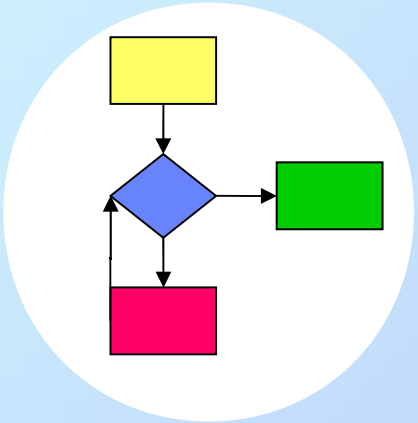
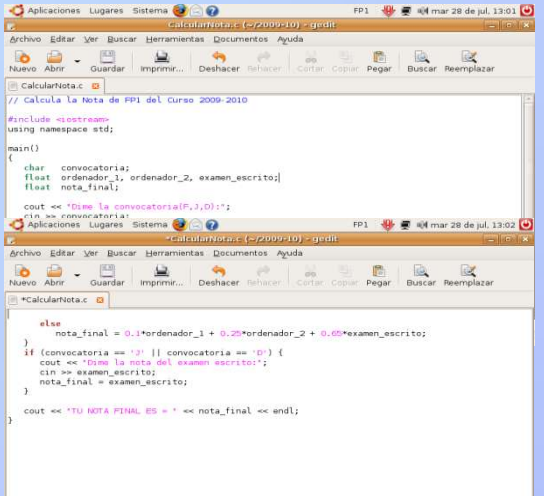


Programming 1

Lecture 3
Control Statements



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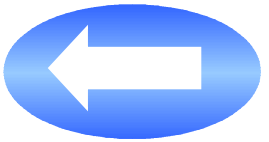
Dpto. de Ciencia de la Computación e Inteligencia Artificial

Objectives

- Understand the concept of algorithm
- Understand the need to design algorithms in order to analyse and solve problems
- Understand and manage the different types of existing control statements in a structured programming language
- Understand the syntax and how the control statements work in C language

Topics

1. **Algorithms and Programs**
2. Algorithmic structures
3. Programming structures
4. Sequential statements
5. Selection statements
6. Iteration statements
7. Comments
8. Program trace
9. General structure of a program
10. Information sources



The concept of Algorithm

Algorithm

Ordered sequence of instructions to solve a problem in a finite number of steps

The algorithms are independent both from the ***programming language*** and the ***computer*** that executes them

The concept of Program

Program

Set of ordered instructions (statements or sentences) written in a programming language for a computer to perform a particular task

The programs ***codify*** algorithms in a programming language, and are ***executed*** in a computer

State of a program

- The state of a program at a given instant is the value of each variable at this instant

PROGRAM = **State** + **Executable statements**

Variables that **store** the state

Statements that **modify** the state

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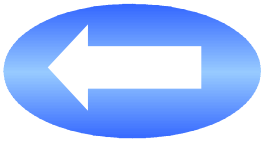
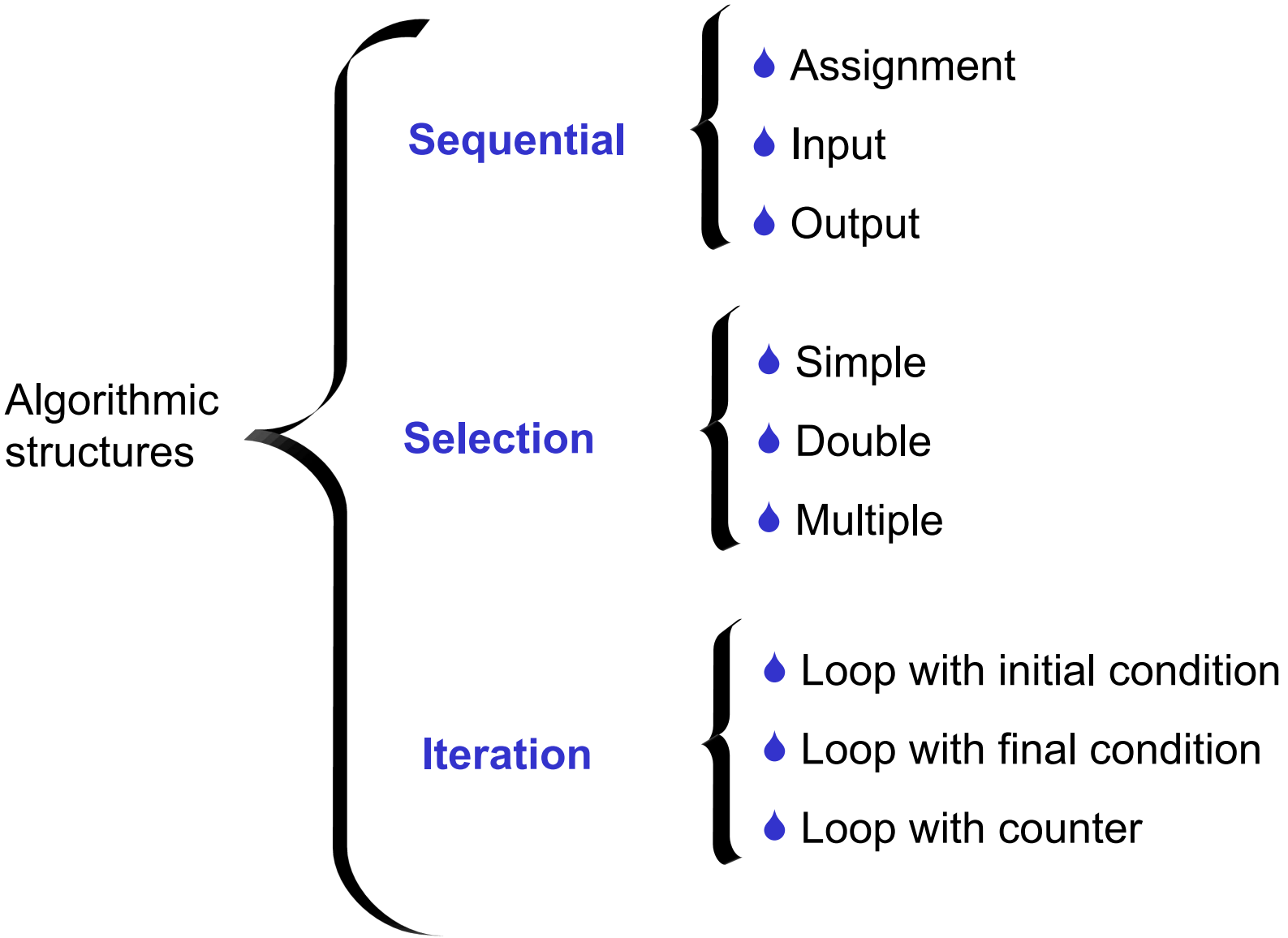


