NEUB CSE 322 Lab Manual 2: Flow Control Instructions

Conditional Jumps

- **jnz** is an example of a conditional jump
- Format is

  j*xxx destination_label*

- If the condition for the jump is true, the next instruction to be executed is the one at *destination_label.*
- If the condition is false, the instruction immediately following the jump is done next
- For **jnz**, the condition is that the result of the previous operation is not zero

Range of a Conditional Jump

- The *destination_label* must precede the jump instruction by no more than 126 bytes, or follow it by no more than 127 bytes
- There are ways around this restriction (using the unconditional **jmp** instruction)

The CMP Instruction

- The jump condition is often provided by the **cmp** (*compare*) instruction:

```
cmp destination, source
```

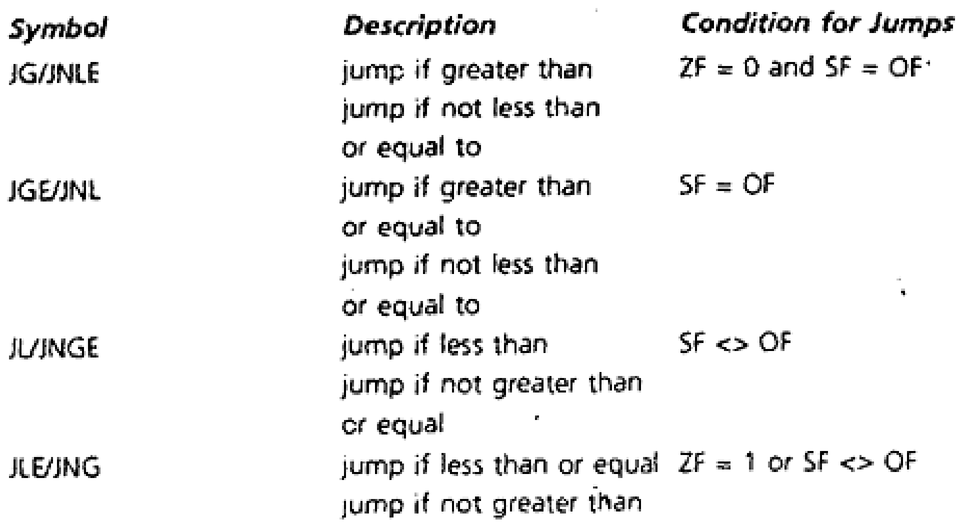
- **cmp** is just like **sub**, except that the destination is not changed -- only the flags are set
- Suppose **ax** = **7FFFh** and **bx** = **0001h**

```
cmp ax, bx
jg below
```

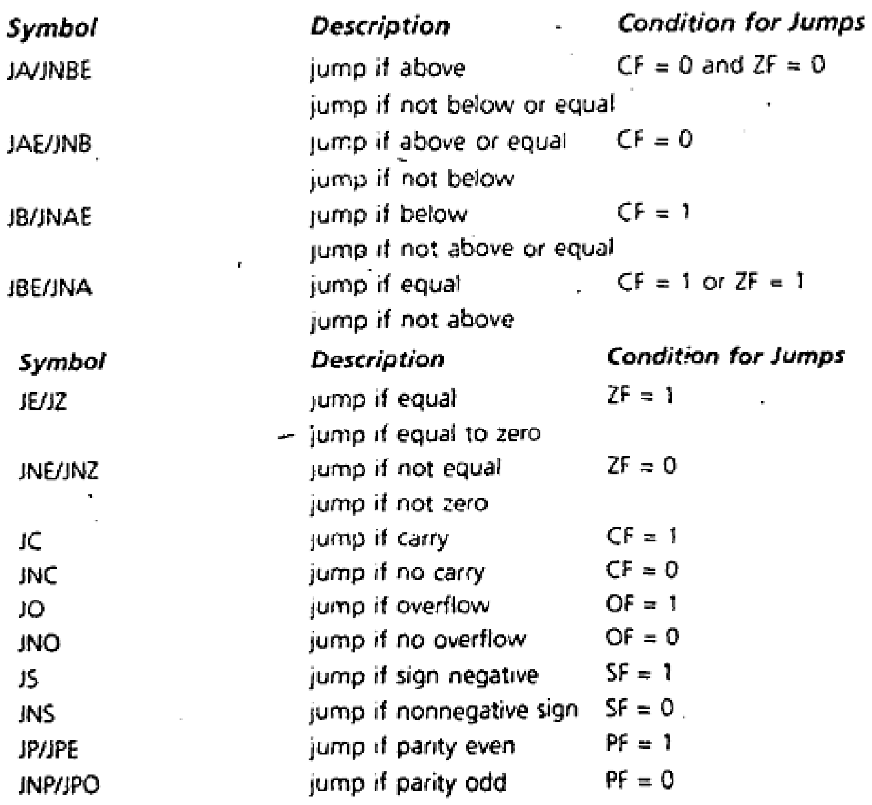
zf = 0 and **sf** = **of** = 0, so control transfers to label `below`

