Foundations of C Programming (Structured Programming) - Loops

Outline

- *While* loop
- *Do-While* loop
- *For* loop
- The *break* statement
- The *continue* statement
- The *goto* statement

Loops

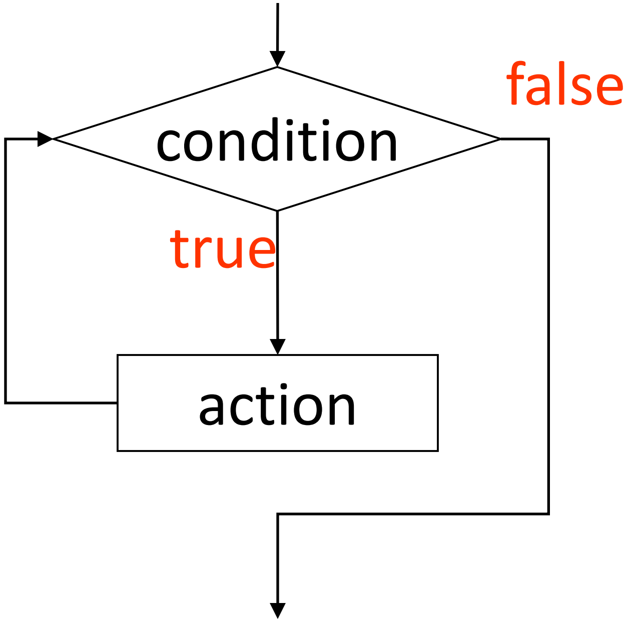
- In our daily life, some actions have been repeated.
  - E.g.,
    - Eat 10 bites of an apple
    - Eat an apple until it is finished

- In a C program, we can also describe repeated actions

The *while* Loop

Syntax:

```
while (<condition>)
      <action>;

or

while (<condition>) {
      <action>;
}
```



- If condition is true then execute action
- Repeat this process until condition evaluates to false
- action is either a single statement or a group of statements within a pair of curly brackets

An Example

```
int n = 10;
while(n > 1){
  printf("%d ",n);
  n--;
}
```

- What is the final value of *n*
- How many times "`n--`" is executed?
- What is the output of this program?
- What is this program's flow chart?

An Example

- Compute factorial of n (n!)
- First step, we need to work out the algorithm for this computation.
  - `1! = 1`
  - `2! = 2 * 1 = 2 * 1!`
  - `3! = 3 * 2 * 1 = 3 * 2!`
  - `4! = 4 * 3 * 2 * 1 = 4 * 3!`
  - …
  - `n! = n * (n – 1) * … * 1 = n * (n – 1)!`

An Example

Compute factorial of n (n!)

```
int number, factorial, counter;
printf("Enter a positive integer:");
scanf("%d", &number);

factorial = 1;  // initialization
counter = 1;

while(counter <= number){
  factorial = factorial * counter;
  counter++; //counter = counter + 1;
}
printf("The factorial of %d is %d.",
                  number, factorial);
```

Class Exercise

- Compute 2^n
- First step, we need to work out the algorithm for this computation.
  - $2^0 = 1$
  - $2^1 = 2 * 2^0$
  - $2^2 = 2 * 2^1$
  - $2^3 = 2 * 2^2$
  - …
  - $2^n = 2 * 2^{n - 1}$

Can you write a program to compute 2^n using *while*

An Example

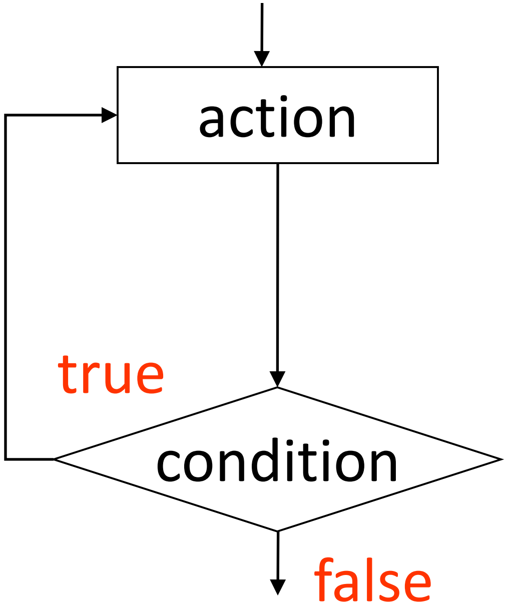
```
int value;  // input value
int max = 0;      // maximum value
printf("Enter a positive integer (-1 to stop):");
scanf("%d", &value);
while(value != -1){
  if(value > max)
    max = value;
  printf("Enter a positive integer (-1 to stop):");
  scanf("%d", &value);
}
printf("The maximum value is %d", max);
```

What does this program do?

