C++ Programing Note

Written by @study_dises

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Before we start

- Before we start to talk about the C++ programming language, please install the C++ IDE or Compiler first.
- If you haven’t done it , Please download the choose one of these Compilers and Download.

- DEV C++ ： https://sourceforge.net/projects/orwelldevcpp/
- Code Blocks ： https://www.codeblocks.org/downloads/

- I will use the DEV C++ to do the sample code.

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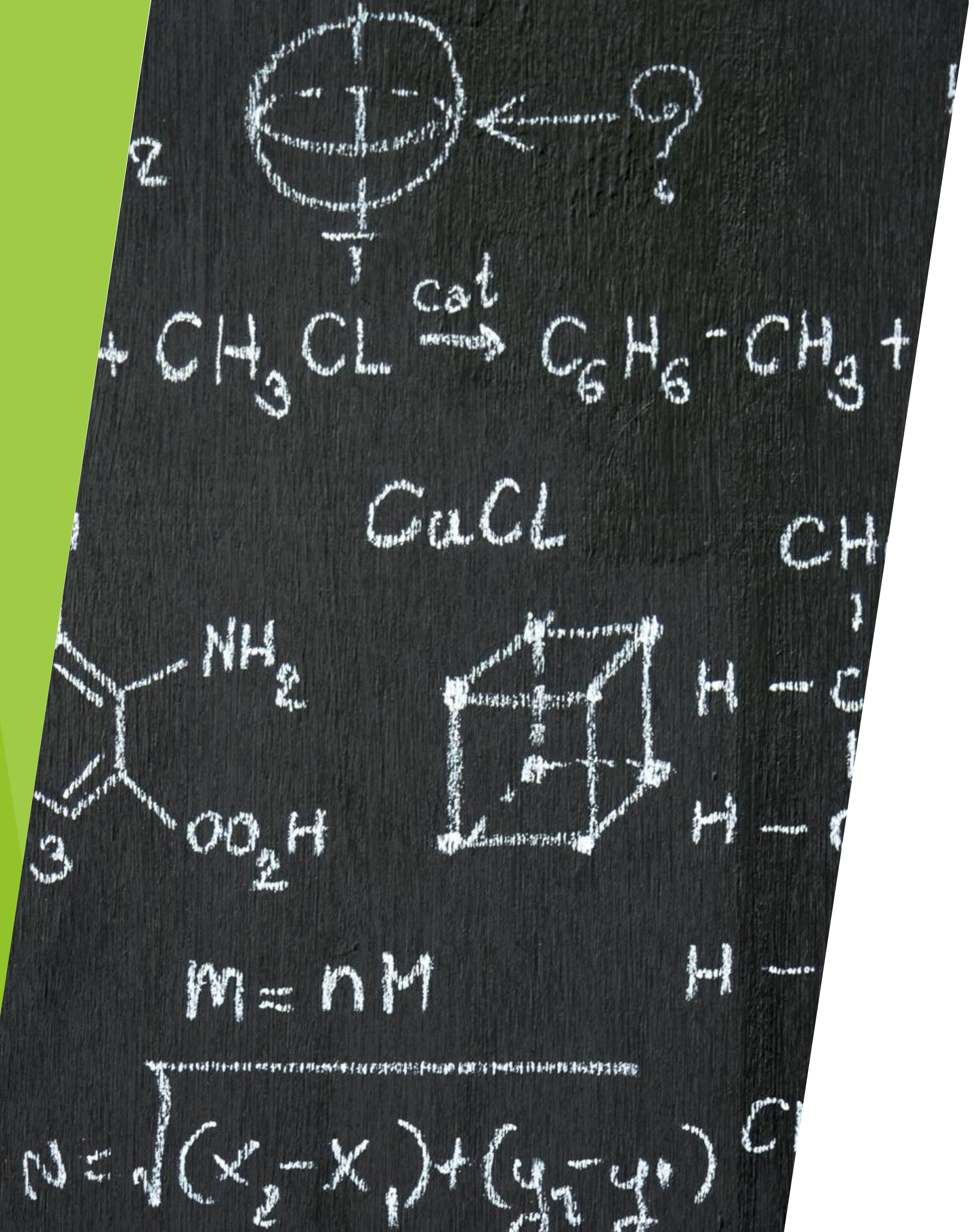
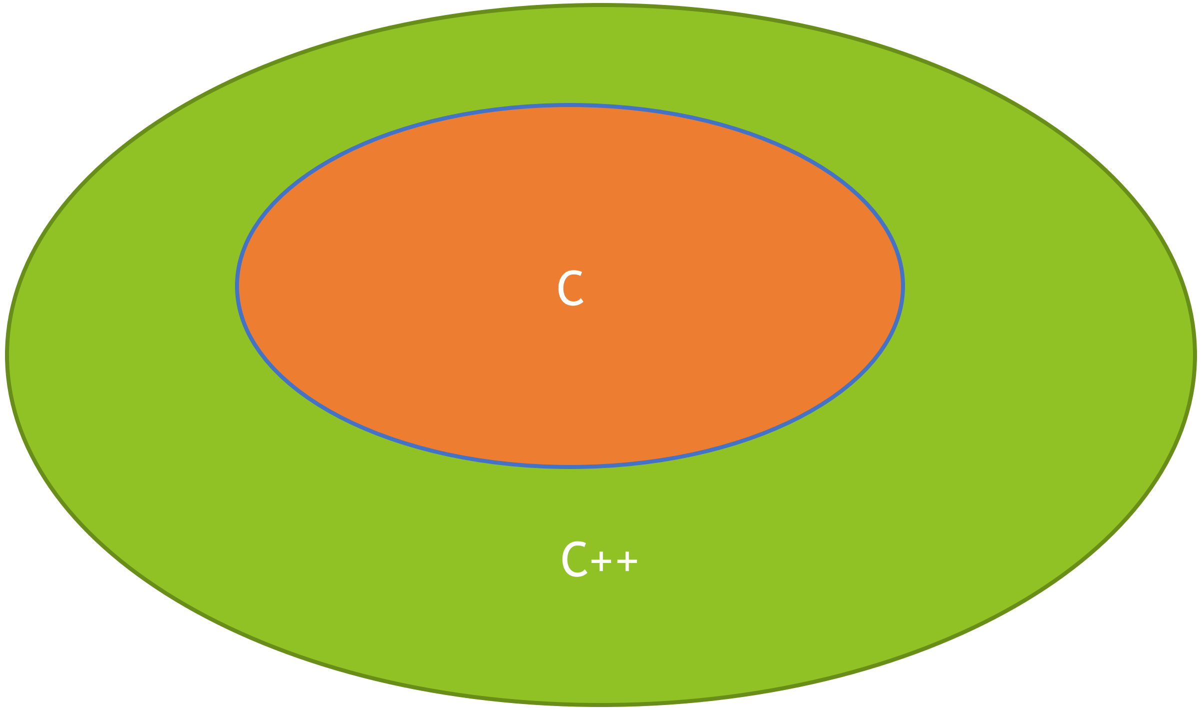