Types of Conditional Jumps

- Signed Jumps:
  - `jg/jnle, jge/jnl, jl/jnge, jle/jng`
- Unsigned Jumps:
  - `ja/jnbe, jae/jnb, jb/jnae, jbe/jna`
- Single-Flag Jumps:
  - `je/jz, jne/jnz, jc, jnc, jo, jno, js, jns, jp/jpe, jnp/jpo`



Symbol	*Description*	*Condition for Jumps*
JG/JNLE	jump if greater than jump if not less than or equal to	ZF = 0 and SF = OF
JGE/JNL	jump if greater than or equal to jump if not less than or equal to	SF = OF
JL/JNGE	jump if less than jump if not greater than or equal	SF <> OF
JLE/JNG	jump if less than or equal jump if not greater than	ZF = 1 or SF <> OF



Symbol	*Description*	*Condition for Jumps*
JA/JNBE	jump if above	CF = 0 and ZF = 0
	jump if not below or equal	
JAE/JNB	jump if above or equal	CF = 0
	jump if not below	
JB/JNAE	jump if below	CF = 1
	jump if not above or equal	
JBE/JNA	jump if equal	CF = 1 or ZF = 1
	jump if not above	

Symbol	*Description*	*Condition for Jumps*
JE/JZ	jump if equal	ZF = 1
	jump if equal to zero	
JNE/JNZ	jump if not equal	ZF = 0
	jump if not zero	
JC	jump if carry	CF = 1
JNC	jump if no carry	CF = 0
JO	jump if overflow	OF = 1
JNO	jump if no overflow	OF = 0
JS	jump if sign negative	SF = 1
JNS	jump if nonnegative sign	SF = 0
JP/JPE	jump if parity even	PF = 1
JNP/JPO	jump if parity odd	PF = 0

Signed versus Unsigned Jumps

- Each of the signed jumps has an analogous unsigned jump (e.g., the signed jump **jg** and the unsigned jump **ja**)
- Which jump to use depends on the context
- Using the wrong jump can lead to incorrect results
- When working with standard ASCII character, either signed or unsigned jumps are OK (msb is always 0)
- When working with the IBM extended ASCII codes, use unsigned jumps

Conditional Jump Example

- Suppose ax and bx contained signed numbers. Write some code to put the biggest one in cx:

```
        mov cx,ax       ; put ax in cx
        cmp bx,cx       ; is bx bigger?
        jle NEXT        ; no, go on
        mov cx,bx       ; yes, put bx in cx
    NEXT:
```

The JMP Instruction

- **jmp** causes an unconditional jump
    - **jmp** ***destination***
- jmp can be used to get around the range restriction of a conditional jump
- e.g, (this example can be made shorter, *how?*)

```
        TOP:                    TOP:
        ; body of loop          ; body of loop
        ; over 126 bytes            dec cx
            dec cx                  jnz BOTTOM
            jnz TOP                 jmp EXIT
            mov ax, bx          BOTTOM:
                                    jmp TOP
                                EXIT:
                                    mov ax, bx
```

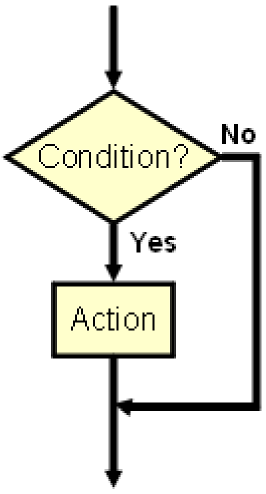
IF-THEN structure

- **Example -- to compute |ax|:**

```
if ax < 0 then
    ax = -ax
endif
```

- Can be coded as:

```
; if ax < 0
        cmp ax, 0      ; ax < 0 ?
        jnl endif      ; no, exit
; then
        neg ax         ; yes, change sign
endif:
```



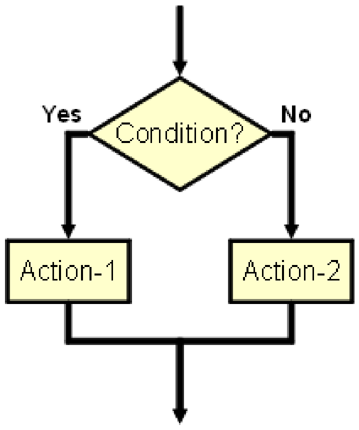
IF-THEN-ELSE structure

- **Example -- Suppose al** and **bl** contain extended ASCII characters. Display the one that comes first in the character sequence:

  if al <= bl then
  display the character in **al**
  else
  display the character **in bl**
  endif