Control flow of an algorithm

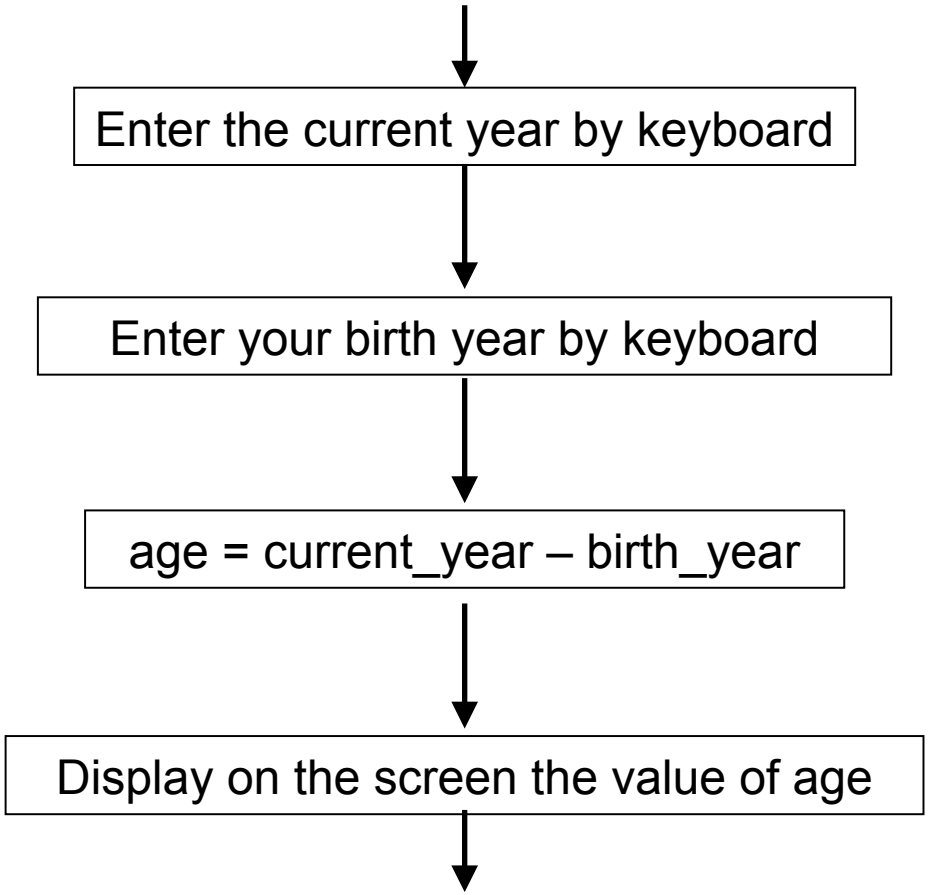
- The control flow defines the order followed by the algorithm instructions
- The control flow is determined by the several types of **algorithmic structures**