Chapter 1 :

Introduction of C++ and Base structure

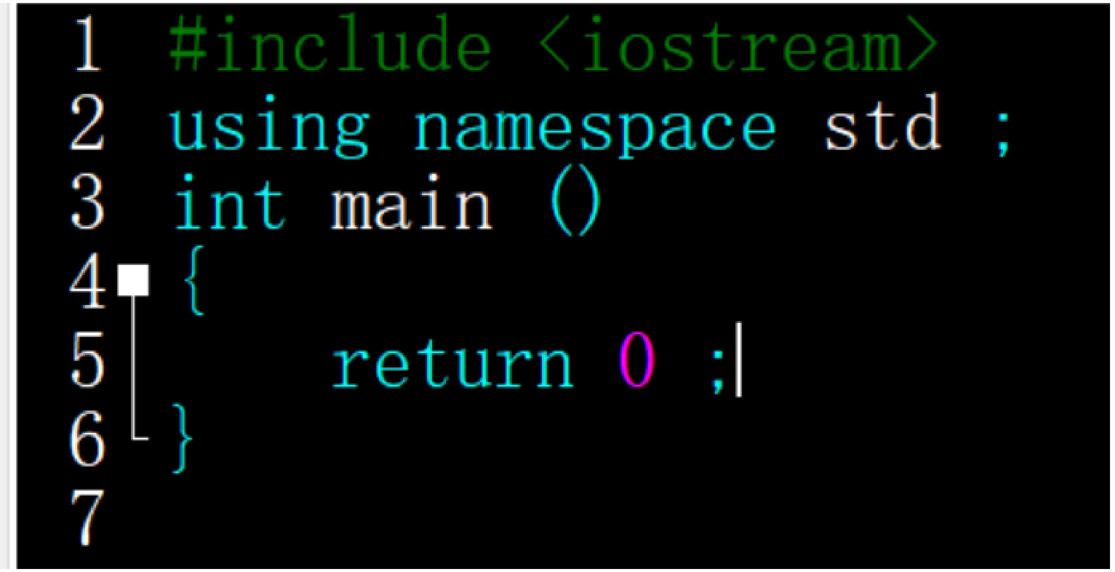
Chapter 1 : Introduction of C++ and Base structure

1. C++ is a Object-oriented coding language, on the other hand, C is not.
2. We can use a graph to show about the relation between C and C++.



- In the graph in the last page, we can easily know that "what we can do in C language, so can C++".
- So if you read my C note before, the any skills I told would be useful in C++,too.
- If you read my C note before , you can skip the chapter 3~7 , they just the same that I wrote in C note.

Base structure of C++



```
#include <iostream>
using namespace std ;
int main ()
{
	return 0 ;
}
```

- Base structure of C++ would be like the graph show to us.
- By the sample case, we need to "include" a C++-Library named "iostream" .
- The instruction of "using namespace std;" will be used to help us to use the input and output instructions.
- After them, we need to declare our main program.

```
peration == "MIRROR_X":
irror_mod.use_x = True
irror_mod.use_y = False
irror_mod.use_z = False
_operation == "MIRROR_Y":
irror_mod.use_x = False
irror_mod.use_y = True
irror_mod.use_z = False
_operation == "MIRROR_Z":
irror_mod.use_x = False
irror_mod.use_y = False
irror_mod.use_z = True

selection at the end -add
_ob.select= 1
ier_ob.select=1
ntext.scene.objects.active
("Selected" + str(modifier
irror_ob.select = 0
 bpy.context.selected_obj
ata.objects[one.name].sel

int("please select exactly

-- OPERATOR CLASSES ----

types.Operator):
 X mirror to the selected
ject.mirror_mirror_x"
rror X"
```

Chapter 2 :

