

C Programming

Sequential and Conditional Control

Lecturer: *Dr. Wan-Lei Zhao*
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Programs for programming

- Integrated Development Environment
 - Microsoft Visual Studio (default option)
 - CodeBlocks (recommended)
 - Eclipse
- Any text editors + C compiler
 - Microsoft C compiler (default option)
 - GCC (recommended)
 - ICC: believed to be the most efficient one
 - Turbo C: classic but being forgotten

The first program

- Create a new file named **main.c**.
- Open it in your text editor of choice.
- Fill it as follows:

```
1 #include <stdio.h>
2 int main(void)
3 {
4     printf(" Hello World!\n");
5     /* Print "Hello World!" on the command line */
6     return 0;
7 }
8
```

From source to bits

Source code: main.c



```
$ gcc main.c
```

(Preprocessing → compiling → assembling → linking)



Executable program

Linux/Mac OS X (**a.out**)

```
$ ./a.out  
$ Hello  
World!
```

Windows (**a.exe**)

```
$ ./a.  
exe  
$  
Hello World!
```

A basic program

```
1 #include <stdio.h>
2 int main()
3 {
4     printf(" Hello World!\n");
5     /* Print "Hello World!" on the
6        command line */
7     return 0;
8 }
```

} Preprocessing statements

} Main function

- Processed before compilation
- Have their own language, start with a #
- In 'stdio.h', function '**printf()**' has been defined

The main function

- Basic function of every program
- Exists **exactly once** per program
- Called on program start

```
1 int main(void)
2 {
```

- As a function, *main()* can take parameters and return a value
- Get used to *void* and *int*. They will be explained later
- '{' marks the start of the main function scope

The main function scope

- Contains program statements
- They are processed from top to bottom

```
1  return 0;  
2  }
```

- Last statement, ends main function (and thus the whole program)
- `0` tells the OS that everything went right
- `'}'` marks the end of the main function scope

Statements

- Instructions for the computer
- End with a ; (semicolon)

```
1 printf(" Hello World!\n" );
```

- Here is the empty statement:

```
;
```

- All statements are located in function blocks

Comments

- Information for the programmer, cut out before compilation

Single line comments:

```
1 // Prints "Hello World!" on the command line
```

Block comments (multi-line):

```
1 /* Prints "Hello World!"  
2    on the command line */
```

Better style of block comments:

```
1 /*  
2  * Prints "Hello World!"  
3  * on the command line  
4  */
```

Order of execution

- Statements inside one function executed from top to bottom
- This is a convention for languages

```
#include <stdio.h>
int main()
{
    printf(" Hello _China!\n" );
    printf(" Hello _World!\n" );
    printf(" Hello _Universe!\n" );
    return 0;
}
```

```
1      Hello  China!
2      Hello  World!
3      Hello  Universe
      !
4
```

- For **clarity**, one statement in one line

Calculate the Area of a circle (1)

- Available information
 - radius, $\pi = 3.1415$
- Requirements
 - Allows user input radius of a circle
 - Calculate its area and print it out

$$a = \pi \cdot r^2$$

- Let's do it step by step

Calculate the Area of a circle (2)

- Create a new file named **main.c**
- Open it in your editor
- Fill it as follows:

```
1 #include <stdio.h>
2 int main()
3 {
4     return 0;
5 }
6
```

Calculate the Area of a circle (3)

- Define variables needed

```
1 #include <stdio.h>
2 int main()
3 {
4     float pi = 3.1415;
5     float r = 0;
6     return 0;
7 }
8
```

Calculate the Area of a circle (4)

- Allows user to input radius,

```
1 #include <stdio.h>
2 int main()
3 {
4     float pi = 3.1415;
5     float r = 0;
6     scanf("%f", &r);
7     return 0;
8 }
9
```

Calculate the Area of a circle (5)

- Allows user to input radius

```
1 #include <stdio.h>
2 int main()
3 {
4     float pi = 3.1415;
5     float r = 0, area = 0;
6     scanf("%f", &r);
7     area = r*r*pi;
8     return 0;
9 }
```

- The complete program

```
1 #include <stdio.h>
2 int main()
3 {
4     float pi = 3.1415;
5     float r = 0, area = 0;
6     scanf("%f", &r);
7     area = r*r*pi;
8     printf("Area: %f", area);
9     return 0;
10 }
11
```

Solve Quadratic Equation (1)

- Given following equation
- Allows user input a , b and c

$$ax^2 + bx + c = 0$$

- Solve x out

Solve Quadratic Equation (2)

- The solution for this quadratic equation is well-known
- Given $b^2 - 4ac > 0$, we have

$$x_1 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$
$$x_2 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$$

