UNIT 4. CONTROL FLOW

Programming
Year 2017-2018
Grade in Industrial Technology Engineering

Paula de Toledo.
David Griol

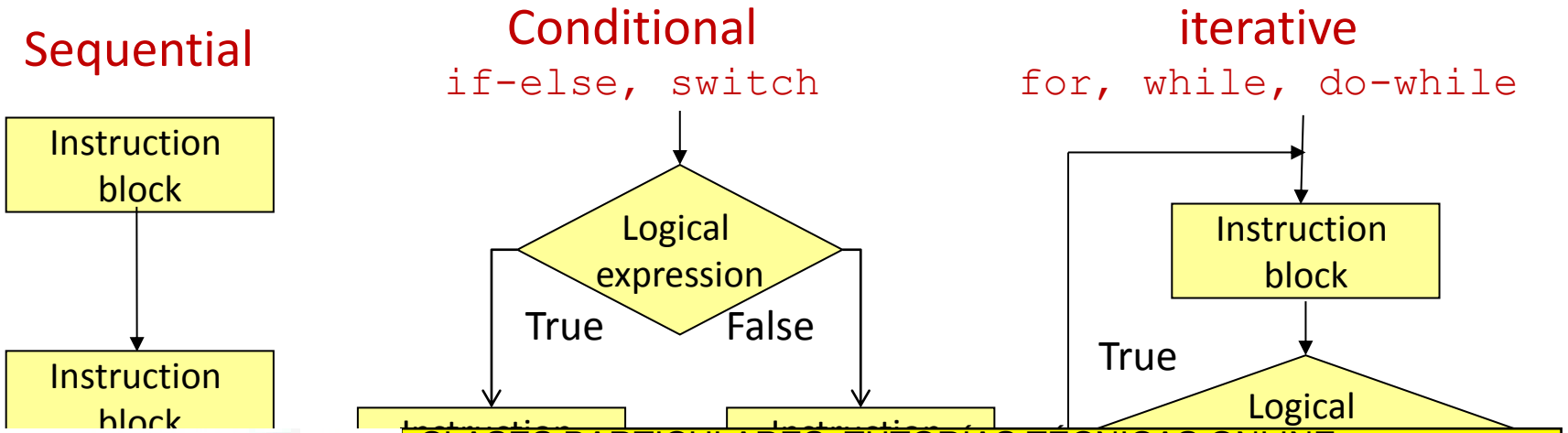
Contents

Control flow structures

- Alter the standard flow of program execution
  - Standard = Starting from the first instruction of the main method, sequential order

- Control flow instructions break up this sequence
  - **Conditional control flow structures**
    - Decision-making instructions
    - Blocks of instructions are executed depending on the result of a boolean expression (the condition)
  - **Repetitive (Iterative) control flow structures (AKA Loops)**
    - Blocks of instructions are executed while a condition holds

Every possible algorithm can be implemented using only these three control flow structures



Structured programming

- Programing paradigm
  - Best practice for developing good programs
    - Good = easy to develop and to maintain (correct, upgrade)

- Basic principles of structured programming
  - Single entry and exit end point (start /end)
  - Only secuential, conditional and interative control flow structures allowed

- Never use “go to” instructions!

2. CONDITIONAL INSTRUCTIONS

2.1 IF-ELSE

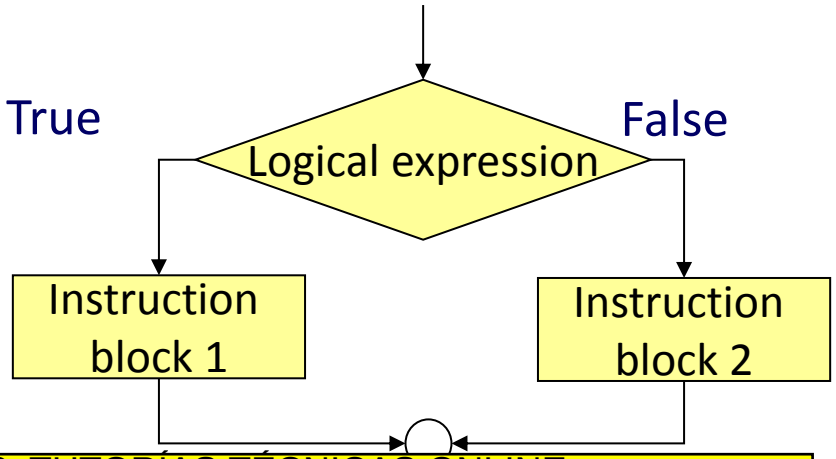
Conditional structure `if - else`

- Logic expression is evaluated
  - If the expression is true block of code 1 is run
  - If the expression is false block of code 2 is run
  - After either branch has been executed, control returns to the point after the if

