

# The Carry Flag

Young W. Lim

2024-07-23 Tue

## 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)

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# 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 interpreting **signed** and **unsigned** numbers (1)

- interpreting 0xFFFFBDC3

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as an **unsigned** (positive) number    +0xFFFFBDC3    +4294950339<sub>10</sub>

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as a **signed** (negative) number    -0x0000423D    -16957<sub>10</sub>

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

# Examples of interpreting **signed** and **unsigned** numbers (2)

- interpreting 0xFFFFBDC3
  - as an **unsigned** (positive) number | +0xFFFFBDC3 | +4294950339<sub>10</sub> |

$$15 * 16^7 + 15 * 16^6 + 15 * 16^5 + 15 * 16^4 \\ + 11 * 16^3 + 13 * 16^2 + 12 * 16^1 + 3 * 16^0$$

- as a **signed** (negative) number | -0x0000423D | -16957<sub>10</sub> |

$$0 * 16^7 + 0 * 16^6 + 0 * 16^5 + 0 * 16^4 \\ + 4 * 16^3 + 2 * 16^2 + 3 * 16^1 + 13 * 16^0$$

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



# Examples of interpreting signed and unsigned numbers (3)

- the 2's complement of 0xFFFFBDC3 : 0x0000423D (= +16957<sub>10</sub>)

	F	F	F	F	B	D	C	3
0xFFFFBDC3	0x1111	1111	1111	1111	1011	1101	1100	0011
0x0000423D	0x0000	0000	0000	0000	0100	0010	0011	1100
0x0000423D	0x0000	0000	0000	0000	0100	0010	0011	1101
	0	0	0	0	4	2	3	D

- the 2's complement of 0x0000423D : 0xFFFFBDC3 (= -16957<sub>10</sub>)

	0	0	0	0	4	2	3	D
0x0000423D	0x0000	0000	0000	0000	0100	0010	0011	1101
0x0000BDC2	0x1111	1111	1111	1111	1011	1101	1100	0010
0xFFFFBDC3	0x1111	1111	1111	1111	1011	1101	1100	0011
	F	F	F	F	B	D	C	3

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

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

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

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**0x0000195D - 0x0000618D**      **unsigned** subtraction

subtraction by hand

---

**0x0000195D + (-0x0000618D)**      **signed** subtraction

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

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

## 2's complements

- the 2's complement of **0x0000618D** : 0xFFFF8E73 (= -24973<sub>10</sub>)

		F	F	F	F	8	E	7	3	
0xFFFF9E73		0x1111_1111_1111_1111_1001_1110_0111_0011								
0x0000617C		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 **0xFFFF8E73** : 0x0000618D (= +24973<sub>10</sub>)

		0	0	0	0	6	1	8	D	
0x0000618D		0x0000_0000_0000_0000_0110_0001_1000_1101								
0xFFFF9E72		0x1111_1111_1111_1111_1001_1110_0111_0010								(1's complement)
0xFFFF9E73		0x1111_1111_1111_1111_1001_1110_0111_0011								(2's complement)
		F	F	F	F	8	E	7	3	

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

# Unsigned subtraction

- **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
-----
0xFFFB7D0  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
```

- 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

- $0x0000195D + (-0x0000618D)$  : 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)
```

- signed integer overflow is indicated by the **overflow** flag (OF)
  - the **carry** flag is set by the **inverted** carry of a transformed addition

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

# Interpreting the result as a signed or an unsigned integer

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

- the 2's complement of `0xFFFFB7D0` : `0x00004830` ( $= +18480_{10}$ )

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

- the 2's complement of `0x00004830` : `0xFFFFB7D0` ( $= -18480_{10}$ )

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

<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)

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## Summary of **signed** and **unsigned** subtractions (2)

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0xFFFFB7D0    the result of **unsigned** subtraction    4294948816<sub>10</sub>  
with CF=1    with **unsigned** integer overflow

---

-0x00004830    the result of **signed** subtraction    -18480<sub>10</sub>

---

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



# Examples of **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),

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# Examples of 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*, ( $N + N \rightarrow P$ )

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# 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

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

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

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

[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

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

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

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

# Addition and Subtraction

- addition

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

	$a_{n-1}$	$a_{n-2}$	⋯	$a_1$	$a_0$
	$b_{n-1}$	$b_{n-2}$	⋯	$b_1$	$b_0$
	$c_{n-1}$	$c_{n-2}$	⋯	$c_1$	$0$
$c_n$	$s_{n-1}$	$s_{n-2}$	⋯	$s_1$	$s_0$

- subtraction - transformed addition

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

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

[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

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## 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** ( $CF=0$ )
  - **$CF = !C_n$**

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## 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

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# 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)

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[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)

# TOC: Method for computing the carry flag

- 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
$A + B = A + B + \mathbf{0}$	$A - B = A + \overline{B} + \mathbf{1}$
$\{c_n, s_{n-1}\}$ $= a_{n-1} + b_{n-1} + c_{n-1}$	$\{c_n, s_{n-1}\}$ $= a_{n-1} + \overline{b_{n-1}} + c_{n-1}$

[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,

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

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- **CF** - Carry Flag in x86
- **Cn** - 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)