- In order to simplify the calculation
- We have

$$p = \frac{-b}{2a}, \quad q = \frac{\sqrt{b^2 - 4ac}}{2a}$$
$$x_1 = p + q, \quad x_2 = p - q$$

Solve Quadratic Equation (3)

- Let's now think about how to implement it in C

$$p = \frac{-b}{2a}, \quad q = \frac{\sqrt{b^2 - 4ac}}{2a}$$
$$x_1 = p + q, \quad x_2 = p - q$$

- Define variables and user input

```
1 #include <stdio.h>
2 int main()
3 {
4     float a = 0, b = 0, c = 0, delta = 0;
5     float x1 = 0, x2 = 0, p = 0, q = 0;
6     printf("Input a, b and c:\n");
7     scanf("%f %f %f", &a, &b, &c);
8     return 0;
9 }
10
```

Solve Quadratic Equation (4)

$$p = \frac{-b}{2a}, \quad q = \frac{\sqrt{b^2-4ac}}{2a}$$
$$x_1 = p + q, \quad x_2 = p - q$$

```
1 #include <stdio.h>
2 #include <math.h>
3 int main()
4 {
5     float a = 0, b = 0, c = 0, delta = 0;
6     float x1 = 0, x2 = 0, p = 0, q = 0;
7     printf("Input a, b and c:\n");
8     scanf("%f %f %f", &a, &b, &c);
9     delta = b*b - 4*a*c;
10    p = -b/(2*a);
11    q = sqrt(delta)/(2*a);
12    x1 = p + q; x2 = p - q;
13    printf("x1=%f, x2=%f\n", x1, x2);
14    return 0;
15 }
16
```

$$p = \frac{-b}{2a}, \quad q = \frac{\sqrt{b^2 - 4ac}}{2a}$$
$$x_1 = p + q, \quad x_2 = p - q$$

- In above example, we did not consider the case
- $\sqrt{b^2 - 4ac} < 0$
- For which, we should output “no real solution”
- That means, we should check $\sqrt{b^2 - 4ac}$
- For different case, we give different answer
- This is where `if...else` fits in

Start with a simple example

- Guess what the following code for

```
1 #include <stdio.h>
2 int main()
3 {
4     int x = 5;
5     if(x%2 == 0)
6     {
7         printf("x is an even number.");
8     }
9     return 0;
10 }
11
```

- **if** statement makes a judgement
- If the **logic/conditional** expression is **true**
- The statement(s) inside {...} will be executed
- Otherwise, statement(s) will be **ignored**

Logic/conditional expression (1)

- Let's now focus on the conditional expression

```
1 #include <stdio.h>
2 int main()
3 {
4     int x = 5;
5     if(conditional_expression)
6     {
7         printf("x is an even number.");
8     }
9     return 0;
10 }
11
```

- It is a expression that returns **true** or **false**
- For example, statement “you are undergraduate student”
- We can judge whether it is true or false
- Paradox**, story shared

Logic/conditional expression (2)

- In C, expression with **relational operators** is used as conditional expressions
- They are
 - ① `<`, `>`, `<=`, `>=`
 - ② `==` for “equal to”
 - ③ `!=` for “not equal to”
- It returns 1 (true) or 0 (false)

```
1 int main()  
2 {  
3     int a = 0, b = 0, c = 0;  
4     a = (3 > 5);  
5     b = (2*2 > 4);  
6     c = (3 == 3);  
7     return 0;  
8 }
```

$$p = \frac{-b}{2a}, \quad q = \frac{\sqrt{b^2 - 4ac}}{2a}$$
$$x_1 = p + q, \quad x_2 = p - q$$

- For the case $\sqrt{b^2 - 4ac} < 0$
- We should output “no real solution”
- For the case, $\sqrt{b^2 - 4ac} \geq 0$
- We should output x_1 and x_2

Solve Quadratic Equation

```
1 #include <stdio.h>
2 #include <math.h>
3 int main()
4 {
5     float a = 0, b = 0, c = 0, delta = 0;
6     float x1 = 0, x2 = 0, p = 0, q = 0;
7     printf("Input a, b and c:\n");
8     scanf("%f%f%f", &a, &b, &c);
9     delta = b*b - 4*a*c;
10    if(delta >= 0){
11        p = -b/(2*a);
12        q = sqrt(delta)/(2*a);
13        x1 = p + q; x2 = p - q;
14        printf("x1=%f, x2=%f\n", x1, x2);
15    } else {
16        printf("No real solution!\n");
17    }
18    return 0;
19 }
20
```

Logical Operators (1)

- In some cases, single conditional statement is not enough
- For example, we want to express following condition
- If $a > b$ AND $b > c$, then ...
- We need a way to connect several statements
- Usually, we use AND, OR and NOT
- In C, they are `&&`, `||` and `!`

