ECE 3120
Computer Systems
HCS12 Assembly Programming
- Review

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Program Structure

LABEL:	OPCODE	OPERAND	;Comments

Assembler Directives
Initializations
Reserving Memory
Declaring array elements

Main Logic of the program

Arithmetic Programming

- Addition
- Subtraction
- Multiprecision Addition (Carry Flag)
- Multiprecision Subtraction (Borrow Flag)
- BCD
- Multiplication
- Division

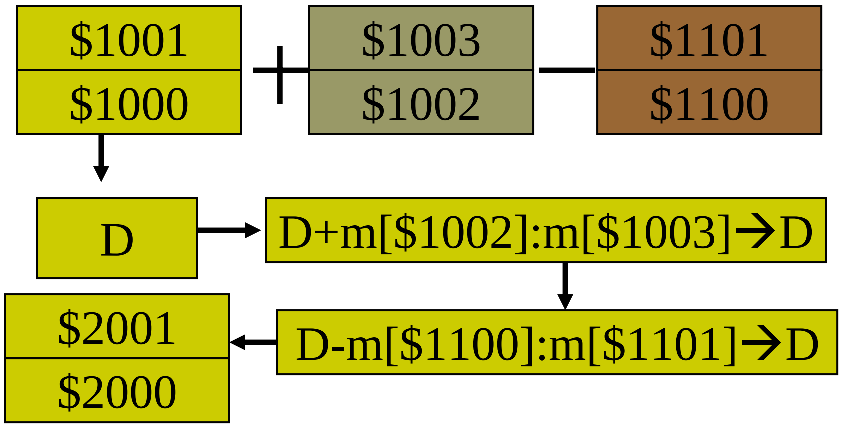
Example1: Addition of 16 bit numbers

Write a program to add two 16 bit numbers, one of which is \$1234 and the other is stored at memory location \$1000~1001. Store the result in \$2000

```
org     $1500
ldd     #$1234          ;place 16 bit number in D
                        ;D=$1234
addd    $1000           ;D + m[$1000]:m[$1001]→D
std     $2000           ;Sum → $2000
```

Example2: Subtraction & Addition

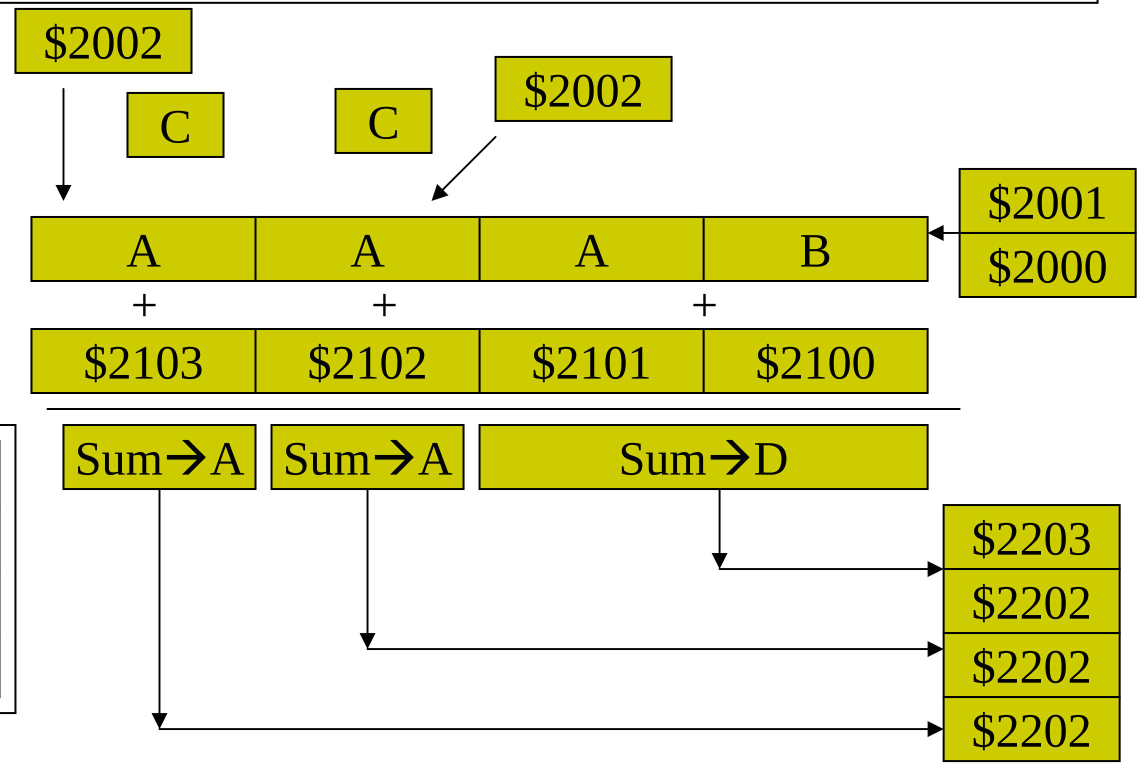
Write a program to add two 16 bit numbers, one of which is at $1000~$1001 and the other is stored at memory location $1002~1003 and subtract a 16 bit number that is stored in $1100~1101from the sum. Store the result in $2000