The *do-while* Loop

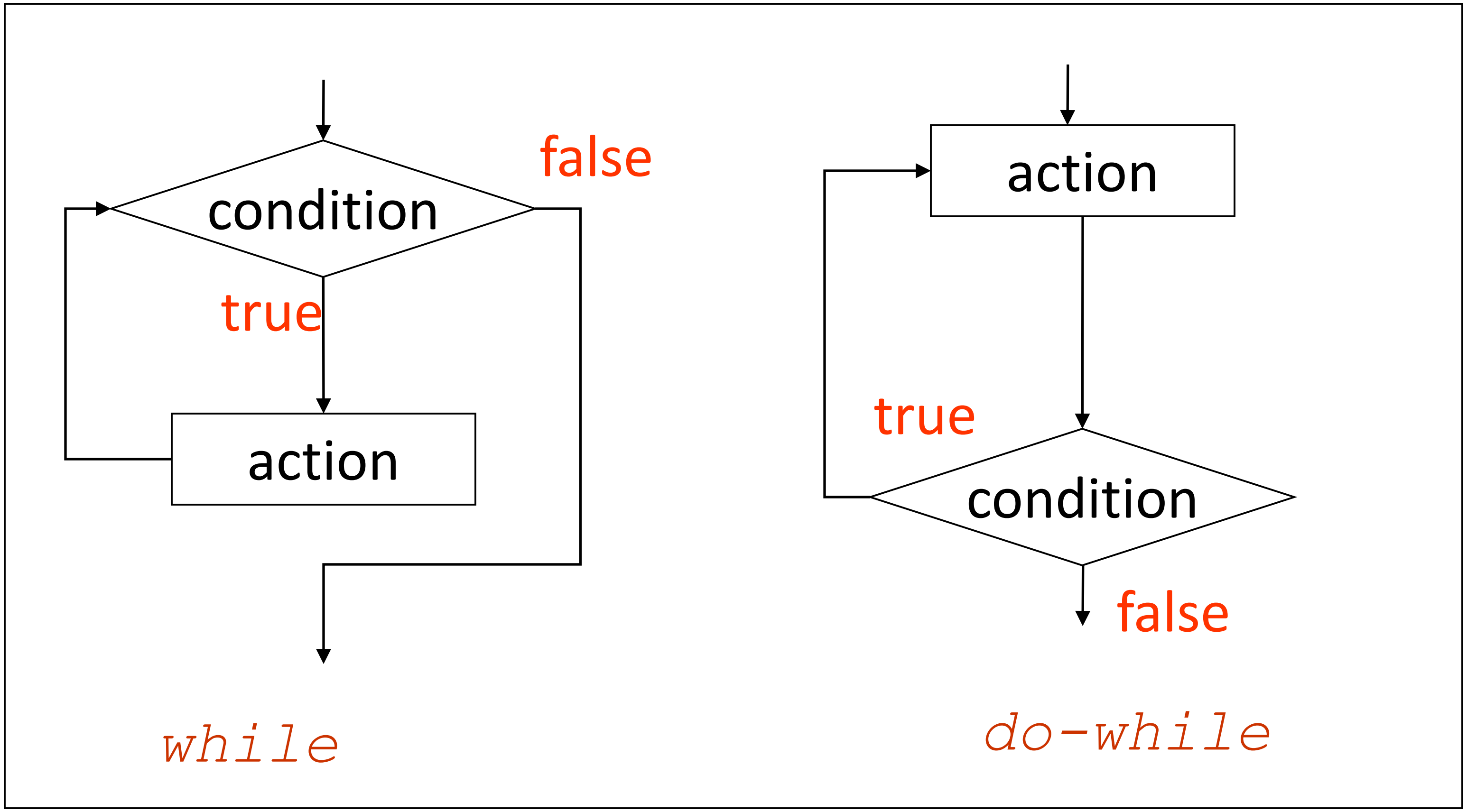
Syntax:

```
do
   <action>;
while(<condition>);

or

do{
   <action>;
} while(<condition>);
```



- First execute the action, then check the condition of the loop
- action is either a single statement or a group of statements within a pair of curly brackets

Compare while and do-while



What are the differences?