- AND (`c1 && c2`): means only when `c1` and `c2` both are true, it is true
- OR (`c1 || c2`): means when either `c1` or `c2` is true, it is true
- NOT (`!c1`): means reverse it, `c1` is true, `!c1` is false; `c1` is false, `!c1` is true

Logical Operators (2)

- AND ($c1 \ \&\& \ c2$): means only when $c1$ and $c2$ both are true, it is true
- OR ($c1 \ || \ c2$): means when either $c1$ or $c2$ both is true, it is true
- NOT ($!c1$): means reverse it, $c1$ is true, $!c1$ is false; $c1$ is false, $!c1$ is true

```
1 int main()  
2 {  
3     int a = 0, b = 0, c = 0;  
4     a = (3 > 5) && (2 > 1);  
5     b = (2 * 2 > 4) || (2 == 1);  
6     c = !(3 == 3);  
7     return 0;  
8 }
```

Logical Operators (3): truth tables

c1	c2	c1 && c2
1	1	1
1	0	0
0	1	0
0	0	0

c1	c2	c1 c2
1	1	1
1	0	1
0	1	1
0	0	0

c1	!c1
1	0
0	1

- One should be able to deduce for cases that more than two statements are involved

How the logic expression is evaluated in C

- C actually checks only whether it is zero or non-zero
- For example

```
1 int main()
2 {
3     float a = 3.1, b = 0;
4     if(a){
5         printf("it is true");
6     }else{
7         printf("it is false");
8     }
9     if(a && b){
10        printf("it is true");
11    }else{
12        printf("it is false");
13    }
14    return 0;
15 }
```

if...else

Decisions are made during run time:

```
if(condition)
    statement1;
else
    statement2;
```

statement1 is only executed if the truth value of **condition** is *true*.
Otherwise **statement2** is executed.

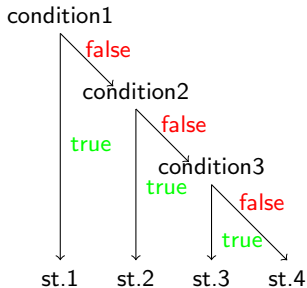
For multiple statements inside the **if-else**, use braces **{}**:

```
if(condition) {
    statement1;
    statement2;
}
```

- The **else** part is OPTIONAL

else if

To differentiate between more than two cases, you can use the if condition as a statement in the else body:



```
if(condition1)
    statement1;
else if(condition2)
    statement2;
else if(condition3)
    statement3;
else
    statement4;
```

Judge the Type of an Input Character (1)

- Judge an input character is a digit, a character, space or something else
- Steps outlined
 - ① Accept/take input character
 - ② Check whether in digit range ('0'-'9')
 - ③ Otherwise, check whether it is in character range ('a'-'z')
 - ④ Otherwise, check whether it is in ('A'-'Z')
 - ⑤ Otherwise, check whether it is space (' ')
- Work it by yourself first...

Judge the Type of an Input Character (2)

```
1 #include <stdio.h>
2 int main()
3 {
4     char ch = ' ';
5     printf(" Please input a character: ");
6     ch = getchar();
7     printf(" Character is: %c", ch);
8     if(ch >= '0' && ch <= '9'){
9         printf(" a digit\n");
10    }else if(ch >= 'a' && ch <= 'z'){
11        printf(" char in lower case\n");
12    }else if(ch >= 'A' && ch <= 'Z'){
13        printf(" char in upper case\n");
14    }else if(ch == ' '){
15        printf(" It is space\n");
16    }else{
17        printf(" not digit , char or space\n");
18    }
19    return 0;
20 }
```

Judge whether it is a leap year (1)

- Leap year should satisfy one of follow two conditions
 - ① It is dividable by 4, but not by 100
 - ② It is dividable by 400

[Steps]

- ① Accept input number
- ② Check whether it is dividable by 4
- ③ If no, it is not leap year
- ④ Otherwise, check whether it is dividable by 100
 - ① If no, it is leap year
 - ② Otherwise, check whether it is dividable by 400
 - ① If yes, it is leap year
 - ② Otherwise, it is not

Give your solution first....