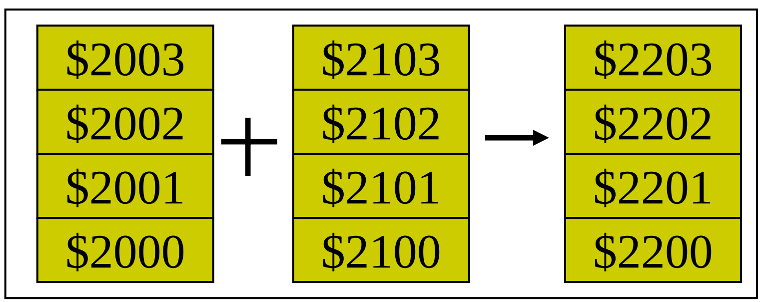



```
org     $1500
ldd     $1000   ;D←m[$1000]:m[1001]
addd    $1002   ;D←D+m[$1002]:m[$1003]
subd    $1100   ;D←D-m[$1100]:m[$1101]
std     $2000   ;m[$2000]←D
```

Example3: Multiprecision Addition

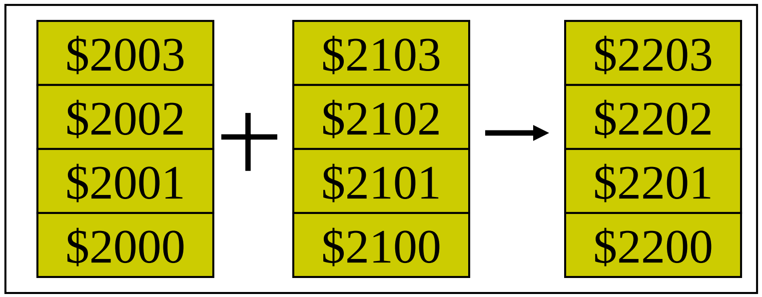
Write a program to add two 4 byte numbers that are stored at \$2000~\$2003 & \$2100~\$2103 and store the result at \$2200~\$2203





Example 3: Multiprecision Addition

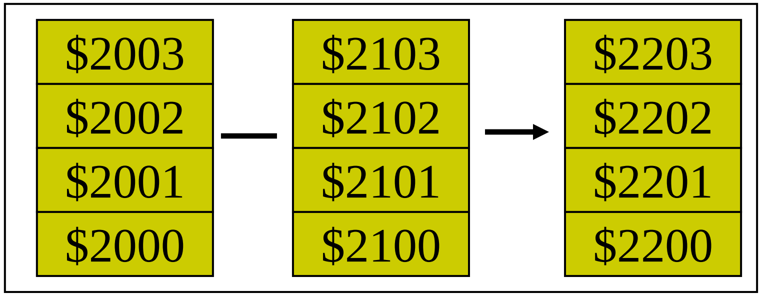
Write a program to add two 4 byte numbers that are stored at \$2000~\$2003 & \$2100~\$2103 and store the result at \$2200~\$2203




```
org     $1000
ldd     $2000   ;D←m[$2000]:m[$2001]
addd    $2100   ;D←D+m[$2100]:m[$2101]
std     $2200   ;m[$2200]←D
ldaa    $2002   ;A←m[$2002]
adca    $2102   ;A←A+m[$2102]
staa    $2202   ;m[$2202]←A
ldaa    $2003   ;m[$2003]
adca    $2103   ;A←A+m[$2103]
staa    $2203   ;m[$2203]←A
```