Syntax

```
if (Logical expression){
        instruction_block_1;
}
else {
        instruction_block_2;
}
```

Flow diagram



Example


```
    printf("A smaller than or equal to B");
```

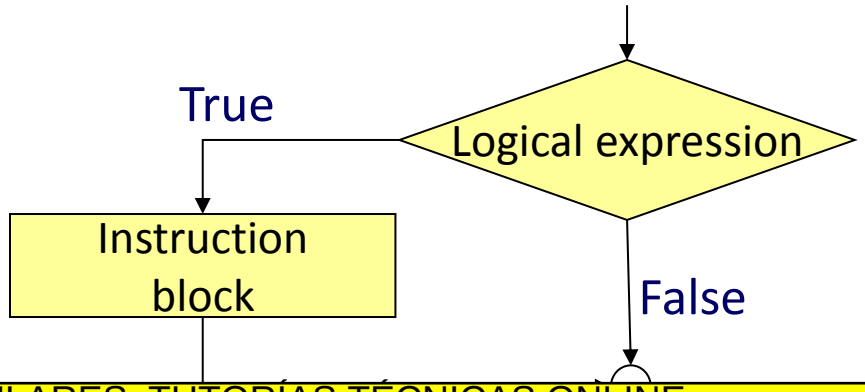
Conditional structure `if`

- Simplest version
- If the expression is true the block is run
- If it is not, nothing happens

Syntax

```
if (Logical expression) {
    instruction_block;
}
```

Flow diagram



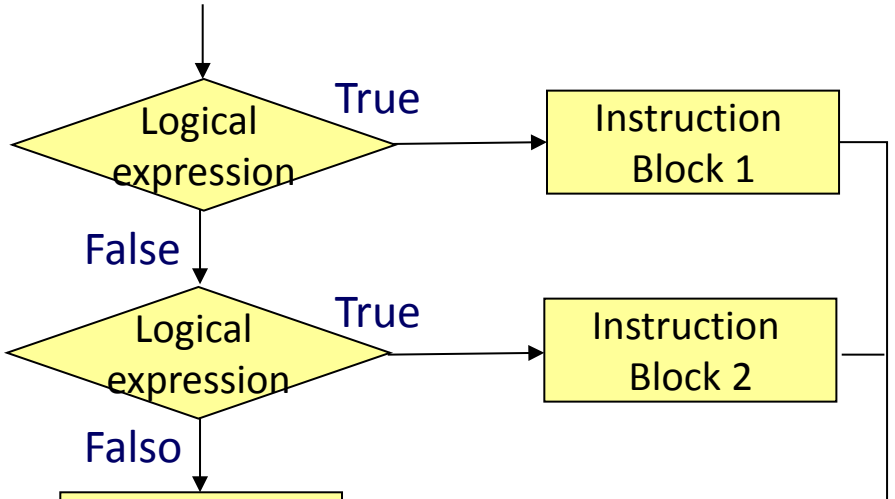
Example

```
if (age < 18){
```

Nested if structures

- To define diferent alternative and mutually exclusive paths
- If all logical expressions are false the last block is run

```
if (logical_expression_1){
        instruction_block_1;
}
else{
    if(logical_expression_2){
       instruction_block_2;
    }
    else {
```



Exercise

- Develop a program that queries the user for the mark in one exam and displays the corresponding grade
  - Sobresaliente: 9 to 10
  - Notable: 7 to 9
  - Bien: 5 to 7
  - Insuficiente: less than 5
  - Error –the mark is not between 0 and 10