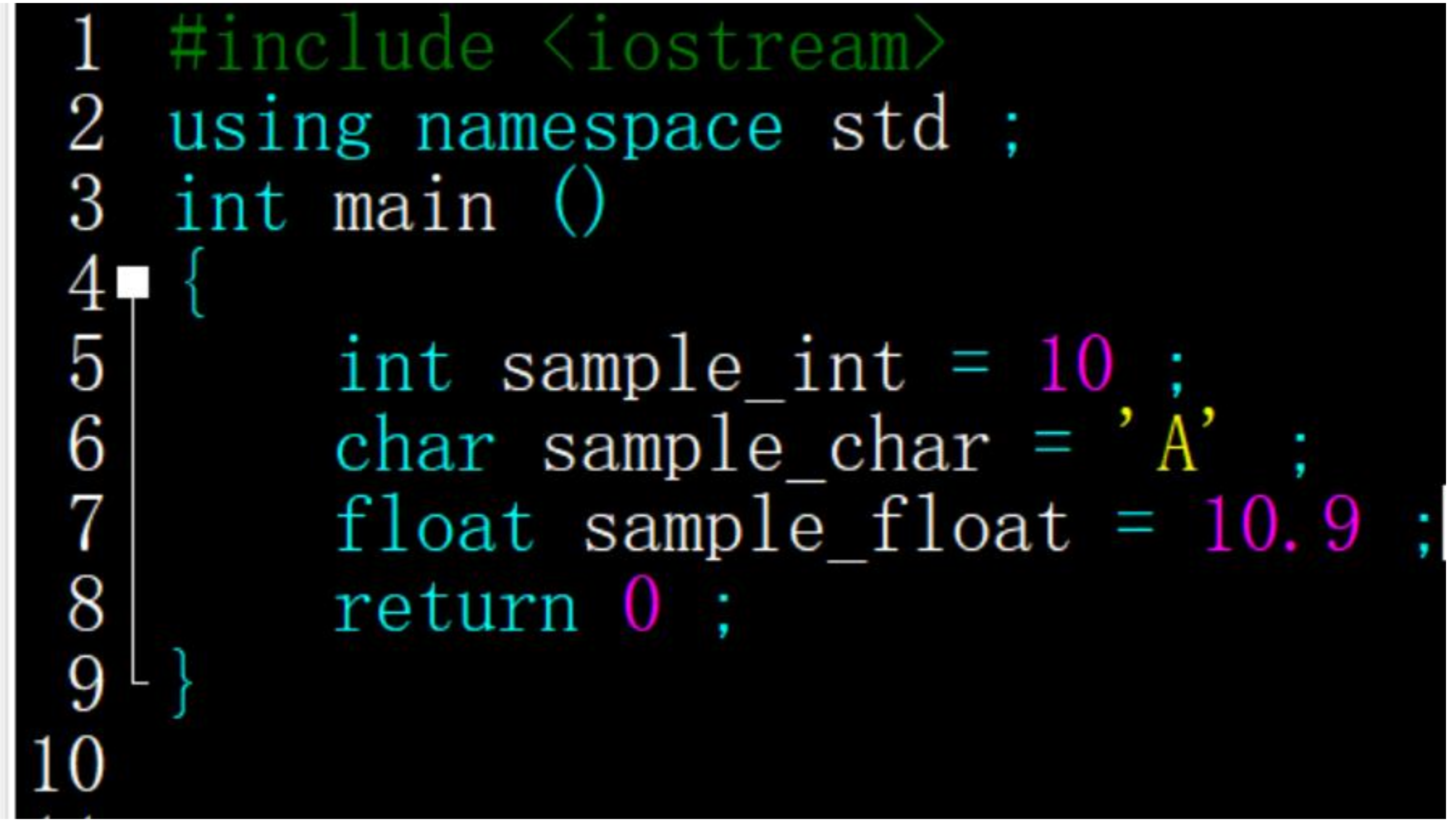
Define variables and Input, Output

Chapter 2 :
Define variables and Input, Output

In C++ langange code, We have some types of variables.

int	It means this variable is a integer number type. And this number will be in the closed interval [-2^31 , 2^31-1].
char	It means this variable is a single word like 'A' , 'B' or 'z'.
float	It means this variable is a number which has a decimal point. And it just can be accurate at about 6 to 7 numbers after the point.
double	Just same as float, but it can be accurate at about 15 to 16 numbers after the point.
bool	Store "true" or "false".

DEFINE VARIABLES SAMPLE



```
#include <iostream>
using namespace std ;
int main ()
{
        int sample_int = 10 ;
        char sample_char = ’A’  ;
        float sample_float = 10.9 ;
        return 0 ;
}
```

Input and Output instructions

- In C++, we also can use the scanf() function and printf() function which we use in C language, too.
- But in C++, we have a easier way to do that by the "std" which we declared by the instruction "using namespace std;".

Input	cin	int a , b ; cin >> a >> b ;
Output	cout	cout << "hello world" ;

The important points of cin and cout

- When we use the cin and cout in C++ for input and output, we must be careful about the >> and << .
- When we use cin , the dirction of arrow is to be right side ">>" .
- On the other hand, the cout instruction , the direction of arrow is to be the left side "<<" .
- I have a way to let you remember these rules in mind easier.
  - When we need to input a "thing" "into" a variable, so in this way, we have to use "cin(input) >>(to) variable" .
  - When we need to output a "thing" "from" a variable, so in this way, we have to use "cout <<(from) variable" .

Escape character and endl

- In this page, I just want to discuss about the '\n' first.
- We can use '\n' to let we output the New Line.
- "cout << '\n' ; "
- In C++ , we also have the other way to do this by the "endl" .
- "cout << endl ; "
- These two instructions would be the same function in C++ .

\n	New line
\0	the end of a string
\t	a tab
\a	Bell , an alarm sound
\'	Output " ' "
\"	Output " " "

Practice 2.1

- Please output your name with an adjective like "Dises is handsome."

Practice 2.2

- Please write a program to input 2 numbers "m" and "n" .
- And define a new variable named "a" equal m+n , a new variable named "b" equal
- m-n , a new variable named "c" equal m*n .
- Output the results of a , b , c .

Practice 2.3

- Please write a program to input two number with height and weight.
  - The unit of height is meters.
  - The unit of weight is kliograms.
  - And they "might" have a decimal point.
  - Please calculate the BMI by the formula (weight)/(height*height) and output the answer.

  - Sample input : 1.78 90
  - Sample Output : 28.405506

```
rror_mod = modifier_ob.
t mirror object to mirror
irror_mod.mirror_object
peration == "MIRROR_X":
irror_mod.use_x = True
irror_mod.use_y = False
irror_mod.use_z = False
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_ob.select= 1
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int("please select exactly

- OPERATOR CLASSES ----

types.Operator):
 X mirror to the selected
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context):
ext.active_object is not
```

Chapter 3 :

Calculate program and Repeated program

Calculate program

- When we need to do a calculate program, we have to some knowledges about the C++ for calculating.
- In C++ , we have some simple calculate symbol in the table , some of which just like we use in math.

+	A plus B	A+B
-	A minus B	A-B
*	A times B	A*B
/	A divides B	A/B
%	A take the remainder in B	A%B

Calculate program

- In C++ language, we also have some kinds of symbols that can simplify our code.
- Just like the table it decribe.

+=	A += B	Just like	A = A + B
-=	A -= B		A = A - B
*=	A *= B		A = A * B
/=	A /= B		A = A / B
%=	A %= B		A = A % B
++	A++		A = A + 1
--	A--		A = A - 1

Repeated program

- If you want to keep typing in the program, and you have a stop entering condition,
- Then, you will need to use some ways to do it.
- The instruction will use the while-loop function + cin instruction.
- I will introduce the while-loop function in chapter 5, but we need it now,
- It will be looked like
- while (cin >> variable)
- {

```
         ….....
          Program.....
        ….....
  }
```

Practice 3.1

- Please write a program for inputing two variables A and B , and calculate the answer for **A take the remainder in B.**
- **Simple Input : 10 9**
- **Simple Output : 1**

Practice 3.2

- At a stand, each bottle of water costs $5. Customers are standing in a queue to buy from you and order one at a time.
  - The customer will tell you he wants n bottles of water and he will give you m dollars.
  - As a staff, you need to give changes to customers in the minimum coins, and you only have $100, $50, $10, $5 and $1.
  - Please calculate how much coins the staff needs to pay and output it.
  - # from leetcode #860
  - Sample input : 5 100
  - Sample output : 4
  - (Describe about sample ， 100 – 5*5 = 75 = 50 + 2*10 + 5 , so the answer is 4 .)