Example 4: Multiprecision Subtraction

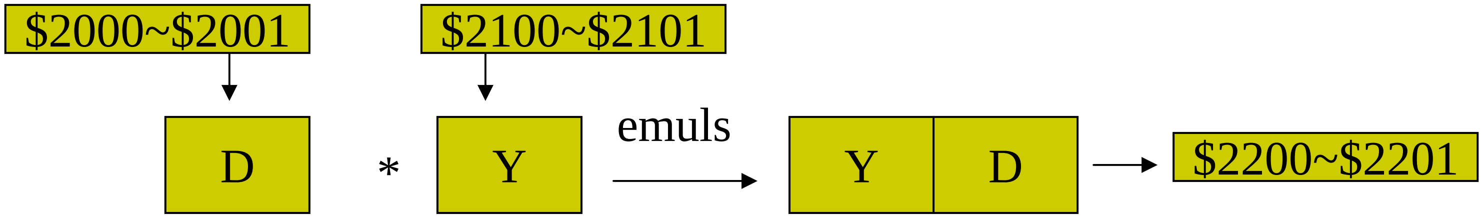
Write a program to subtract two 4 byte numbers that are stored at $2000~$2003 & $2100~$2103 and store the result at $2200~$2203




```
org     $1000
ldd     $2000    ;D←m[$2000]:m[$2001]
subd    $2100    ;D←D-m[$2100]:m[$2101]
std     $2200    ;m[$2200]←D
ldaa    $2002    ;A←m[$2002]
sbca    $2102    ;A←A-m[$2102]
staa    $2202    ;m[$2202]←A
ldaa    $2003    ;m[$2003]
sbca    $2103    ;A←A-m[$2103]
staa    $2203    ;m[$2203]←A
```

Example 5: Multiplication

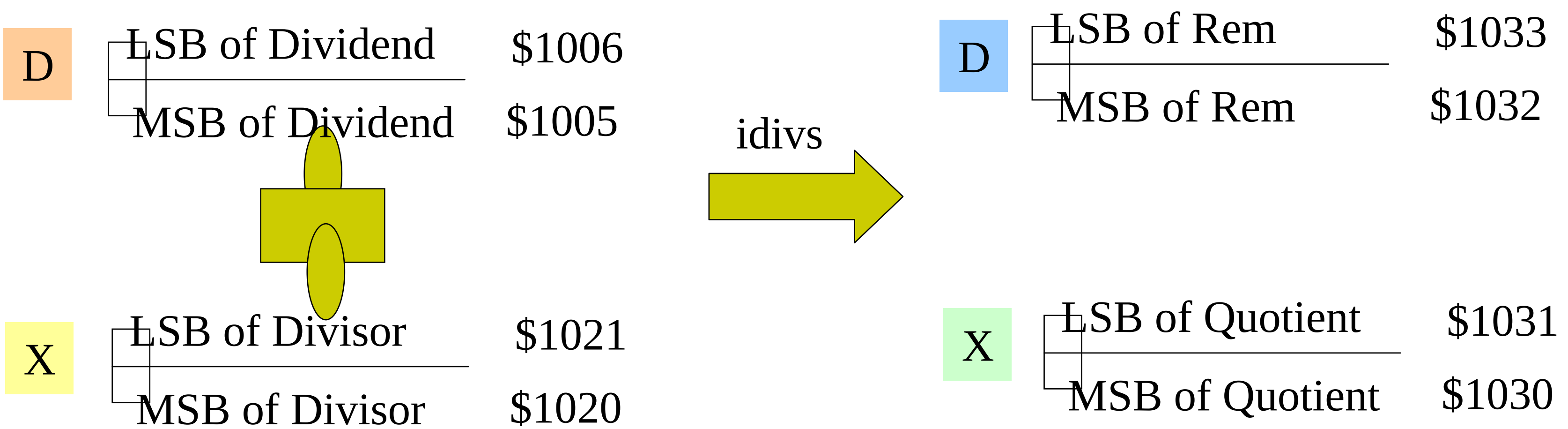
Write a program to multiply two **signed 16 bit numbers** that are stored at $2000~$2001 & $2100~$2101and store the result at $2200~$2201




```
org     $1000
ldd     $2000     ;D←m[$2000]:m[$2001]
ldy     $2100     ;Y← [$2100]:m[$2101]
emuls
std     $2201     ;m[$2201]←D
sty     $2200     ;m[$2200]←Y
```

