A Quick Review

- Decimal to binary
- Binary to decimal
- Binary to hexadecimal
- Hexadecimal to binary
- Hexadecimal to Decimal
- Binary addition
- Binary subtraction
- Binary shift

Decimal to Binary

- 146d = ????????b
- 146/2 = 73 Remainder = 0 LSB (73)
- 73/2 = 36 Remainder = 1 (36.5)
- 36/2 = 18 Remainder = 0 (18)
- 18/2 = 9 Remainder = 0 (9)
- 9/2 = 4 Remainder = 1 (4.5)
- 4/2 = 2 Remainder = 0 (2)
- 2/2 = 1 Remainder = 0 (1)
- 1/2 = 0 Remainder = 1 MSB (0.5)
- 146d = 10010010b

Binary to Decimal

- 10010010b = ???d
- Which positions have ones?
  - 7, 4 and 1
- $1*2^7 + 1*2^4 + 1*2^1 = 128 + 16 + 2 = 146$

Binary to Hexadecimal

- 10010010b = ??h
- Split binary string into 4 bit components
- 1001b = 9d = 9h
- 0010b = 2d = 2h
- Concatenate the hex digits
- 10010010b = 92h

Hexadecimal to Binary

- 92h = ????????b
- Each hex digit is encoded by four bits
- 9h = 1001b
- 2h = 0010b
- Concatenate the bits
- 92h = 10010010b

Hexadecimal to Decimal

- 92h = ???d
- $9*16^1 + 2*16^0 = 144 + 2 = 146$
- Or, convert hexadecimal to binary and then convert binary to decimal.
  - Some find it easier to perform decimal conversion using binary base

Binary Addition

- 1+1 = 10 (carry 1)
- 0+1 = 1
- 1+0 = 1
- 0+0 = 0
- 1+1+1=11 (carry 1)

	1	1		1				
	0	1	1	0	1	1	0	1
+	0	1	1	0	1	0	1	0
	1	1	0	1	0	1	1	1

							1	
						1	0	9
+						1	0	6
						2	1	5

Binary Subtraction

- 1-1 = 0
- 1-0 = 1
- 0-1 = 1 (borrow)
- 0-0 = 0

- *) borrow

							*	
	0	1	1	0	1	1_0	0	1
-	0	1	1	0	1	0	1	0
	0	0	0	0	0	0	1	1

						1	0	9
-						1	0	6
						0	0	3

Multiplication and Division by Shifting (Optimization trick)

- 0001010b = 10d
- Shift left (multiply by 2)
  - 00101010b = 20d
  - 01010100b = 40d
- Shift right (divide with 2)
  - 00001010b = 5d (remainder 0 shifted out)
  - 00000101b = 2d (remainder 1 shifted out)

Calculating Two Complement

- 58d = 00111010b
- -58d = TC(58d) = TC(00111010b) = ?
- One complement
  - OC(00111010b) = 11000101b
- Add one

							1	
	1	1	0	0	0	1	0	1
+	0	0	0	0	0	0	0	1
	1	1	0	0	0	1	1	0

- -58d = 11000110b

Two Complement Reversibility

- TC(TC(58d)) = 58d = 00111010b
- We know TC(58d) = 11000110b
- TC(11000110b) = ?
- One complement
  - OC(11000110b) = 00111001b
- Add one

							1	
	0	0	1	1	1	0	0	1
+	0	0	0	0	0	0	0	1
	0	0	1	1	1	0	1	0

Two Complement Addition

- 122d + (-58d) = 64d
- 122d = 01111010b
- -58d = TC(58d) = 11000110b
- 64d = 01000000b

1	1	1	1	1	1	1		
	0	1	1	1	1	0	1	0
+	1	1	0	0	0	1	1	0
	0	1	0	0	0	0	0	0

Two Complement Addition

- 48d + (-58d) = -10d
- 48d = 00110000b
- -58d = TC(58d) = 11000110b
- -10d = TC(10d) = 11110110b

	0	0	1	1	0	0	0	0
+	1	1	0	0	0	1	1	0
	1	1	1	1	0	1	1	0