Example

```
#include <stdio.h>
int main(void)
{
  int mark; //student's mark - numeric value

  printf("Insert mark: (0-10) \n");
  scanf("%i", &mark);

  if ( (mark >= 0) && (mark < 5) ){
    printf("Failed\n");
  }
  else{
      if ( (mark >= 5) && ( mark <= 10 )){
        printf("Passed \n");
      }
      else{
        printf("mark value not valid");
        printf("valid range is 0-10\n");
```

Option 1

Option 2

Default option

2. CONDITIONAL INSTRUCTIONS
2.2. SWITCH

switch

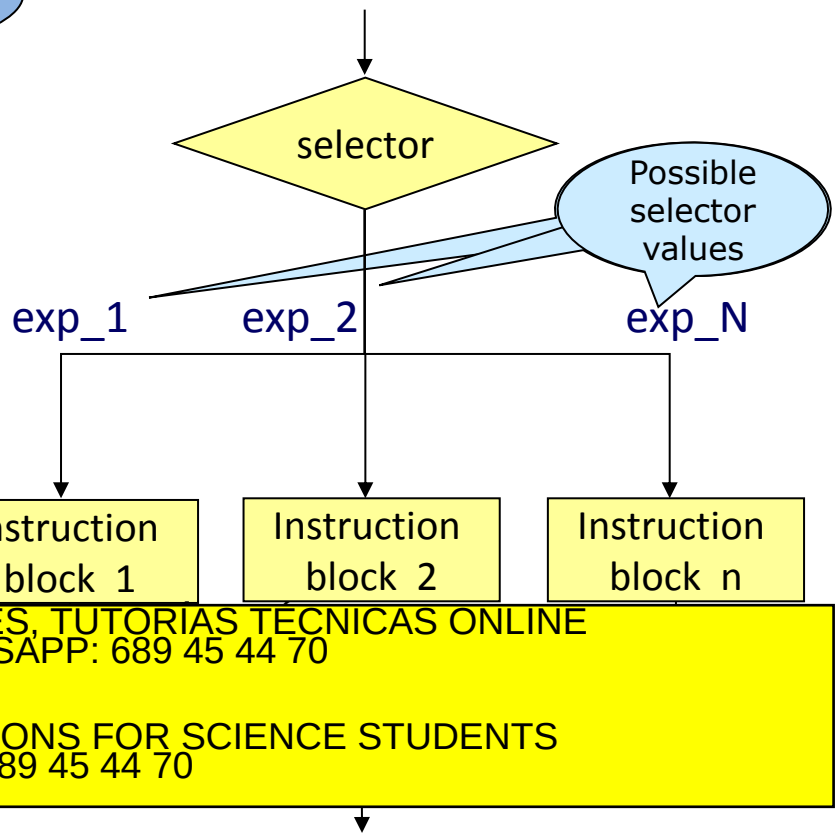
- Simplifies multiple selection structures based on a selector variable

Syntax

int o char variable

```
switch(selector){
   case constant_expression_1:
      instruction_block_1;
      break;
   case constant_expression_2:
      instruction_block_2;
      break;
   case constant_expression_N:
      instruction_block_N;
      break;
}
```

Flow diagram



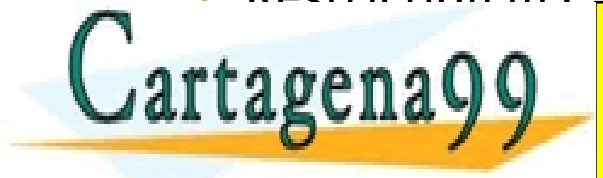
Example: Tell the polygon name according to the number of sides

```
#include <stdio.h>

int main(void)
{
  int numSides;
  printf ("Insert number of sides: ");
  scanf("%i", & numSides);
  switch (numSides){ //numSides is the selector for the switch
    case 0: case 1: case 2:
        printf("not a polygon \n");
        break;
    case 3:
        printf("triangle\n");
        break;
    case 4:
        printf("rectangle\n");
        break;
    case 5:
```

switch

- selector:
  - Must be a variable or expression of any of the following datatypes: integer, logical, char
    - Can't be a real number (float, double)
    - Avoid using a logical expression, in that case "if" is a better option
- case
  - Each "case" clause is followed by a constant expression of the same datatype as the selector
    - Examples 12, MAXIMUM, MAXIMUM+5
  - Value ranges cant be set, a new case clause needed for each value
    - Example case 1: case 2: case 3: case 4
    - Restriction in C, this is possible in most languages



clauses, the default block will be run (if existing)