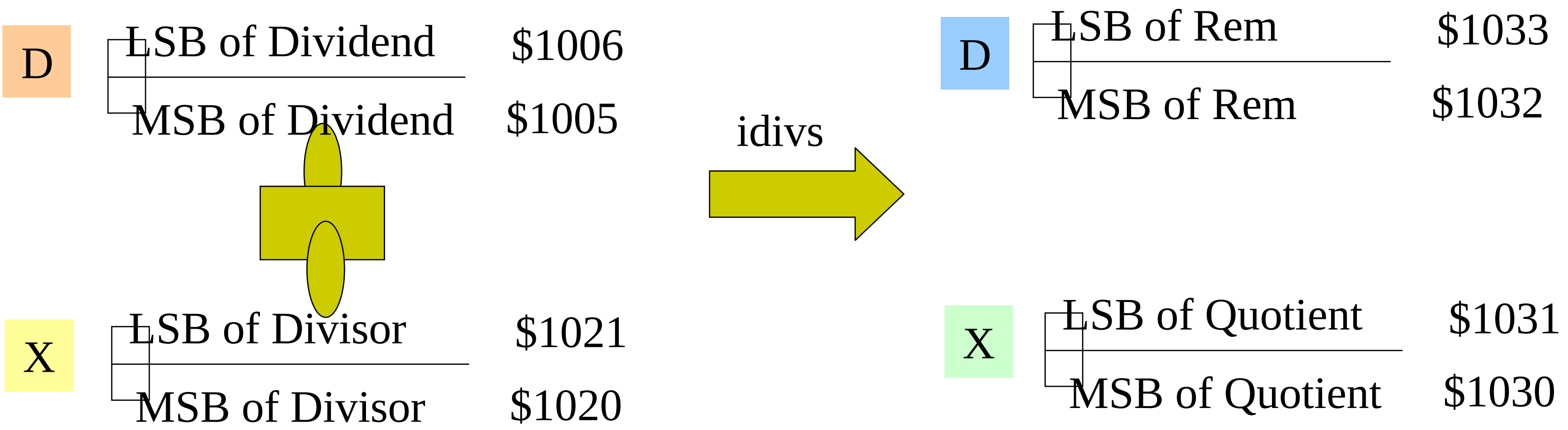
Example 6: Division

Write an instruction sequence to divide the signed 16-bit number stored at $1005-$1006 by the signed 16-bit number stored at $1020-$1021 and store the quotient and remainder at $1030-$1031 and $1032-$1033, respectively.




```
ldd     $1005     ;load the dividend into D
ldx     $1020     ;load the divisor into X
idivs             ; perform signed division
stx     $1030     ;storing the quotient
std     $902      ;storing the remainder
```

Example 2.11 Write an instruction sequence to divide the signed 16-bit number stored at $1005-$1006 by the signed 16-bit number stored at $1020-$1021 and store the quotient and remainder at $1030-$1031 and $1032-$1033, respectively.



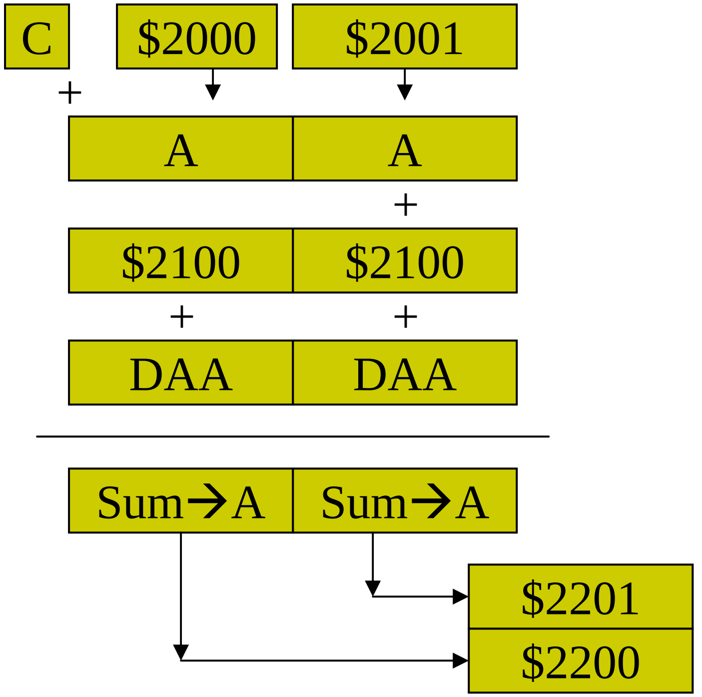

```
ldd     $1005     ;load the dividend into D
ldx     $1020     ;load the divisor into X
idivs             ; perform signed division
stx     $1030     ;storing the quotient
std     $902      ;storing the remainder
```

