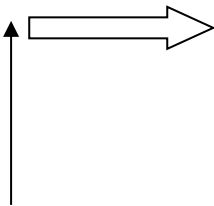# Conversion to and from Decimal numeral systems to binary system

- **To convert from a base-10 integer numeral to its base-2 (binary)** equivalent, the number is divided by two, and the remainder is the least-significant bit. The (integer) result is again divided by two, its remainder is the next most significant bit. This process repeats until the result of further division becomes zero.

For example, 118_{10}, in binary, is:

```
   ÷2    R
118 | 59   0
 59 | 29   1
 29 | 14   1        ⟹    118₂ = 1110110₂
 14 | 7    0
  7 | 3    1
  3 | 1    1
  1 | 0    1
```

$$118_2 = 1110110_2$$

- **Conversion from base-2 to base-10**

Multiply each binary number by its position-value and add the results together. The rightmost bit has a position value 1, the next 2, the value at the third position is 4, fourth 8 and so on: The position-value of the nth bit from right is 2^{n-1}.

Example: $1101_2 = 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 1 \times 2^0$ (or simply, 8+4+1) $= 13_{10}$

Example: $0001_2 = 0 \times 2^4 + 0 \times 2^3 + 0 \times 2^2 + 1 \times 2^0$ (or simply, 1) $= 1_{10}$

Exercise: Convert the following binary numbers to decimal:
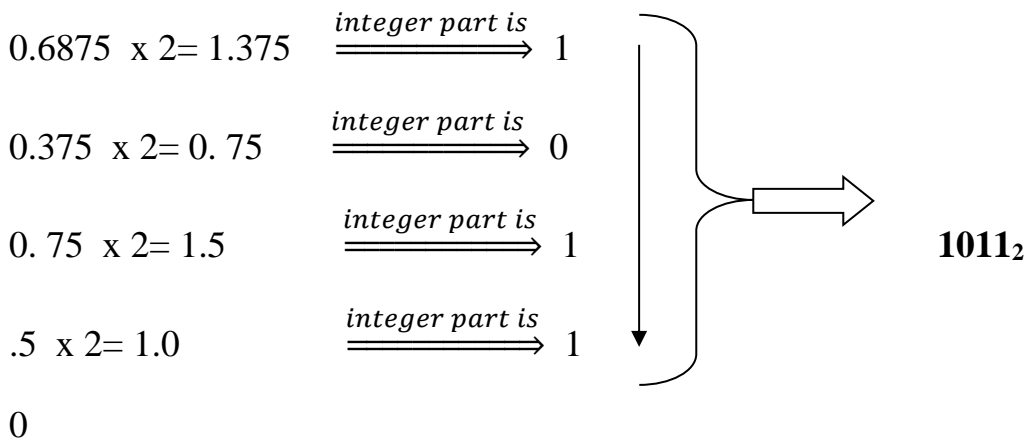
$111_2, 11001_2, 10010110_2$

Fractions in binary:

To convert a decimal number with fraction part into a binary system, for integer part do as before and for the fractional part, multiply by 2. Split the result into an integer part and a fractional part. Continue multiplying the fractional part. Use the integer part from top to bottom.as follows:

For example, to convert 38.6875_{10} into binary system

First: $38_{10}=0100110$

And

$0.6875 \ x\ 2= 1.375 \quad \xrightarrow{\text{integer part is}} \quad 1$

$0.375 \ x\ 2= 0.\ 75 \quad \xrightarrow{\text{integer part is}} \quad 0$

$0.\ 75 \ x\ 2= 1.5 \quad \xrightarrow{\text{integer part is}} \quad 1$

$.5 \ x\ 2= 1.0 \quad \xrightarrow{\text{integer part is}} \quad 1$

1011_{2}

0

Combining: $38.6875_{10} = \mathbf{0}100110.1011_{2}$

Now for previous example, to convert from fractional binary into decimal numeral system do as follows:

Convert $(100110.1011_{2}$) **to decimal :**

100110.1011_{2}

$= 1*2^5+0*2^4+0*2^3+1*2^2+1*2^1+0*2^0 +(1*2^{-1}+0*2^{-2}+1*2^{-3} +1*2^{-4})$

$=32+4 + 0.5+.125 +0.0625 = \mathbf{38.6875_{10}}$

Note:/ There are another numeral system such as :

- Octal- base 8 ={0,1,2,3,4,5,6,7}
- Hexadecimal- base 16={0, 1,2,3,4,5,6,7,8,9,A,B,C,D,E.F}

And operations and conversions to and from these systems, left as an activity for students.

Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Binary	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
Hexa	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Octal	0	1	2	3	4	5	6	7	10	11	12	13	14	15	16	17

Algorithm:

An algorithm is list of clear and well-defined instructions for completing a task needed to solve a problem. It may be expressed in either:

- Human language (English, Kurdish, Arabic,…)
- Graphical representation like a flowchart.

Example1/ if we have a problem for adding three numbers, we do as follows:

Algorithm1:

Step1: Start

Step2: Suppose that the first number is **x**, second is **y** and third number is **z**

Step3: Define a new variable and put the summation on it: **sum**= x+y+z

Step4: Output the value of **sum**

Step5: End of the problem.

Example2/ write the algorithm for calculating the average of seven numbers?

Algorithm2:

Step1: Start

Step2: Define the value of deg1, deg2, deg3, deg4, deg5, deg6, deg7

Step3: Define a new variable and put the summation on it:

$$\textbf{sum}= deg1+ deg2+ deg3+ deg4+ deg5+ deg6+ deg7$$

Step4: Calculate the average of the given data by the equation

AV=**sum**/ 7

Step5: Output the value of **AV**

Step6: End

Example3// write an algorithm for finding the maximum number between three numbers?

Algorithm3:

Step1: Start

Step2:Let the first number is **x** , second is **y** and third is **z**.

Step3: We assume that the maximum number is **x**, that is **max**=**x**

Step4: Make comparison between our assumption and the second number y, as follows: (if **y** is greater than **max** then we change the value of **max** , i.e **max**=y)

Step5: make comparison between **max** and the third number **z**,

(i.e/ if **z** is greater than **max** then we change the value of **max** , i.e **max**=**z**)

**Step6**: Output the value of **max**.

Step7: End

Homework:

- Write an algorithm for finding the maximum number between five numbers?

- Write an algorithm for finding the roots of the equation $aX^2+bX+c=0$.

- Write an algorithm for finding the absolute value of any number.

- Write an algorithm to determine if a number is even or odd.

Flowcharts:

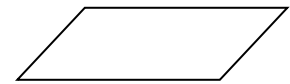Flowcharts are basic symbols for expressing the solution of any problem which contains the followings:

- This symbol used for starting or ending the program (problem)
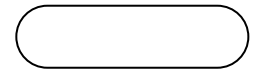
- This symbol used for input and output statements
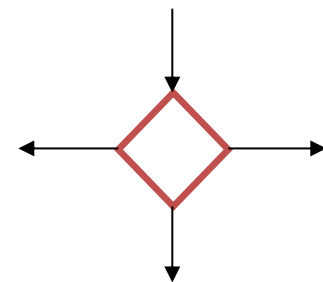
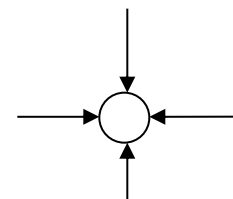   (print, write, input, read)

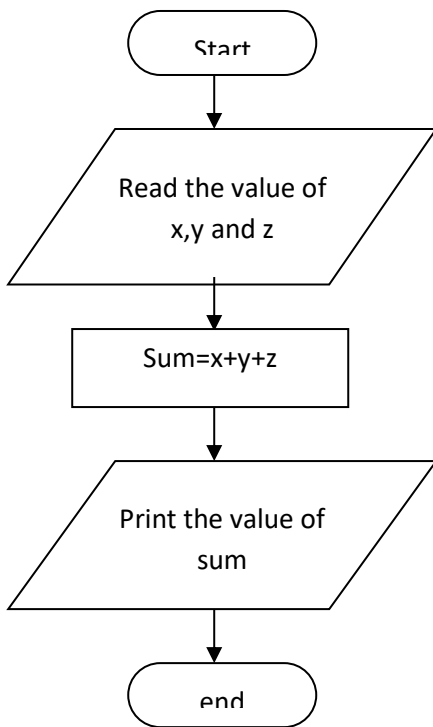- This symbol used generally for computation or for explanation
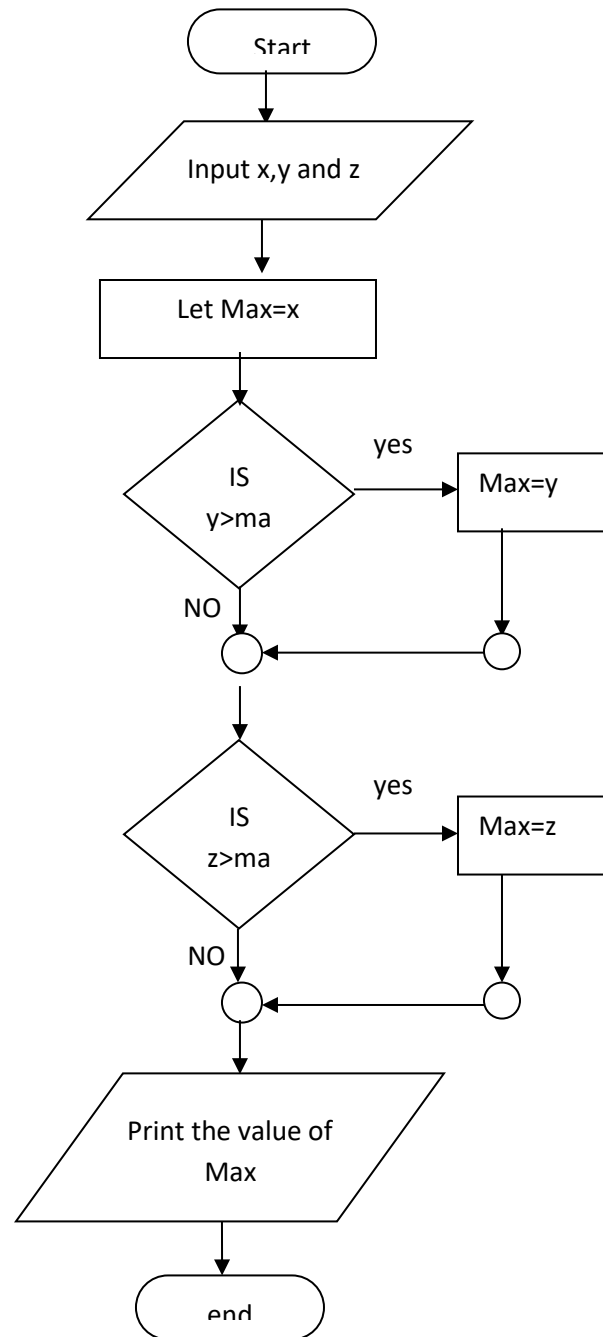
- This symbol used when we have a decision

-This symbol used for connecting another symbols

Ex/ draw a flowchart for adding

Three numbers?

Ex/ draw a flowchart to find max

no. between three numbers?

```
        ( Start )
            │
            ▼
    ╱───────────────╲
   ╱ Read the value of╲
   ╲    x,y and z     ╱
    ╲───────────────╱
            │
            ▼
    ┌───────────────┐
    │   Sum=x+y+z    │
    └───────────────┘
            │
            ▼
    ╱───────────────╲
   ╱ Print the value of╲
   ╲      sum         ╱
    ╲───────────────╱
            │
            ▼
        ( end )
```

```
                ( Start )
                    │
                    ▼
            ╱───────────────╲
           ╱ Input x,y and z  ╲
            ╲───────────────╱
                    │
                    ▼
            ┌───────────────┐
            │   Let Max=x    │
            └───────────────┘
                    │
                    ▼
                ◇ IS ◇    yes    ┌───────┐
                  y>ma    ───►   │ Max=y │
                    │            └───────┘
                NO  │                │
                    ▼                ▼
                  ( ○ ) ◄──────────( ○ )
                    │
                    ▼
                ◇ IS ◇    yes    ┌───────┐
                  z>ma    ───►   │ Max=z │
                    │            └───────┘
                NO  │                │
                    ▼                ▼
                  ( ○ ) ◄──────────( ○ )
                    │
                    ▼
            ╱───────────────╲
           ╱ Print the value of╲
           ╲      Max         ╱
            ╲───────────────╱
                    │
                    ▼
                ( end )
```

Ex/ write the algorithm and draw the flowchart to evaluate the value of y where:

$$Y = \begin{cases} 4x^3 + 5x & if \, x \geq 0 \\ 2x & if \, x < 0 \end{cases}$$

Solution: the algorithm corresponding to this problem is:

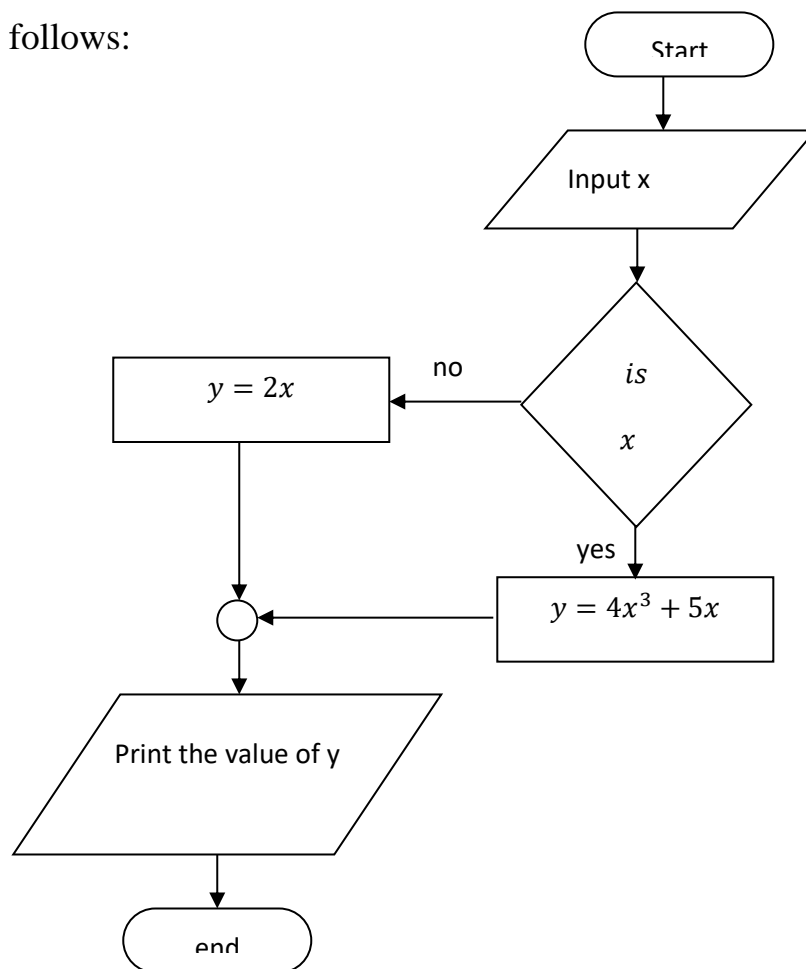**Step1**: start program.

Step2: input(define) the value of x.

Step3: if the value of x is greater or equal to zero then compute the value of y, where
$y = 4x^3 + 5x$.

