Computer Org. & Assembly Language Lab

Lab#07: Conditional Processing

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Boolean and Comparison Instructions

AND Instruction

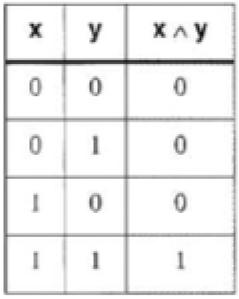
The AND instruction performs a boolean (bitwise) AND operation between each pair of matching bits in two operands and places the result in the destination operand:

```
AND destination,source
```

The following operand combinations are permitted:

```
AND reg,reg
AND reg,mem
AND reg,imm
AND mem, reg
AND mem,imm
```

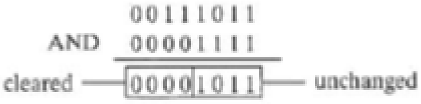
The operands can be 8, 16, or 32 bits, and they must be the same size.



x	y	x ∧ y
0	0	0
0	1	0
1	0	0
1	1	1

Truth Table

The AND instruction is often used to clear selected bits and preserve others. In the following example, the upper four bits are cleared and the lower four bits are unchanged:



Converting Characters to Upper Case

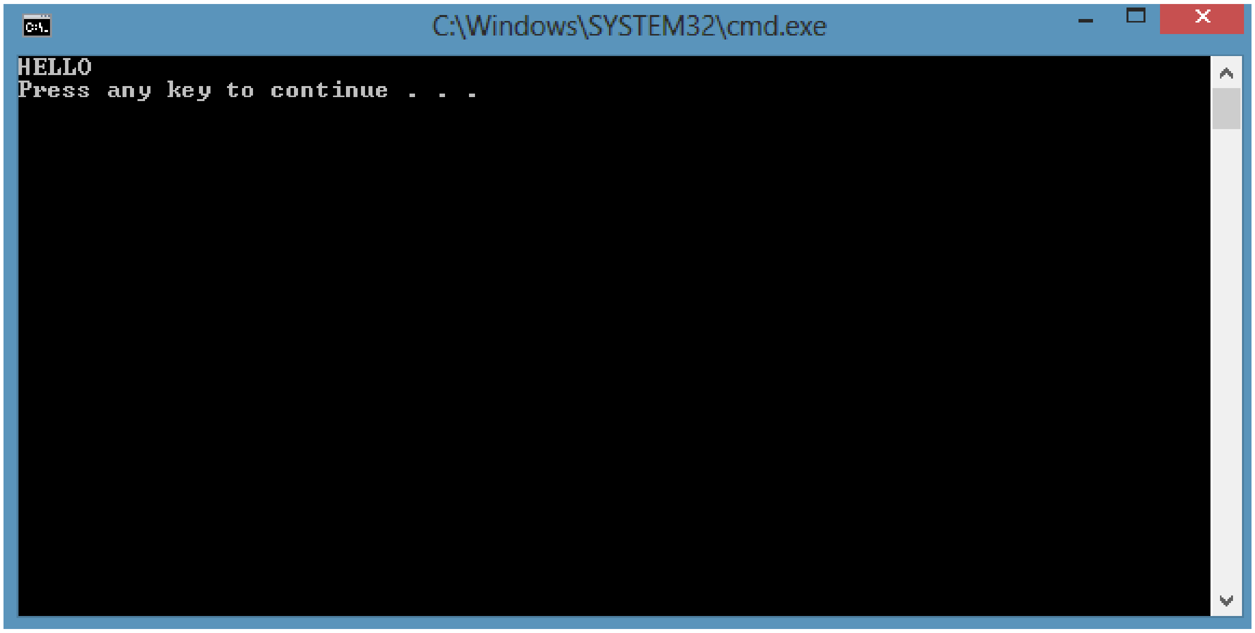
The AND instruction provides an easy way to translate a letter from lowercase to uppercase. If we compare the ASCII codes of capital A and lowercase a, it becomes clear that only one bit is different:

```
0 1 1 0 0 0 0 1 = 61h ('a')

0 1 0 0 0 0 0 1 = 41h (' A' )
```

The rest of the alphabetic characters have the same relationship. If we AND any character with 110111111 binary, all bits are unchanged except for bit 5, which is cleared. In the following example, all characters in an array are converted to uppercase

```
Include irvine32.inc

.data

      array BYTE "hello",0

.code
main PROC

      mov ecx,LENGTHOF array
      mov esi,OFFSET array
      dec ecx

      Ll:
            and BYTE PTR [esi], 11011111b
            inc esi
      loop Ll

      mov edx, OFFSET array
      Call WriteString
      Call Crlf

      ;Alternate method, read character by character
      ;mov ecx, LENGTHOF array
      ;mov esi, OFFSET array

            ;L2:
                  ;mov al, [esi]
                  ;Call WriteChar
                  ;inc esi
            ;loop L2
exit
main ENDP
END main
```

Output



```
HELLO
Press any key to continue . . .
```

Flags: The AND instruction always clears the Overflow and Carry flags. It modifies the Sign, Zero flags according to the value of the destination operand.

OR Instruction

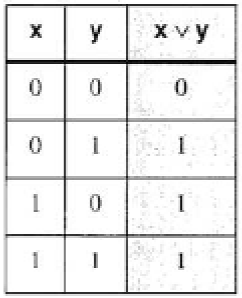
The OR instruction performs a boolean OR operation between each pair of matching bits in two operands and places the result in the destination operand:

```
OR destination, source
```

The OR instruction uses the same operand combinations as the AND instruction:

```
OR reg, reg
OR reg,mem
OR reg,imm
OR mem,reg
OR mem,imm
```

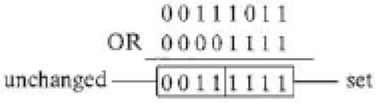
The operands can be 8, 16, or 32 bits, and they must be the same size.



x	y	x ∨ y
0	0	0
0	1	1
1	0	1
1	1	1

Truth Table

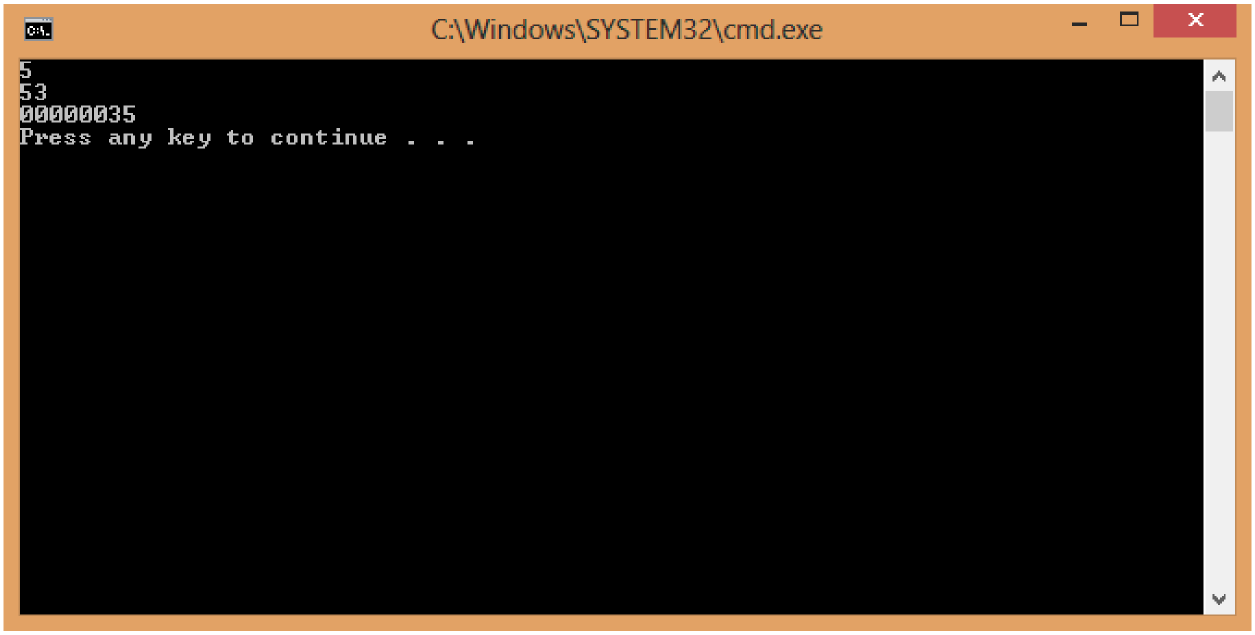
The OR instruction is often used to set selected bits and preserve others. In the following figure, 3Bh is ORed with OFh. The lower four bits of the result are set and the high four bits are unchanged:



The OR instruction can be used to convert a byte containing an integer between 0 and 9 into an ASCII digit. To do this, you must set bits 4 and 5. If, for example, AL =05h, you can OR it with 30h to convert it to the ASCII code for the digit 5 (35h):

```
Include irvine32.inc

.data

val byte 5

.code
main PROC
      or val,30h
      movzx eax,val

      call WriteChar
      call Crlf

      call WriteDec
      call Crlf

      call WriteHex
      call Crlf

exit
main ENDP
END main
```

Output



```
5
53
00000035
Press any key to continue . . .
```

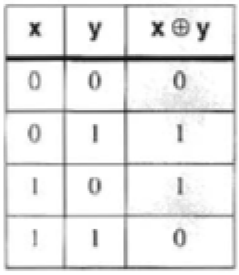
Flags: The OR instruction always clears the Overflow and Carry flags. It modifies the Sign, Zero flags according to the value of the destination operand.

XOR Instruction

The XOR instruction performs a boolean exclusive-OR operation between each pair of matching bits in two operands, and stores the result in the destination operand:

```
XOR destination, source
```

The operands can be 8, 16, or 32 bits.



x	y	x ⊕ y
0	0	0
0	1	1
1	0	1
1	1	0

Truth Table

Flags: The XOR instruction always clears the Overflow and Carry flags. It modifies the Sign. Zero . and Parity flags according to the value of the destination operand.

NOT Instruction

The NOT instruction toggles all bits in an operand. The result is called the one's complement. The following operand types are permitted:

```
NOT reg
NOT mem
```

For example, the one's complement of F0h is 0Fh:

```
mov al,11110000b
not al                  ; AL = 00001111b
```

Flags: No flags are affected by the NOT instruction

```
;for Boolean instructions
XOR EAX,EAX
XOR EBX,EBX

mov al,10101010b
mov bl,01010101b

call DumpRegs

AND bl,al
call DumpRegs

OR bl,al
call DumpRegs

NOT al
call DumpRegs

;call WriteBin
```

TEST Instruction

The TEST instruction performs an implied AND operation between each pair of matching bits in two operands and sets the flags accordingly. The only difference between TEST and AND is that TEST does not modify the destination operand. The TEST instruction permits the same operand combinations as the AND instruction. TEST is particularly valuable for finding out if individual bits in an operand are set.

Example: *Testing Multiple Bits*

The TEST instruction can check several bits at once. Suppose we want to know if either bit 0 or bit 3 is set in the AL register. We can use the following instruction to find this out:

```
test al,00001001b       ; test bits 0 and 3
```

From the following example data sets, we can infer that the Zero flag is set only when all tested bits are clear:

```
0 0 1 0 0 1 0 1 <- input value
0 0 0 0 1 0 0 1 <- test value
0 0 0 0 0 0 0 1 <- result : ZF = 0
0 0 1 0 0 1 0 0 <- input value
0 0 0 0 1 0 0 1 <- test value
0 0 0 0 0 0 0 0 <- result: ZF = 1
```

Flags: The TEST instruction always clears the Overflow and Carry flags. It modifies the Sign, Zero, and Parity flags in the same way as the AND instruction.

CMP Instruction

It compares the destination operand to the source operand by subtracting source operand from a destination operand. No operand is modified.

Remember these combinations for comparison:

```
mov al,6
cmp al,5 ; ZF=0, CF=0 ; if(al>5)
```

```
mov al,4
cmp al,5 ; Carry flag set ; if (al<5)
```

```
mov al,5
cmp al,5 ; Zero flag set ; if(al==5)
```

CMP for Signed Integers is given below

```
mov al,5
cmp al,-2    ;Sign flag == Overflow flag    ;if(al > -2)
```

```
mov al,-1
cmp al,5     ;Sign flag != Overflow flag    ;if(al < 5)
```

Conditional Jumps

Jcond Instruction

A conditional jump instruction branches to a label when specific register or flag conditions are met.

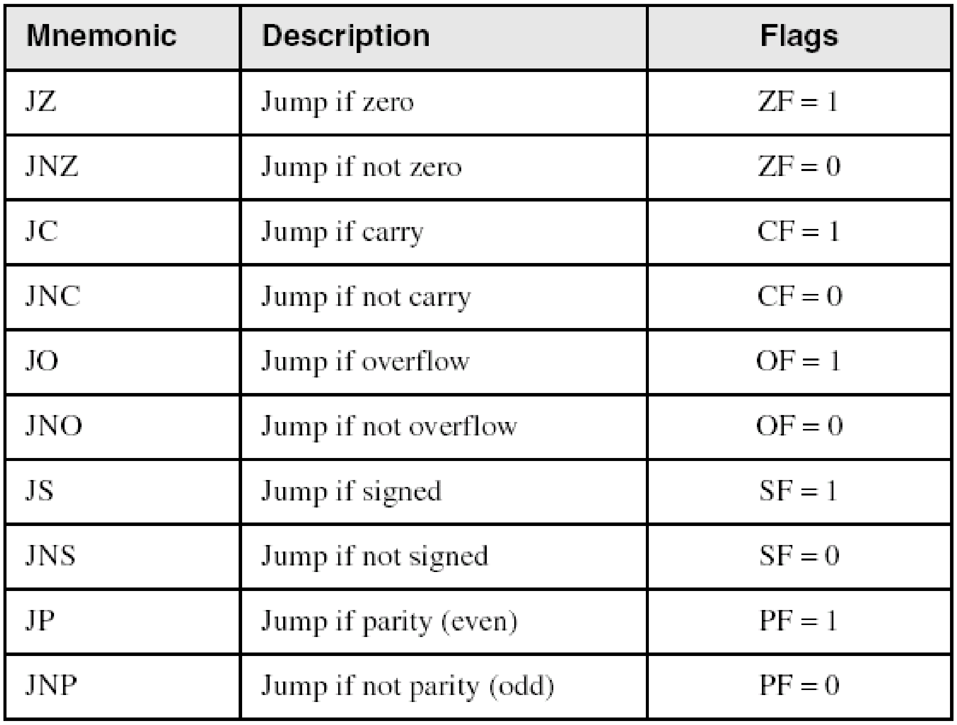
For example

- JE/ JZ: Jump to a label if the ZF=1 (set)
- JS: Jumps to a label if the SF=1(set)
- JNE/ JNZ: Jump to a label if the ZF=0 (clear)
- JECXZ: Jumps to a label if ECX = 0 (default used by Loop instruction)

```
cmp al, 0

   jz  L1       ;jump if ZF = 1

   .

   .

L1:
```

Jump Based on Specific Flags

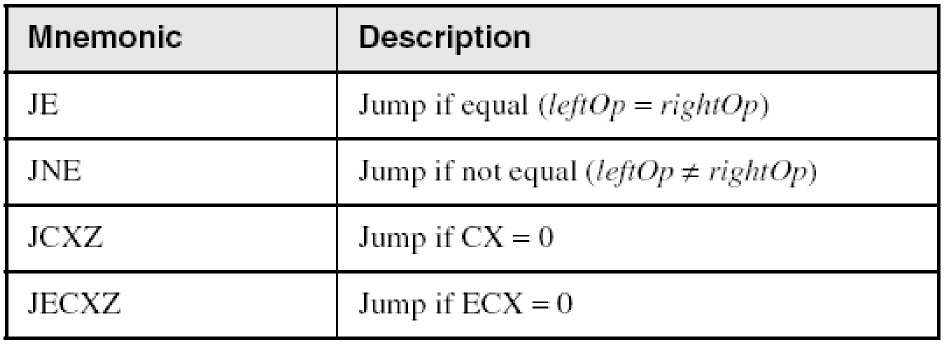
There conditional jump instructions that act on the basis of the status flags are as given below.



Mnemonic	Description	Flags
JZ	Jump if zero	ZF = 1
JNZ	Jump if not zero	ZF = 0
JC	Jump if carry	CF = 1
JNC	Jump if not carry	CF = 0
JO	Jump if overflow	OF = 1
JNO	Jump if not overflow	OF = 0
JS	Jump if signed	SF = 1
JNS	Jump if not signed	SF = 0
JP	Jump if parity (even)	PF = 1
JNP	Jump if not parity (odd)	PF = 0