Types of algorithmic structures



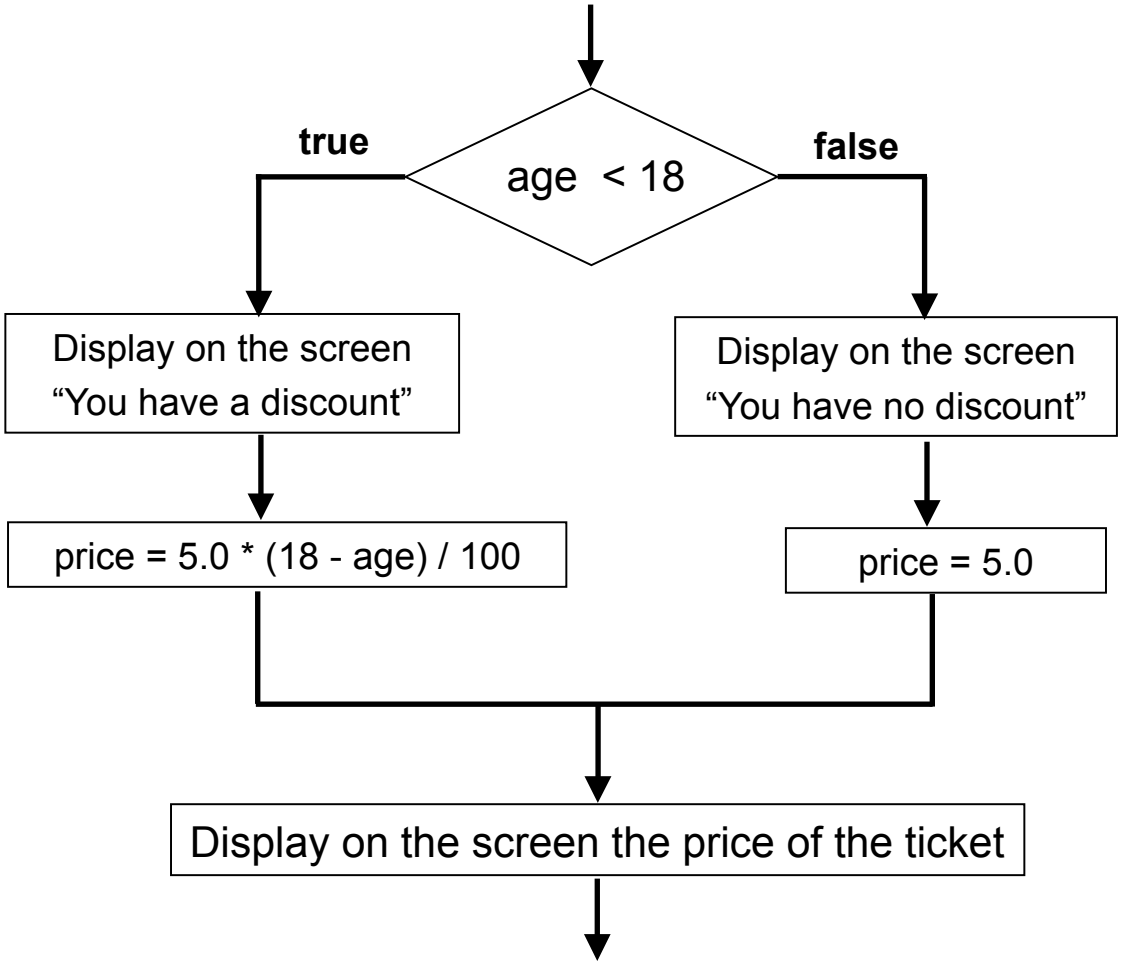
Sequential structure

- The actions (instructions) are consecutively performed one after another.



Selection structure

- It allows you to make decisions between different alternative actions depending on the value of a condition