Practice 3.3

- Zerojudge a002：
- Link：https://zerojudge.tw/ShowProblem?problemid=a002
  - Please write a program, input two variables a and b.
  - Output a+b
  - The program will stop if the input is EOF condition.

Practice 3.4

- Please write a program to input two number with height and weight.
- The unit of height is meters.
- The unit of weight is kliograms.
- And they "might" have a decimal point.
- Please calculate the BMI by the formula (weight)/(height*height) and output the answer.
- The program will stop when input is not numbers.

Chapter 4 :

Conditional expressions

If-else conditional expression

- If-else conditional expression is very very very important in whole coding world.
- Conditional expressions will be used if you need to judge a thing or a condition and then it will have lots of result depending on the result of judging.
- In C++ , we have two different kinds of conditional expressions , one is our topic today , the other one will introduce in next chapter called "switch-case".
- In C++ , if-else expression will be used like (see next page).

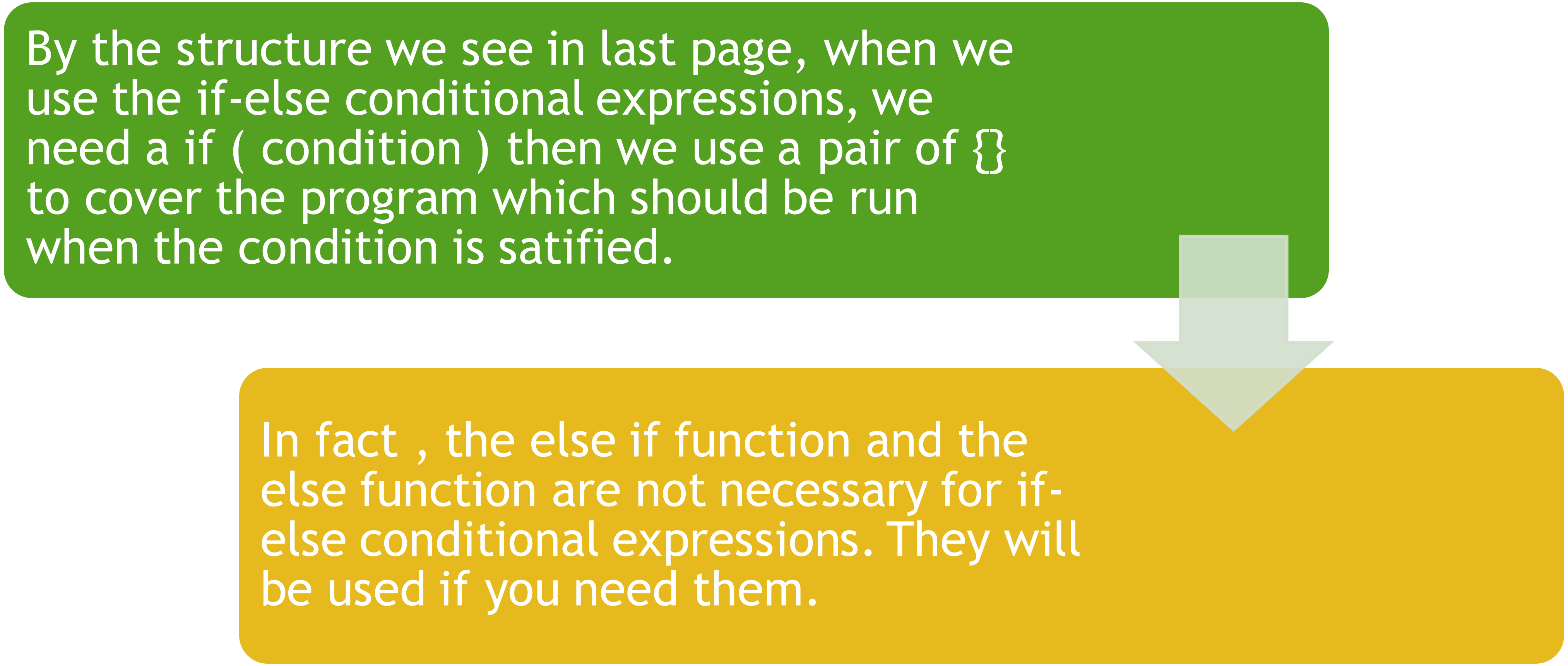
If-else conditional expression

```
if ( the conditions )
{
    ...
    program
    ...
}
else if ( others condition )
{

}
else
{

}
```

If-else conditional expression explain



By the structure we see in last page, when we use the if-else conditional expressions, we need a if (condition) then we use a pair of {} to cover the program which should be run when the condition is satified.

In fact , the else if function and the else function are not necessary for if-else conditional expressions. They will be used if you need them.

Boolean Algebra and Compare Symbols

- When we use the conditional expresstion, we usually use the compare symbol lile < , > …etc. Then we sometimes will use the boolean algebra for supporting.

>	A > B , means when A bigger than B	if (A > B)
<	A < B , means when A smaller than B	if (A < B)
>=	A >= B , means A bigger than or equal to B	if (A >= B)
<=	A <= B , means A smaller than or equal to B	if (A <= B)
==	A == B , means A equal to B	if (A == B)
&&	A_condtion && B_condition A and B condition are all satisfied.	if ((A) && (B))
||	A_condtion || B_condition A or B condition are satisfied	if ((A) || (B))
!	!A_condition A condition are not satified.	if (!(A))

