

# The Carry Flag

Young W. Lim

2024-09-09 Mon

- 1 Based on
- 2 The Carry flag
  - TOC: Carry flag
  - Examples of signed and unsigned integer arithmetic
  - The Carry flag in unsigned and signed computations
  - Rules for the carry flag
  - Method for computing the carry flag
  - More examples of the carry flag

- The CARRY flag and OVERFLOW flag in binary arithmetic  
Ian! D. Allen - idallen@idallen.ca - www.idallen.com  
[https://teaching.idallen.com/dat2343/10f/notes/  
040\\_overflow.ttx](https://teaching.idallen.com/dat2343/10f/notes/040_overflow.ttx)

I, the copyright holder of this work, hereby publish it under the following licenses: GNU head Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled GNU Free Documentation License.

CC BY SA This file is licensed under the Creative Commons Attribution ShareAlike 3.0 Unported License. In short: you are free to share and make derivative works of the file under the conditions that you appropriately attribute it, and that you distribute it only under a license compatible with this one.

# Compiling 32-bit program on 64-bit gcc

- `gcc -v`
- `gcc -m32 t.c`
- `sudo apt-get install gcc-multilib`
- `sudo apt-get install g++-multilib`
- `gcc-multilib`
- `g++-multilib`
- `gcc -m32`
- `objdump -m i386`

- Examples of signed and unsigned integer arithmetic
- Carry flag in unsigned and signed computations
- Rules for the carry flag
- Method for computing the carry flag
- More examples of the carry flag

# TOC: Examples of signed and unsigned integer arithmetic

- Examples of interpreting **signed** and **unsigned** numbers
- Examples of **signed** and **unsigned** integer arithmetic
- 2's complements
- **Unsigned** subtraction
- **Signed** subtraction
- Interpreting the result as a **signed** or an **unsigned** integer
- Summary of **signed** and **unsigned** subtractions
- Examples of **unsigned** integer overflows
- Examples of **signed** integer overflows

# Examples of **signed** and **unsigned** integer arithmetic

- subtracting **0x0000618D** from **0x0000195D**

---

**unsigned** subtraction    **0x0000195D - 0x0000618D**    = **0xFFFFB7D0**

subtraction by hand

---

**signed** subtraction    **0x0000195D + (-0x0000618D)**    = **-0x00004830**  
                                 **0x0000195D + 0xFFFF9E73**    = **0xFFFFB7D0**

the *transformed addition* using  
the 2's complement of subtrahend

---

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

## 2's complement of the subtrahend 0x0000618D

- the 2's complement of 0x0000618D  $\rightarrow$  0xFFFF9E73 ( $= -24973_{10}$ )

	F	F	F	F	9	E	7	3	
0xFFFF9E73	0x1111_1111_1111_1111_1001_1110_0111_0011								
0x0000618C	0x0000_0000_0000_0000_0110_0001_1000_1100								(1's complement)
0x0000618D	0x0000_0000_0000_0000_0110_0001_1000_1101								(2's complement)
	0	0	0	0	6	1	8	D	

- the 2's complement of 0xFFFF9E73  $\rightarrow$  0x0000618D ( $= +24973_{10}$ )

	0	0	0	0	6	1	8	D	
0x0000618D	0x0000_0000_0000_0000_0110_0001_1000_1101								
0xFFFF8E72	0x1111_1111_1111_1111_1001_1110_0111_0010								(1's complement)
0xFFFF8E73	0x1111_1111_1111_1111_1001_1110_0111_0011								(2's complement)
	F	F	F	F	9	E	7	3	

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>



# Interpreting 0xFFFF9E73 (1)

- interpreting 0x0xFFFF9E73
  - as an **unsigned** Number :  $+0xFFFF9E73 (= +4294942323_{10})$