If the condition is true **Then**

<action1>

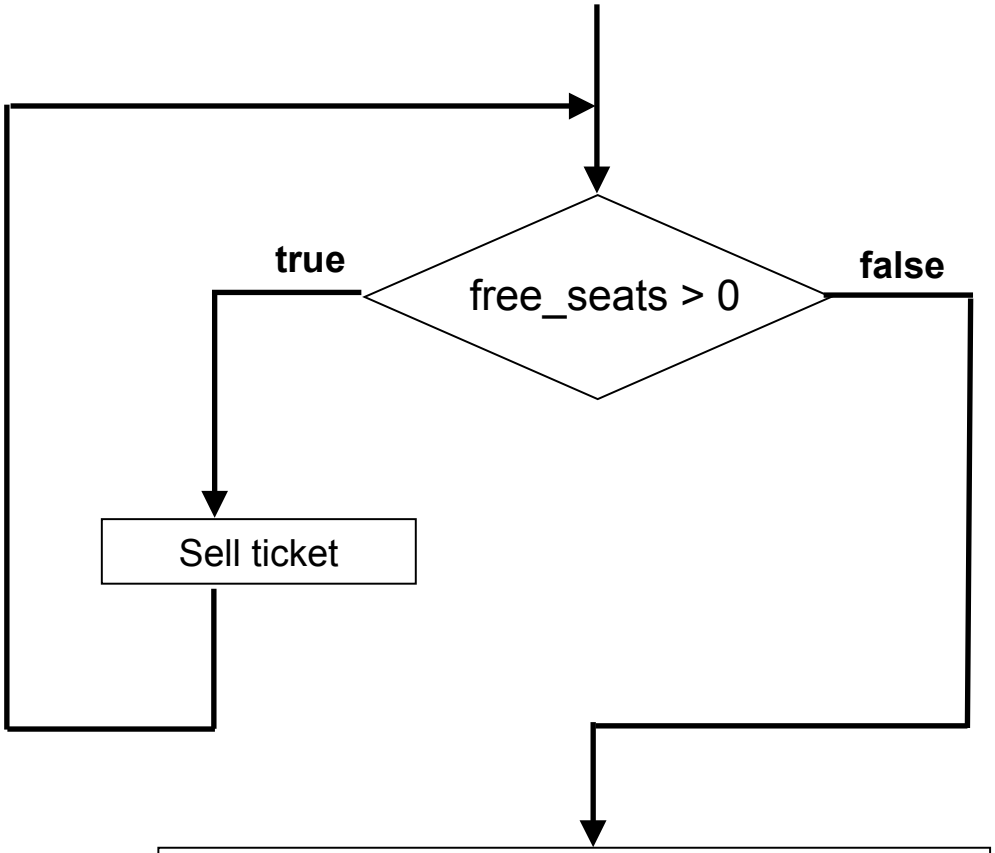
Else

<action2>

End_selection_statement

Iterative structure

- It allows you to repeat actions depending on the value of a condition



While the condition is true **Do**

<action>

End_Iterative_Statement

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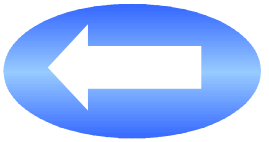
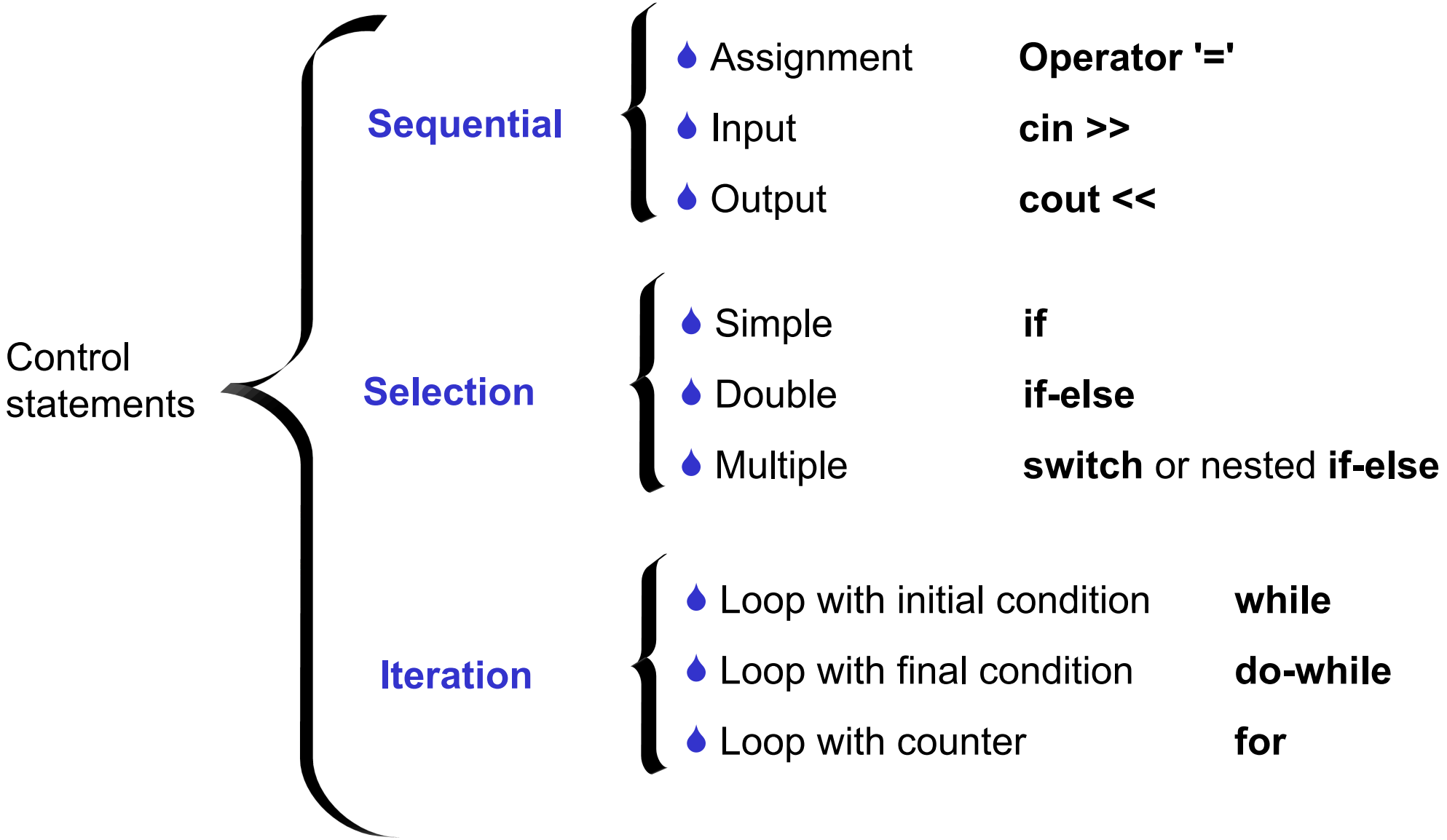


Execution flow of a program

- The execution flow defines the order in which the program statements are executed
- The execution flow is determined by the different types of **programming structures** (control statements)

Types of control statements



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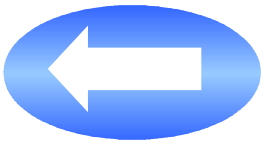

Simple sequential statements

- Assignment statement

```
variable  =  value ;
```

```
x = 20;
y = 3;
quotient = x / y;
remainder = x % y;
```

- Input statement (read data)

```
cin  >>  variable ;
```

```
cin >> x;
cin >> y;
```

- Output statement (write data)

```
cout  <<  datum ;
```

```
cout << “This text is written on the screen”;
cout << quotient;
cout << “\n”;
```

Sequence of statements in C and C++ languages

- A sequence of statements is made up of N statements, N ≥ 0
- When N > 1, the sequence of statements must be written between curly brackets ({ })

```
{
    sequence of statements
}
```

```
{   // beginning of the sequence

   cout << “Enter two integer numbers”;
   cin >> x  >>  y;
   quotient = x / y;
   remainder = x % y;
   cout << “The quotient is: “ << quotient << endl;
   cout << “The remainder is: “ << remainder;
   cout << endl;

}  // end of sequence
```

Remember: all the statements in C and C++ end with a semicolon ;

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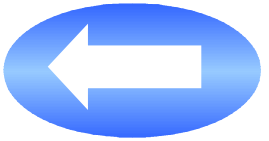

Select one alternative: if statement

- Decide whether a sequence of statements is executed

```
if (logic_ expression) {
    sequence of statements
}
```

```
if (speed > 120) {
   cout << "WARNING: you may be fined";
}  // end of if statement

cout << "your current speed is: ";
cout << speed << endl;
```