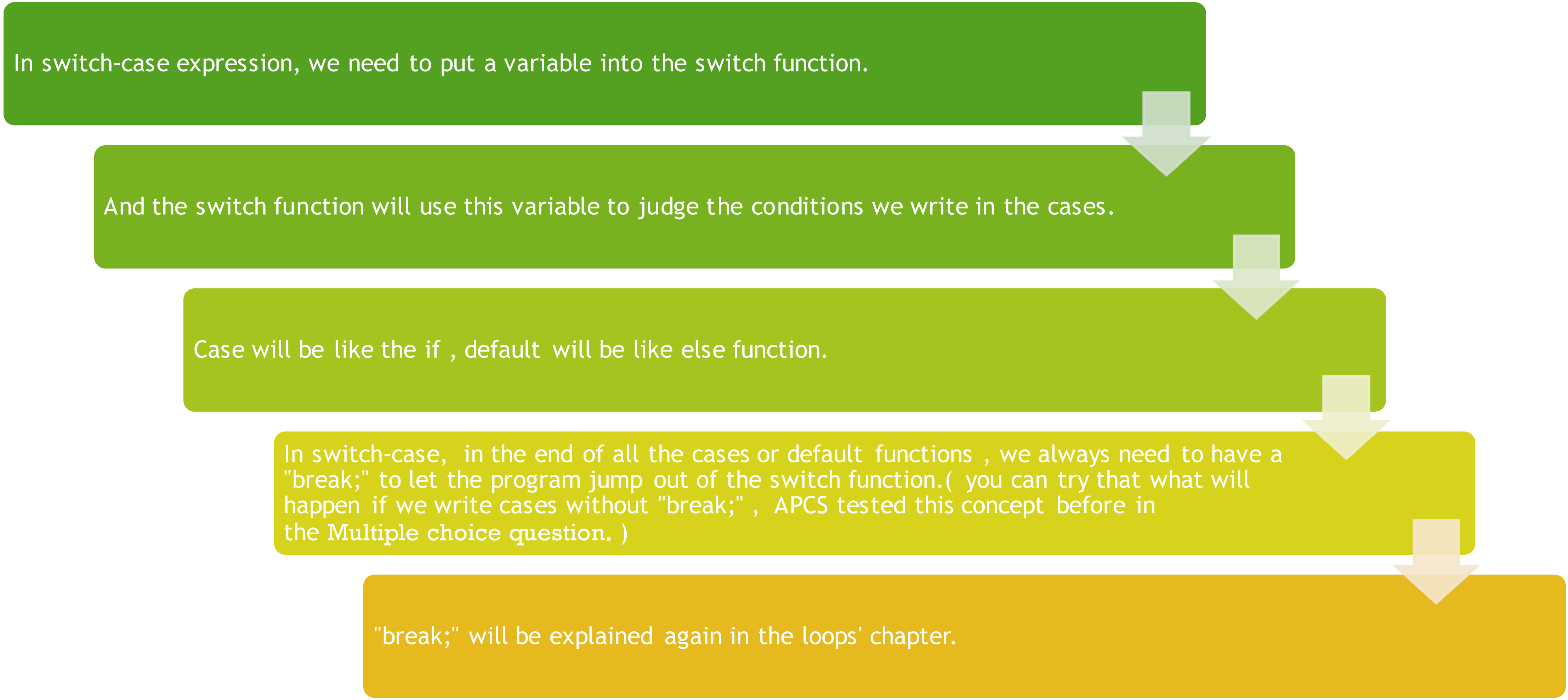
Switch-case conditional expression

- Switch-case conditional expression is another skill for conditional expresstions.
- Actually, we usually use if-else and seldom use switch-case because if-else is more convenient than switch-case, but in APCS , Switch-case appears very frequently. In this term, we still have to know this skill.
- When we use switch-case , it will be like (see next page) .

Switch-case conditional expression

```
switch( variable which would be judged  )
{
        case the conditon ( might be a number , a char or a range ) :
                  //program
                  break;
          case another conditon ( might be a number , a char or a range ) :
                      //program
                      break;
        default :
                 //program
                 break;
}
```

Switch-case conditional expression explain



In switch-case expression, we need to put a variable into the switch function.

And the switch function will use this variable to judge the conditions we write in the cases.

Case will be like the if , default will be like else function.

In switch-case, in the end of all the cases or default functions , we always need to have a "break;" to let the program jump out of the switch function.(you can try that what will happen if we write cases without "break;" , APCS tested this concept before in the Multiple choice question.)

"break;" will be explained again in the loops' chapter.

Case condition expression

```
switch( variable )
  {
    case 1 : // like  a number  ( if varialbe  = 1 )
      printf( "1\n" ) ;
      break;
    case 'A' : // like  a char ( if variable  = 'A' )
      printf( "2\n" ) ;
      break;
    case 1 ... 90 : // like  a tange of number  ( if 1 <= variavle  <= 90 )
      printf( "3\n" ) ;
      break;
    default :    // else
      printf( "4\n " ) ;
      break;
  }
```

Practice 4.1

- Zerojudge a003 :
- Link : https://zerojudge.tw/ShowProblem?problemid=a003
  Please write a program and it will input two variable M and D.
  - By the formula calculate S = (M*2+D)%3
  - When S = 0 , output "普通".
  - When S = 1 , output "吉".
  - When S = 2 , output "大吉".

Practice 4.2

- Please write a program, input a variables as a score.
- When score >= 90 , output "A" .
- When 90 > score >= 80 , output "B".
- When 80 > score >= 70 , output "C".
- When 70 > score >= 60 , output "D".
- When score < 60 , output "F".
- Please use the switch-case conditional expression to do it.

Practice 4.3

- Zerojudge c461:
- APCS (2017/10/18-1) Logic Operators
- Link : https://zerojudge.tw/ShowProblem?problemid=c461

Chapter 5 :

Loops

Switch-case conditional expression

- Switch-case conditional expression is another skill for conditional expresstions.
- Actually, we usually use if-else and seldom use switch-case because if-else is more convenient than switch-case, but in APCS , Switch-case appears very frequently. In this term, we still have to know this skill.
- When we use switch-case , it will be like (see next page) .

Introduction of loops

- Loop is a very important part in the program.
- In C++ , we have two kinds of loops , one is for() , the other one is while() function.
- We talk about the for-loop first.
- For-loop , we have a formula to keep it in mind.
- for (*start_point* ; *stop condition* ; *counter*)
- {
- //repeating program
- }

For-loop

Start point	Stop condition	counter
We can use like "int i = 0 , int j = 1 "...etc. to set the start point.	It just like the if-else condition expression which we put into the () ;	Like i++ , j++ , ++i ,++j , i = i + 1 , j = j + 2 ...etc.
For example: for (int j = 0 ; j < 10 ; j++) { //program ; } It means that when we run the program in the for-loop one time, j will plus one until j >= 10 (the condition is not satisfied). In this example , j will from 0 to 9 and it will stop at j = 10 , so it will run for 10 times.		

Break and Continue

Break is a skill that we can use it to **jump out of this loop.**

Continue is a skill that we can use it to **jump out of this time by some conditions.**

This two skills will be use very widely if we use the loops. Keep these two in mind.

