

# Binary Arithmetic

September 22, 2000

CSC201 Section 002

Fall, 2000

# Unsigned Addition

- When adding two numbers, for each bit position there are two addends, and a carry-in

If...	Then sum =	And carry-out =
0 inputs = 1	0	0
1 input = 1	1	0
2 inputs = 1	0	1
3 inputs = 1	1	1

$$\begin{array}{r} 01010 \\ + 00111 \\ \hline \end{array} \qquad \begin{array}{r} 10 \\ + 7 \\ \hline \end{array}$$

# Unsigned Addition (cont.)

- Overflow occurs if the carry-out from the most-significant bit == 1

	0	1	0	1	0			10
+	1	1	1	0	1		+	29
<hr/>								

# Unsigned Subtraction

- Bad idea; don't do it!

# Two's Complement Addition

- Exactly like unsigned addition, except for overflow detection

$$\begin{array}{r} 01010 \\ + 11101 \\ \hline \end{array} \qquad \begin{array}{r} 10 \\ + -3 \\ \hline \end{array}$$

- Doesn't matter what the sign of the inputs or output are; same operation!

$$\begin{array}{r} 10100 \\ + 11101 \\ \hline \end{array} \qquad \begin{array}{r} -12 \\ + -3 \\ \hline \end{array}$$

# Two's-Complement Addition (cont.)

- Overflow occurs if  $\text{sign}(\text{addend1}) == \text{sign}(\text{addend2})$  and  $\text{sign}(\text{addend1 or addend2}) \neq \text{sign}(\text{sum})$

$$\begin{array}{r} 0 \ 1 \ 0 \ 0 \ 1 \\ + \ 0 \ 0 \ 1 \ 1 \ 1 \\ \hline \end{array}$$

$$\begin{array}{r} 9 \\ + \ 7 \\ \hline \end{array}$$

$$\begin{array}{r} 1 \ 1 \ 1 \ 0 \ 0 \\ + \ 1 \ 0 \ 0 \ 0 \ 1 \\ \hline \end{array}$$

$$\begin{array}{r} -4 \\ + \ -15 \\ \hline \end{array}$$

# Two's Complement Subtraction

- (Terminology: minuend - subtrahend)
- Steps
  - two's-complement the subtrahend
  - then add to the minuend

$$\begin{array}{r} 01101 \\ - 01001 \\ \hline \end{array}$$



$$\begin{array}{r} 01101 \\ + 10111 \\ \hline \end{array}$$







# Unsigned Division (cont.)

- Dividing two  $n$ -bit numbers produces  $n$ -bit quotient and  $n$ -bit remainder
- Overflow possible
  - If most significant half of dividend greater than or equal to divisor
- Also, check for division by zero first

# Two's-Complement Multiplication and Addition

- Skip it!