F	F	F	F	9	E	7	3
15	15	15	15	9	14	7	3
$16^7$	$16^6$	$16^5$	$16^4$	$16^3$	$16^2$	$16^1$	$16^0$

- as a **signed** number :  $-0x0000618D (= -24973_{10})$

0	0	0	0	6	1	8	D
0	0	0	0	6	1	8	13
$16^7$	$16^6$	$16^5$	$16^4$	$16^3$	$16^2$	$16^1$	$16^0$

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

## Interpreting 0xFFFF9E73 (2)

- interpreting 0xFFFF9E73

---

as an **unsigned** number    +0xFFFF9E73    +4294942323<sub>10</sub>

---

as a **signed** number        -0x0000618D    -24973<sub>10</sub>

---

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

# Unsigned subtraction 0x0000195D - 0x0000618D (1)

- 0x0000195D - 0x0000618D : unsigned subtraction

subtraction by hand

```

          0  0  0  0  1  9  5  D
0x0000195D  0x0000_0000_0000_0000_0001_1001_0101_1101
- 0x0000618D  0x0000_0000_0000_0000_0110_0001_1000_1101
-----
0xFFFFB7D0  1 0x1111_1111_1111_1111_1011_0111_1101_0000 (hand subtraction)
          1   F   F   F   F   B   7   D   0
          .
          V borrow (CF=1) : unsigned integer overflow
```

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

## Unsigned subtraction $0x0000195D - 0x0000618D$ (2)

- $0x0000195D - 0x0000618D$  : unsigned subtraction  
subtraction by hand
  - A borrow is indicated by the carry flag (CF=1)
    - whenever an unsigned integer overflow happened
    - $A - B$ , when  $A < B$ , for non-negative integers  $A, B$

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

# Signed subtraction $0x0000195D + (-0x0000618D)$ (1)

- $0x0000195D + (-0x0000618D)$  : signed subtraction

the *transformed addition* using the 2's complement of subtrahend

```

          0  0  0  0  1  9  5  D
0x0000195D  0x0000_0000_0000_0000_0001_1001_0101_1101 (+0x0000195D)
+ 0xFFFF9E73 0x1111_1111_1111_1111_1001_1110_0111_0011 (-0x0000618D)
          F  F  F  F  9  E  7  3
-----
0xFFFFB7D0 0 0x1111_1111_1111_1111_1011_0111_1101_0000 (hand addition)
0          F  F  F  F  B  7  D  0
-0x00004830 . 0x0000_0000_0000_0000_0100_1000_0011_0000 (2's complement)
.          0  0  0  0  4  8  3  0
V no carry in the transformed addition (Cn=0) --> (CF=1)
```

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

## Signed subtraction $0x0000195D + (-0x0000618D)$ (2)

- $0x0000195D + (-0x0000618D)$  : signed subtraction  
the *transformed addition* using the 2's complement of subtrahend
  - signed integer overflow is indicated by the **overflow** flag (OF)
    - the **carry** flag is set by the **inverted** carry of a transformed addition

ADD	SUB
$CF = c_n$	$CF = \overline{c_n}$

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

# Interpreting the result 0xFFFFB7D0

- subtracting 0x0000618D from 0x0000195D  
the results of **unsigned** and **signed** subtractions have  
the same bit pattern 0xFFFFB7D0

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

## 2's complement of the result 0xFFFFB7D0

- the 2's complement of 0xFFFFB7D0 : 0x00004830 (= +18480<sub>10</sub>)

	F	F	F	F	B	7	D	0
0xFFFFB7D0	0x1111_1111_1111_1111_1011_0111_1101_0000							
0x0000482F	0x0000_0000_0000_0000_0100_1000_0010_1111							(1's complement)
0x00004830	0x0000_0000_0000_0000_0100_1000_0011_0000							(2's complement)
	0	0	0	0	4	8	3	0

- the 2's complement of 0x00004830 : 0xFFFFB7D0 (= -18480<sub>10</sub>)

	0	0	0	0	4	8	3	0
0x00004830	0x0000_0000_0000_0000_0100_1000_0011_0000							
0xFFFFB7CF	0x1111_1111_1111_1111_1011_0111_1100_1111							(1's complement)
0xFFFFB7D0	0x1111_1111_1111_1111_1011_0111_1101_0000							(2's complement)
	F	F	F	F	B	7	D	0

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>



# Interpreting 0xFFFFB7D0 (1)

- interpreting 0x0xFFFFB7D0
  - as an **unsigned** Number :  $+0xFFFFB7D0 (= +4294948816_{10})$

F	F	F	F	B	7	D	0
15	15	15	15	11	7	13	0
$16^7$	$16^6$	$16^5$	$16^4$	$16^3$	$16^2$	$16^1$	$16^0$

- as a **signed** number :  $-0x00004830 (= -18480_{10})$

0	0	0	0	4	8	3	0
0	0	0	0	4	8	3	0
$16^7$	$16^6$	$16^5$	$16^4$	$16^3$	$16^2$	$16^1$	$16^0$