While-loop

- While-loop is the other method to do the loops in C++.
- We can see that the while-loop is a "variant" of for-loop might be easier to understand it.
- The expression of while-loop would be like
- int counter = *start_point* ;
- while (*counter < stop_point*)
- {
- //program
- count++;
  }

Compare between while-loop and for-loop

```
for ( int i = 0 ; i < 10 ;  i++ )
{
     // program
}

int i = 0 ;
while ( i < 10 )
{
     //program
    i++ ;
}
```

This two loop have the same effect in fact.

Practice 5.1

- Please output the graph like

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

- Use the for-loop (it needs double for-loop)

Practice 5.2

- Please output the graph like
- *
- **
- ***
- ****
- *****
- Use the while-loop (it needs double for-loop)

Practice 5.3

- Zerojudge a005
- Link : https://zerojudge.tw/ShowProblem?problemid=a005
- For-loop can do it too.

Practice 5.4

- Zerojudge d649:
- Hint : use the sample practice to modify
- Link : https://zerojudge.tw/ShowProblem?problemid=d649

Practice 5.5

- Zerojudge a038:
- Link : https://zerojudge.tw/ShowProblem?problemid=a038

Chapter 6 :

Array in 1-D

Array

Array is a base data structure in C++ and it is very important and useful.

To say simply, array in 1-D just like a "list" of a type of data.

In the system, the memory spaces that an array occupy would be continuous.

Array implement

- If we need to do a project that you must store ten values, and we haven't learned what is array, you would write that **int a , b , c , d , e , f , g , h , ….. . That is too inefficient.**
- If we use the method of array in 1-D , we just have to write that **int array_name[n]**, n is represent that how much values you need to store.
- We can imagine that what array it will become a "1*n" table , have n blanks.

Array[0]	Array[1]	Array[2]	Array[3]	Array[4]	Array[5]	Array[6]	…	Array[n-1]
value	value	value	value	value	value	value		value

- The number in the [] we called that is an "index", and the range of index should be from 0 to n-1.

Practice 6.1

- Zerojudge b964:
- Link : https://zerojudge.tw/ShowProblem?problemid=b964
- APCS 2016/03/05-1

Practice 6.2

- Zerojudge g595:
- Link : https://zerojudge.tw/ShowProblem?problemid=g595
- APCS 2021/11-1

Practice 6.3

- Zerojudge i399:
- Link : https://zerojudge.tw/ShowProblem?problemid=i399
- APCS 2022/06-1

```
irror_mod = modifier_ob.
set mirror object to mirror
mirror_mod.mirror_object
operation == "MIRROR_X":
mirror_mod.use_x = True
mirror_mod.use_y = False
mirror_mod.use_z = False
_operation == "MIRROR_Y":
mirror_mod.use_x = False
mirror_mod.use_y = True
mirror_mod.use_z = False
_operation == "MIRROR_Z":
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mirror_mod.use_y = False
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selection at the end -add
_ob.select= 1
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print("please select exactly

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types.Operator):
 X mirror to the selected
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context):
ext.active_object is not
```

Chapter 7 :

Array in 2-D

Array in 2-D

- We memtioned the 1-D array in last chapter. Now, we have to describe about the array in 2-D even the array in n-D.
- We imagine that 1-D array is just like a 1*n table, by the same way, we also can imagine that 2-D array is just like a n*m table.
- The code which is going to declare a 2-D array would be like
- int array[n][m] ;
- An integer array in 2-D for example.

Array in 2-D

- int Array[n][m] ; It would be like :

Array[0][0] value	Array[0][1] value	Array[0][2] value	……….	Array[0][n-1] value
Array[1][0] value	Array[1][1] value	Array[1][2] value	……….	Array[1][n-1] value
Array[2][0] value	Array[2][1] value	Array[2][2] value	……….	Array[2][n-1] value
Array[3][0] value	Array[3][1] value	Array[3][2] value	……….	Array[3][n-1] value
………..	………..	………..	……….	……….
Array[m-1][0] value	Array[m-1][1] value	Array[m-1][2] value	……….	Array[m-1][n-1] value

Practice 7.1

- Zerojudge g275 :
- Link : https://zerojudge.tw/ShowProblem?problemid=g275
- APCS 2021/9 - 1

Practice 7.2

- Zerojudge f580 :
- Link : https://zerojudge.tw/ShowProblem?problemid=f580
- APCS 2020/7 - 2

Practice 7.3

- Zerojudge f313 :
- Link : https://zerojudge.tw/ShowProblem?problemid=f313
- APCS 2020/10 - 2

Chapter 8 :

String in C++

String in C++

- In C++, we have two types could represent "String" .
- One is using the "character array" to represent a string.
- The other one is that we are going to mention.
  C++ provides a type named "string" to represent a string.
- Unlike the character array which is finite , the string type is "infinite".

Character Array Method to use String

- We can imagine that a char means a "letter", so an array of "chars" means many "letters". What it would be by an array of chars, we can imagine that it is a "string" easily.
- In the end of a character array string, there is a '\0' to tell the computer that this string is finished.
- '\0' is an escape character we mentioned before.

Character Array Method to use String

- In the C++ , we define a character array to represent a string , but this method is originated from the C language. Therefore, if we use this method to do a string, we must use the scanf() and printf() function to do , mustn't use the cin and cout .
- We define that is "%s", so if we mention a string and do a program to input and output it. It would be written becoming
- char string[100] ;
- scanf("%s" , string) ;
- //the string type we don't use "&" before the variable name ,we will discuss about it when we get to the "pointer" chapter
- printf("%s\n" , string) ;

String type Method in C++

- In the C++ , we usually use this method to represent a string.
- If we use this method, the same, we also can’t use the scanf() and printf() function to do the input and output, only can use cin and cout to do.
- The code for example:
- string s ;
- cin >> s ;
- cout << s << endl ; //Output whole the string
- cout << s[0] << endl ;// Output the first character od string

String C++ library

- When we use the string skill, we will usually include the string library to help us to do something easier.
- When we use the Character Array Method, we will include <string.h> or <cstring> (These two are the same thing, I will explain it in the C++ library chapter).
- On the other hand , when we use the String type Method, we will include <string> to help us.
- These two library are defined lots of thing which is the same, for example, memset() function is defined in both.

#include <string.h> or <cstirng>

- In the <string.h> library, we have these function to help us to do.