Compare while and do-while

- *while* loop
  - First check the condition of the loop
  - then execute the body of the loop
- *do-while* loop
  - First execute the body of the loop
  - Then check the condition of the loop
  - the body of the loop is executed at least once

The *n*! Example

```
int number, factorial, counter;

printf("Enter a positive integer:");
scanf("%d", &number);
factorial = 1;  // initialization
counter = 1;

do{
  factorial *= counter;
  counter++;
}while(counter <= number);

printf("The factorial of %d is %d.",
      number,factorial);
```

Any difference between this program and the one which uses while?

After-Class Exercise

- Compute 2^n
- First step, we need to work out the algorithm for this computation.
  - $2^0 = 1$
  - $2^1 = 2 * 2^0$
  - $2^2 = 2 * 2^1$
  - $2^3 = 2 * 2^2$
  - …
  - $2^n = 2 * 2^{n - 1}$

Can you write a program to compute 2^n using *do-while*

Hint： consider the initialization carefully so when n = 0, the result is 1.

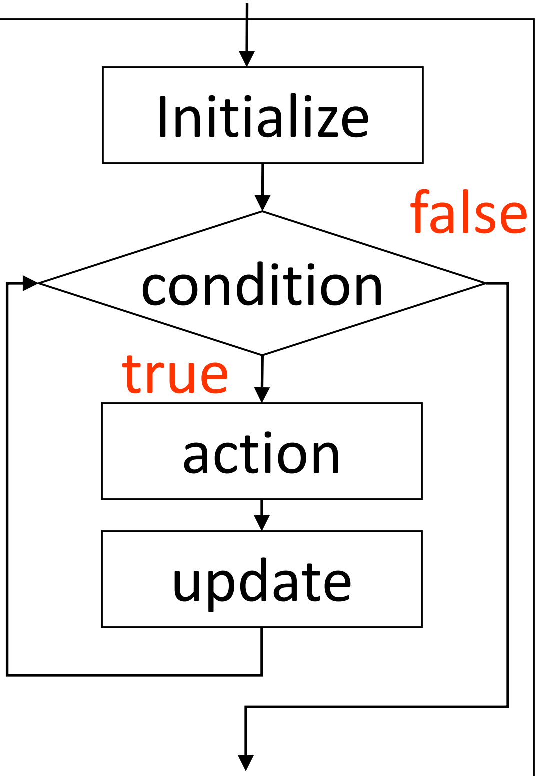
The *for* Loop

Syntax:

```
for (<initialize>; <condition>; <update>)
      <action>.
```

or

```
for (<initialize>; <condition>; <update>){
      <action>
}
```



- Initialize first
- while condition is true, execute action and execute update
- Initialization, condition and update can be empty

The *n*! Example

```
int number, factorial, i;

printf("Enter a positive integer:");
scanf("%d", &number);
factorial = 1;  // initialization

for(i = 1; i <= number; i++)
  factorial *= i;

printf("The factorial of %d is %d.",
      number,factorial);
```

After-Class Exercise

- Compute 2^n
- First step, we need to work out the algorithm for this computation.
  - $2^0 = 1$
  - $2^1 = 2 * 2^0$
  - $2^2 = 2 * 2^1$
  - $2^3 = 2 * 2^2$
  - …
  - $2^n = 2 * 2^{n - 1}$

Can you write a program to compute 2^n using *for?*

Attentions in Loops

- Make sure there is a statement that will eventually stop the loop.
  - Infinite loop == loop that never stops or stops after unreasonable unexpected huge number of loops.

```
int i = 1;
int number = 100;
int sum = 0;
while (i <= number){
 sum = sum + i;
 i--;
}
printf("the sum of integers from 1 to
      100 is %d", sum);
```

Infinite Loops

- The following format can cause the infinite loops if no special statement is used to terminate the loop
  - while (1)
  - for (; ;)
- Wrong conditions can cause infinite loops
  - E.g.

```
scanf("%d", &n);
while (n = 10) {// always true
   ……
}
```

Attentions in Loops

- Make sure to initialize loop counters correctly.
  - Off-by-one == the number of times that a loop is executed is one more time or one less.

```
int i = 1;
int number = 100;
int sum = 0;
while (i < number){
 sum = sum + i;
 i++;
}
printf("the sum of integers from 1 to
      100 is %d", sum);
```

Which Loop to Use?