- If the result of evaluating *logic_ expression* is **true** then the sequence of statements associated with the if statement is executed
- If the value of *logic_ expression* is **false** then the sequence of statements is not executed and the statement following the if is executed

In C and C++, the **parentheses** enclosing the logical expression are **required**

Select between two alternatives: if-else statement

- Select between two different sequences of statements

```
if  (logic_expression)  {
   sequence of statements 1
}
else  {
   sequence of statements 2
}
```

```
if (number % 2 == 0) {
      cout << “the number is even”;
}
else {
     cout << “the number is odd”;
} // end of if-else statement

cout << endl;
cout << “enter another number:”;
```

- If the value of *logic_ expression* is **true** then the sequence of statements associated with the *if* is executed (sequence of statements 1)
- If the value of *logic_ expression* is **false** then the sequence of statements associated with the *else* is executed (sequence of statements 2)

Select from multiple alternatives: nested if-else statement

- Select from several sequences of statements

```
if  (logic_expression_1 )  {
   sequence of statements 1
}
else  if (logic_expression_2) {
   sequence of statements  2
}
else  if (logic_expression_3) {
   sequence of statements  3
}
```

```
if (mark >= 9  &&  mark <= 10)
   cout << “your mark is SOBRESALIENTE”;
else if (mark >= 7  &&  mark < 9)
  cout << “your mark is NOTABLE”;
else if (mark >= 5  &&  mark < 7)
  cout << “your mark is APROBADO”;
else if (mark >=0  && mark < 5)
  cout << “your mark is SUSPENSO”;
 else // last alternative of nested if-else
   cout << “your mark is not correct”;

// here is the next sentence
// after the nested if-else
```

- Only the sequence of statements associated with the first logic expression that is evaluated as **true** is executed
- If every logic expression is **false**
  - The sequence of statements following the whole nested *if-else* is executed
  - Unless the last alternative is associated with an *else*. In this case, this branch is executed.

Select from multiple alternatives: switch statement

- Select from several sequences of statements

```
switch  (expression )  {
   case  value_1 : sequence of statements 1;
                   break;
   case  value_2 : sequence of statements 2;
                   break;
   case  value_3 : sequence of statements 3;
                   break;
   default       : sequence of statements 4;
}
```

```
switch (operator) {
   case '+'  :  res = x + y;
                break;
   case '-'  :  res = x - y;
                break;
   case '*'  :  res = x * y;
                break;
   case '/'  :  res = x / y;
                break;
}  // en of switch statement

cout << "Result of the operation : ";
cout << res;
```

- Only the sequence of statements associated with the ***case*** is executed, which has a value that corresponds to the result of the *expression* in ***switch.***
- If the value of the *expression* in ***switch*** is not in any ***case***, the sequence of statements associated with the branch ***default*** is executed (this branch is optional)

Exercises

1. Write a program to read two different numbers from the keyboard and display a text message on screen indicating which is the greatest one.
2. Write a program to read a figure in seconds and display this figure as hours, minutes and seconds.
3. Write a program to read the coordinates of three points in a plane and display whether they make up an equilateral triangle.
4. Write a program to display three menu options and let the user select one of them. After that, a message should appear on the screen that shows the selected option or an error message if the option is incorrect:

Execution example 1

```
1. Menu option 1
2. Menu option 2
3. Menu option 3

Enter a menu option:  2
The selected menu option is 2
```

Execution example 2

```
1. Menu option 1
2. Menu option 2
3. Menu option 3

Enter a menu option:  4
The selected menu option is incorrect
```

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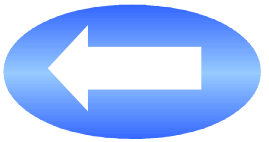


Loops

- A loop is a programming structure made up of a sequence of statements, called the **loop body**, that can be repeated several times
- Each execution of the loop body is an **iteration**
- The number of times the loop body is executed is controlled by a **condition** (logic expression)
- Therefore, when designing and implementing a loop, we must take into account two aspects:

1. Which one should be the loop body?
2. How many times must the loop body be iterated?

Loop types

- Depending on where the condition that controls the execution of the loop body is, the following types of loops can be distinguished:
  - Loops with initial condition
    - *While* statement
    - *For* statement (repeat with counter)
  - Loops with final condition
    - *Do-while* statement

Loops with initial condition: while statement

- Repeat zero or more times the execution of a sequence of statements while the condition is **true**

```
while  (logic_expression)  {
   sequence of statements
}
```

```
sweets = 0;
cout << "Do you want a sweet?:";
cin >> answer;
while (answer == 'Y' || answer == 'y') {
   sweets=sweets+1;
   cout << "Do you want another sweet?:";
   cin >> answer;
}  // end of while statement

cout << "You have "<< sweets <<" sweets";
```

- While the result of evaluating the *logic_expression* is **true**, the sequence of statements (*loop body*) will be executed repeatedly

Loops with final condition: do-while statement

- Repeat once or more times the execution of a sequence of statements while the condition is true

```
do {
   sequence of statements
} while (logic_expression);
```

```
do  {
   cout << "Enter the menu option:";
   cin >> option;
}  while (option < 1  ||  option > 4);
```

- First, the *loop body* (sequence of statements) is executed, and then the *logic_expression* is evaluated
- While the result of evaluating the *logic_expression* is **true**, the sequence of statements (*loop body*) will be executed repeatedly

Loops with initial condition: for statement

- Repeat a given number of times the execution of a sequence of statements
- The number of the loop iterations is controlled by a variable, used as a counter

```
for  (counter initialization ; logic_expression ; counter increment)  {
   sequence of statements
}
```

```
for ( i = 1;  i <= 10; i++)  {
   cout << "This is the iteration number " << i;
}
```

In C and C++, the **i++** statement is an assignment statement equivalent to i = i+1

The counter increment can be any other number than 1, for instance: i = i+2; i = i*2; …

The counter can also be decremented: i = i-1

How does the for statement work?

