# Binary Arithmetic

**COE 202** 

Digital Logic Design

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### Adding Bits

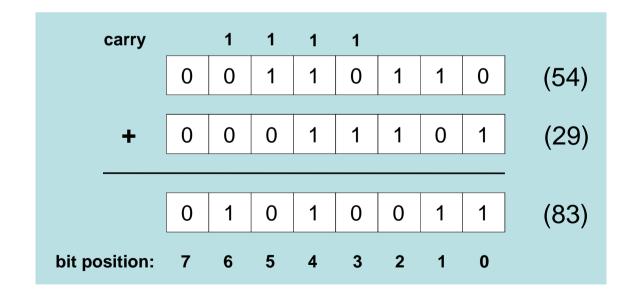
- 4 1 + 1 = 2, but 2 should be represented as  $(10)_2$  in binary
- ❖ Adding two bits: the sum is S and the carry is C

❖ Adding three bits: the sum is S and the carry is C

0	0	0	0	1	1	1	1
0	0	1	1	0	0	1	1
+ 0	+ 1	+ 0	<u>+ 1</u>	+ 0	+ 1	+ 0	+ 1
0 0	0 1	0 1	10	0 1	10	10	11

### Binary Addition

- Start with the least significant bit (rightmost bit)
- Add each pair of bits
- Include the carry in the addition, if present



# Subtracting Bits

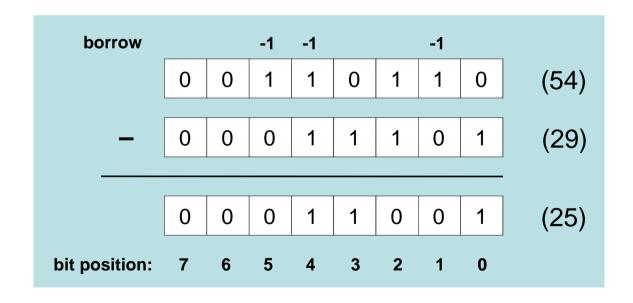
❖ Subtracting 2 bits (X – Y): we get the difference (D) and the borrow-out (B) shown as 0 or -1

❖ Subtracting two bits (X – Y) with a borrow-in = -1: we get the difference (D) and the borrow-out (B)

borrow-in -1 -1 -1 -1 -1 -1 
$$\frac{1}{X}$$
 0 0 1 1 1  $\frac{1}{Y}$  -0 -1 -1 -0 -1

### Binary Subtraction

- Start with the least significant bit (rightmost bit)
- Subtract each pair of bits
- Include the borrow in the subtraction, if present



# Binary Multiplication

Binary Multiplication table is simple:

$$0\times0=0\,,\quad 0\times1=0\,,\quad 1\times0=0\,,\quad 1\times1=1$$
Multiplicand
$$1100_2 = 12$$
Multiplier
$$\times \quad 1101_2 = 13$$

$$1100$$

$$0000$$

$$1100$$

$$1100$$
Binary multiplication is easy 
$$0\times \text{multiplicand} = 0$$

$$1\times \text{multiplicand} = \text{multiplicand}$$

**Product** 

$$10011100_2 = 156$$

- $\bullet$  *n*-bit multiplicand  $\times$  *n*-bit multiplier = 2*n*-bit product
- Accomplished via shifting and addition

#### Hexadecimal Addition

- Start with the least significant hexadecimal digits
- Let Sum = summation of two hex digits
- ❖ If Sum is greater than or equal to 16
  - $\Rightarrow$  Sum = Sum 16 and Carry = 1
- Example:

$$5 + B = 5 + 11 = 16$$
  
Since Sum  $\ge 16$   
Sum =  $16 - 16 = 0$   
Carry = 1

#### Hexadecimal Subtraction

- Start with the least significant hexadecimal digits
- Let Difference = subtraction of two hex digits
- If Difference is negative
  - ♦ Difference = 16 + Difference and Borrow = -1
- Example:

