BASIC ELEMENTS

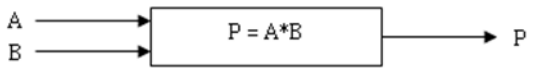
The algorithmic language is a language close to human language and is defined by a set of reserved words and syntax for writing actions.

1. Problem Solving Approach

Problem solving involves three main phases, namely:

1. Study Phase: This is a phase that involves understanding and analyzing the problem to determine the data (inputs) and the results (outputs) to produce.
2. Algorithm Writing Phase: This is a phase of translating the previous phases based on the rules of the algorithmic language.
3. Programming Phase: This is a phase of translating the algorithm into a program in a programming language.

Example: We want to calculate the product of two integers, A and B.



2. Basic Concepts

2.1. Definition of an Algorithm

An algorithm is a structure for solving a given problem. This structure consists of two essential parts:

- The first part (the header) defines the set of data structures and/or objects to use. It can be thought of as a set of tools necessary to solve the problem at hand.
- The second part (the body) contains a sequence of actions to be performed to arrive at a determined result from a given situation in a finite time.

2.2. Structure of an Algorithm

```
ALGORITHM algorithm_name
CONST
   {Set of constants and their values}
TYPE
   {Definition of custom types}
VAR
   {Set of variables to use within the body of the algorithm}
BEGIN
   {Sequence of actions to execute}
END
```

The words ALGORITHM, BEGIN, and END represent keywords that must exist in an algorithm.
The words CONST, TYPE, and VAR are keywords that may or may not exist in an algorithm depending on the requirements.

2.3 Concept of an Object

1. Definition of an Object

An object is a "memory location" characterized by an identifier and a type, capable of holding a value and undergoing specific actions.

2. Object Identifier

The identifier of an object is its name. It is composed of letters of the alphabet, digits, and possibly the character "_", and must start with a letter.

3. Object Type

A type defines the set of values an object of that type can take, as well as the actions allowed on it.

Types can be classified based on several criteria, including whether they are simple or compound and whether they are predefined or custom.

Note: Once a type is fixed for an object in an algorithm, it cannot be changed within the same algorithm.

4. Nature of an Object

An object can be either constant or variable but not both at the same time. It is variable if its value can change during the algorithm, and it is constant if its value remains fixed throughout the algorithm.

5. Use of an Object

An object can be used in one of the following ways:

- Input object: It is an object whose value is used as data for the problem to be solved.
- Output object: It is an object whose value is the solution to the problem.
- Working object: It is a tool that acts as an intermediary between input and output objects.

Example: For a quadratic equation:

- Input objects: a, b, and c
- Output objects: x1 and x2
- Working object: Delta

6. Declaration of an Object

It is the specification of objects to use in the same algorithm. This is presented in the header of the algorithm.

Every object used in an algorithm must be declared one and only once, either in the VAR block or in the CONST block.

Syntax

- **Declaration of a constant:**

```
Const_id = value
```

The type of a constant is deduced from its value.

- **Declaration of a variable:**

```
Variable_id: base_type
```

Example

```
CONST
   VAT = 0.18
VAR
   Quantity: real
   PriceExcludingVAT: real
   PriceIncludingVAT: real
```

Application 1

Write the header of an algorithm to calculate the perimeter of a circle.

Solution

```
ALGORITHM Perimeter_Circle
CONST
   PI = 3.14
VAR
   Radius: real
   Perimeter: real
```

3. Simple Algorithmic Actions

An action is a command given by the user to the computer. There are three simple algorithmic actions: display, input, and assignment.

3.1. Display

- **Definition**

The display action allows communicating a message or the content of one or more objects to the user on the screen (or printer).

- **Syntax**

WRITE (ARG1, ARG2, ..., ARGn)

Where ARGi can be:

- The identifier of an object (constant or variable).
- An arithmetic expression.
- A message.

Examples

- WRITE (A): displays the content of object A.
- WRITE ("message"): displays the word 'message' in its entirety.
- WRITE (B * B - 4 * a * c): displays the result of the expression; this assumes that the values of a, B, and c are known.
- WRITE ("The square of", A, "is equal to", A * A)

3.2. Input

- **Definition**

This action allows placing a value provided by the user into the memory location associated with a variable. The execution of this action involves temporarily stopping the algorithm's execution, waiting for a value given by the user.

- **Syntax**

READ (VAR1, VAR2, ..., VARn)

Note

You can input each variable separately, or you can input multiple variables with a single READ command.

Example

```
READ (A)
READ (B)      ⟺      READ (A,B,C)
READ (C)
```

Application 1

Write an algorithm to display the perimeter of a circle.

Solution

```
ALGORITHM Perimeter_Circle
CONST
   PI = 3.14
VAR
```

```
    Radius: real
BEGIN
    WRITE("Enter the value of the radius: ")
    READ(Radius)
    WRITE("The perimeter of the circle is: ", 2 * Radius * PI)
END
```

Application 2

Write an algorithm to display the average of a student for a subject. For each subject, the student has a homework score and an exam score with weights of 0.4 and 0.6, respectively.

Solution

```
ALGORITHM Subject_Average
CONST
    HomeworkWeight = 0.4
    ExamWeight = 0.6
VAR
    HomeworkScore: real
    ExamScore: real

BEGIN
    WRITE("Enter the homework score: ")
    READ(HomeworkScore)
    WRITE("Enter the exam score: ")
    READ(ExamScore)
    WRITE("The student's average is:", HomeworkScore * HomeworkWeight + ExamScore * ExamWeight)
END
```

3.3. Assignment

- **Definition**

Assignment is an operation that allows placing a value into a memory location associated with a variable. The value can be the content of another variable, the content of a constant, a given value, or the result of an arithmetic or logical expression.

- **Syntax**

VAR_NAME ← EXPRESSION

Where:

- VAR_NAME is the name of the target variable that will receive the value (the left-hand side of the assignment).
- EXPRESSION can be a value, a variable or constant identifier, or an arithmetic or logical expression (the right-hand side of the assignment).

In an assignment operation, the right-hand side is evaluated, and the result of the evaluation is stored in the left-hand side.

Examples

```
A ← 3
B ← A * 5
A ← B - 2
C ← A
C ← B + 6
B ← B + 1
```

Important Remarks

- At the time of assignment, the type of the right-hand expression's result must be the same as that of the target variable (or compatible).
- Assigning values to a variable can be done multiple times, and the variable's value will change with each assignment, losing its previous value. You'll have the last assigned value in the variable.
- A constant can never appear on the left side of an assignment since its value cannot be changed.
- When a variable appears on the right side of an assignment, it's assumed that it contains a value. This value must have been assigned to it previously (through input or assignment); otherwise, the variable is considered "undefined," and the result of the assignment is also undefined.

Exercise :

Write an algorithm to swap two integers A and B :

• using an additional variable C,

• without the use of an additional variable.

Solution 1 :

```
ALGORITHM   Swap_With_Extra_Var
VAR
    A: integer
    B: integer
    C: integer
BEGIN
    WRITE("Enter the value of A: ")
    READ(A)
    WRITE("Enter the value of B: ")
    READ(B)
    C ← A
    A ← B
    B ← C
    WRITE("The new value of A is ", A)
    WRITE("The new value of B is ", B)
END
```

Solution 2 :

```
ALGORITHM   Swap_Without_Extra_Var
VAR
    A: integer
    B: integer
BEGIN
    WRITE("Enter the value of A: ")
    READ(A)
    WRITE("Enter the value of B: ")
    READ(B)
    A ← A + B
    B ← A - B
    A ← A - B
    WRITE("The new value of A is ", A)
    WRITE("The new value of B is ", B)
END
```

4. Simple Types

Remember that a type defines the set of values an object can take and the actions allowed on it.

4.1. Integer Type

- **Definition**

This type is associated with objects that take their values within a finite range of integers, with predefined lower and upper bounds, included in the set (Z). An object of the integer type can be positive, negative, or zero.

- **Declaration**

identifier1, identifier2, ..., identifierN: Integer

- **Manipulation Operations**

An object of the integer type can undergo the following operations:

- Simple algorithmic actions.
- Standard operations: real division (/), addition (+), subtraction (-), and multiplication (*).
- Exponentiation, noted as "**" where "N**P" gives N^P.
- Integer division, noted as "DIV," where "N DIV P" gives the integer part of the result of N divided by P.
- Modulus, noted as "MOD," where "N MOD P" gives the remainder of the integer division of N by P.
- Square root, noted as SQRT, where SQRT(x) gives the square root.
- Absolute value, noted as ABS, where ABS(x) gives |x|.
- Comparison operators (<, <=, >, >=, <>, =).

Examples

14 MOD 3 returns 2
14 DIV 3 returns 4
14 / 4 returns 3.5

Application 1

Write an algorithm that reads an integer (assumed to be composed of 3 digits) and displays its units, tens, and hundreds digits.

Solution

```
ALGORITHM Decomposition
VAR
   N, U, T, H: integer
BEGIN
   WRITE("Enter a three-digit integer: ")
   READ(N)
   H ← N DIV 100
   T ← (N MOD 100) DIV 10
   U ← N MOD 10
   WRITE("The units digit is ", U)
   WRITE("The tens digit is ", T)
   WRITE("The hundreds digit is ", H)
END
```

4.2. Real Type

- **Definition**

This type corresponds to objects that take their values within a finite set of real numbers, with predefined lower and upper bounds, included in the set (R).

- **Declaration**

identifier1, identifier2, ..., identifierN: real

- **Manipulation Operations**

The allowed operations on this type are the same as those allowed on the "Integer" type, except for the MOD and DIV operators.

Application

Write an algorithm that reads two integer variables, A and B, calculates the sum, difference, average, and product, and displays the results.

4.3. Character Type

- **Definition**

This type allows defining objects representing an element taken from the set of editable characters (uppercase and lowercase letters, punctuation characters, whitespace, digits, etc.).
A value of the character type is always enclosed in single quotes: this allows us to distinguish a character ('3') from the corresponding integer (3) or an alphabetic character ('A') from the name of a variable (A).
The "space" character is represented by two single quotes separated by a space: ' '.

- **Declaration**

identifier1, identifier2, ..., identifierN: char

- **Manipulation Operations**

The allowed operations on the character type are as follows:

- Simple algorithmic actions (input, output, and assignment).

- ORD: so that ORD(C) gives the ASCII code (order in the ASCII table) of the character existing in object C. The result is of the integer type.

Example :

```
ORD('A') returns 65
A ← 'B'
ORD(A) returns 66
```

- CHR: so that CHR(N) gives the character corresponding to the ASCII code of the content of object N (N being of the integer type). The result is of the character type.

Example :

```
CHR(65) returns 'A'.
```

Note :

The two functions CHR and ORD are reciprocal. That is, for a variable C of the character type and a variable N of the integer type, we have:

CHR(ORD(C)) returns C
ORD(CHR(N)) returns N

- Comparison operators (<, <=, >, >=, =, <>): Comparing two characters is equivalent to comparing their respective ASCII codes.

4.4. Boolean Type

- **Definition**

This type is associated with objects that take their values in the set {True, False}.

- **Declaration**

identifier1, identifier2, ..., identifierN: Boolean

- **Manipulation Operations**
  - Negation (denoted as "NOT").

A	*NOT A*
True	False
False	True

  - Intersection (denoted as "AND").

AND	True	False
True	True	False
False	False	False

  - Union (denoted as "OR").

OR	True	False
True	True	True
False	True	False

Note: Operator Precedence

Each category of operators is associated with a precedence order. In fact, the evaluation of an expression is done by following the ascending order of operator precedence. If parentheses do not exist in an expression to be evaluated, and the operators have the same precedence, the evaluation is done from left to right.

Table 1 illustrates the order of precedence for arithmetic and logical operators.

Precedence Order	Operator Categories	Operators
1	Parentheses	(,)
2	Unary Operators	+ , -
3	Exponentiation	**
4	Multiplicative Operators	* , / , MOD , DIV
5	Additive Operators	+ , -
6	Comparison Operators	= , <> , < , > , <= , >=
7	Logical Negation	NOT
8	Logical AND	AND
9	Logical OR	OR

Table 1: Order of precedence for arithmetic and logical operators

CONTROL FLOWS

1. The Alternative

1.1. Definition

The alternative is based on the evaluation of a condition. It allows deciding which treatment to execute based on the value returned by the condition (logical expression).

1.2. Conditional Scheme Formats

Reduced Form

```
IF<< Condition(s) >>THEN
  << Treatment 1 >>
END IF
```

Full Form

```
IF<< Condition(s) >> THEN
  << Treatment 1 >>
ELSE
  << Treatment 2 >>
END IF
```

If the condition is TRUE, Treatment 1 is executed in both forms. If it is FALSE, in the first form, nothing is done (it proceeds to the next action immediately after END IF); in the second form, Treatment 2 is executed before moving on to the action immediately after END IF.

Example

Consider the following algorithm:

```
ALGORITHM Try
VAR
    A, B, C: integer
BEGIN
    Read(A, B, C)
    IF (A < B and C > A) THEN
        A ← B + C
        B ← C * 2
    ELSE
        A ← C - B
        C ← 0
    END IF
    Write(A, B, C)
END
```

Manually trace the algorithm for the values:
a- A = 1, B = 4, and C = 2
b- A = 3, B = 2, and C = 4

Application 1
Write an algorithm that reads a real number as a test score and checks if the value is correct or not.
Application 2
Write an algorithm that reads an integer and determines its parity.
Application 3
Write an algorithm that reads a character and checks if it corresponds to an alphabetic letter or not.

1.3. Nesting of Conditional Schemes

Sometimes, Treatment 1 and Treatment 2 can themselves contain conditional schemes. In this case, it is called the nesting of conditional schemes. The general scheme can be presented as follows:

```
IF <<Condition 1>> THEN
    <<Treatment 11>>
    IF <<Condition 2>> THEN
        <<Treatment 21 >>
    ELSE
        <<Treatment 22 >>
    END IF
    <<Treatment 12 >>
ELSE
    <<Treatment 21 >>
    IF <<Condition 3>> THEN
        <<Treatment 31 >>
    ELSE
        <<Treatment 32 >>
    END IF
    <<Treatment 22 >>
END IF
```

Application 1

Write an algorithm that determines the sign of a number.

Application 2

Write an algorithm that compares two numbers.

Application 3

Write an algorithm that reads two integers A and B and checks if A is divisible by B or not.

2. The Selective

2.1. Definition

If, in the case of nested conditional schemes, the condition always pertains to the same variable (or expression), the selective can be used. It involves selecting a treatment from several options based on the value of the selector.

2.2. Syntax

```
SELECT (Selector) DO
    <Value List 1>: <<Treatment 1>>
    <Value List 2>: <<Treatment 2>>
    ...
    <Value List n>: <<Treatment n>>
    [OTHERWISE: <<Treatment n+1>>]
END SELECT
```

Where: <<Selector>> is an identifier of an object or an expression,
<<Treatment i>> is a series of actions to execute,
<<Value List i>> can be given as constants and/or intervals of constants of a type compatible with that of <<Selector>>.

Remarks

• Each value of the selector can appear only once in the value lists.

• The SELECT form triggers the execution of the treatment corresponding to the value list containing the value of the selector. The algorithm execution continues with the action immediately following END SELECT.

• If the value of the selector does not match any value in the value lists, and if the OTHERWISE block exists, the treatment corresponding to that block will be executed. If the OTHERWISE block is not present, no treatment will be executed, and the execution will continue with the action immediately following END SELECT.

• The selector cannot be of a real type or a string type.

• The comparison between the selector and the value lists is done successively by going through the lists one by one until arriving at the value list that matches, the OTHERWISE block, or END SELECT if the OTHERWISE block does not exist.

Application 1
Write an algorithm that reads a month number and displays the month in full words.
Application 2
Write an algorithm that reads a month number and displays the corresponding quarter.
Application 3
Write an algorithm that reads a month number and displays the number of days in that month.
Application 4
Write an algorithm that reads a character and displays whether it is a lowercase alphabetic character, an uppercase alphabetic character, or a digit. (Use both the alternative and the selective)."

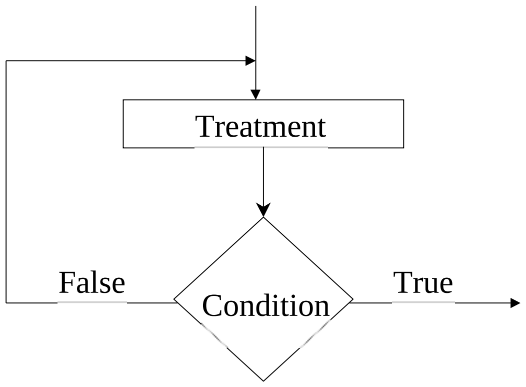
The algorithmic language has three repetitive structures:

- REPEAT ... UNTIL
- WHILE
- FOR

3. The REPEAT ... UNTIL Structure

Syntax

```
REPEAT
        <<Treatment>>
UNTIL (Condition)
```



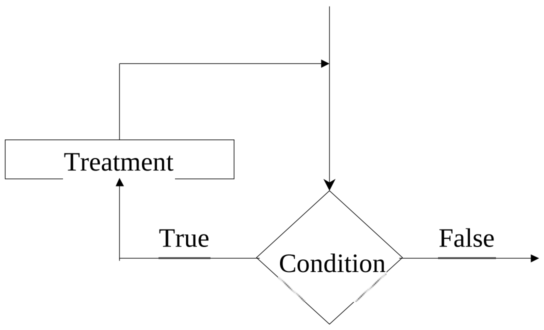
The evaluation and testing of the condition are done after the execution of the treatment (a set of actions composing the loop body). As a result, the treatment is executed at least once, and the number of repetitions is not known in advance. If the condition returns False, the treatment is repeated. There must be at least one action (part of the loop body) that changes the condition's value after a certain number of iterations.

Application 1
Write an algorithm to read a positive integer.
Application 2
Write an algorithm to read an alphabetic character.
Application 3
Write an algorithm to display the multiples of 2 between 2 and 100.
Application 4
Write an algorithm to display the multiples of 2 between two values A and B provided by the user, with the condition A < B and A >= 2.
Application 5
Write an algorithm to calculate the sum of 10 values provided by the user.

4. The WHILE Structure

Syntax

```
WHILE (Condition) DO
        <<Treatment>>
END DO
```



The evaluation and testing of the condition are done before the execution of the treatment (a set of actions composing the loop body). As a result, the treatment may not be executed (if the first evaluation of the condition returns False), and the number of repetitions is not known in advance. There must be at least one action (part of the loop body) that changes the condition's value after a certain number of iterations.

Note
It is always possible to replace a REPEAT structure with a WHILE structure.

```
REPEAT
    <<Treatment>>
UNTIL (Condition)
```

```
<<Treatment1>>
While (not Condition) Do
    <<Treatment>>
End Do
```

Treatment1 is included or equal to Treatment.

Example 1

```
REPEAT
    Read(A)
UNTIL (A > 0)
```

```
Read(A)
While (A <= 0) Do
    Read(A)
End Do
```

Example 2

```
S ← 0
I ← 1
REPEAT
    S ← S + I
    I ← I + 1
UNTIL (I > 5)
```

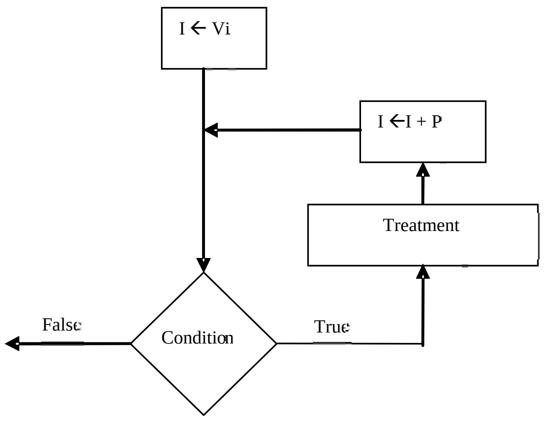
```
S ← 0
I ← 1
While (I <= 5) Do
    S ← S + I
    I ← I + 1
End Do
```

Applications
Revise applications 1, 3, and 5 from the previous section using the WHILE structure.

5. The FOR Structure

Syntax

```
FOR I from Vi to Vf [ BY p] DO
    <<Treatment>>
END DO
```



With:

I: the loop control variable
Vi: the initial value of I
Vf: the final value of I
p: the step value of I, defaults to 1.
The initialization of I to Vi and its incrementation by p are two actions performed automatically.
The condition to decide whether to iterate or not depends on the sign of the step p:

If $p > 0$: the condition is $I <= Vf$.
If $p < 0$: the condition is $I >= Vf$.
The number of iterations depends on the values Vi, Vf, and p:

If Vi <= Vf and p > 0: the number of iterations is given by the formula: ((Vf - Vi) div p) + 1.
If Vi >= Vf and p < 0: the number of iterations is given by the formula: ((Vi - Vf) div (-p)) + 1.
If Vi <= Vf and p < 0 or Vi >= Vf and p > 0: the number of iterations is 0.
Note
It is always possible to replace a FOR structure with a WHILE structure, but the reverse is not always straightforward (if the number of repetitions is not known).

In the case of p > 0:

```
FOR I from Vi to Vf by p DO
        Treatment
END DO
```

Can be replaced by:

```
I ← Vi
WHILE (I <= Vf) DO
        Treatment
        I ← I + p
END DO
```

Application 1
Write an algorithm to display all even numbers in the range 0 to 100.

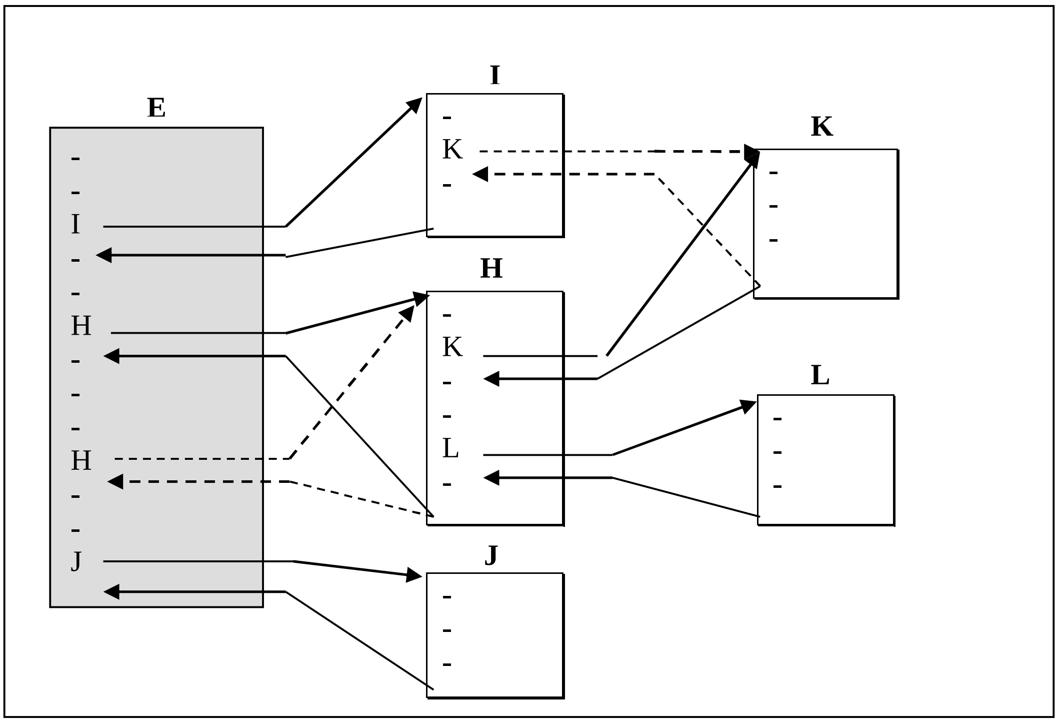
Application 2
Write an algorithm to calculate the sum of 10 integers provided by the user.

Application 3
Write an algorithm to display all odd numbers between 50 and 100 in descending order.

SUBROUTINES

1. Introduction

A subroutine is an algorithmic structure that allows a sequence of actions (representing a process) to be treated as a relatively independent entity, which can be called from the body of the main algorithm or from another subroutine.
Let's consider subroutine E, which references subroutines H, I, and J.



The subroutine E utilizes the services of the subroutines H, I, and J. E is referred to as the calling subroutine; H, I, and J are called subroutines concerning E.
A called subroutine can also be a caller if it calls another subroutine. In the previous example, the subroutine H is called by the subroutine E and is a caller of the subroutines K and L.
When calling a subroutine, the calling subroutine "pauses" to give control to the called subroutine. The calling subroutine will resume its execution when the called subroutine's execution is complete. It resumes its processing from the action immediately following the call.
A subroutine can be called multiple times within the same subroutine or by different subroutines.
The notion of subroutines has three main advantages:

- It avoids duplicating actions performing a given process when this process is needed in multiple parts of the same algorithm (e.g., calling H twice in E).
- It allows for the reuse of algorithm parts that have been tested in other algorithms (e.g., calling K once in I and another time in H).
- It enhances the clarity of algorithms; it decomposes each process into small units that could be developed and modified independently (each subroutine should address a specific sub-problem).

2. Types of Parameters Manipulated by Subroutines

2.1. Formal Parameters

These are objects declared when defining a subroutine. This type of object is used for communication between the calling subroutine and the called subroutine.

These objects are allocated at the time of calling a called subroutine and will be released when control returns to the calling subroutine. These parameters (also called formal parameters) do not have actual values.

Example:

In the ASCII code example, if the variable CC is not declared as global in the main algorithm, it can be used as a formal parameter for the Code_Ascii subroutine:

```
SUBROUTINE Code_Ascii(CC: Char)
   VAR CA: Integer
BEGIN
   CA ← ORD(CC)
   Write("The ASCII code of ", CC, " is ", CA)
END Code_Ascii
```

2.2. Actual Parameters

During a call, a calling subroutine must communicate the necessary values for the execution of a called subroutine through actual calling parameters.

At the time of the call, the calling subroutine copies the content of the actual parameters into the corresponding formal parameters.

The actual parameters of a calling subroutine and the formal parameters of the called subroutine should be:

- Of the same types respectively
- Listed in the same order
- The same in number

Example:

In the ASCII code example, the main algorithm can call the subroutine more than once, each time with a new actual parameter. If you wish to display the ASCII codes of two characters entered by the user, the following algorithm can be used:

```
ALGORITHM Character
VAR CC1, CC2: Char
   A: Integer
BEGIN
   Read(CC1, CC2)
   Code_Ascii(CC1)
   Code_Ascii(CC2)
END
```

Remarks:

- Do not give the same name to local variables as formal parameters because the subroutine won't be able to differentiate between them.
- You can give the same name to local variables (or formal parameters) as variables in other subroutines without them having the same content.
- When calling a subroutine, it is necessary to respect the number, type, and order of the parameters.

3. Functions

3.1. Definition

A function is a subroutine that provides a single result. A function is similar to the concept of mathematical functions.

3.2. Definition Syntax

The general syntax of the definition can be presented as follows:

```
FUNCTION Function_Name({List of formal parameters}): Base_type
VAR {declaration of local variables}
BEGIN
   {Set of actions}
   Function_Name ← result
END Function_Name
```

3.3. Function Call

The call to a function is not an action in itself. It is done by referring to its name while indicating the actual parameters to use.