Example 7 : BCD

Write a program to add the 4 digit BCD numbers that are stored at $2000~$2001 & $2100~$2101and store the result at $2200~$2201

Similar to normal addition, except we have to take care of the decimal adjustment part by using the 'daa' instruction. Works with only reg A so have to work with one byte at a time starting from the LSB

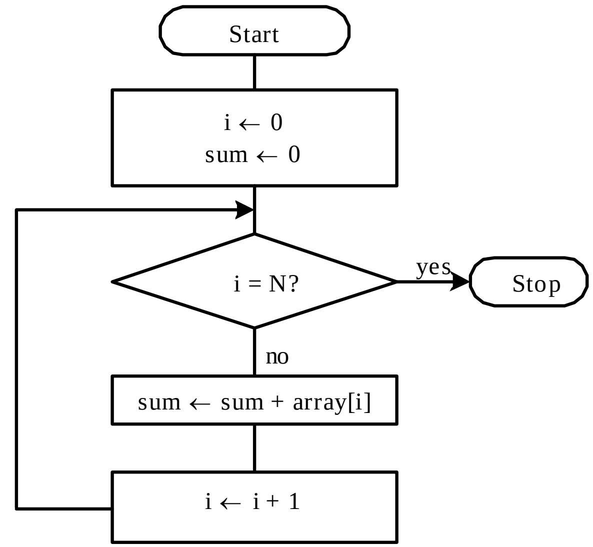
```
org     $1000
lda     $2001     ;A←m[$2001
adaa    $2101     ;A←A+m [$2101]
daa               ;decimal adjust lower byte
staa    $2201     ;m[$2201]←A
lda     $2000     ;A←m[$2000]
adaa    $2100     ;A←A+m [$2100]
daa               ;decimal adjust Higher byte
staa    $2200     ;m[$2200]←A
```



Example 8 :Loops

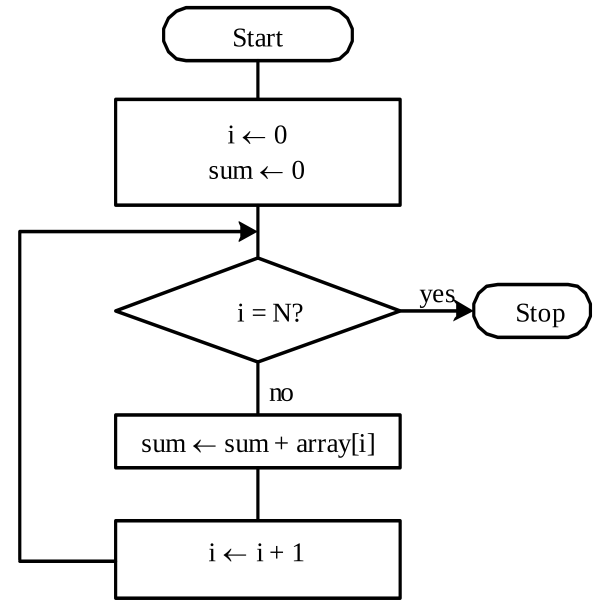
Write a program to compute the sum of 10, 16-bit unsigned numbers stored at the memory address $1000~$1020 and store the result in $1100~$1103

```
N       equ     10      ;array count
        org     $1000   ;starting address of the elements
array   dw      320,333,321,420,500,550,620,700,400,300
sum     rmb     4       ;array sum
i       rmb     1       ;array index
        org     $1500   ;starting addr of program
        ldaa    #0
        staa    sum     ;initiallize sum to 0
        staa    sum     ;
        staa    sum     ;
        staa    sum     ;
        staa    i       ; intialize loop counter zero
```



Example 8 : Loops Contd..

```
loop    ldab    i        ;B←i
        cmpb    #N       ;is i=N?
        beq     done     ;if i=N then branch to label 'done'
        ldx     #array   ;use index register X as pointer to
                         the array , X=$1000
        abx              ;X←X+B = X+I, to compute the
                         ;addr of current element
        ldd     0,x      ;place array[i] in D
        addd    sum+2    ;D←D+sum
        std     sum+2
        ldaa    #0
        adca    sum+1    ;propagating carry to msb
        staa    sum+1
        inc     i        ;moving to next element
        inc     I
        bra     loop
done    swi
        end
```



