03: CONTROL STRUCTURES

Programming Technique I

(SCSJ1013)

Boolean and Logical Operator

- In C++ logical data declared as `bool` data type

  e.g.

```
bool variable_name;
```

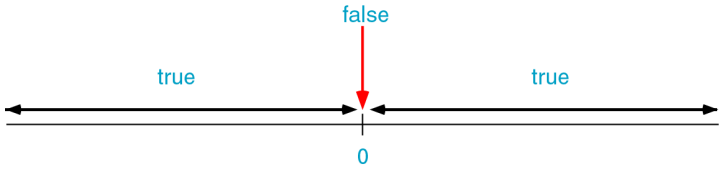
- There are only two values: `true` and `false`
- Type-casting `bool` to `int`:
  - `true => 1`
  - `false => 0`

Example

```
int number;
number = 2 + true;
cout << number; //output: 3
```


Boolean and Logical Operator

- Type-casting `int` to `bool`:
  - A *Zero value* => `false`
  - A *Non-Zero value* => `true`



Example:

```
bool b = false;     // b initially is false
int number = 0;
b = -10;            // Now, b is true
b = number;         // Here, b is false again
```


Boolean and Logical Operator

What would be printed by this code segment

```
bool b;
int p;
int q = 5;

b = q;
p = b;
cout <<"The value of p is " << p <<endl;
```

Logical operators truth table

not

x	!x
false	true
true	false

logical

!

x	!x
zero	1
nonzero	0

C Language

and

x	y	x&&y
false	false	false
false	true	false
true	false	false
true	true	true

logical

&&

x	y	x&&y
zero	zero	0
zero	nonzero	0
nonzero	zero	0
nonzero	nonzero	1

C Language

or

x	y	x || y
false	false	false
false	true	true
true	false	true
true	true	true

logical

||

x	y	x || y
zero	zero	0
zero	nonzero	1
nonzero	zero	1
nonzero	nonzero	1

C Language

Operations for logical and/or

false && (anything)

⇩

false

true || (anything)

⇩

true

Relational operators

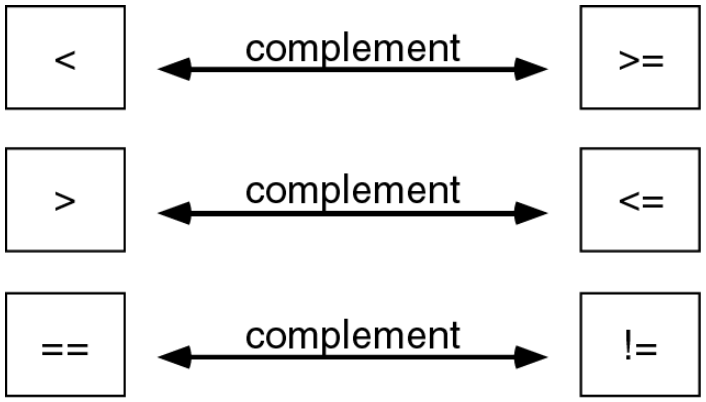
Operator	Meaning
<	less than
<=	less than or equal
>	greater than
>=	greater than or equal
==	equal
!=	not equal

Logical expression

Example:

```
int a=10;

cout << a;
cout << (a==1);
cout << (a>1);
cout << (a=5);

a = (a != 5);
out << a;
```

Logical operator complements

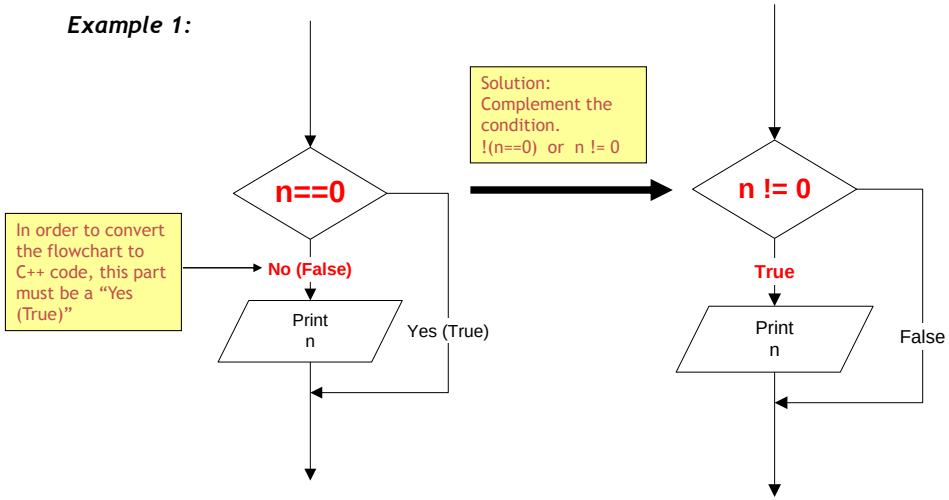


- Another way to complement an expression is just putting a Not operator (!) in front of it.