There are three ways to call a function:

- In an assignment: VBLE ← Function_Name({actual parameters})
- In a display: Write("The result is: ", Function_Name({actual parameters}))
- In an expression: Expression Operator Function_Name({actual parameters})

Example:

```
FUNCTION ASCII(C: Char): Integer
VAR
   CA: Integer
BEGIN
   CA ←ORD(C)
   ASCII ← CA
END ASCII
```

```
ALGORITHM Character
VAR
   C: Char
   A: Integer
BEGIN
   Read(C)
   A ← ASCII(C)
   Write(A)
END
```

Application 1:

- Write a function that allows the input of a positive integer.
- Write a function that calculates the maximum of two values.
- Write an algorithm that reads two positive integers A and B and displays the greater of the two.

Application 2:

Write a function that checks if a character is an uppercase letter or not.

Application 3:

Write a function that takes two characters C1 and C2 and checks if they represent the same character.

4. Procedures

4.1. Definition

In the case where the subroutine returns more than one result or a result of a compound type (other than a string), it must be declared as a procedure.

4.2. Definition Syntax

```
PROCEDURE Procedure_Name (
   INPUT {List of input formal parameters};
   OUTPUT {List of output formal parameters};
   IN_OUT {List of input and output formal parameters})
VAR
{declaration of local variables}
BEGIN
   {Set of actions}
END Procedure_Name
```

With:

- The keyword **INPUT** is used to declare the list of formal parameters used by the procedure, and whose values are provided by the calling subroutine. The procedure can modify the value of one of these parameters, but when it returns to the main algorithm, it returns with the initial value.
- The keyword **OUTPUT** is used to declare the list of formal parameters used by the procedure to return its results.
- The keyword **IN_OUT** is used for the list of formal parameters used in both input and output.

4.3. Procedure Call

The call of a procedure is an action itself:

```
Procedure_Name({actual parameters})
```

Application 1:

```
PROCEDURE PROC(INPUT A: Integer; OUTPUT B: Integer; IN_OUT C: Integer)
BEGIN
   A ← A - 1
   B ← A + 5
   C ← C * 3
   Write(A, B, C)
END PROC
ALGORITHM X
VAR N, P, Q: Integer
BEGIN
   N ← 2
   P ← 2
   Q ← 2
   PROC(N, P, Q)
   Write(N, P, Q)
END
```

Application 2:

We want to display a triangle of asterisks (*) as shown in the following example:

```
                *
            *   *
        *   *   *
    *   *   *   *
*   *   *   *   *
```

To do this, you are asked to write:

- A procedure that takes two integers i and N as input and displays (N-i) spaces and i '*'.
- A function that allows entering an odd integer N between 5 and 39.
- The main algorithm that calls the previous modules to display a triangle of N lines of asterisks.

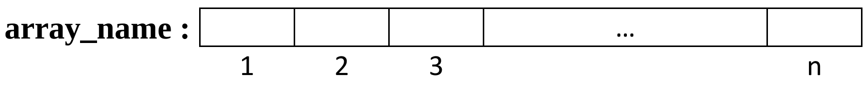
ARRAYS

1. Definition

A array is a data structure consisting of a fixed number of components, all of the same type, called the base type. Any variable of an array type is identified by a name representing it in its entirety.
An array can be one-dimensional or multidimensional.

2. One-dimensional Arrays (Vectors)

2.1. Schematic Representation



with:

- array_name: identifier of the array.
- 1, 2, …, n: order numbers (indices) of the elements of the array.

2.2. Declaration

The declaration of an array can be done in two ways:
Syntaxes

VAR array_name: array [lb .. ub] of base_type

Or

TYPE array_type = array [lb .. ub] of base_type
VAR array_name: array_type

Where:

- lb represents the lower bound of the closed bounded interval.
- ub represents the upper bound of the closed bounded interval.
- (ub - lb + 1) represents the number of elements in an array: it will be fixed definitively (in algorithmics, lb is always equal to 1).
- The index can take any value between lb and ub.
- base_type can be :
  - a simple type (logical, character, integer, etc.)
  - or a composite type (string, etc.).

Examples

- VAR T: array [1 .. 100] of integer

- TYPE TAB = array [1 .. 100] of real
  VAR T: TAB

- CONST
  ```
          lb=1
          ub=100
  TYPE TAB = array [lb  .. ub] of char
  VAR T: TAB
  ```

2.3.Manipulation Operations

a) Accessing an element of an array

The only primitive for accessing elements of an array relies on the indexing operation following the syntax:

```
array_name[i] with i ∈ [lb .. ub]
```

The index doesn't have to be a constant; it can also be a variable or even an expression.

Examples:

T : array of real numbers with size n.

T	1,5	0	-1	…	7,2
indices →	1	2	3		n

T[1] = 1.5
T[3] = -1
T[i]: provides the content of the element at index i.
T[3*i-2]: the evaluation of the expression 3*i-2, if it belongs to [lb .. ub], provides the index of an element in array T.

b) Reading / Writing / Assignment

An array must be treated element by element and not as a single entity.

~~READ (array_name)~~

All operations allowed on the base type of the array are also applicable to the elements of the array.

Application1
Write an algorithm that loads an array of 30 integers.
Application2
Write an algorithm that fills an array T with N integers (maximum 50), with N given by the user.
Application3
Write a main algorithm and the necessary routines to fill and display the elements of an array of N real numbers.
Application4
Write a main algorithm and the necessary routines to fill an array T of N integers and calculate the sum of its elements.

3. Two-dimensional Arrays

3.1.Definition

Two-dimensional arrays (also called matrices) are a special case of multidimensional arrays of dimension 2. In fact, a matrix is defined by a number of rows and a number of columns.

3.2.Declaration

Syntax 1

```
VAR matrix_name: array [1 .. nrows, 1 .. ncols] of base_type
```

Syntax 2

```
CONST
  lb = 1
    ub = nrows
    lc = ncols
TYPE
    Matrix = array [lb .. ub, lb .. lc] of base_type
VAR
    matrix_name: Matrix
```

3.3.Manipulation Operations

a) Accessing an element

To access an element of a matrix, you must have two indices: one for the row number and the other for the column number.