Example: Tell if the letter entered is a vowel

```
int main(void){
  char c;
  printf ("Enter a letter :");
  scanf("%c", &c);
  switch (c){
     case 'A': case 'a':
        printf ("vowel A\n");
        break;
     case 'E': case 'e':
        printf (" vowel E\n");
        break;
     case 'I': case 'i':
        printf (" vowel I\n");
        break;
     case 'O': case 'o':
        printf (" vowel O\n");
        break;
     case 'U': case 'u':
        printf (" vowel U\n");
        break;
```



```
}
```

Switch: break instruction

- Usually we want all the case blocks in a switch to be mutually exclusive
  - To get this behaviour we end each case block with a break instruction
  - If the break instruction is missign, all the following case blocks from that point on will be run (fall through behaviour) switch a until a break instruction, is found
- When a break instruction is found, the switch is terminated

Switch with no break, example

- Occasionally we may want to write some code that falls through the different options of the switch
- Example: Madrid anti-pollution protocol: three different scenarios (1-2-3) according to severity, increasing traffic restrictions

```
int scenario;
printf("Enter the scenario ");
scanf("%i",&scenario);

switch(scenario){
    case 3:
       printf("Half of cars banned, according to plate number");
    case 2:
       printf("On-street parking banned for cars with no resident permit");
    case 1:
```

3. ITERATIVE STRUCTURES - LOOPS

Iterative control flow structures

- Other names: repetitive structures, loops
- Three options in C
  - `for`
    - The instruction block is repeated a given number of times, that is known beforehand (when the loop starts)
      - Example :
        - Display all numbers from 1 to 100.
  - `while` and `do-while`
    - The instruction block is repeated while a given condition holds
    - Used when the number of iterations is not known a priori (for example depends on the user inputs)

For control flow structure

Syntax

```
for (initialization; control_expression; update) {
        instruction_block;
}
```

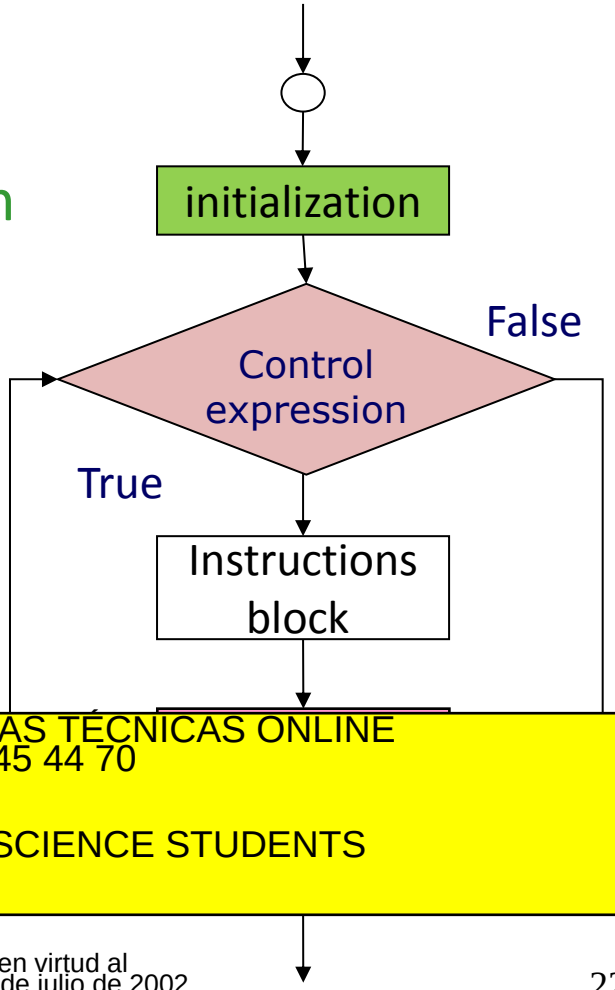
Initialization

An initial value is assigned to the de control variable

Control expression:

Boolean (logical) expression that is checked before each loop iteration and determines if the block is run once more or not