Step4: if the value of x is less than zero then compute the value of y, where $y = 2x$.
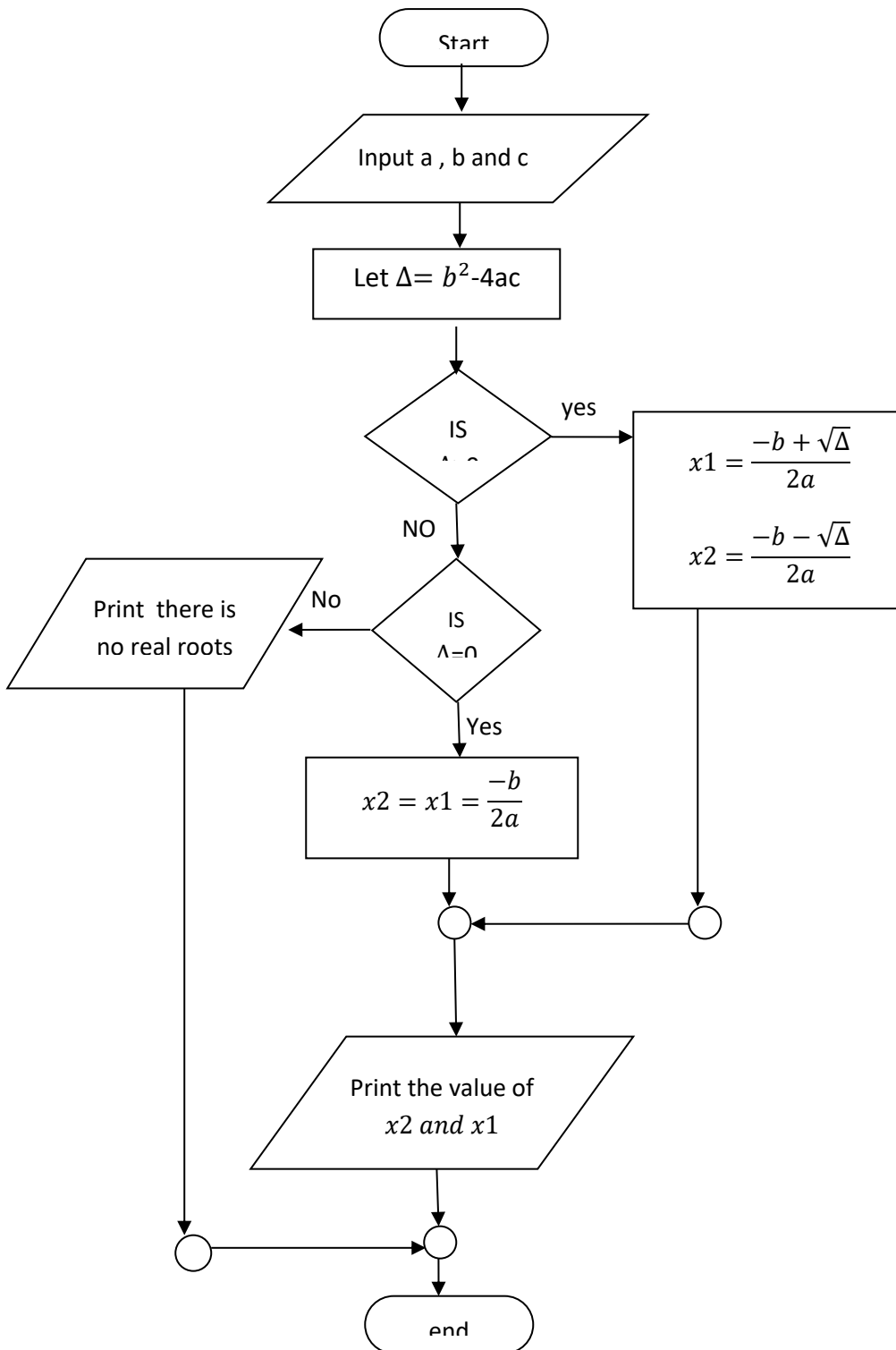
Step5: print(output) the value of y.

Step6: end.

And the flowchart is as follows:

Ex/ Draw the flowchart to find the roots of quadratic polynomial ax^2+bx+c=0:

Start

Input a , b and c

Let Δ= b^2-4ac

IS

yes

$$x1 = \frac{-b + \sqrt{\Delta}}{2a}$$

$$x2 = \frac{-b - \sqrt{\Delta}}{2a}$$

NO

Print there is
no real roots

No

IS
Δ=0

Yes

$$x2 = x1 = \frac{-b}{2a}$$

Print the value of
$x2\ and\ x1$

end

Ex/ Draw the flowchart to decide if a student pass, if you know that he/she has 7 degrees:

Start

Input degrees
a,b,c,d,e,f,g

$$set\ Av = \frac{a + b + c + d + e + f + g}{7}$$

NO

Is

yes

Output "Fail"

Output "pass"

end