Syntax:

```
Matrix_name [row_number, column_number]
```

b) Reading / Writing / Assignment

A matrix must be treated element by element and not as a single entity.
All operations allowed on the base type of a matrix are also applicable to the elements of the matrix.

Application1
Write an algorithm to load a matrix of 5 rows and 10 columns.

Application2
Write an algorithm that:

- loads a matrix (L * C) of real numbers,
- finds the maximum value in the matrix.

Application3
Write an algorithm and the necessary routines to:

- fill a square matrix of characters,
- read a character C and calculate its number of occurrences in the matrix.

Homework N°1
Simple Data Types and Their Processing

Exercise 1

Consider the following algorithm:

```
Algorithm EX1
VAR
    t, h, m, s: integer
BEGIN
    Write ("Enter an integer")
    Read (t)
    h ← t div 3600
    m ← (t mod 3600) div 60
    s ← t mod 60
    Write ("H=", h, "M=", m, "S=", s)
END
```

1. Perform the manual execution of this algorithm with t=3665.
2. Deduce the purpose of this algorithm.

Exercise 2

Consider the following algorithm:

```
Algorithm EX2
VAR
    A, B, C: integer
BEGIN
    Write ("Enter three integers")
    Read (A, B, C)
    Write ("The values of A, B, and C are: ", A, B, C)
    A ← A + B + C
    C ← A - B - C
    B ← A - B - C
    A ← A - B - C
    Write ("The new values of A, B, and C are:", A, B, C)
END
```

1. Perform the manual execution of this algorithm with the following values :
   - A = 12, B = 5, C = 0
   - A = 7, B = 10, C = 13
2. Deduce the purpose of this algorithm.
3. Propose a second solution to the same problem.

Exercise 3

Write an algorithm that allows entering two integers, each assumed to have two digits, and insert the first integer in the middle of the second integer.

Example: N = 21 and M = 36, the algorithm will display the number 3216.

Exercise 4

Write an algorithm that allows entering a first integer N, assumed to have three digits, and a second integer M, assumed to have two digits, and insert the first integer in the middle of the second integer.

Example: N = 215 and M = 36, the algorithm will display the number 32156.

Exercise 5

Write an algorithm that reads a four-digit integer N and determines its mirror image. The "mirror of N" is the number formed by reversing the digits of N.

Example: N = 2369, so the mirror image of N is 9632.

Homework N°2
Control Flow

Exercise 1

Write an algorithm that allows entering three integers and displays the smallest among them.

Exercise 2

Write an algorithm that reads an integer and checks if it corresponds to the ASCII code of an alphabetic character.

Exercise 3

Write an algorithm that reads two integers and displays the sign of their product without having to calculate it. (The product can be positive, negative, or zero).

Exercise 4

Write an algorithm that allows reading a positive number of up to three digits and checks if it is cubic or not. A number is considered cubic if it is equal to the sum of the cubes of its constituent digits. Example: 153 = 1^3 + 5^3 + 3^3, so it is cubic.

Exercise 5

Write an algorithm that solves a second-degree equation ax^2 + bx + c = 0 in the set of real numbers (IR) and displays the result. The parameters a, b, and c will be provided by the user. All cases should be considered.

Exercise 6

Write an algorithm that allows entering two alphabetic characters, c1 and c2, and checks if these two characters correspond to the same letter, even if one is in uppercase and the other is in lowercase.

Exercise 7

Write an algorithm that reads a character and displays whether the character is an alphabetic letter or not. In the case of a lowercase (respectively uppercase) alphabetic letter, it displays its equivalent in uppercase (respectively lowercase).

Exercise 8

Consider the set of arithmetic operators:

OP ∈ {+, -, *, /}

Write an algorithm to:

- Read two operands,
- Read an operator OP in the form of a character,
- Perform the corresponding operation,
- Display the result.

The problem should be solved using both the selective and alternative methods.

Exercise 9

Write an algorithm that allows entering a student's overall average and determines their result and distinction. The re-sit conditions are applied from an average of 9.75. In this case, the student will only be allowed to re-sit if the total number of absences does not exceed 20, and the number of teachers in favor of the re-sit is greater than the number of teachers against it.

Exercise 10

Write an algorithm that calculates the amount of overtime for an employee, based on the unit price of an hour and the total number of hours worked according to the following scale:

The first 39 hours have no overtime pay.
Beyond the 39th hour up to the 44th hour, there is a 50% overtime pay.
Beyond the 44th hour up to the 49th hour, there is a 75% overtime pay.
Beyond the 49th hour, there is a 100% overtime pay.
Example: Total hours worked = 53, unit price of an hour = 15 DT. Overtime amount = 5 * (15 + 15 * 0.5) + 5 * (15 + 15 * 0.75) + 4 * 30.

Exercise 11

Write an algorithm that reads a date in the format of day, month, and year and checks the validity of this date. If it's valid, it displays the next date.

Homework N°3
Control Flow

Exercise 1

Write an algorithm that displays the multiples of 5 between 50 and 100.

Exercise 2

Write an algorithm that allows you to:
Enter N non-zero integer values,
Calculate and display their sum and product.

Exercise 3

Write an algorithm that allows you to enter a positive number N, calculate, and display its factorial given by the following formula:
$F = 1 * 2 * 3 * ... * (N-1) * N$
Knowing that for $N = 0$, $F = 1$.

Exercise 4

Write an algorithm that allows you to enter a positive number and check if it is a cubic number or not. A number is considered cubic if it is equal to the sum of the cubes of its constituent digits.

