# Data Size and Arithmetic: Examples and Sample Problems

ICS312

**Machine-Level and Systems Programming**

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# Example

```
mov al 0A7h         ; as a programmer, I view this
                    ; as a unsigned, 1-byte quantity
                    ; (decimal 167)
mov bl 0A7h         ; as a programmer, I view this
                    ; as a signed 1-byte
                    ; quantity (decimal -89)

movzx eax, al;      ; extend to a 4-byte value
                    ; (000000A7)
movsx ebx, bl;      ; extend to a 4-byte value
                    ; (FFFFFFA7)
```

# Practice

- Consider the following code

```
mov       al, 0B2h
movsx     eax, al
mov       bx, eax
movzx     ebx, bx
```

- What’s the final value of eax?
- What’s the final value of ebx?

# Practice (Solution)

| | | EAX | | | | EBX | | | |
|---|---|---|---|---|---|---|---|---|---|
| mov | al, 0B2h | ?? | ?? | ?? | B2 | ?? | ?? | ?? | ?? |
| movsx | eax, al | FF | FF | FF | B2 | ?? | ?? | ?? | ?? |
| mov | bx, eax | FF | FF | FF | B2 | ?? | ?? | FF | B2 |
| movzx | ebx, bx | FF | FF | FF | B2 | 00 | 00 | FF | B2 |

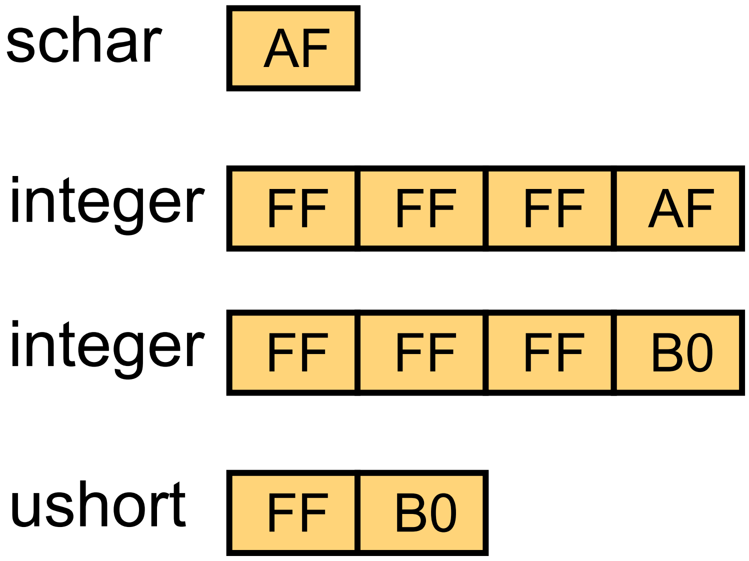
# Example

```
unsigned short      ushort;    // 2-byte quantity
signed   char       schar;     // 1-byte quantity
int                 integer;   // 4-byte quantity

schar = 0xAF;
integer = (int) schar;
integer++;
ushort = integer;

printf("ushort = %d\n",ushort);
```

- What does this code print?
  - Or at least what’s the hex value of the decimal value it prints?

# Example

```
unsigned short          ushort;
signed   char           schar;
int                     integer;

schar = 0xAF;

integer = (int) schar;

integer++;

ushort = integer;

printf("ushort = %d\n",ushort);
```



schar AF

integer FF FF FF AF

integer FF FF FF B0

ushort FF B0

Because printf doesn’t specify “h” ushort is size augmented to 4-bytes using movzx (because declared as unsigned): 00 00 FF B0
The number is then printed as a signed integer (“%d”): 65456

# Carry/Overflow bits

- Which of these operations set the Carry bit to 1? (presumably we care because we think of these as unsigned operations)
  - 0F12 + F212 (2-byte quantities)
  - 00E3 + F74F (2-byte quantities)
  - F1 - FA (1-byte quantities)
  - FB12 - A3AA (2-byte quantities)
  - A314 - B010 (2-byte quantities)
- Which of these operations set the Overflow bit to 1? (presumably we care because we think of these as signed operations)
  - 00E3 + FF4F (2-byte quantities)
  - F1 - 7A (1-byte quantities)

# Carry/Overflow bits (Solution)

- Which of these operations set the Carry bit to 1?

```
      0F12
+     F212
=    10124                Carry bit is set

      00E3
+     F74F
=     F832                Carry bit is not set
```

- □ F1 - FA: F1 < FA Carry bit is set
- □ FB12 - A3AA: FB12 > A3AA Carry bit is not set
- □ A314 - B010: A314 < B010 Carry bit is set

# Carry/Overflow bits (Solution)

- Which of these operations set the Overflow bit to 1?
    - 00E3 + FF4F
        - 00E3 > 0,  equal to decimal +227
        - FF4F < 0, 2’s complement = 00B0+1 = B1, equal do decimal -177
        - +243 - 177 = 50
        - 2 byte unsigned numbers are in [-32,768, +32,767]
        - Overflow bit is not set
    - F1 - 7A
        - F1 < 0, 2’s complement = 0E+1 = 0F, equal to decimal -15
        - 7A > 0, equal to 122
        - -15 - 122 = -137
        - 1-byte unsigned numbers are in [-128,+127]
        - Overflow bit is set

# Unsigned Overflow

On web site as
ics312_overflow_unsigned.asm

```
mov      al, 0F0h       ; al = F0h
mov      bl, 0A3h       ; bl = A3h
add      al, bl         ; al = al + bl
movzx    eax, al        ; increase size for printing
call     print_int      ; print al as an integer
```

- As a programmer we decided to do some computation with unsigned values
- We put value F0h in al (unsigned F0h is decimal 240)
- We put value A3h in bl (unsigned A3h is decimal 163)
- We add them together
- The “true” result should be decimal 240+163 = 403, which cannot be encoded on 8 bits (should be < 255)
- But the processor just goes ahead: F0 + A3 = 193h, and then drops the leftmost bits to truncate to a 1-byte value to get 93h!
- To call print_int, we need the integer in eax, so we movzx al into eax
- print_int print the decimal value corresponding to 00000093h, that is: 147!
- This is obviously wrong, and we can tell (or will be able to shortly) because the carry bit is in fact set to 1
- Note that this is all correct if we assume signed values and replace movzx by movsx, but then our initial interpretation of the two values is different

# Signed Overflow

On web site as
ics312_overflow_signed.asm

```
mov      al, 09Ah      ; al = 9Ah
mov      bl, 073h      ; bl = 73h
sub      al, bl        ; al = al - bl
movsx    eax, al       ; increase size for printing
call     print_int     ; print al as an integer
```

- As a programmer we decided to do some computation with signed values
- We put value 9Ah in al  (signed 9Ah is decimal -102)
- We put value 73h in bl  (signed 73h is decimal +115)
- We subtract bl from al
- The “true” result should be decimal -102 - 115 = -217, which cannot be encoded on 8 bits (should be >= -128)
- But the processor just goes ahead: 9A - 73 = 27h
- To call print_int, we need the integer in eax, so we movsx al into eax
- print_int prints the decimal value corresponding to 00000027h, that is: 39!
- This is obviously wrong, and we can tell (or will be able to shortly) because the overflow bit is in fact set to 1
- Note that this is all correct if we assume unsigned values and replace movsx by movzx, but then our initial interpretation of the two values is different