Example: Complement of n==0 is
`! (n==0)`

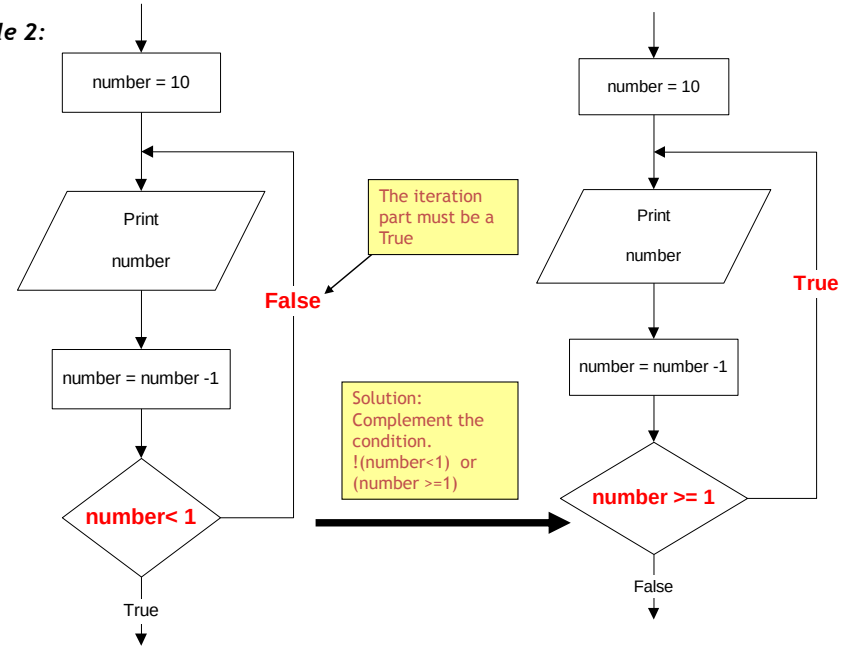
- When to use complement?

Example 1:



- When to use complement?

Example 2:



Selection / Branch

- Sometimes your programs need to make logical choices.
- Example:

  IF score is higher than 50
  THEN grade is PASS
  ELSE grade is FAIL

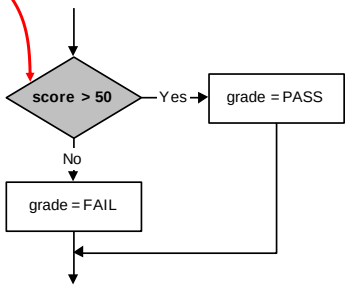
- In C++, this corresponds to `if` statement with three parts:

```
if (score > 50)   //part 1
{
    grade  = PASS;   //part 2
}
else
{
    grade = FAIL;   //part 3
}
```

if statement

- Part 1 : the **condition** - an expression that evaluates to `true` or `false`.

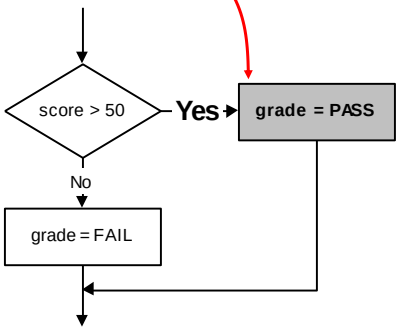
```
if (score > 50)
{
    grade  = PASS;
}
else
{
    grade = FAIL;
}
```



if statement

- Part 2 : the **TRUE-PART** - a block of statements that are executed if the condition evaluates to `true`

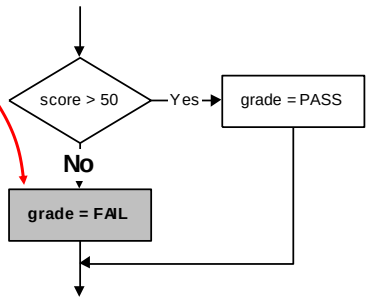
```
if (score > 50)
{
    grade  = PASS;
}
else
{
    grade = FAIL;
}
```



if statement

- Part 3 : the **FALSE-PART** - a block of statements that are executed if the condition evaluates to `false`

```
if (score > 50)
{
   grade = PASS;
}
else
{
    grade  = FAIL;
}
```

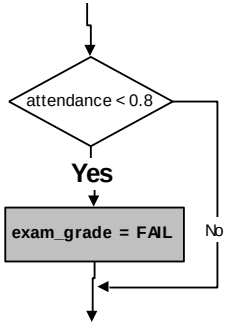


if the condition evaluates to `false`, the TRUE-PART is skipped.

if statement

- Sometimes there is no FALSE-PART. The "**else**" is omitted

```
if ( attendance < 0.8 )
{
    exam_grade = FAIL;
}
```



if statement

- If the TRUE-PART (or FALSE-PART) consists of only one statement, then the curly braces may be omitted.