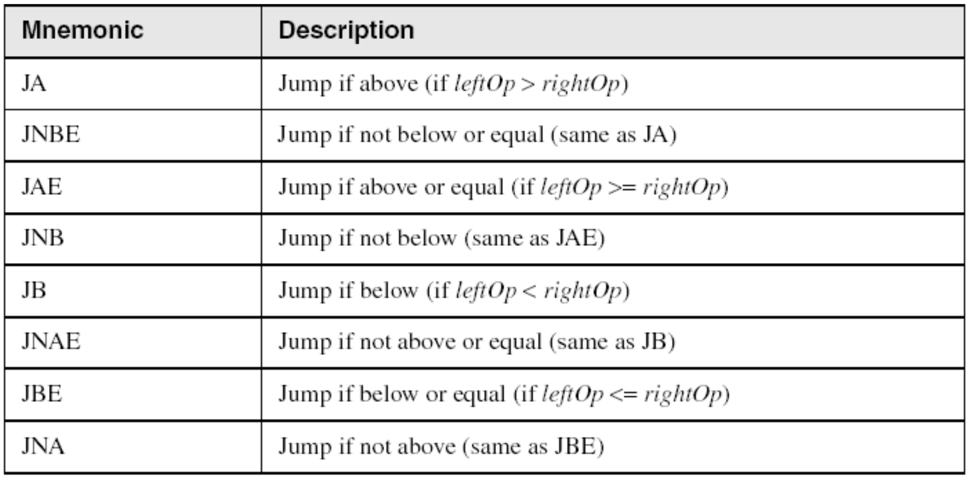
Jump Based on Equality

Equity based JUMP Based Instructions are given below.



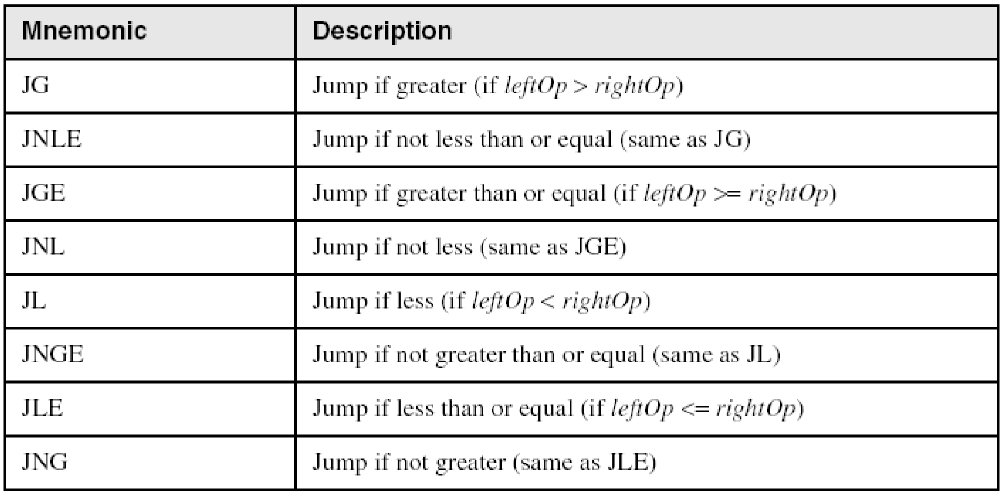
Mnemonic	Description
JE	Jump if equal (*leftOp* = *rightOp*)
JNE	Jump if not equal (*leftOp* ≠ *rightOp*)
JCXZ	Jump if CX = 0
JECXZ	Jump if ECX = 0

Jump based on Unsigned Comparisons



Mnemonic	Description
JA	Jump if above (if *leftOp* > *rightOp*)
JNBE	Jump if not below or equal (same as JA)
JAE	Jump if above or equal (if *leftOp* >= *rightOp*)
JNB	Jump if not below (same as JAE)
JB	Jump if below (if *leftOp* < *rightOp*)
JNAE	Jump if not above or equal (same as JB)
JBE	Jump if below or equal (if *leftOp* <= *rightOp*)
JNA	Jump if not above (same as JBE)

Jump Based on Signed Comparisons



Mnemonic	Description
JG	Jump if greater (if *leftOp* > *rightOp*)
JNLE	Jump if not less than or equal (same as JG)
JGE	Jump if greater than or equal (if *leftOp* >= *rightOp*)
JNL	Jump if not less (same as JGE)
JL	Jump if less (if *leftOp* < *rightOp*)
JNGE	Jump if not greater than or equal (same as JL)
JLE	Jump if less than or equal (if *leftOp* <= *rightOp*)
JNG	Jump if not greater (same as JLE)