S	S+1	S+2	S+3

Carry	Sum of nos

Example 9: Bit Condition Branch Instructions

Write a program to count the number of elements that are divisible by 4 in an array of N 8-bit numbers

Numbers divisible by 4 have the least significant two bits to be 00

```
N       equ     10
        org     $1000   ;starting address of the 1st element in the array
array   db      1,2,3,4,5,6,7,8,9,10
total   rmb     1       ;variable counting no.of elements divisible by 4
        org     $1500   ;starting address of the program
        clr     total   ;initializing counter to 0
        ldx     #array  ;loading x with the address of the array, X= $1000
        ldab    #N      ;B is used as the loop counter
loop    brclr   0,x,$03,yes
```

Operand at the memory location pointed by 0,x → 00000100

Operand provided by the mask in the instr → 00000011

AND result = 0

Execution will branch to the location specified in the label (yes)

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        org     $1000   ;starting address of the 1st element in the array
array   db      1,2,3,4,5,6,7,8,9,10
total   rmb     1       ;variable counting no.of elements divisible by 4
        org     $1500   ;starting address of the program
        clr     total   ;initializing counter to 0
        ldx     #array  ;loading x with the address of the array, X= $1000
        ldab    #N      ;B is used as the loop counter
loop    brclr   0,x,$03,yes
        bra     chkend
yes     inc     total   ;add 1 to total as the number is divisible by 4
chkend  inx             ;move the array pointer
        dbne    b,loop
        end
```

Example 10: Bit Condition Branch Instructions

Write a program to count the number of elements that whose bit 1,4,7 are 1's using brset

7	6	5	4	3	2	1	0
1	0	0	1	0	0	1	0

→ Mask = $49

```
N       equ     10
        org     $1000   ;starting address of the 1st element in the array
array   db      1,2,3,4,5,6,7,8,9,10
total   rmb     1       ;variable counting no.of elements having the required pattern
        org     $1500   ;starting address of the program
        clr     total   ;initializing counter to 0
        ldx     #array  ;loading x with the address of the array, X= $1000
        ldab    #N      ;B is used as the loop counter
loop    brclr   0,x,$49,yes
```

Operand at the memory location pointed by 0,x → 11010110 → Inv →00101001

Operand provided by the mask in the instr → 10010010

AND result = 0

Execution will branch to the location specified in the label (yes)

Example 10: Bit Condition Branch Instructions

Write a program to count the number of elements that whose bit 1,4,7 are 1's using brset

7	6	5	4	3	2	1	0
1	0	0	1	0	0	1	0

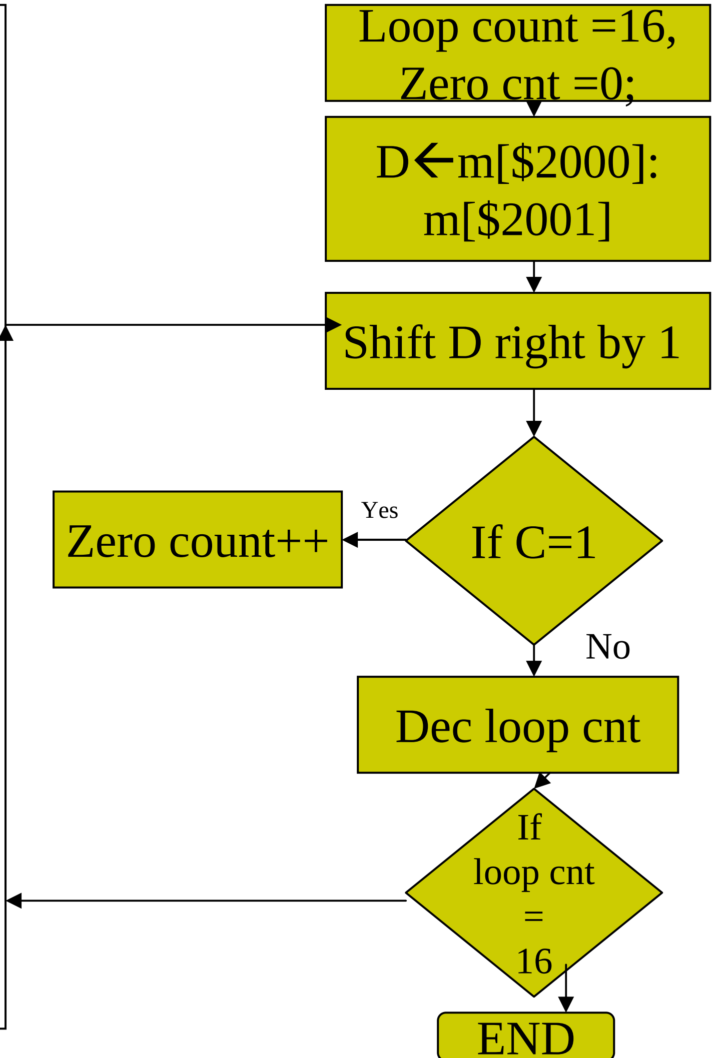
→ Mask = $49