- *Example: these two statements are equivalent:*

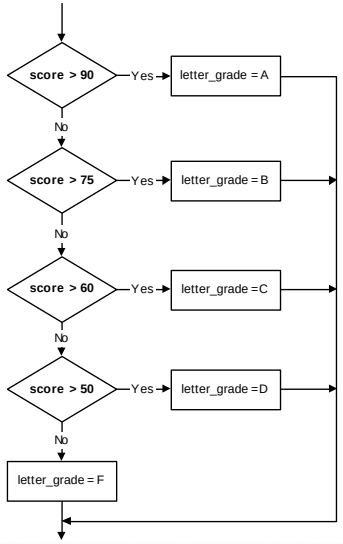
```
if (score > 50)
{
   grade  = PASS;
}
else
{
   grade = FAIL;
}
```

```
if (score > 50)
      grade  = PASS;
else
      grade = FAIL;
```

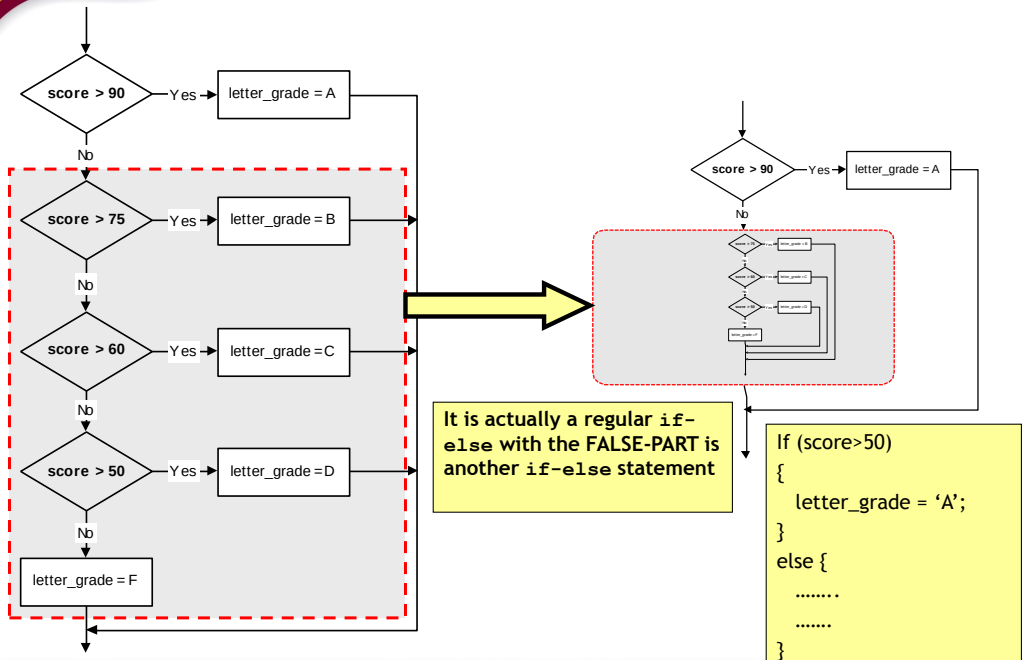

if statement

- Sometimes there are more than two parts. In those cases you may use nested **if-else** statements:

```
if (score > 90)
      letter_grade  = 'A';
else if (score > 75)
      letter_grade = 'B';
else if (score > 60)
      letter_grade = 'C';
else if (score > 50)
      letter_grade = 'D';
else
      letter_grade = 'F';
```



Let's look closer



It is actually a regular **if-else** with the FALSE-PART is another **if-else** statement

```
If (score>50)
{
   letter_grade = 'A';
}
else {
   ……..
   …….
}
```


if statement

- Three forms of **if** statements are shown at the next table.