- **This example may be coded as:**

```
     mov ah, 2      ; prepare for display
; if al <= bl
     cmp al, bl     ; al <= bl ?
     jnbe else_     ; no, display bl
; then ; al <= bl
     mov dl, al     ; move it to dl
     jmp display
else_:             ; bl < al
     mov dl, bl
display:
     int 21h        ; display it
; endif
```



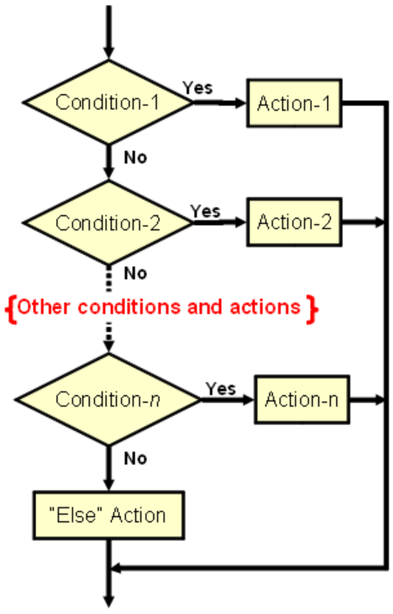
The CASE structure

- Multi-way branch structure with following form:

  case *expression*
  value$_1$: *statement*$_1$
  value$_2$: *statement*$_2$
  …
  value$_n$: *statement*$_n$
  endcase

- **Example -- If ax** contains a negative number, put -1 in **bx**; if 0, put 0 in **bx**; if positive, put 1 in **bx**:

  case ax
  < 0 : *put* **-1** *in* **bx**
  = 0 : *put* **0** *in* **bx**
  > 0 : *put* **1** *in* **bx**
  endcase



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- This example may be coded as:

```
; case ax
     cmp ax, 0      ; test ax
     jl neg         ; ax < 0
     je zero        ; ax = 0
     jg pos         ; ax > 0
neg:
     mov bx, -1
     jmp endcase
zero:
     mov bx,0
     jmp endcase
pos:
     mov bx, 1      ; put 1 in bx
endcase:
```

- Only one **cmp** is needed, because jump instructions do not affect the flags

AND conditions

- **Example -- read a character and display it if it is uppercase:**

```
read a character into al
if char >= 'A' and char <= 'Z' then
     display character
endif
```

```
; read a character
           mov ah, 1       ;prepare to read
           int 21h         ;char in al
; if char >= 'A' and char <= 'Z'
           cmp al,'A'      ;char >= 'A'?
           jnge endif      ;no, exit
           cmp al,'Z'      ;char <= 'Z'?
           jnle endif      ;no, exit
;then display character
           mov dl,al       ;get char
           mov ah,2        ;prep for display
           int 21h         ;display char
endif:
```

OR conditions

- **Example -- read a character and display it if it is 'Y' or 'y':**

```
read a character into al
if char = 'y' or char = 'Y' then
     display character
endif
```

```
; read a character
           mov ah, 1     ;prepare to read
           int 21h       ;char in al
; if char = 'y' or char = 'Y'
           cmp al,'y'    ;char = 'y'?
           je then       ;yes, display it
           cmp al,'Y'    ;char = 'Y'?
           je then       ;yes, display it
           jmp endif     ;no, exit
then:
           mov ah,2      ;prep for display
           mov dl,al     ;move char
           int 21h       ;display char
endif:
```

The FOR Loop using `LOOP`

- The loop statements are repeated a known number of times (counter-controlled loop)

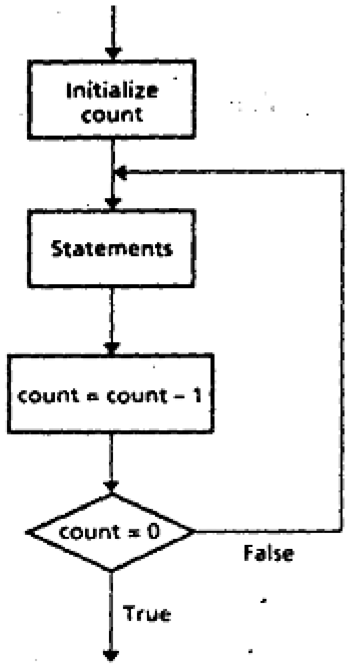
```
    for loop_count times do
        statements
    endfor
```

- The **loop** instruction implements a **FOR** loop:

  `loop` ***destination_label***

- The counter for the loop is the register **cx** which is initialized to *loop_count*
- The **loop** instruction causes **cx** to be decremented, and if **cx**≠0, jump to ***destination_label***
- The destination label must precede the **loop** instruction by no more than 126 bytes
- A FOR loop can be implemented as follows:

```
                ;initialize cx to loop_count
    TOP:
                ;body of the loop
                loop TOP
```



FOR loop example

- a counter-controlled loop to display a row of 80 stars

```
            mov cx,80      ; # of stars
            mov ah,2       ; disp char fnctn
            mov dl,'*'     ; char to display
TOP:
            int 21h        ; display a star
            loop TOP       ; repeat 80 times
```

- The FOR loop implemented with the loop instruction always executes at least once
- **If cx** = 0 at the beginning, the loop will execute 65536 times!
- To prevent this, use a **jcxz** before the loop

```
            jcxz SKIP
TOP:
            ; body of loop
            . . .
            loop TOP
SKIP:
```

JCXZ *destination*

- Directly compares **CX** to 0 and jumps to the destination if equal
- This instruction does not affect the flags
- It is commonly used to bypass the first iteration of a loop if the count is already 0

```
;for(i=1; i<x; i++)  do_it();
     mov cx,x
     jcxz skip_it
top_loop:
     call do_it
     loop top_loop
skip_it:
```

LOOPZ/E and LOOPNZ/E

- Enhancement of the LOOP instruction
- The state of the ZERO Flag may also cause loop termination
- Loop while ZF/equal && CX!=0

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- Loop while (NZ/ not equal) && CX!=0
- Remember that LOOP decrements CX, but this does not affect the flags!
- LOOPZ == LOOPE
- LOOPNZ==LOOPNE
- Some action inside the loop should affect the zero flag **(`cmp` ?)**

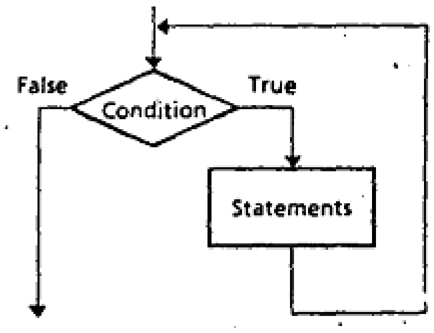
LOOPNZ Example

- This program accepts at most 9 characters from the keyboard
- When the 9th character is pressed (or the enter key is used) the number of keypresses is displayed

```
        mov ah,1
        mov cx,9
next_char:
        int 21h
        cmp al,13
        loopne next_char
;determine count
        mov ax, 0239h
        sub al,cl
        int 21h
```

The WHILE Loop

```
while condition do
        statements
endwhile
```



- The condition is checked at the top of the loop
- The loop executes as long as the condition is true
- The loop executes 0 or more times

WHILE example

- **Count the number of characters in an input line**

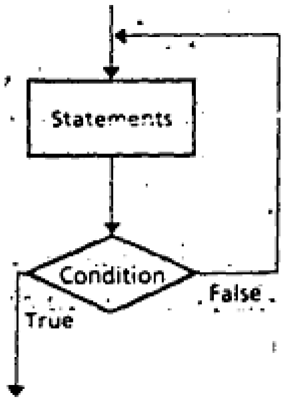
```
count = 0
read char
while char ≠ carriage_return do
        increment count
        read char
endwhile
```

```
                mov dx,0        ;DX counts chars
                mov ah,1        ;read char fnctn
                int 21h         ;read char into al
WHILE_:
                cmp al,0Dh      ;ASCII CR?
                je ENDWHILE     ;yes, exit
                inc dx          ;not CR, inc count
                int 21h         ;read another char
                jmp WHILE_      ;loop back
ENDWHILE:
```

- The label **`WHILE_`** is used because **`WHILE`** is a reserved word

The REPEAT Loop

```
repeat
        statements
until condition
```



- The condition is checked at the bottom of the loop
- The loop executes until the condition is true
- The loop executes 1 or more times

REPEAT example

- read characters until a blank is read
  repeat
    read character
  until *character is a blank*

```
           mov ah,1      ;read char function
REPEAT:
           int 21h       ;read char into al
;until
           cmp al,' '    ;a blank?
           jne REPEAT    ;no, keep reading
```

- Using a **while** or a **repeat** is often a matter of personal preference. The **repeat** may be a little shorter because only one jump instruction is required, rather than two

1. Marut Chapter 4 programming exercise 7-12
2. Marut Chapter 6 example 6.1-6.10
3. Marut Chapter 6 exercise question 1-2
4. Marut Chapter 6 programming exercise 8-11