1. strlen(*character array name*) ;

   //return the length of the string

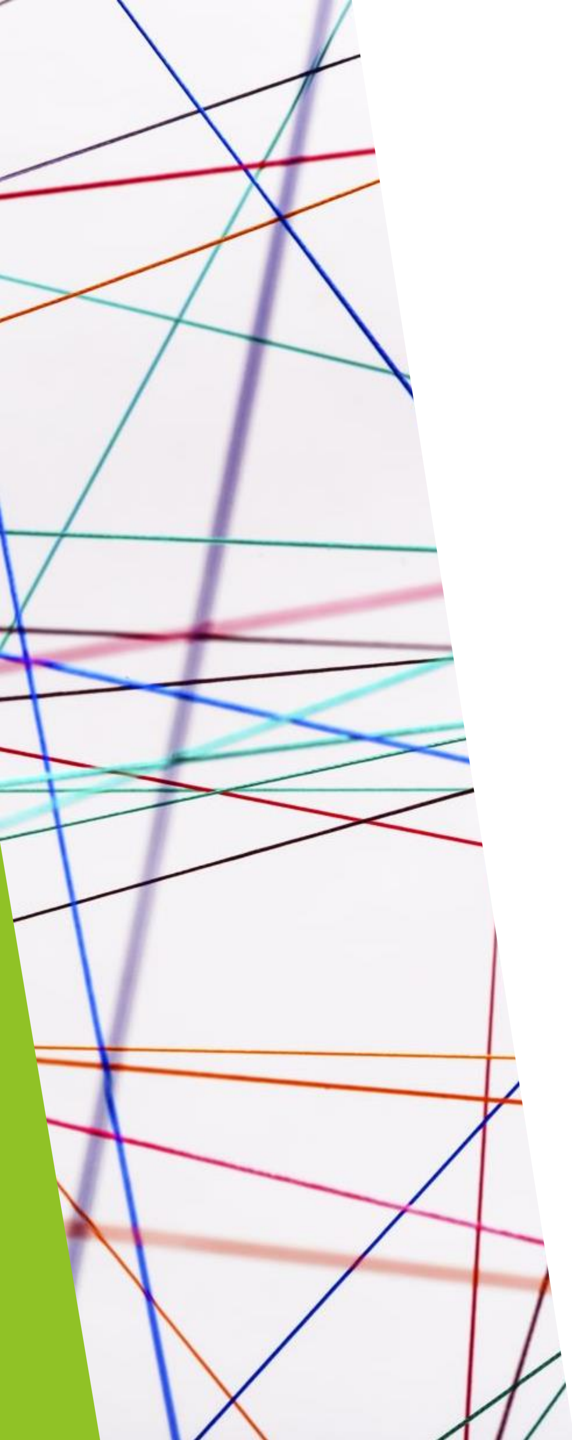
2. strcmp(*character array name* , *the other string*) ;

   // if the array equal to the other string , return 0

   // else return 1

3. memset(*array_name*, *a letter or an integer* , sizeof(*array_name*)) ;

   // It is alse defined in <string> library. To let the whole spaces of the array become the letter or the integer.



#include <string>

- In the <string> library, we have these function to help us to do.

1. *string_name*.size() ; or *string_name.length()* ;

   //return the length of the string

Practice 8.1

- Zerojudge a001:
- Link : https://zerojudge.tw/ShowProblem?problemid=a001

Practice 8.2

- Zerojudge g006:
- Link : https://zerojudge.tw/ShowProblem?problemid=g006

```
peration == "MIRROR_X":
irror_mod.use_x = True
irror_mod.use_y = False
irror_mod.use_z = False
 operation == "MIRROR_Y"
irror_mod.use_x = False
irror_mod.use_y = True
irror_mod.use_z = False
 operation == "MIRROR_Z"
irror_mod.use_x = False
irror_mod.use_y = False
irror_mod.use_z = True

selection at the end -add
  _ob.select= 1
  er_ob.select=1
  ntext.scene.objects.active
  ("Selected" + str(modifier
  irror_ob.select = 0
  bpy.context.selected_obj
  ata.objects[one.name].sel

 int("please select exactly

 OPERATOR CLASSES

  types.Operator):
  X mirror to the selected
  ject.mirror_mirror_x"
  rror X"
```

Chapter 9:

C++ library

C++ library

- In this chapter , we will introduce some useful C++ library.
- Before we discuss about it, we have to explain a concept between C and C++ library.
- In C language, when we include a library, in the end of the library always have a ".h".
- In fact , in C++ , we also can use the ".h" library, but C++ also define another type of it ---- use "c".
- For example , when we include <stdio.h> in C++ , we also can write it become include <cstdio>.
- These two are the same.

C++ library

- So ,in conclusion, all of C language library can be included in a C++ code.
- On the other hand , there are also some C++ library which are C++ only.
- Now , we show some of them.

C++ library

- #include <algorithm>

  // we will use it in chapter 10 and 11
- #include <vector>

  // we will use it in chapter 12
- #include <stack>
- #include <queue>

  // we won’t discuss these two in this note.
- ………………….

C++ library

- We can observe these library and compare with the C library, we can see that these C++ only library they don't have "c" in the front or ".h" in the end. Because of it , we can say that "the C++ only library" wouldn't have ".h" or "c" in the <> .

Chapter 10:

Sort function in a 1-D array

Sort function in a 1-D array

- Sort is a base algorithm in the coding world.
- There are many types of sort algorithms , for example , bubble sort , search sort , binary sort...etc.
- But in C++ , we have a function named sort() which is defined in the C++ only library <algorithm>.
- We can use it to sort a 1-D array easily.

Sort function in a 1-D array

- The formula of sort() will show like
- sort(*the_start_pointer_of_the_array* , *the_end_pointer_of_the_array*) ;
- You might have a question , what is pointer ?
- Pointer is an advanced concept of C++ , so we wouldn't explain it now.
- Because of it , I will show an easy way to let you to use it.
- sort(*the_array_name* , *the_array_name* + *how_much_spaces_of_the_array*) ;
- We can use the second way to remember this function, but we also need to keep the original definition in mind. The original definition will be used in the chapter 12.