Flow diagram



`For` control flow structure

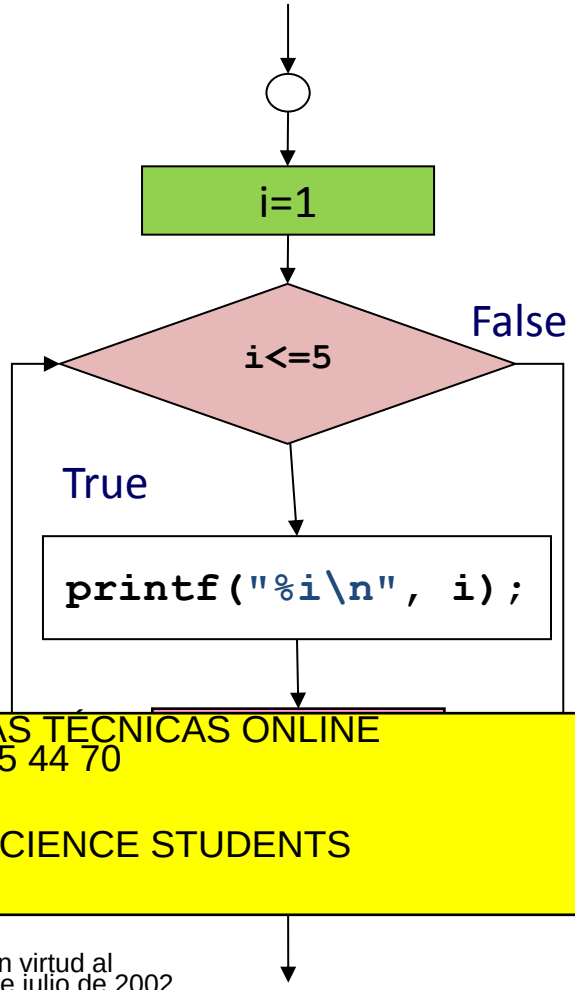
- Repeats an instruction block a given number of times

- For loops comprise
  - An initialization instruction
    - Executed before the first iteración (only)
  - An update instruction
    - Updates the value of the control variable, executed after every iteration
  - A control expression, that is evaluated after the update
  - If the control expresion is true the block of instructions is

For Example 1

- Program displaying all integer numbers from 1 to 5

```
#include <stdio.h>
int main(void) {
    int i;
    for (i=1; i<=5; i++){
        printf("%i\n", i);
    }
    return 0;
}
```



For: Program to add all integers from 1 to 10

initialization | **Control expression** | **update**

```
#include <stdio.h>

int main(void)
{
   int i;
   int sum=0;

   for (i=1; i<=10; i++){
      sum=sum+i;
      printf ("i variable's value now is %i \n", i);
      printf ("sum value is now %i \n", sum);
   }
   printf ("The final value of i is %i \n", i);
}
```