Exercise 5

Write an algorithm that displays all the cubic numbers between two values V1 and V2 given by the user.

Exercise 6

Write an algorithm that allows you to enter a student's grades in 10 subjects and calculate their average. Each subject has a homework grade and an exam grade with weights of 40% and 60%, respectively.

Exercise 7

Revisit Exercise 6 to calculate the averages of N students and calculate and display:
The overall class average,
The highest average,
The lowest average,
The number of students with an average score greater than or equal to 10.

Exercise 8

Write an algorithm that allows you to convert a non-zero positive number into binary, using successive divisions by 2.

Exercise 9

Write an algorithm that allows you to determine if a number is prime or not. A number is prime if it is divisible only by 1 and itself.

Exercise 10

Write an algorithm that allows you to display all prime numbers between two positive values V1 and V2 provided by the user.

Exercise 11

Write an algorithm that allows you to:
Read two strictly positive integers N and P,
Calculate and display the quotient of the integer division of N by P without using the DIV function,
Calculate and display the remainder of the integer division of N by P without using the MOD function.

Homework N°4
Subroutines

Exercise 1

Write a function that verifies the validity of a given date in the form of 3 integers (day, month, and year). This function returns true if the date is valid, and false otherwise.
Write a procedure that displays a supposed correct date in the form: DD Month YYYY.
Write the corresponding main algorithm.

Exercise 2

Write an algorithm to verify if a strictly positive integer N is symmetrical or not. A number is symmetrical if it reads the same from left to right as it does from right to left. To achieve this, use:

- A subroutine Input that allows entering a strictly positive integer.
- A subroutine Reverse that determines the symmetrical form of a given integer.

Exercise 3

Write a function to calculate the Nth term of a sequence U_N defined by:
$U_0 = 3$, $U_1 = 1$, and $U_N = U_{N-1} - U_{N-2}$
Write a function that calculates the sum of the first N terms of the sequence defined above.

$$S = \sum_{i=0}^{N} U_i$$

Write the main algorithm that inputs the order of the requested term (N) and calculates the Nth term of the sequence as well as the sum of the first N terms.

Exercise 4

Write a function to read a positive integer or -1.
Write a function to verify if an integer is even or not.
Write an algorithm to read a queue of positive integers (terminated by -1) and calculate and display the percentage of even integers.

Exercise 5

Write a function Remainder(...) that calculates the remainder of the integer division of two given positive integers.
Utilize this function in a subroutine isPrime(...) that checks if a number is prime or not.
Use this function in an algorithm to display the first 100 prime numbers.

Homework N°5
Arrays

Exercise 1
Write an algorithm and the necessary subroutines to:
- Fill an array of N integers
- Find the minimum value, the maximum value, and the average of the elements in this array
- Display all the numbers in the array that are less than the average.

Exercise 2
Write an algorithm along with the necessary subroutines to:
- Fill an array of N alphabetic characters
- Read a character C and calculate the number of occurrences of that character in the array.

Exercise 3
Write an algorithm along with the necessary subroutines to:
- Fill an array of N integers
- Read an integer V and check if it exists in the array.

Exercise 4
Write an algorithm and the necessary subroutines to:
- Fill an array T with N positive integers
- Display the elements of the array in reverse order
- Reverse the array T:
  - In another array Tinv
  - In the same array

Exercise 5
1. Write a subroutine that fills an array V with alphabetic characters.
2. Write a subroutine that splits an array of alphabetic characters into two vectors, VC and VV, containing consonants and vowels, respectively.
3. Write an algorithm that fills an array T with alphabetic characters of size N, splits it into two vectors TC and TV containing consonants and vowels, and then displays the vectors TC and TV.

Exercise 6
Write an algorithm and the necessary subroutines to fill an array of N integers and check if the elements in the array are in ascending order or not.

Exercise 7
Write an algorithm and the necessary subroutines to:
Fill an array of N integers in ascending order
Input a value V, check its existence, and display its first occurrence position in the array if it exists.

Exercise 8
Write an algorithm and the necessary subroutines to:
- Fill two arrays V1 and V2 in strictly ascending order
- Merge the two arrays into a third ordered array V3.

Exercise 9
Write a subroutine to check the existence of a given value in a matrix (m*n) of characters in different ways:
- Respond with true or false.
- Provide the indices of its position in the matrix if it exists and (0,0) otherwise.

Exercise 10
Write an algorithm and the necessary subroutines to:
- Load a square matrix of integers.
- Display the elements of the first and second diagonal of this matrix.
- Calculate and display the sums of these diagonals.

Exercise 11
Write an algorithm and the necessary subroutines to:
- Fill two matrices M1 and M2 with real numbers of the same size.
- Calculate and display their sum M3.

Exercise 12
Write an algorithm and the necessary subroutines to:
- Fill a matrix of integers.
- Fill and display the arrays Row and Column containing the sum of the elements of the rows and columns of the matrix, respectively.

Exercise 13
Write an algorithm and the necessary subroutines to:
- Fill two matrices M1 and M2.
- Calculate and display their product M3 if possible.

Exercise 14
Write an algorithm and the necessary subroutines to:
- Fill a square matrix of characters
- Check if the matrix is symmetrical with respect to its main diagonal.

Exercise 15
We want to write an algorithm to check if the elements of a matrix are in ascending order. To do this, we proceed as follows:
- Fill a matrix of integers.
- Place all the elements of the matrix into a vector.
- Check if the resulting vector is in ascending order.
- Display whether the matrix is in ascending order or not.

Example:
Consider the matrix Mat whose elements are placed in the vector V. The elements of this matrix are not in ascending order.

MAT

1	3	10
5	6	-1

V

1	3	10	5	6	-1