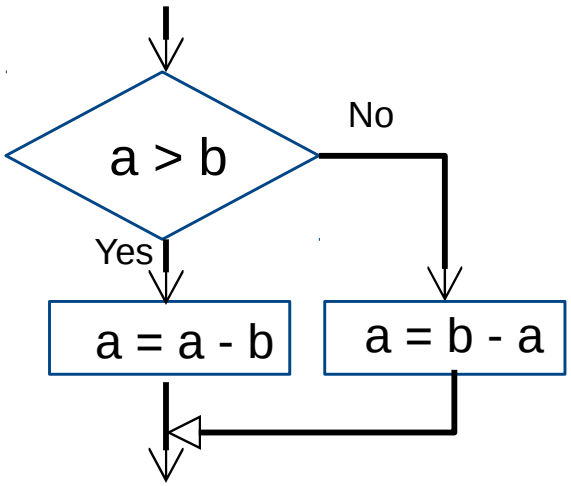
C Programming
Sequential and Conditional Control



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Outline

Programs for programming

- Integrated Development Environment
  - Microsoft Visual Studio (default option)
  - Dev-C++ (recommended)
  - VScode
  - Codeblocks
- 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

Outline

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

$\Downarrow$

```
$ gcc main.c
```

(Preprocessing $\rightarrow$ compiling $\rightarrow$ assembling $\rightarrow$ linking)

$\Downarrow$

Executable program

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

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

Windows (**a.exe**)

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

Outline

A basic program

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

```c
#include <stdio.h>
int main()
{
    printf("Hello China!\n");
    printf("Hello World!\n");
    printf("Hello Universe!\n");
    return 0;
}
```

```
Hello China!
Hello World!
Hello Universe!

```

- For clarity, one statement in one line

Outline

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 }
10
```

- 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)

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

```
#include <stdio.h>
#include <math.h>
int main()
{
    float a = 0, b = 0, c = 0, delta = 0;
    float x1 = 0, x2 = 0, p = 0, q = 0;
    printf("Input a, b and c:\n");
    scanf("%f%f%f", &a, &b, &c);
    delta = b*b - 4*a*c;
    p = -b/(2*a);
    q = sqrt(delta)/(2*a);
    x1 = p + q; x2 = p - q;
    printf("x1=%f, x2=%f\n", x1, x2);
    return 0;
}

```

Comments

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

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

Outline

Outline

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 statment(s) inside {...} will be executed
- Otherwise, statment(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 }
```

Comments

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

- For the case $b^2 - 4ac < 0$
- We should output "no real solution"
- For the case, $b^2 - 4ac \geq 0$
- We should output *x1* and *x2*

Solve Quadratic Equation

```c
#include <stdio.h>
#include <math.h>
int main()
{
    float a = 0, b = 0, c = 0, delta = 0;
    float x1 = 0, x2 = 0, p = 0, q = 0;
    printf("Input a, b and c:\n");
    scanf("%f%f%f", &a, &b, &c);
    delta = b*b - 4*a*c;
    if(delta >= 0){
        p = -b/(2*a);
        q = sqrt(delta)/(2*a);
        x1 = p + q; x2 = p - q;
        printf("x1=%f, x2=%f\n", x1, x2);
    }else{
        printf("No real solution!\n");
    }
    return 0;
}
```

Exercise

```c
#include <stdio.h>
int main()
{
    int a = -1;
    unsigned int b = 600;
    if(a > b)
    {
        printf("%d is greater than %d\n", a, b);
    }else{
        printf("%d is smaller than %d\n", a, b);
    }
    return 0;
}

```

- What is the answer??