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

## Interpreting 0xFFFFB7D0 (2)

- interpreting 0xFFFFB7D0

---

as an **unsigned** number    +0xFFFFB7D0    +4294948816<sub>10</sub>

---

as a **signed** number        -0x00004830    -18480<sub>10</sub>

---

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

# Summary of signed and unsigned subtractions (1)

- subtracting  $0x0000618D$  from  $0x0000195D$ 
  - $0x0000195D - 0x0000618D$  : unsigned integer subtraction  
hand subtraction
  - $0x0000195D + (-0x0000618D)$  : signed integer subtraction  
the *transformed addition* using the 2's complement of the subtrahend
  - the same result :  $0xFFFFB7D0$  (the same bit pattern)
    - interpreting as a unsigned integer  $4294948816_{10}$   
 $0xFFFFB7D0$  with a borrow (CF=1)
    - interpreting as a signed integer  $-18480_{10}$   
 $-0x00004830$  (meaningless CF=1)

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

## Summary of signed and unsigned subtractions (2)

---

unsigned subtraction     $0x0000195D - 0x0000618D$      $0xFFFFB7D0$   
4294948816<sub>10</sub>  
subtraction by hand    with CF=1

---

signed subtraction     $0x0000195D + (-0x0000618D)$      $-0x00004830$   
-18480<sub>10</sub>  
the *transformed addition* using  
the 2's complement of subtrahend

---

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

# Carry Flag (CF) and **unsigned** integer overflows

- $0x0000195D - 0x0000618D$  : **unsigned** subtraction
  - there is an **unsigned** integer overflow  
so the **carry** flag will be set ( $CF=1$ ) to indicate a **borrow**
  - $A - B$ , when  $A < B$ , for non-negative integers  $A, B$   
(unsigned integers can't be negative),

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

# Overflow Flag (OF) and signed integer overflows

- $0x0000195D + (-0x0000618D)$  : signed subtraction
  - there is no signed integer overflow  
the overflow flag won't be set (OF=0)
  - signed overflow occurs , in the transformed addition,
    - two *positive* numbers are added and  
the result is a *negative*, ( $P + P \rightarrow N$ ), or
    - two *negative* numbers are added and  
the result is a *positive*, ( $N + N \rightarrow P$ )

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

# TOC Carry flag in unsigned and signed computations

- 2's complement numbers : 4-bit
- Addend and augend in a  $n$ -bit addition
- Full adder operation in each bit position
- Internal and external carry bits
- Addition and Subtraction
- Using the Carry Flag as a borrow

## 2's complement numbers : 4-bit

---

0111	(+7)	1000	(-8)
0110	(+6)	1001	(-7)
0101	(+5)	1010	(-6)
0100	(+4)	1011	(-5)
0011	(+3)	1100	(-4)
0010	(+2)	1101	(-3)
0001	(+1)	1110	(-2)
0000	(0)	1111	(-1)

---

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)



# Addend and augend in a $n$ -bit addition

$n$	bits	addended	$A$	$\{ a_{n-1}, a_{n-2}, \dots, a_1, a_0 \}$
$n$	bits	augend	$B$	$\{ b_{n-1}, b_{n-2}, \dots, b_1, b_0 \}$
$(n+1)$	bits	carry bits	$C$	$\{ c_n, c_{n-1}, c_{n-2}, \dots, c_1, c_0 \}$
$n$	bits	sum bits	$S$	$\{ s_{n-1}, s_{n-2}, \dots, s_1, s_0 \}$

external carry bits :  $c_n$  carry out,  $c_0$  carry in

$$\begin{array}{cccccc} a_{n-1} & a_{n-2} & \cdots & a_1 & a_0 & \\ b_{n-1} & b_{n-2} & \cdots & b_1 & b_0 & \\ \hline & & & & c_0 & \\ c_n & s_{n-1} & s_{n-2} & \cdots & s_1 & s_0 \end{array}$$

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Full adder operation in each bit position

