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)

- 1/2 = 0 Remainder = 1 MSB (0.5)
- 146d = 10010010b

Binary to Decimal



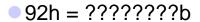
- 10010010b = ???d
- Which positions have ones?
 - 07, 4 and 1
- $1*2^7 + 1*2^4 + 1*2^1 = 128 + 16 + 2 = 146$

Binary to Hexadecimal



- Split binary string into 4 bit components
- 0.01b = 9d = 9h
- 0010b = 2d = 2h
- Concatenate the hex digits
- 10010010b = 92h

Hexadecimal to Binary



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

Hexadecimal to Decimal



 $9*16^1 + 2*16^0 = 144 + 2 = 146$

- Or, convert hexadecimal to binary and then convert binary to decimal.
 - Some find it easier to perform decimal conversion using binary base

Binary Addition



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	တ
+			1	0	6
			2	1	5

Binary Subtraction



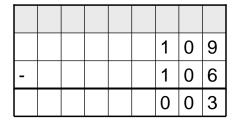
1-0 = 1

0-1 = 1 (borrow)

0 - 0 = 0

• *) borrow

							,	*	
Γ		0	1	1	0	1	1.	0	1
Ŀ	-	0	1	1	0	1	0	1	0
		0	0	0	0	0	0	1	1



Multiplication and Division by Shifting (Optimization trick)

- 0001010b = 10d
- Shift left (multiply by 2)
 - 0010100b = 20d
 - 0101000b = 40d
- Shift right (divide with 2)
 - \bigcirc 0000 $\boxed{101}$ b = 5d (remainder 0 shifted out)
 - \bigcirc 0000010b = 2d (remainder 1 shifted out)

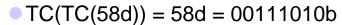
Calculating Two Complement

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

							' x	
	1	1	0	0	0	1	0	•
+	0	0	0	0	0	0	0	•
	1	1	0	0	0	1	1	(

-58d = 1	1000110b
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- We know TC(58d) = 11000110b
- TC(11000110b) = ?
- One complement
 - OC(11000110b) = 00111001b
- Add one

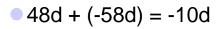
							1,	
	0	0	1	1	1	0	0	1
+	0	0	0	0	0	0	0	1
	0	0	1	1	1	0	1	0

Two Complement Addition

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