- The *condition must be placed* in parentheses

- Statement may exist either as a single statement or as a collection of statements (also called compound statement)

```
if(condition)
   statement;
```

```
if (condition)
{ statement;
     ⋮
  statement;
}
```

```
if (condition)
{ statement;
     ⋮
  statement;
}
else
{ statement;
     ⋮
  statement;
}
```

- A **compound statement** is one or more statements that are grouped together by enclosing them in brackets , `{}`.

- **Example:**

```
if (value>0)
  cout << value;

value = value * 2;

if (value>10)
{
  value = 10;
  cout << value;
}
```

This is a single statement. The semi-colon belongs to "if" not to "cout"

a single statement

This is a compound statement which consists two single statements.

Related issues

- The condition must be placed in parentheses

Example:

```
if (0<x) && (x<10)     //syntax error
    cout << x;
```


Related issues

- But be careful when converting mathematical comparisons. Some of them are not straight forward

Example: Print x only if (2<x<9)

```
if (2<x<9)
   cout << x;
```

There is no syntax error, but this leads to a **logic error** due to the misinterpretation.

The condition **always evaluates to true**, whatever the value of x

Let say x=1
(2<x<9)
⇒(2<1<9)
⇒(false<9)
⇒(0<9)
⇒true

Let say x=5
(2<x<9)
⇒(2<5<9)
⇒(true<9)
⇒(1<9)
⇒true

Related issues

- The condition must evaluate to a Boolean value (i.e. either `true` or `false`)

- There are only two types of expression that result a Boolean value
  - Comparison expression (e.g. `a>2`)
  - Boolean expression (e.g. `b && false`)

- If the result of the condition is not a Boolean, it will be type-casted

Example:

```
int n=0;

if (n)
   cout << "Yes";
else
   cout << "No";
```

The condition evaluates to 0. It then is type-casted to Boolean, becomes `false`

Example:

The condition evaluates to 5. It then is type-casted to Boolean, becomes **true**

```
int n=0;

if (n + 5)
   cout << "Yes";
else
   cout << "No";
```


Example:

Remember! This is an **assignment expression**, not an equality.

The value of the expression is 0. It then is type-casted to Boolean, becomes **false**. The result is always false.

```
int x=0;

if (x=0)
   cout << "Yes";
else
   cout << "No";
```


Example:

Remember! This is an **assignment expression**, not an equality.

The value of the expression is 10. It then is type-casted to Boolean, becomes **true**. The result is always true.

```
int y=5;

if (y=10)
   cout << "Yes";
else
   cout << "No";
```


Example:

Remember! This is an **assignment expression**.

The condition always evaluates to **true**. The value of **y** is changed to 5 due to the side-effect caused by the assignment operator

```
int y=1;

if (y=5)
   cout << y
```

Related issues

- Be careful when using the Boolean operator NOT (!)

Example:

```
int n=5;

if (!n>9)
   cout << "Yes";
else
   cout << "No";
```

Operator **!** has higher precedence then operator **>**. So, it is executed first.

Expression **!n** is evaluated as **!true** where n is type-casted from `integer 5` to `Boolean true`. The result is **false**

The expression is further evaluated as **(false>9)**. The false value is then type-casted to 0, since it will be compared with an integer. The expression then looks like **(0 > 9)** and the final result is **false**

Example:

```
int n=5;

if (!(n>9))
   cout << "Yes";
else
   cout << "No";
```


Related issues

- Statements should be indented correctly to avoid misinterpretations

Example:

```
if (x<3)
   cout <<"Yes" << endl;
   cout <<"No" << endl;
```

Let say x=1

Let say x=3

Example:

```
if (x<y)
   cout << x;
   x = y;
else
   cout << y;
```

Syntax error - misplace else. There must only be a single statement before **else**. If more than that, use a compound statement.

Example:

Print x only if it is an odd number less than 10, otherwise print "Wrong number"

```
if (x%2==1)
    if (x<10)
       cout <<x;
else
  cout << "Wrong number";
```

There is no syntax error, but this leads to a **logic error** due to the misinterpretation.

The **else** part actually belongs to the **second if** (`if (x<10)`), not to the first one

Let say x=7,
Output:

```
7
```

Correct!

Let say x=11,
Output:

```
Wrong Number
```

Correct!

But, when x=12,
There is no output. This is incorrect.
It suppose to print "Wrong number"

Related issues

- Null statements are statements that do nothing

Example:

```
if (x<3);
   cout <<"Yes";
```

The semi-colon represents a null statement. Either the condition evaluates to true or false, there is nothing to do.

The `cout` doesn't belong to `if statement`. The statement has already been ended up with semi-colon previously.