- *for* loop
  - for calculations that are repeated a fixed number of times
  - controlled by a variable that is changed by an equal amount (usually 1) during each iteration
- *while* loop
  - The number of iterations depends on a condition which could be changed during execution.
- *do-while* loop
  - The code segment is always executed at least once.

Examples

```
for (i = 1; i <= 10; i++)
  printf("***********\n")
```

```
i = 1;
while (i <= 10){
  printf("***********\n");
  i++;

}
```

```
i = 1;
do{
  printf("***********\n");
  i++;
}while(i <= 10));
```

Compare these three segments, which one is better?

Examples

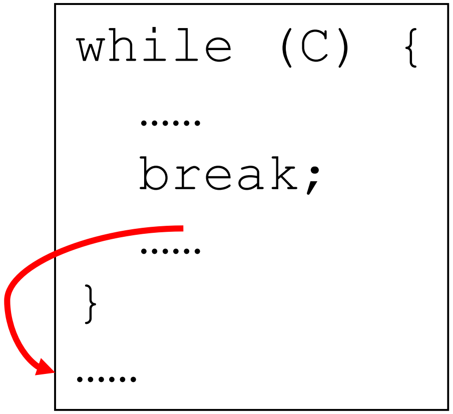
```
char reply;
printf("************\n");
printf("continue? (y/n)");
scanf("%c", &reply);
while(reply != 'n');{
  printf("************\n");
  printf("continue? (y/n)");
  scanf("%c", &reply);
}
```

Compare these two segments, which one is better?

```
char reply;
do{
  printf("************\n")
  printf("continue? (y/n)");
  scanf("%c", &reply);
} while(reply != 'n');
```

Stop the Loop

- There are two ways to stop the loop
  - Normal way: check the conditions in the *for*, *while* and *do-while*, if the condition is false, stop the loop.
  - Forced way: Use *break* statement
    - When the *break* statement is executed, the loop statement terminates immediately.
    - The execution continues with the statement following the loop statement.



```
while (C) {
   ……
   break;
   ……
}
……
```

Examples

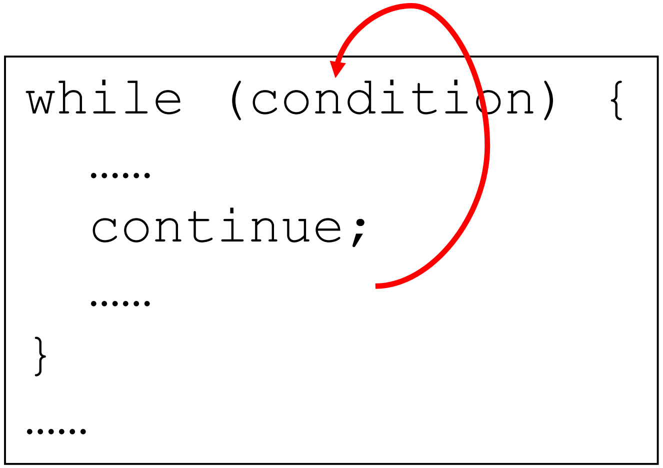
```
sum = 0;
for (i = 1; i <= 100; i++){
  sum = sum + i;
  if (sum >= 1000)
    break;
}
printf("i = %d, sum = %d", i, sum);
```

```
sum = 0;
for (i = 1; i <= 100; i++)
  sum = sum + i;
printf("i = %d, sum = %d", i, sum);
```

Compare these two programs

The *continue* Statement

- The *continue* command terminates the current iteration (i.e., ignore the rest statements) and starts the next iteration.



```
while (condition) {
   ……
   continue;
   ……
}
……
```

Examples

```
sum = 0;
for (i = 1; i <= 100; i++){
  if (i % 2 == 0)
    continue;
  sum = sum + i;
}
printf("i = %d, sum = %d", i, sum);
```

```
sum = 0;
for (i = 1; i <= 100; i++)
  sum = sum + i;
printf("i = %d, sum = %d", i, sum);
```

Compare these two programs

Examples

```
sum = 0;
for (i = 1; i <= 100; i++){
  if (i % 2 == 0)
    continue;
  sum = sum + i;
}
printf("i = %d, sum = %d", i, sum);
```