---

full adder operation in the  $i^{\text{th}}$  bit position

$$\{c_{i+1}, s_i\} = a_i + b_i + c_i$$

---

$$\begin{array}{r} a_i \\ b_i \\ c_i \\ \hline c_{i+1} \quad s_i \end{array}$$

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Internal and external carry bits

external carries      $c_n$  output,  $c_0$  input  
 internal carries      $\{c_{n-1}, c_{n-2}, \dots, c_2, c_1\}$      output / input  
 sum bits                  $\{s_{n-1}, s_{n-2}, \dots, s_1, s_0\}$      output

	$a_{n-1}$	$a_{n-2}$	$\dots$	$a_1$	$a_0$
	$b_{n-1}$	$b_{n-2}$	$\dots$	$b_1$	$b_0$
$c_n$	$c_{n-1}$	$c_{n-2}$	$\dots$	$c_1$	$c_0$
	$s_{n-1}$	$s_{n-2}$	$\dots$	$s_1$	$s_0$

	$a_{n-1}$	$a_{n-2}$	$\dots$	$a_1$	$a_0$
	$b_{n-1}$	$b_{n-2}$	$\dots$	$b_1$	$b_0$
					$c_0$
$c_n$	$s_{n-1}$	$s_{n-2}$	$\dots$	$s_1$	$s_0$

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Addition and Subtraction

- addition

$$\{c_n, S\} = A + B = A + B + 0$$

$$\begin{array}{cccccc} & a_{n-1} & a_{n-2} & \cdots & a_1 & a_0 \\ & b_{n-1} & b_{n-2} & \cdots & b_1 & b_0 \\ \hline & c_{n-1} & c_{n-2} & \cdots & c_1 & 0 \\ \hline c_n & s_{n-1} & s_{n-2} & \cdots & s_1 & s_0 \end{array}$$

- subtraction - transformed addition

$$\{c_n, S\} = A - B = A + \bar{B} + 1$$

$$\begin{array}{cccccc} & a_{n-1} & a_{n-2} & \cdots & a_1 & a_0 \\ & b_{n-1} & b_{n-2} & \cdots & b_1 & b_0 \\ \hline & c_{n-1} & c_{n-2} & \cdots & c_1 & 1 \\ \hline c_n & s_{n-1} & s_{n-2} & \cdots & s_1 & s_0 \end{array}$$

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Using the Carry Flag as a borrow (1)

- a **borrow** (CF=1) occurs in the **subtraction**  $A - B$  when  $b$  is larger than  $a$  ( $A < B$ ) as unsigned numbers
- Computer hardware can detect a **borrow** (CF=1) in **subtraction** by looking at whether a carry out (Cn) occurred in the transformed addition

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

## Using the Carry flag as a borrow (2)

- a **borrow** ( $CF=1$ ) occurs in the **subtraction**  $A - B$  ( $A < B$ ) as unsigned numbers
- a carry out ( $C_n$ ) in the transformed addition
  - If there is no **carry** ( $C_n=0$ ) then there is a **borrow** ( $CF=1$ )
  - If there is a **carry** ( $C_n=1$ ) then there is no **borrow** ( $CF=0$ )
  - **$CF = !C_n$**

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

## Using the Carry Flag as a borrow (3)

- the same *addition* and *subtraction* instructions are used for both **unsigned** and **signed** integer arithmetic.
  - no special *addition* and *subtraction* instructions for **unsigned** and **signed** integer arithmetic
- the only difference is
  - which flags you *test* afterwards and
  - how you *interpret* the result

<https://stackoverflow.com/questions/47333458/assembly-x86-64-setting-carry-flag-f>

# TOC Rules for the carry flag

- 2's complement numbers : 4-bit
- The 1st rule for setting the carry flag
- The 2nd rule for setting the carry flag
- Cases for clearing the carry flag
- Computing CF in unsigned additions and subtractions



## 2's complement numbers : 4-bit

---

0111	(+7)	1000	(-8)
0110	(+6)	1001	(-7)
0101	(+5)	1010	(-6)
0100	(+4)	1011	(-5)
0011	(+3)	1100	(-4)
0010	(+2)	1101	(-3)
0001	(+1)	1110	(-2)
0000	(0)	1111	(-1)

---

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# The 1st rule for setting the carry flag

- 1 **CF = 1** : **carry** in **unsigned addition**
  - the **carry flag** is set if the **addition** of two **unsigned** numbers causes a **carry** out of the most significant bits added.
  - **unsigned integer overflow** in **unsigned addition**
  - *hand addition rule*

