numbers

- Addition works like it does with decimal integers
  - Align them to the right
  - Work from right to left carrying anything not in the column you are working on.
- Remember:
  - `1 + 1 = 10`
  - `1 + 1 + 1 = 11`
  - `1 + 1 + 1 + 1 100`

Adding Binary Numbers

```
                1          1        1 1       11 1      111 1
 10101101  10101101  10101101  10101101  10101101  10101101
 +  11101  +  11101  +  11101  +  11101  +  11101  +  11101
                 0         10       010      1010     01010
```

```
 1111 1     1111 1      1111 1
10101101  10101101   10101101
+  11101  +  11101   +  11101
  001010   1001010   11001010
```

Two's Compliment

- Negative binary numbers are stored as a two's compliment number.
- An 8 bit number can have the range
  - 0-255 unsigned
  - -128 to 127 signed
- To calculate a 2's compliment:
  - Pad with zeros on the left until length specified.
  - Subtract 1
  - Flip all bits (1 to 0 and 0 to 1)

Two's Compliment

```
Calculate 8 bit negative of these:

101101            1011             1          1111111          1100

1)  pad it out
00101101     00001011     00000001         01111111     00001100

2) subtract 1
00101100     00001010     00000000         01111110     00001011

3) flip bits
11010011     11110101     11111111         10000001     11110100
```

Subtract using Two's Compliment

- Parts of a subtraction problem:
  - `Minuend - Subtrahend = Difference`

1. Calculate the Two's Compliment of the Subtrahend
2. Add #1 to the Minuend
3. Ignore the last carry bit.

Binary Subtraction

- Subtract 0100 from 0110 (4 bits)
  - 0110 – 0100 = ???? (should be 0010)

1 2's compliment (3 steps)

  i Pad out `0100`

  ii Subtract 1 `0011`

  iii Flip bits `1100`

2 Add

```
                        1      11
0110   0110   0110   0110   0110
1100   1100   1100   1100   1100
          0     10    010   0010
```

3 Ignore the last carry = `0010`

Thank you

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3.