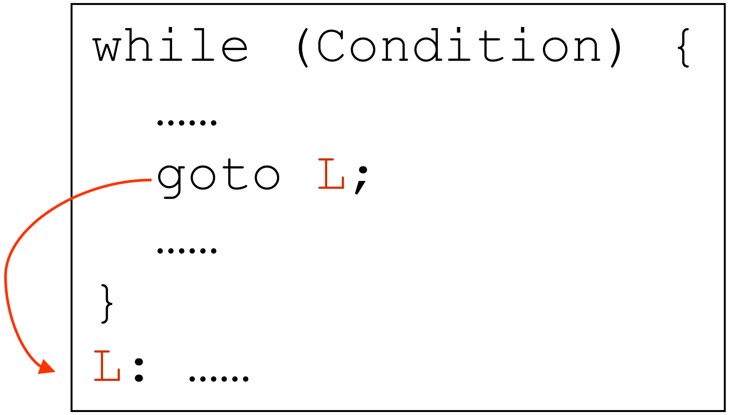
What if we change *continue* to *break*?

An Example

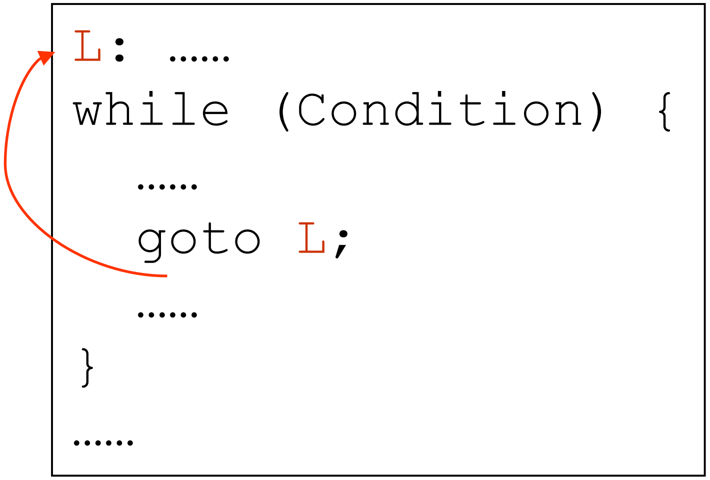
```
int mycard = 3;
int guess;
for(;;) // infinite loop, we can also use while(true)
{
  printf("Guess my card:");
  scanf("%d",&guess);
  if(guess == mycard){
      printf("Good guess!\n");
      break;   // get out of the infinite loop
  }
  else
      printf("Try again.\n");
}
```

The *goto* Statement

- It performs a one-way jump to another line of code.
- The jumped-to locations are usually identified using labels



```
while (Condition) {
   ......
   goto L;
   ......
}
L:  ......
```



```
L:  ......
while (Condition) {
   ......
   goto L;
   ......
}
......
```