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# The 2nd rule for setting the carry flag

- ② **CF = 1 : borrow in unsigned subtraction**
  - the **carry flag** is also set if the **subtraction** of two **unsigned** numbers requires a **borrow** into the most significant bits subtracted.
  - **unsigned integer overflow in unsigned subtraction**
  - *hand subtraction rule*

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Cases for clearing the carry flag (1)

- Otherwise, the **carry flag** is turned off (zero).
  - all three interpretations have the same CF=1, the same S=0000

unsigned addition		signed addition		signed subtraction
0111 ( 7)		0111 (+7)		0111 (+7)
+1001 +( 9)		+1001 +(-7)		-0111 -(+7)
-----		-----		-----
10000 (16)		10000 ( 0)		10000 ( 0)
CF=1		Cn=1 -> CF=1		Cn=1 -> CF=1
CF means 16		CF meaningless		CF meaningless
S = 0000		S = 0000		S = 0000
* think hand		* think Cn of the corresponding addition		
addition		CF <- Cn		

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

## Cases for clearing the carry flag (2)

- Otherwise, the **carry flag** is turned off (zero).
  - all three interpretations have the same CF=0, the same S=1111

unsigned addition		signed addition		signed subtraction
0111 ( 7)		0111 (+7)		0111 (+7)
+1001 +(- 9)		+1001 +(-7)		-0111 -(+7)
-----		-----		-----
10000 (16)		10000 ( 0)		10000 ( 0)
CF=1		Cn=1 -> CF=1		Cn=1 -> CF=1
CF means 16		CF meaningless		CF meaningless
S = 0000		S = 0000		S = 0000
* think hand		* think Cn of the corresponding addition		
addition		CF <- Cn		

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Computing CF in unsigned additions and subtractions

- Computing CF in an **unsigned** addition
  - do the **signed** addition
  - $C_n$  is the carry out
  - $CF \leftarrow C_n$
- Computing CF in an **unsigned** subtraction
  - do the transformed **signed** addition
  - do the **signed** addition
  - $C_n$  is the carry out
  - $CF \leftarrow !C_n$

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

- Carry flag computation

# Carry flag computation (1)

ADD (addition)	SUB (subtraction)
$CF = c_n$	$CF = \overline{c_n}$
normal carry of a 2's complement addition	<b>inverted</b> carry of a transformed addition
$A + B = A + B + 0$	$A - B = A + \overline{B} + 1$
$\{c_n, s_{n-1}\}$ $= a_{n-1} + b_{n-1} + c_{n-1}$	$\{c_n, s_{n-1}\}$ $= a_{n-1} + \overline{b_{n-1}} + c_{n-1}$

[https://www.csie.ntu.edu.tw/~cyy/courses/assembly/12fall/lectures/handouts/lec14\\_1](https://www.csie.ntu.edu.tw/~cyy/courses/assembly/12fall/lectures/handouts/lec14_1)



## Carry flag computation (2)

- In **unsigned** arithmetic,
  - the **carry flag** is used to detect *overflow*
  - the **carry flag** is used to extend *n-bit* result into *(n+1)-bit* result
  - for **addition**, the **carry flag** is a **carry out**
  - for **subtraction**, the **carry flag** is a **borrow in**
- In **signed** arithmetic,
  - the **carry flag** is useless
  - the **carry flag** neither detects overflow nor extends n-bit result

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Carry flag computation (3)

- In **unsigned** arithmetic,

---

Addition	<b>CF = 1</b> means <b>carry out</b>	when <b>C<sub>n</sub> = 1</b>
Subtraction	<b>CF = 1</b> means <b>borrow in</b>	when <b>C<sub>n</sub> = 0</b>

---

- **CF** - Carry Flag in x86
- **C<sub>n</sub>** - the normal carry out
  - the carry out of a 2's complement addition for **ADD**
  - the carry out of a *transformed* addition for **SUB**
- In **signed** arithmetic,
  - the **carry** flag is useless

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# TOC: More examples of the carry flag

- Summary I
- Summary II
- Cases for setting the carry flag
- Cases for clearing the carry flag