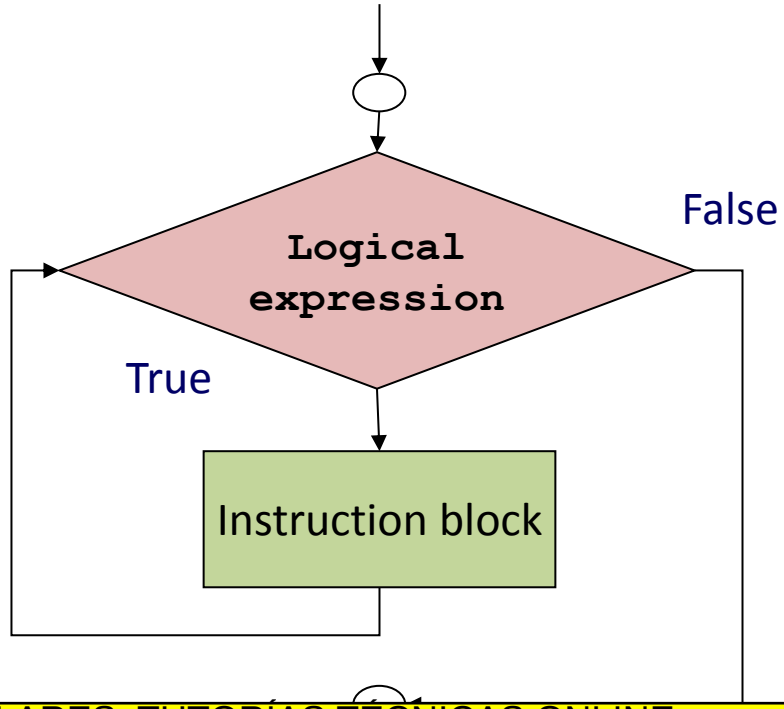
WHILE

`while` control structure

Syntax

```
while (logical_expresion) {
    instruction_block;
}
```

Flow diagram



`while` control structure

- Repeats a block of instruction **while** the logical expression (condition) is true
- The logical expression is evaluated **before** starting to run the instruction block
  - Therefore the **number of repetitions can be 0**.
  - After each execution of the instruction block the condition is re-evaluated.
  - If the condition is still true, the instruction block is repeated.
  - If the condition is now false, the loop terminates.
- We should check that the condition will be false under some

PROGRAM TO ADD ALL INTEGERS FROM 1 TO 10 IS WHILE THE BEST OPTION?

PROGRAM TO ADD ALL NUMBERS ENTERED BY THE USER UNTIL USER ENTERS A 0

Example: random number generator

```c
#include <stdio.h>
#include <stdlib.h>

int main(void)
{
  int num;
  int answer;

  printf ("Do you want to generate random numbers (1->YES 0->NO)");
  scanf ("%d", &answer);

  //The loop will only run if answer is 1
 while (answer==1){
     num=rand()%1024;
     printf ("%d \n", num);
     printf ("Do you want to generate more random numbers (1->YES 0->NO)? ");
     scanf ("%d", & answer);
  }
```

Exercises: Guess secret number

- For Beginners
  - Secret number is set in the code as a constant
  - Hints: "bigger than", "smaller than"
- Advanced user
  - Limited number of attempts
- Expert user
  - A second number is a "bomb" – if you hit the bomb game is over

3.3. DO-WHILE

Do – while control structure

- The instruction block is executed at least once

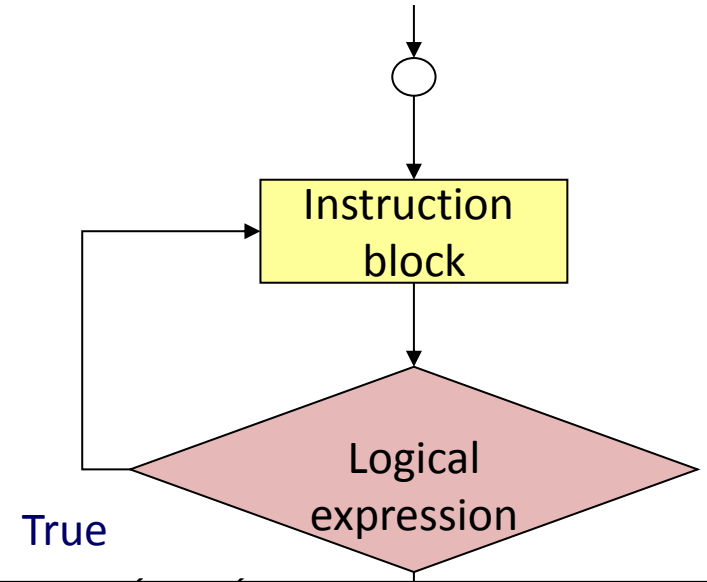
Sintaxis

```
do {

        instruction_block;

} while (logical_expression);
```

Flow diagram



Do – while control structure

- As in while, the instruction block is executed **while** a condition or logical expression is true
- Only difference: the logical expression is evaluated **after** the instruction block is executed.
  - Mínimum number of repetitions is one.
- After executing the instruction block the expression is evaluated again.
  - If the condition is still true, the instruction block is repeated.
  - If the condition is now false, the loop terminates

do-while example

- Display menu, read option, until exit (0).

```
int main(void)
{
  int option; // no need to initialize option here

  do{
    printf ("Select one option\n");
    printf ("1: Add numbers\n");
    printf ("2: Subtract numbers\n");
    printf ("3: Multiply numbers\n");
    printf ("0: Exit\n");

      // --- code for operations here ----

    scanf ("%d", &option);
  } while (option!=0);  // the loop will stop only when option is 0
```