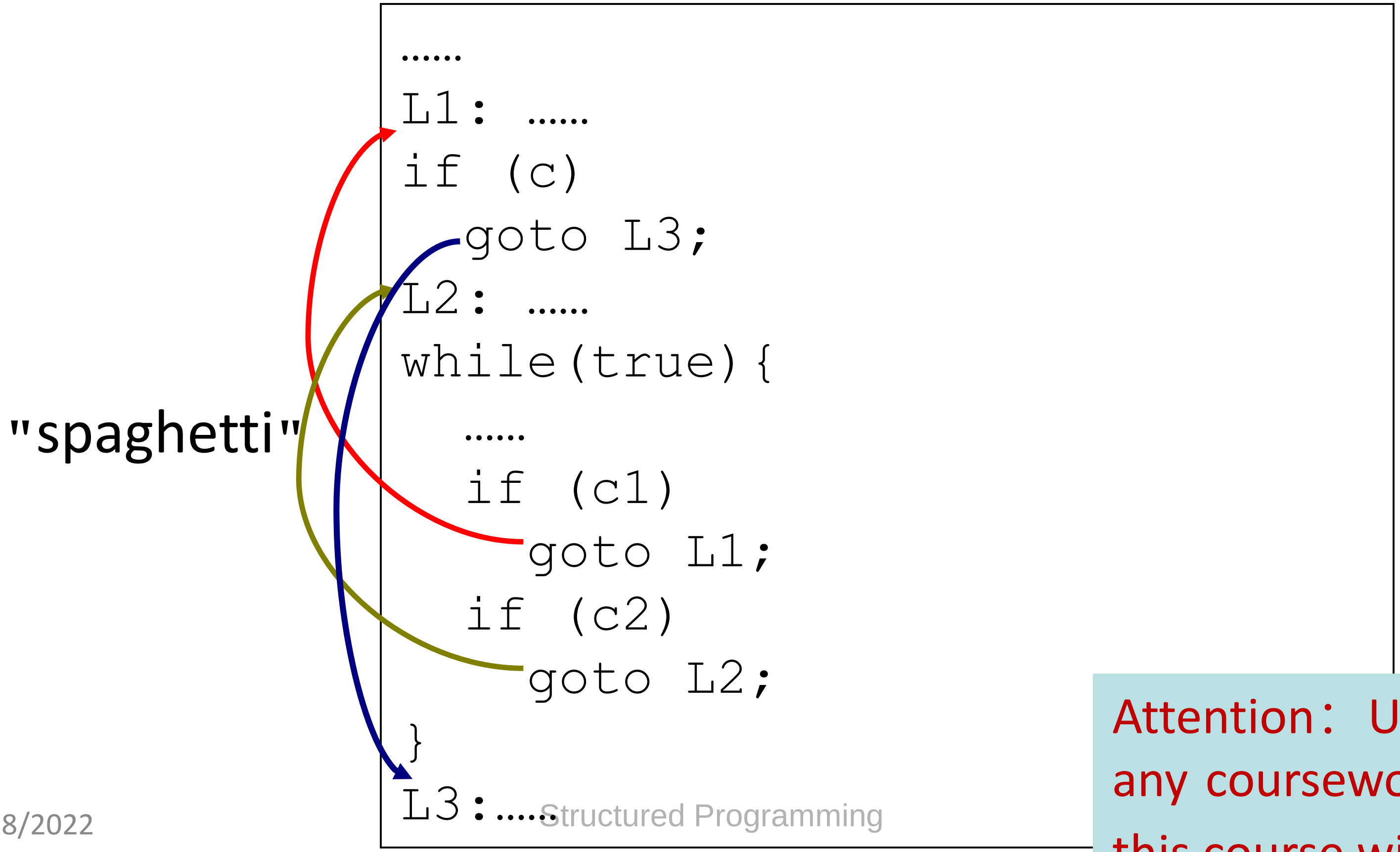
The *goto* Statement

- The goto statement is often combined with an *if* statement to cause a conditional transfer of control.

```
int mycard = 3;
int guess;
for(;;){ // infinite loop, we can also use while(true)
   printf("Guess my card:");
   scanf("%d",&guess);
   if(guess == mycard){
       printf("Good guess!\n");
       goto L;    // get out of the infinite loop
   }
   else
       printf("Try again.\n");
}
L: printf("Guess successfully!\n")
```

The *goto* Statement

- Use of *goto* statements results in "spaghetti code" that is difficult to read and maintain
- It is suggested that NO *goto* statements are used in programs



"spaghetti"

```
......
L1: ......
if (c)
   goto L3;
L2: ......
while(true){
   ......
   if (c1)
      goto L1;
   if (c2)
      goto L2;
}
L3:......
```

Attention： Use of *goto* in any coursework or exam in this course will be given 0

Nested Loops

- Nested loops are loops within loops.
- Nested loops are similar in principle to nested *if* and *if-else* statements.

```
int row;      // Outer loop counter
int col;      // Inner loop counter

for(row = 1; row <= 10; row++){
   for(col = 1; col <= 10; col++)
        printf("%d ",row * col);
   printf("\n");
}
```

1. How many times "printf("%d",row*col);" is executed?
2. How many times "printf("\n");" is executed?
3. What is the output of this program?

Nested Loops

```
Output:
1 2 3 4 5 6 7 8 9 10
2 4 6 8 10 12 14 16 18 20
3 6 9 12 15 18 21 24 27 30
4 8 12 16 20 24 28 32 36 40
5 10 15 20 25 30 35 40 45 50
6 12 18 24 30 36 42 48 54 60
7 14 21 28 35 42 49 56 63 70
8 16 24 32 40 48 56 64 73 80
9 18 27 36 45 54 63 72 81 90
10 20 30 40 50 60 70 80 90 100
```

1. How many times "printf("%d",row*col);" is executed? 100
2. How many times "printf("\n");" is executed? 10

Class Exercise

- How to use nested loops to produce the following output?

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

Summary

- Loops in a program
  - while
  - do-while
  - for
- Pay attention to the difference between *continue* statement and *break* statement
- Loops can be nested