# Summary I

unsigned add/sub			signed addition			signed subtraction			CF	OF
1101	(13)		1101	(-3)		1101	(-3)			
+1110	+(14)	ADD	+1110	+(-2)	ADD	-0010	-(-2)			
-----	-----		-----	-----		-----	-----			
11011	(11) (+16)		11011	(-5)		11011	(-5)		1	0
0011	( 3)		0011	(+3)		0011	(+3)			
-1110	-(14)	SUB	+0010	+(+2)		-1110	-(-2)	SUB		
-----	-----		-----	-----		-----	-----			
10101	( 5) (-16)		00101	(+5)		00101	(+5)		1	0
0011	( 3)		0011	(+3)		0011	(+3)			
+0010	+( 2)	ADD	+0010	+(+2)	ADD	-1110	-(-2)			
-----	-----		-----	-----		-----	-----			
00101	( 5) (+ 0)		00101	(+5)		00101	(+5)		0	0
1101	(13)		1101	(-3)		1101	(-3)			
-0010	-( 2)	SUB	+1110	+(-2)		-0010	-(-2)	SUB		
-----	-----		-----	-----		-----	-----			
11011	(11) (-16)		11011	(-5)		11011	(-5)		0	0

# Summary II

unsigned add/sub			signed addition			signed subtraction			CF	OF
1011	(11)		1011	(-5)		1011	(-5)			
+1100	+(12)	ADD	+1100	+(-4)	ADD	-0100	-(+4)			
-----	-----		-----	-----		-----	-----			
10111	( 7) (+16)		10111	(+7)		10111	(+7)		1	1
0101	( 5)		0101	(+5)		0101	(+5)			
-1100	-(12)	SUB	+0100	+(+4)		-1100	-(-4)	SUB		
-----	-----		-----	-----		-----	-----			
11001	( 9) (-16)		01001	(-7)		01001	(-7)		1	1
0101	( 5)		0101	(+5)		0101	(+5)			
+0100	+( 4)	ADD	+0100	+(+4)	ADD	-1100	-(-4)			
-----	-----		-----	-----		-----	-----			
01001	( 9) (+ 0)		01001	(-7)		01001	(-7)		0	1
1011	(11)		1011	(-5)		1011	(-5)			
-0100	-( 4)	SUB	+1100	+(-4)		-0100	-(+4)	SUB		
-----	-----		-----	-----		-----	-----			
00111	( 7) ( 0)		10111	(+7)		10111	(+7)		0	1

# Cases for setting the carry flag (1) CF=1, OF=0

- unsigned integer overflow (CF=1 means +16)

* unsigned addition		* signed addition		signed subtraction
1101 (13)		1101 (-3)		1101 (-3)
+1110 +(14) ADD		+1110 +(-2) ADD		-0010 -(+2)
-----		-----		-----
11011 (11) (+16)		11011 (-5)		11011 (-5)
CF=1		Cn=1 -> CF=1		Cn=1 -> CF=1
CF means 16		CF meaningless		CF meaningless
S = 0000		S = 0000		S = 0000
* think hand		* think Cn of the corresponding addition		
addition		CF <- Cn (for unsigned addition)		

\* CF=1, S=1011, OF=0 for all three interpretations

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Cases for setting the carry flag (2) CF=1, OF=0

- unsigned integer overflow (CF=1 means -16)

* unsigned subtraction		signed addition		* signed subtraction
0011 (3)		0011 (+3)		0011 (+3)
-1110 -(14) SUB		+0010 +(2)		-1110 -(-2) SUB
-----		-----		-----
10101 (5) (-16)		00101 (+5)		00101 (+5)
CF=1		Cn=0 -> CF=1		Cn=0 -> CF=1
CF means -16		CF meaningless		CF meaningless
S = 0101		S = 0101		S = 0101
-----		-----		-----
* think hand subtraction		* think Cn of the transformed addition		
		CF <- !Cn (for unsigned subtraction)		
-----		-----		-----

\* CF=1, S=0101, OF=0 for all three interpretations

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Cases for setting the carry flag (3) CF=1, OF=1

- unsigned integer overflow (CF=1 means +16)

* unsigned addition		* signed addition	signed subtraction
1011 (11)		1011 (-5)	1011 (-5)
+1100 +(12) ADD		+1100 +(-4) ADD	-0100 -(+4)
-----		-----	-----
10111 ( 7) (+16)		10111 (+7)	10111 (+7)
CF=1		Cn=1 -> CF=1	Cn=1 -> CF=1
CF means +16		CF meaningless	CF meaningless
S = 0111		S = 0111	S = 0111
* think hand addition		* think Cn of the corresponding addition	
		CF <- Cn (for unsigned addition)	