Judge whether it is a leap year (2)

```
1 #include <stdio.h>
2 int main()
3 {
4     int year = 0, leap = 0;
5     printf(" Please enter the year: ");
6     scanf("%d", &year);
7     if(year%4 != 0){
8         leap = 0;
9     } else if(year%100 != 0){
10        leap = 1;
11    } else if(year%400 != 0){
12        leap = 0;
13    } else{
14        leap = 1;
15    }
16    if(leap == 1){
17        printf("%d is leap year\n", year);
18    } else{
19        printf("%d is not leap year\n", year);
20    }
21    return 0;
```

More about if-else clause (1)

- See the result of following code

```
1 int main()
2 {
3     int a = 3, b = 5, c = 3;
4     if(a != 3)
5     if(b > 9)
6         printf("b=%d", b);
7     else
8         printf("c=%d", c);
9     return 0;
10 }
```

More about if-else clause (2)

- See the result of following code

```
int main()
{
    int a = 3, b = 5;
    int c = 3;
    if(a != 3)
    if(b > 9)
        printf("b=%d", b);
    else
        printf("c=%d", c);
    return 0;
}
```

```
1 int main()
2 {
3     int a = 3, b = 5, c = 3;
4     if(a != 3)
5     {
6         if(b > 9)
7             printf("b=%d", b);
8         else
9             printf("c=%d", c);
10    }
11    return 0;
12 }
```

A few words on style

- Do not put statements and conditions on the same line

```
if(cond){ statement; } /* bad style */
```

```
if(cond){ /* looks better, still bad style */  
    statement;  
}
```

```
if(cond)  
    statement; /* It is OK but not recommended, put {} all  
    the time */
```

More words on style

- Inside an `if-else` structure
- Put all blocks of this structure in braces

```
if(cond)           /* bad style , inconsistent */
    statement;
else {
    statement;
    statement;
}
```

```
if(cond){
    /* way better style */
    statement;
} else {
    statement;
    statement;
}
```

```
if(cond)
{
    statement;
} else
{
    statement;
    statement;
}
```

Operator: L=a*b?c:d

- Following codes produce the same results

```
1 int main()
2 {
3     int a = 3, b = 4, c = 1;
4     if(a > b)
5     {
6         a = c;
7     } else {
8         a = b;
9     }
10    printf("a=%d", a);
11 }
```

```
1 int main()
2 {
3     int a = 3, b = 4, c = 1;
4     a = a > b?c:b;
5     printf("a=%d", a);
6 }
```

- “a*b” is a logic expression
- If it is true, c is assigned to the left
- Otherwise, d is assigned to the left

Application: Convert lower case char to upper case (1)

- Given a char of unknown case, convert it to uppercase
- 'a'-'z' to 'A'-'Z'
- Solution:
 - 1 Check whether **ch** is in the range of 'a'-'z'
 - 2 If it is in this range, $ch = ch - 32$
 - 3 Otherwise, do not do anything

Application: Convert lower case char to upper case (2)

```
1 int main()
2 {
3     char ch = getchar();
4     if(ch >= 'a' && ch <= 'z')
5     {
6         ch = ch - 32;
7     }
8     printf("ch=%c", ch);
9 }
```

```
1 int main()
2 {
3     char ch = getchar();
4     ch = (ch >= 'a' && ch <= 'z')
5         ? (ch - 32) : ch;
6     printf("ch=%c", ch);
}
```

- It is concise
- Do not make your expression too long
- Take the left way when you are uncertain

if clause: the last example

```
1 int main()
2 {
3     int a = 3, b = 5, c = 2;
4     if( a > b);
5     {
6         a = c;
7     }
8     a = a*2;
9     printf("a=%d\n", a);
10    return 0;
11 }
```

switch-case clause (1)

- Now you are given a new task
- Convert numbers (1-12) to Month (January - December)
- We can do it by **if-else** clause

```
int main()
{
    int n = 0;
    scanf("%d", &n);
    if(n == 1)
    {
        printf("January\n");
    } else if(n == 2){
        printf("Febuary\n");
    } else if(n == 3){
        printf("March\n");
    }
    ...
    ...
    ...
}
```

switch-case clause (2)

- Now you are given a new task
- Convert numbers (1-12) to Month (January - December)
- We can do it by **if-else** clause

```
int main()
{
    int n = 0;
    scanf("%d", &n);
    switch(n)
    {
        case 1: {printf("January\n"); break;}
        case 2: {printf("Febuary"); break;}
        case 3: {printf("March\n"); break;}
        ...
        case 12: {printf("December\n"); break;}
    }
}
```

switch-case clause (3)

- If you have to check one variable for many constant values
- `switch-case` is your friend:)

```
switch (variable)
{
    case option1: statement1; break;
    case option2: statement2; break;
    case option3: statement3; break;
    default: statement4; break;
}
```

- *case option* defines a jump label
- More than one statement after it possible without braces
- All statements until the next `break;` will be executed

switch-case clause (4)

- What **break** means
- Work out the output of following codes

```
int main()
{
    int n = 3;
    switch(n)
    {
        case 1: {printf("January\n"); }
        case 2: {printf("Febuary"); break;}
        case 3: {printf("March\n"); }
        case 4: {printf("April\n"); }
        case 5: {printf("May\n"); break;}
        ...
        case 12: {printf("December\n"); break;}
        default: break;
    }
}
```