Outline

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

Priority of Relational Operators (1)

```
1 5>3 && 2 || 8<4-!0
```

- "!" is higher than +, -, *, /
- ">", "<", "<=", ">=" and "==" are lower than +, -, *, /
- "&&" and "||" are the lowest
- Please tell me the result of this expression (**3 minutes**)

Priority of Relational Operators (2)

```
1 5>3 && 2 || 8<4-!0
2 5>3 && 2 || 8<4-1
3 5>3 && 2 || 8<3
4 5>3 && 2 || 0
5 1 && 2 || 0
6 1 || 0
7 1
```

- "!" is higher than +, -, *, /
- ">", "<", "<=", ">=" and "==" are lower than +, -, *, /
- "&&" and "||" are the lowest

Priority of Relational Operators (3)

```
1 (5>3) && 2 || (8<(4-!0))
```

- Usually, we put '()' to regularize the priority levels

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 }
```

Outline

if...else

Decisions are made during run time:

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

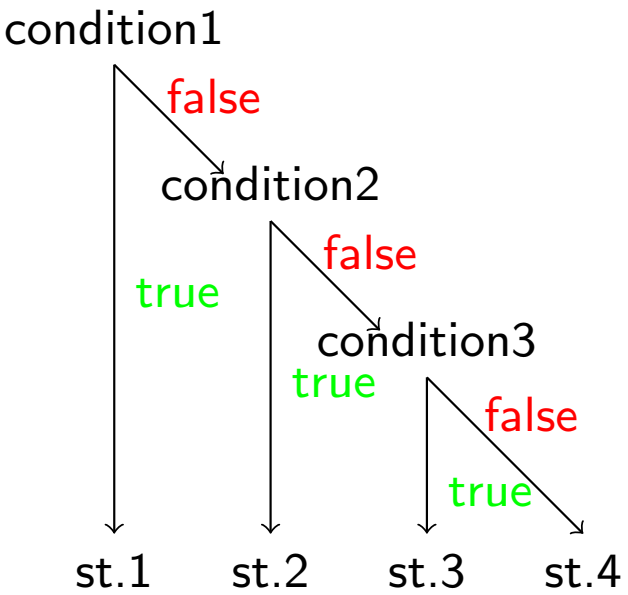
statement1 is only executed if the truth value of **condition** is *true*.
Otherwise **statement2** is executed.
For multiple statements inside the if-else, use braces {}:

```
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)

```c
#include <stdio.h>
int main()
{
    char ch = '';
    printf("Please input a character: ");
    ch = getchar();
    printf("Character is: %c", ch);
    if(ch >= '0' && ch <= '9'){
        printf("a digit\n");
    }else if(ch >= 'a' && ch <= 'z'){
        printf("char in lower case\n");
    }else if(ch >= 'A' && ch <= 'Z'){
        printf("char in upper case\n");
    }else if(ch == ' '){
        printf("It is space\n");
    }else{
        printf("not digit , char or space\n");
    }
    return 0;
}
```

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 400
3. If yes, it is leap year
4. Otherwise, check whether it is dividable by 4 and NOT dividable by 100
   1. If yes, it is leap year
   2. Otherwise, it is not leap year

Give your solution first....

Judge whether it is a leap year (2)

```c
#include <stdio.h>
int main()
{
    int year = 0, leap = 0;
    printf("Please enter the year: ");
    scanf("%d", &year);
    if(year%400 == 0){
        leap = 1;
    }else if(year%4 == 0 && year%100 != 0){
        leap = 1;
    }else{
        leap = 0;
    }
    if(leap == 1){
        printf("%d is leap year\n", year);
    }else{
        printf("%d is not leap year\n", year);
    }
}
```

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

```c
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;
}
```

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

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 recommnended, 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

```c
int main()
{
    int a = 3, b = 4, c = 1;
    if(a > b)
    {
        a = c;
    }else{
        a = b;
    }
    printf("a = %d", a);
}
```

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

- "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)

```c
int main()
{
    char ch = getchar();
    if(ch >= 'a' && ch <= 'z')
    {
        ch = ch - 32;
    }
    printf("ch = %c", ch);
    return 0;
}
```

```c
int main()
{
    char ch = getchar();
    ch = (ch>='a' && ch <='z')
     ?(ch-32):ch;
    printf("ch = %c", ch);
    return 0;
}
```

- 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;}
    }
    return 0;
}
```

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;
    }
    return 0;
}
```