\* CF=1, S=0111, OF=1 for all three interpretations



# Cases for setting the carry flag (4) CF=1, OF=1

- unsigned integer overflow (CF=1 means -16)

* unsigned subtraction		signed addition		* signed subtraction
0101 (5)		0101 (+5)		0101 (+5)
-1100 -(12) SUB		+0100 +(4)		-1100 -(-4) SUB
-----		-----		-----
11001 (9) (-16)		01001 (-7)		01001 (-7)
CF=1		Cn=0 -> CF=1		Cn=0 -> CF=1
CF means -16		CF meaningless		CF meaningless
S = 1001		S = 1001		S = 1001
-----		-----		-----
* think hand subtraction		* think Cn of the transformed addition		CF <- !Cn (for unsigned subtraction)

\* CF=1, S=1001, OF=1 for all three interpretations

# Cases for clearing the carry flag (1) CF=0, OF=0

- no unsigned integer overflow (CF=0)

* unsigned addition		* signed addition	signed subtraction
0011 ( 3)		0011 (+3)	0011 (+3)
+0010 +( 2) ADD		+0010 +( +2) ADD	-1110 -(-2)
-----		-----	-----
00101 ( 5) (+ 0)		00101 (+5)	00101 (+5)
CF=0		Cn=0 -> CF=0	Cn=0 -> CF=0
CF means 0		CF meaningless	CF meaningless
S = 0101		S = 0101	S = 0101
* think hand		* think Cn of the corresponding addition	
addition		CF <- Cn (for unsigned addition)	

\* CF=0, S=0101, OF=0 for all three interpretations

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Cases for clearing the carry flag (2) CF=0, OF=0

- no unsigned integer overflow (CF=0)

* unsigned addition	* signed addition	signed subtraction
1101 (13)	1101 (-3)	1101 (-3)
-0010 -( 2) SUB	+1110 +(-2)	-0010 -(+2) SUB
-----	-----	-----
11011 (11) (-16)	11011 (-5)	11011 (-5)
CF=0	Cn=0 -> CF=0	Cn=0 -> CF=0
CF means 0	CF meaningless	CF meaningless
S = 1011	S = 1011	S = 1011
-----	-----	-----
* think hand subtraction	* think Cn of the corresponding addition	
	CF <- Cn (for unsigned addition)	

\* CF=0, S=1011, OF=0 for all three interpretations

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)

# Cases for clearing the carry flag (3) CF=0, OF=1

- no unsigned integer overflow (CF=0)

* unsigned addition		* signed addition		signed subtraction
0101 ( 5)		0101 (+5)		0101 (+5)
+0100 +( 4) ADD		+0100 +( +4) ADD		-1100 -(-4)
-----		-----		-----
01001 ( 9) (+ 0)		01001 (-7)		01001 (-7)
CF=0		Cn=0 -> CF=0		Cn=0 -> CF=0
CF means +0		CF meaningless		CF meaningless
S = 1001		S = 1001		S = 1001
* think hand		* think Cn of the corresponding addition		
addition		CF <- Cn (for unsigned addition)		

\* CF=0, S=1001, OF=1 for all three interpretations

# Cases for clearing the carry flag (4) CF=0, OF=1

- no unsigned integer overflow (CF=0)

* unsigned subtraction		signed addition		* signed subtraction
1011 (11)		1011 (-5)		1011 (-5)
-0100 -(4) SUB		+1100 +(-4)		-0100 -(+4) SUB
-----		-----		-----
00111 (7) (0)		10111 (+7)		10111 (+7)
CF=0		Cn=1 -> CF=0		Cn=1 -> CF=0
CF means 0		CF meaningless		CF meaningless
S = 0111		S = 0111		S = 0111
* think hand subtraction		* think Cn of the transformed addition		CF <- !Cn (for unsigned subtraction)

\* CF=0, S=0111, OF=1 for all three interpretations

[http://teaching.idallen.com/dat2343/10f/notes/040\\_overflow.txt](http://teaching.idallen.com/dat2343/10f/notes/040_overflow.txt)