Scanning an Array

```
; Scan an array for the first nonzero value.

INCLUDE Irvine32.inc

.data

intArray SWORD  0,0,0,0,1,20,35,-12,66,4,0

noneMsg  BYTE "A non-zero value was not found",0

.code
main PROC
      mov   ebx,OFFSET intArray           ; point to the array
      mov   ecx,LENGTHOF intArray         ; loop counter

L1:
      cmp   WORD PTR [ebx],0  ; compare value to zero
      jnz   found       ; found a value
      add   ebx,2       ; point to next
      loop  L1          ; continue the loop
      jmp   notFound          ; none found

found:
      movsx eax,WORD PTR [ebx]            ; otherwise, display it
      call  WriteInt
      jmp   quit

notFound:
      mov   edx,OFFSET noneMsg            ; display "not found" message
      call  WriteString

quit:
      call  crlf
      exit

main ENDP
END main
```

BT (Bit Test) Instruction

BT instruction copies bit n from an operand into the Carry flag.

```
BT bitBase, n
```

The first operand, called the bitBase is not changed.

Example: jump to label L1 if bit 8 is set in the AX register:

```
Include irvine32.inc

.data

msg_s byte "Eight bit is set",0
msg_c byte "Eight bit is clear",0

.code
main PROC

      Mov AX, 0000000100000000b
      bt AX,8 ; CF = bit 8
      call dumpregs

      jc L1             ; jump if Carry

      mov edx, offset msg_c
      call writestring
      call crlf


      L1:
      mov edx, offset msg_s
      call writestring
      call crlf
exit
main ENDP
END main
```

For example x = 10001000b

Mnemonics	Description	Statement	CF =?	X =?
BTC	Bit Test and Complement	BTC x, 6	CF = 0	X = 11001000b
BTR	Bit Test and Reset	BTR x, 7	CF = 1	X = 00001000b
BTS	Bit Test and Set	BTS x, 6	CF = 0	X = 11001000b

Conditional Loop Instructions

LOOPZ & LOOPE Instructions

The LOOPZ (loop if zero) instruction permits a loop to continue while the Zero flag is set and the unsigned value of ECX is greater than zero.

The LOOPE (loop if equal) instruction is equivalent to LOOPZ. Below is the execution logic of LOOPZ and LOOPE:

```
ECX = ECX - 1
if ECX > 0 and ZF = 1, jump to destination
```

Otherwise, no jump occurs and control passes to the next instruction.

Syntax

```
LOOPZ destination
LOOPE destination
```

```
TITLE LOOPZ / LOOPE

INCLUDE Irvine32.inc

.data

.code
main PROC

      XOR EAX,EAX
      XOR EBX,EBX
      XOR ecx,ecx
      XOR ebx,ebx

      mov ebx,11d
      mov ecx,11d
      mov edx,ebx

      L1:
            mov eax,ecx
            call WriteInt
            call Crlf
            sub ebx,ebx             ; sets => ZF=1
            mov ebx,edx
      LOOPZ L1                      ;loop until ECX>0

      mov ecx , 11                  ; loop counter for LOOPE

      L2:
            mov eax,ecx
            neg eax
            call WriteInt
            call Crlf
            sub ebx,ebx             ; sets => ZF=1
            mov ebx,edx
      LOOPE L2

      exit
main ENDP
END main
```

LOOPNZ & LOOPNE Instructions

The LOOPNZ (loop if not zero) instruction is the counterpart of LOOPZ. The loop continues while the unsigned value of ECX is greater than zero and the Zero flag is clear.

The LOOPNE (loop if not equal) instruction is equivalent to LOOPNZ. Below is the execution logic of LOOPNZ and LOOPNE:

```
ECX = ECX - 1
if ECX > 0 and ZF = 0, jump to destination
```

Otherwise, no jump occurs and control passes to the next instruction.

```
INCLUDE Irvine32.inc

.data

.code
main PROC

      XOR EAX,EAX
      XOR EBX,EBX
      XOR ecx,ecx
      XOR ebx,ebx

      mov ebx,11d
      mov ecx,11d
      mov edx,ebx
      L1:
            mov eax,ecx
            call WriteInt
            call Crlf
      LOOPNZ L1         ; loop until ECX>0

      mov ecx , 11            ; loop counter for LOOPE

      L2:
            mov eax,ecx
            neg eax
            call WriteInt
            call Crlf
      LOOPNE L2

      exit
main ENDP
END main
```