Program that prompts for a password until correct

```
#include <stdio.h>
#define CORRECT_PASSWORD 1234

int main(void)
{
  int password;

  do{
    printf ("Enter your password: ");
    scanf ("%i", &password);

  }while (password!= CORRECT_PASSWORD);

  printf ("Welcome!\n");
```

Password + Limited number of attempts

```
#define CORRECT_PASSWORD 1234

int main(void) {
  int password;
  int attempts = 0;
  do{
    printf ("Enter your password: ");
    scanf ("%i", &password);
    attempts = attempts +1;
  }while ((password!= CORRECT_PASSWORD)&&(attempts<3));

  if (password== CORRECT_PASSWORD){
     printf ("Welcome!\n");
  }else {
      // if password wrong we necessarily have exceeded
      // the number of attempts
      printf ("Sorry, only 3 attempts are allowed"):
      printf (", access denied\n");
```

Complex condition
The block is executed **while** the PASSWORD is not correct **AND** the number of attempts is smaller than 3

We need to test after the loop which of the exit conditions

Integers from 50 to 1 or user exit

- Programa that prints to the screen integer number from 50 to 1 in decreasing number . Stops when 1 is reached or when the user selects to exit (user is prompted after each number if he/she wants to exit)

```
int main(void)
{
    int x = 50;   // x stores the integer value to display
    int continue;// continue stores user answer to continue prompt
    do{
       printf("%i \n", x); // display x
       //decrease x value
       x--; //an alternative way of writing x = x - 1;
       printf("Do you want to display the next number(YES->1; NO->0)? ");
       scanf ("%i", & continue);
    } while ((x>0) && (continue ==1));
```

CONTROL STRUCTURE NESTING

Control structure nesting

- nesting: enclosing control structures one into another
  - The instruction block of any structure can contain other structures

- **Days of the week**
- Program that prompts the user to enter a number and outputs the weekday corresponding to the number
- This will be repeated until the user decides to exit

switch structure nested inside a *do-while*

```
int main(void){
  int continue;
  int n;

  do {
      printf("\n Enter an integer number [1..7]: ");
      scanf("%i", &n);
      switch (n) {
        case 1: printf(" Monday\n "); break;
        case 2: printf(" Tuesday\n "); break;
        case 3: printf(" Wednesday\n "); break;
        case 4: printf(" Thursday\n "); break;
        case 5: printf(" Friday\n "); break;
        case 6: printf(" Saturday\n "); break;
        case 7: printf(" Sunday\n "); break;
        default: printf(" Wrong number\n");
      }
      printf(" Do you want to continue? 1/0: ");
      scanf("%i", & continue);
  } while (continue==1) ;
```

- Write a Program that prompts the user to enter a number and outputs all integers from 1 to that number. Repeat until user wants to exit, this will be specified by entering a 1

for loop nested in a *do-while* loop

```
int main(void){
      int num, i;
      int salir;

    do {//Se repite hasta que el usuario inserte 1
        printf("Introduzca un numero");
        scanf("%d", &num);
        printf("Los numeros del 1 al %d son: ", num);
        for (i=1; i<=num; i++){
            printf("%d, ", i);
        }
        printf("\nDesea salir? (1-si, 0-no) ");
        scanf("%d", &salir);
```



```
}
```

C programming - summary

- Structure of a C program

```
#include <stdio.h>
int main(void)
{
    variable declaration instructions...
     executable instructions ...
    return 0;
    }
```

- Assignment operator

```
=
```

- Variable declaration

```
datatype variable_name
```



```
printf("%i", variable);
```

Conditional control structures

```
if (logical_expression_1){
        instruction_block_1;
}
else {
    if(logical_expression_2){
        instruction_block_2;
    }
    else {
        logical_expression_3;
    }
```

```
switch(selector){
    case value_1:
        instruction_block_1;
        break;
    case value_2:
        instruction_block_2;
        break;
    case value_n:
        instruction_block_n;
        break;
    default:
        instruction_block;
}
```

Iterative control structures (loops)

```
for (initialization; logical_expression; update) {
        instruction_block
}
```

```
while (logical_expression) {
 instruction_block
}
```

```
do {
        instruction_block
} while (logical_expression);
```

TEMA 4.
ESTRUCTURAS DE CONTROL