```
N       equ     10
        org     $1000   ;starting address of the 1st element in the array
array   db      1,2,3,4,5,6,7,8,9,10
total   rmb     1       ;variable counting no.of elements with the pattern
        org     $1500   ;starting address of the program
        clr     total   ;initializing counter to 0
        ldx     #array  ;loading x with the address of the array, X= $1000
        ldab    #N      ;B is used as the loop counter
loop    brset   0,x,$49,yes
        bra     chkend
yes     inc     total   ;add 1 to total as the number has the required pattern
chkend  inx             ;move the array pointer
        dbne    b,loop
        end
```

Example 11: Shift

Write a program to count the number of 1's contained in the memory locations $2000~$2001 and save the result at memory location $1000

```
        org     $2000
word:   dc.w    $2355     ;number to be worked on
one_ct  rmb     1
lp_ct   rmb     1
        org     $1500     ;starting addr of program
        clr     one_ct    ;initializing to 0
        movb    #16,lp_ct ;initializing to 16
        ldd     word      ;place 16 bit number in D
again   lsrd              ;shift right by 1 place
        bcc     chkend    ;branch if lsb is a 0
        inc     one_ct    ;in case of C=1
chkend  dec     lp_ct
        bne     again     ;chk to see if we tested all
                          ;16 bits
        end
```



Example 12:Booloean Logic Instructions

Write a sequence of instructions to clear the lower 4 pins of the I/O port located at $82 using AND

```
ldaa    $82     ;loading the contents of the mem location $82 into A
anda    #$F0    ;clearing lower 4 bits in A
staa    $82     ;A→m[$82]
--------------------------------------------------------------------------------
                m[$82]      =10101010
                Mask=$F0=11110000
                AND         =10100000
```

Example 13: Boolean Logic Instructions

Write a sequence of instructions to set the bit 7 of the I/O port located at $82 using OR

```
ldaa    $82     ;loading the contents of the mem location $82 into A
ora     #$80    ;sets bit 7 in A
staa    $82     ;A→m[$82]
--------------------------------------------------------------------------------
                m[$82]    =00101010
                Mask=$80=10000000
                OR        =10101010
```

Example 14: Boolean Logic Instructions

Write a sequence of instructions to toggle the upper four bits of the I/O port at $82

```
ldaa    $82     ;loading the contents of the mem location $82 into A
eora    #$F0    ;toggles upper 4 bits in A
staa    $82     ;A→m[$82]
```

----

m[$82]　=10101010
Mask=$F0=11110000
XOR　=01011010

Example 15: Bit Test & Manipulate

Write a sequence of instructions to clear the upper four bits at $82

```
bclr	$82,$F0
```

Write a sequence of instructions to set the upper four bits at $82

```
bset	$82,$F0
```

Write a sequence of instructions to test the upper four bits at $82

```
ldaa	$82
bita	#$F0
```

Chapter Review

- Assembly Language Program Structure:
  - Label, operation, operand, comment
- Directives: end,org,db,ds,fill…
- Flow chart
- Arithmetic
- Loops, branch instructions
- Shift and rotate
- Boolean logic
- Bit test and manipulate
- Program execution time

Now, you should be able to:

- Allocate memory blocks, define constants, and create a message using assembler directives
- Write assembly programs to perform simple arithmetic operations
- Write loops to perform repetitive operations
- Use loops to creat time delays
- Use boolean and bit manipulation instructions to perform bit field operations.