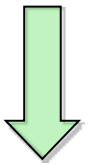
- Step 1: The counter initialization statement is executed (only once)
- Step 2: The logic expression is evaluated:
  - **If** its value is true, **then** the loop body is executed
  - **If** its value is false, **then** the for statement execution is finished
- Step 3: After executing the loop body, the counter increment statement is executed
- Step 4: Go back to step 2

The for loop vs. the while loop. Equivalence

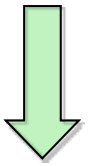
- Any for loop can be rewritten as a while loop

```
for  (expression_1 ; expression_2 ; expression_3)  {
   sequence of statements;
}
```

```
for ( i = 1;  i <= 10; i++)  {
   cout << "This is the iteration num." << i;
}
```



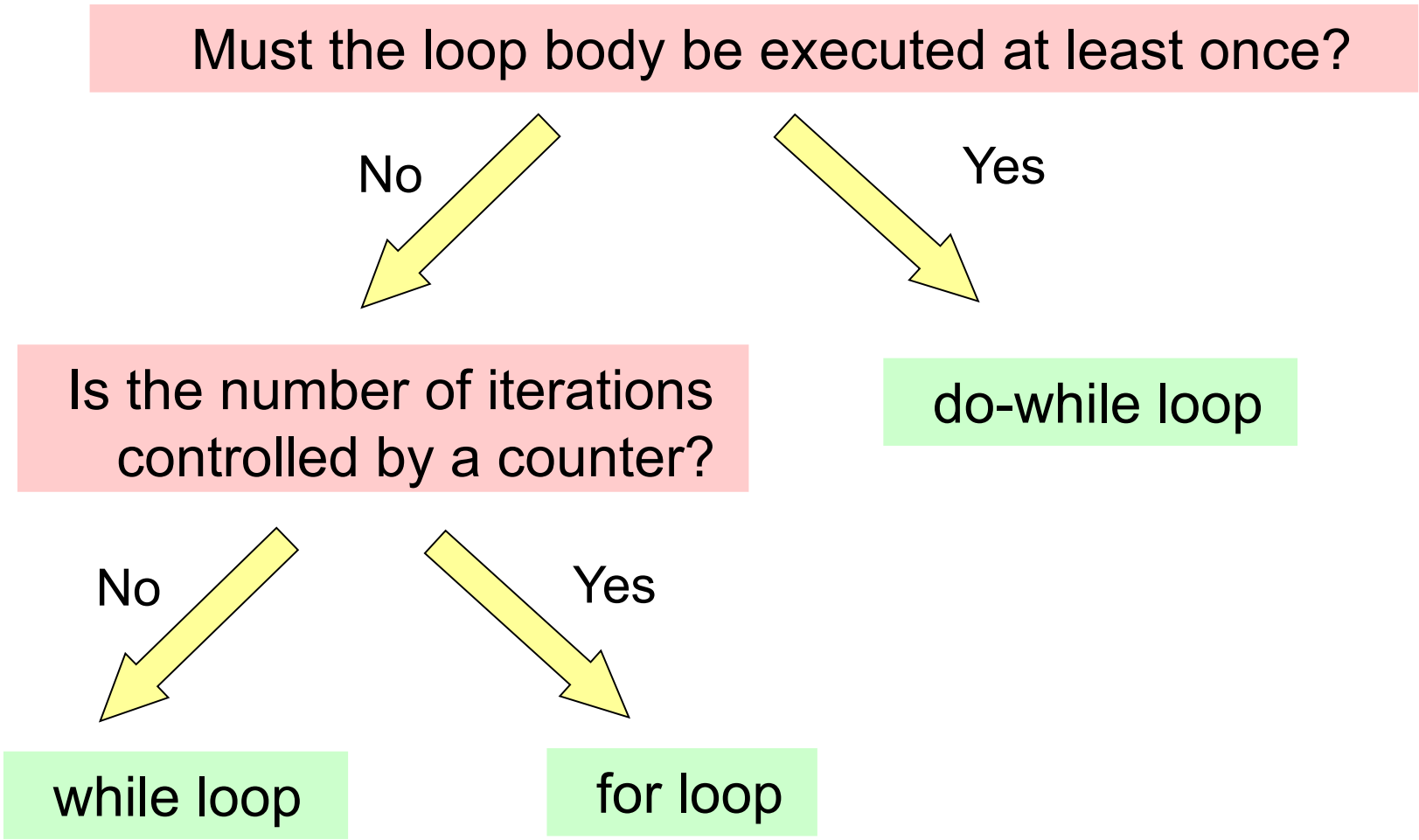
Can be rewritten as



```
expression_1 ;
while  (expression_2)  {
   sequence of statements;
   expression_3;
}
```

```
i = 1;
while ( i <= 10)  {
   cout << "This is the iteration num." << i;
   i++;
}
```

What type of loop should I use?



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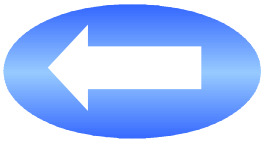


Comments in the source code

- A comment is a short explanation to provide information for people who read the code
- They facilitate the program maintenance
- In C++ language, the symbols // are used
  - The text between // and the end of line is a comment

```
float partial_mark;  // mark of a partial exam (input datum)

// Calculate the average mark and display it on the screen
```

- In C and C++ languages, the symbols /* and */ are also used
  - The text between /* and */ is a comment

```
/* Enter the marks of every partial exam and sum them up
   (only when the entered datum is correct) */
```

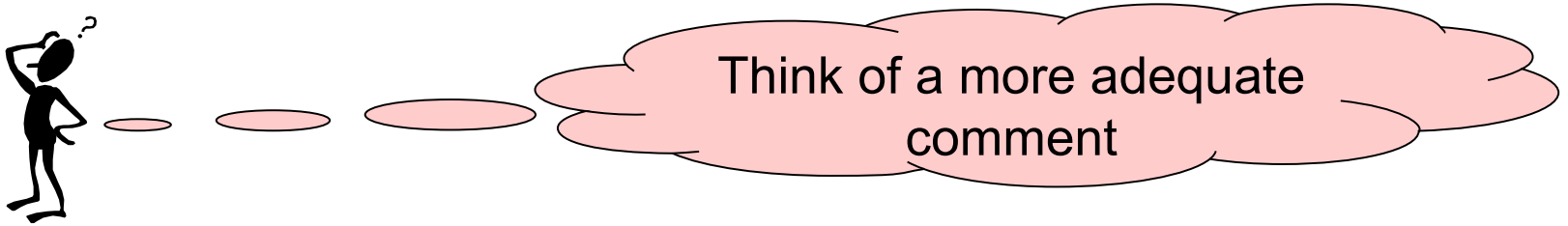
Comments

- A comment must clearly and shortly explain what a code section in a program does, but not how it is done (that is the code itself)
- For the following code …

```
for  (x=1; x <= 10; x++)
   for (y=1; y<=10; y++)
      cout << x  <<  "*"  << y  << "="  <<  x*y  << endl;
```

- … what do you think about the following comment?

```
/ * We have two nested for loops that are each repeated 10 times
 In the inner loop a message is printed on the screen to
 indicate the product of the two variables used as counters in the for loops
 A total amount of 100 lines are printed on the screen * /
```



Comments: where and how many?

- Where must I include a comment?
  - In a module definition (what does the module do?)
  - At the beginning of a code section that makes an important action or which has a meaning that is not obvious by itself
  - At the beginning of a program (a heading with the program name, author, date, program description...)
- How many comments must I include in my program?
  - Too many comments are just as bad as having too few

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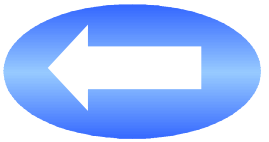


Program trace concept

- A program trace is a sequence of states through which the program passes, that is, the value taken by the variables as the program is executed
- The trace is carried out through a sequential manual execution of the program statements
- The traces are mainly used for debugging the program

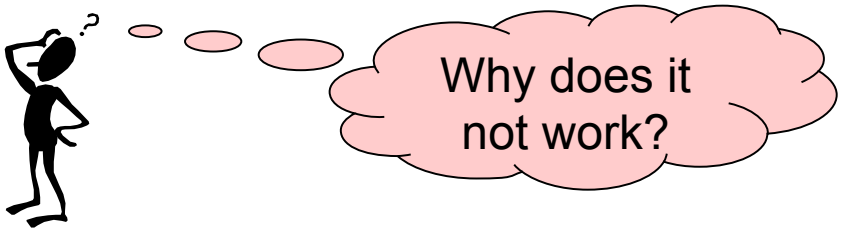
The variables store the program state, and the executable statements modify this state

Debugging a program is correcting the execution errors that are detected during the execution.

Debugging a program using a trace

```
// Let N > 0 be a number, calculate the addition
// all the odd numbers that are less than N
#include <iostream>
using namespace std;
main() {
   int num;   // read number (input datum)
   int sum;   // addition result  (output datum)
   int i;     // loop counter (auxiliary datum)

   cout << "Enter a number, greater than 0:";
   cin >> num;

   // calculate the addition and display on screen
   sum = 0;
   for (i=1; i < num; i++) {
      if ( (num % 2) != 0)
         sum = sum + i;
   }
   cout << "The result is: " << sum << endl;
}
```

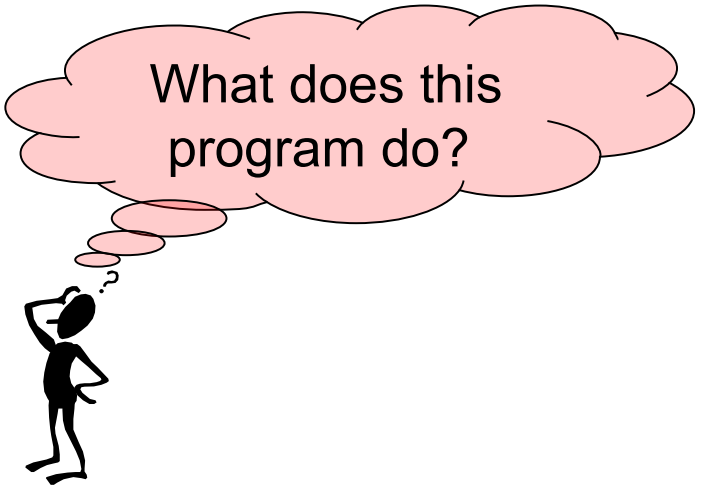
	num	sum	i
cin	5		
Initialize sum	5	0	
Initialize counter	5	0	1
1st for iteration	5	1	1
Counter increment	5	1	2
2nd for iteration	5	3	2
Counter increment	5	3	3
3rd for interation	5	6	3
Counter increment	5	6	4
4th for iteration	5	10	4
Counter increment	5	10	5



Understanding a program using a trace

- A program trace can also be used to understand what a program or a part of it does

```
#include <iostream>

using namespace std;

main() {

   float a, r;
   int b, i;

   cout << "Enter a real number:";
   cin >> a;
   cout << "Enter an integer number:";
   cin >> b;
   r = 1;
   for (i=0; i < b; i++)
      r = r * a;


   cout << "The result is: " << r << endl;
}
```



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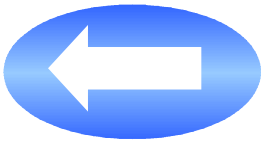


What type of program must I be able to do?