Practice 10.1

- Zerojudge a104:
- Link : https://zerojudge.tw/ShowProblem?problemid=a104

Practice 10.2

- Zerojudge f312:
- Link : https://zerojudge.tw/ShowProblem?problemid=f312
- APCS 2020/10-1

```
peration == "MIRROR_X":
irror_mod.use_x = True
irror_mod.use_y = False
irror_mod.use_z = False
_operation == "MIRROR_Y":
irror_mod.use_x = False
irror_mod.use_y = True
irror_mod.use_z = False
_operation == "MIRROR_Z":
irror_mod.use_x = False
irror_mod.use_y = False
irror_mod.use_z = True

selection at the end -add
_ob.select= 1
er_ob.select=1
ntext.scene.objects.active
("Selected" + str(modifier
irror_ob.select = 0
bpy.context.selected_obj
ata.objects[one.name].sel

int("please select exactly

OPERATOR CLASSES ----

types.Operator):
X mirror to the selected
ject.mirror_mirror_x"
ror X"
```

Chapter 11:

Reverse function in a 1-D array

Reverse function in a 1-D array

- The formula of reverse() will show like
- reverse(*the_start_pointer_of_the_array* , *the_end_pointer_of_the_array*) ;
- reverse(*the_array_name* , *the_array_name* + *how_much_spaces_of_the_array*) ;
- The same as sort() function.

Practice 11.1

- Zerojudge f345:
- Link : https://zerojudge.tw/ShowProblem?problemid=f345

Chapter 12:

C++ STL <vector>

C++ STL <vector>

- In the end chapter of C++ note , I want to introduce a very important thing in C++ , it called STL <vector>.
- We have learned what is array before. We know that array is a finite list of variables.
- But actually , the problems we
  meet usually need unknown of spaces ,in these cases, the vector skill can help us to deal with it.

C++ STL <vector>

- Vector is a STL (Standard Template Library) in C++.
- We can imagine that vector is an "infinite" array.
- But it has some specific method to do it.

C++ STL <vector> Method

- #include <vector>
- …
- vector < *type* > *vector_name* ;

  // declare a vector
- *vector_name*.push_back(*variable*) ;

  // put a variable into the vector
- *vector_name*.clear( ) ;

  // clear whole the vector
- *vector_name*.begin() ;

  // return the first pointer of the vector
- *vector_name*.end() ;

  // return the end pointer of the vector

C++ STL <vector> Method

- *vector_name*.size( ) ;

  // return the length of the vector

- *vector_name*.earse(*the_element_pointer*) ;

  // delete the element in the vector

Practice 12.1

- Zerojudge g005:
- Link : https://zerojudge.tw/ShowProblem?problemid=g005

Practice 12.2

- Zerojudge c296:
- Link : https://zerojudge.tw/ShowProblem?problemid=c296
- APCS 2016/10-3

- # Ending~~~~~~~~~~~~~~~~~~~~~~~~~~~~

  We finish whole essential concepts of C++

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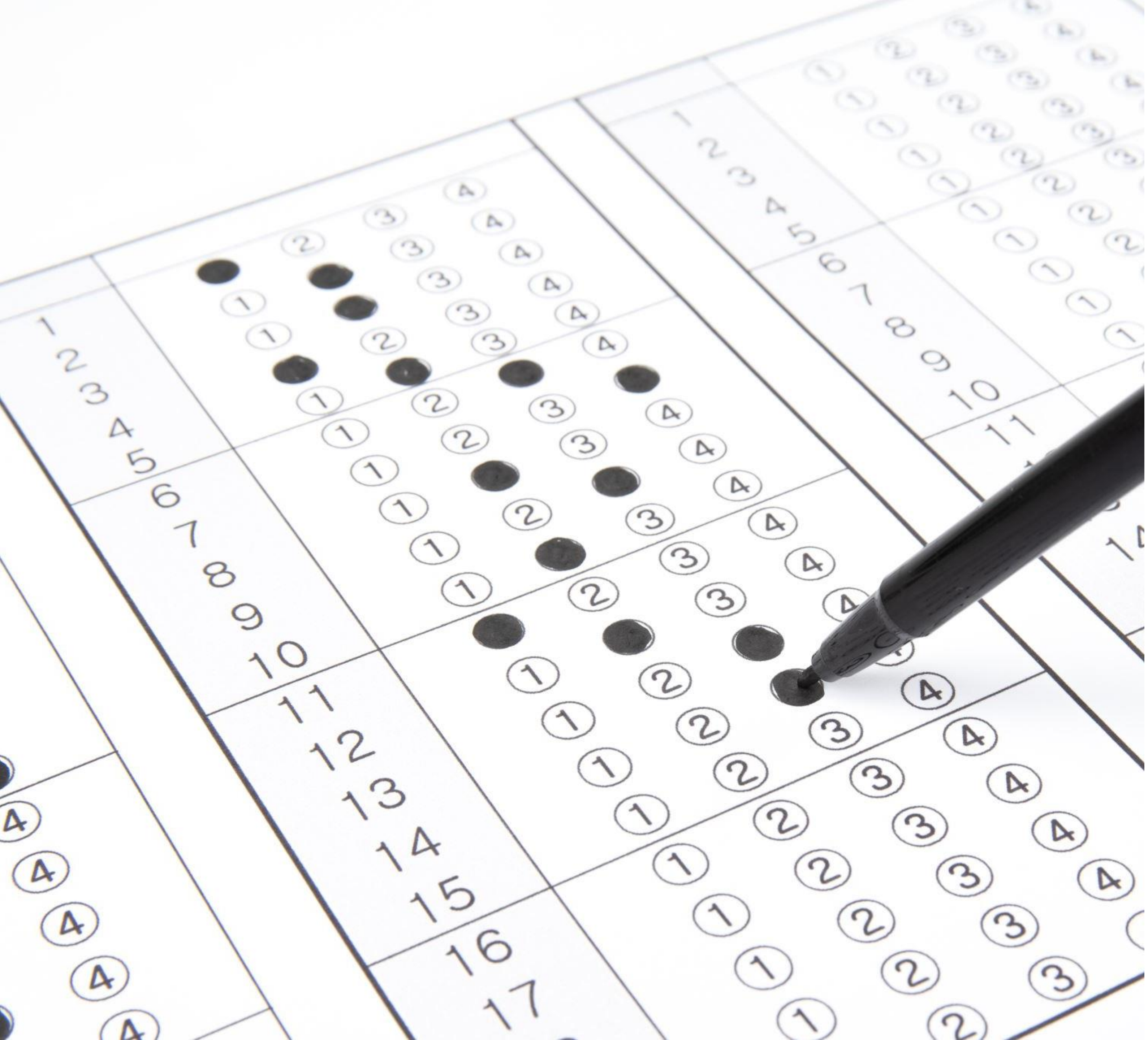

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