#preprocesor directives

Constants declaration

main() {

Variables declaration:

of simple data types

Main body (executable statements)

Input and Output statements

assignment statements

selection statements

iterative statements

}

Program example

```
#include <iostream>
using namespace std;

const int NUM_PARTIALS =  5;  // Number of partial exams

main() {
   float partial_mark;  // mark of a partial exam  (input datum)
   float sum; // total sum of marks (auxiliary datum)
   int    i;  // counter for 'for' loop (auxiliary datum)
   bool incorrect_mark; // true if the entered mark is incorrect   (auxiliary datum)
  float final_mark; // average mark of all the partial exams (output datum)

   sum = 0;
   // Enter the marks of all the partial exams and add them up (only if the datum is correct)
   for (i=1; i <= NUM_PARTIALS; i++) {
      do {
         cout << "Enter the mark of partial number " << i ":";
         cin >> partial_mark;
         incorrect_mark = (partial_mark < 0.0 || partial_mark > 10.0);
         if  (incorrect_mark)
            cout << "The entered mark is incorrect" << endl;
      } while (incorrect_mark);
      sum = sum + partial_mark;
   }
  // Calculate the average mark and display it on the screen
   final_mark = sum / NUM_PARTIALS;
   cout << "Your final mark is: " << final_mark << endl;
}
```

Rules for a good style of writing programs

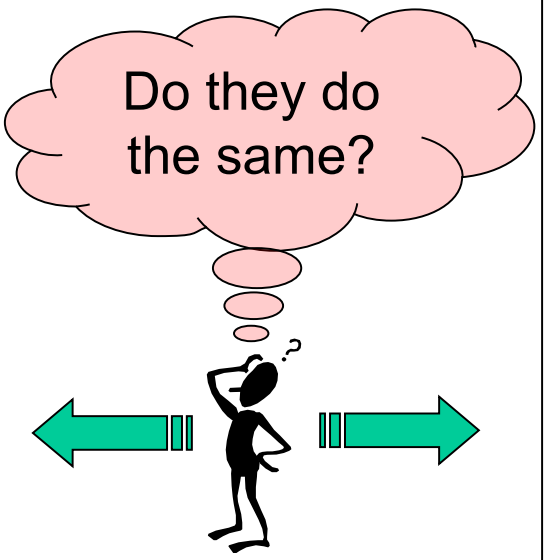
- The variables and constants names must suggest their use
- Use line breaks between parts that are logically separated
- Properly indent the code

```
#include <iostream>
using namespace std;

main() {
   float base, power;
   int exponent, i;

   cout << "Enter a real number:";
   cin >> base;
   cout << "Enter an integer number:";
   cin >> exponent;
   power = 1;
   for (i=0; i < exponent; i++)
      power = power * base;

   cout << "Power: " << power << endl;
}
```




```
#include <iostream>
using namespace std;

main() {  float a, r;  int
 b, i;  cout <<
"Enter a real number:";  cin >>
a;  cout <<
"Enter an integer number:";
   cin >> b;  r
 = 1;  for
(i=0
; i < b;
i++)      r = r * a;
   cout << "The result is: " << r <<
 endl; }
```

A program written following a good programming style is easier to read (more readable) and easier to modify (more maintainable)

Exercises

5. After executing each of the following program fragments, which is the final value of variable *x* in each case?

Case A

```
x = 0;
n = 16;
while ( n != 0) {
    x = x + n;
    n = n / 2;
}
```

Case B

```
z = 12;
x = 0;
if ((z % 4) == 0)
   for (j = 0; j < 10; j + 4)
       x = x + j;
else
    for (j = 0; j < 10; j + 2)
       x = x + j;
```

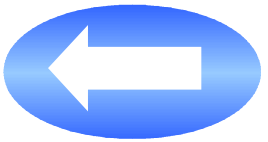
6. Write a program that reads positive numbers and displays their addition and the amount of input numbers.

7. Write a program that reads an integer number, greater than 0, and displays all its divisors.

8. Modify the program from exercise 4 to add a fourth option called “EXIT”. The program must continuously display the menu, let the user select the option, and exit the program only when the option 4 is chosen.

Topics

1. Algorithms and Programs
2. Algorithmic structures
3. Programming structures
4. Sequential statements
5. Selection statements
6. Iteration statements
7. Comments
8. Program trace
9. General structure of a program
10. **Information sources**



Information sources

Fundamentos de Programación
Jesús Carretero, Félix García, y otros
Thomson-Paraninfo 2007. ISBN: 978-84-9732-550-9

✓ Capítulo 5

Problemas Resueltos de Programación en Lenguaje C
Félix García, Alejandro Calderón, y otros
Thomson (2002) ISBN: 84-9732-102-2

✓ Capítulo 3

Resolución de Problemas con C++
Walter Savitch
Pearson Addison Wesley 2007. ISBN: 978-970-26-0806-6

✓ Capítulo 2 (Apartado 2.4)
✓ Capítulo 7