Example:

```
if (x<3)
   cout <<"Yes" <<endl;
else;
   cout <<"No" <<endl;
```

Let say x=5,

Let say x=1,

Simplifying `if` statements

- Simplifying conditions:

Original statement

```
if ( a != 0 )
   statement;
```

```
if ( a > 0 )
   statement;
```

```
if ( a < 0 )
   statement;
```

Simplified statement

```
if ( a )
   statement;
```

```
if ( a == 0 )
   statement;
```

```
if ( !a )
   statement;
```

Simplifying `if` statements

- Example 1 : print a number only if it is an odd number

Original statement *Simplified statement*

```
if ( n%2==1 )
    cout << n;
```

```
if ( n%2 )
    cout << n;
```

- Example 2: print a number only if it is an even number

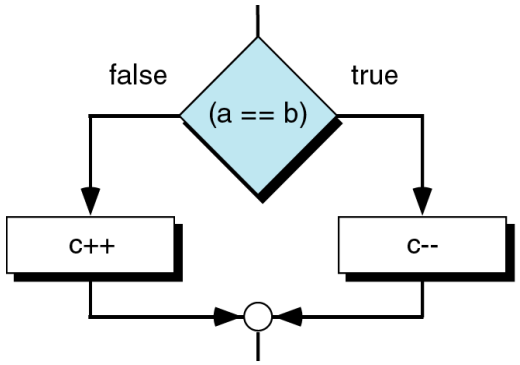
Original statement *Simplified statement*

```
if ( n%2==0 )
      cout << n;
```

```
if ( !(n%2) )
    cout << n;
```


Simplifying `if` statements

- Conditional Expressions:



(a) Logic Flow

```
a==b ? c--: c++
```

(b) Code

Simplifying `if` statements

- Conditional Expressions:

If the condition is **true**, take the **value1**

If the condition is **false**, take the **value2**

Syntax:

```
condition ? value1 : value2
```

Example:

```
p = (q<5) ?  q + 1  : 5;
```

This statement means

```
if (p<5)
     p = q + 1;
else
     p = 5;
```


`switch` statement

- If there are many nested if/else statements, you may be able to replace them with a switch statement:

```
if (letter_grade == 'A')
        cout << "Excellent!";
else if (letter_grade == 'B')
        cout << "Very good!";
else if (letter_grade == 'C')
        cout << "Good";
else if (letter_grade == 'D')
        cout << "Adequate";
else
        cout << "Fail";
```

```
switch (letter_grade)
{
 case 'A' : cout <<"Excellent!";
            break;

 case 'B' : cout <<"Very good!";
            break;

 case 'C' : cout <<"Good";
            break;

 case 'D' : cout <<"Adequate";
            break;

 default  : cout <<"Fail";
            break;
}
```

switch statement

```
switch (expression)
{
 case value1: statements_1;
              break;

 case value2 : statements_2;
              break;
  ...

 default : statements;
           break;
}
```

How the **switch** statement works?

1. Check the value of expression.
2. Is it equal to value1?
   - If yes, execute the statements_1 and break out of the switch.
   - If no, is it equal to value2? etc.
3. If it is not equal to any values of the above, execute the default statements and then break out of the switch.

switch statement

Example 1:

```
int value = 1;

switch (value)
{
 case 1: cout << "One";
         break;

 case 2: cout << "Two";
         break;

 default : cout << "Neither One nor Two";
           break;
}
```

evaluates to 1

it is equal to this case-value (i.e. 1==1). So, execute the statements of 'case 1'.

Prints One

break out of the switch

switch statement

Example 2:

```
int value = 1;

switch (value + 1)
{
 case 1: cout << "One";
         break;

 case 2: cout << "Two";
         break;

 default : cout << "Neither One nor Two";
           break;
}
```

this expression evaluates to 2

it is not equal to this case-value (i.e. 2!=1). So, skip the statements of 'case 1' and move to the next case.

it is equal to this case-value (i.e. 2==2). So, execute the statements of 'case 2'.

Prints Two

break out of the switch

switch statement

Example 3:

```
int value = 5;

switch (value)
{
 case 1: cout << "One";
         break;

 case 2: cout << "Two";
         break;

 default : cout << "Neither One nor Two";
           break;
}
```

evaluates to 5

The switch expression (i.e. 5) is not equal to both cases (i.e 5!=1 and 5!=2). So, their statements are skipped.

When the 'default case' is reached, its statements are always executed.

Prints Neither One nor Two

break out of the switch

switch statement

What if the `break` statement is not written?

```
int value = 1;

switch (value)
{
 case 1: cout << "One\n";

 case 2: cout << "Two\n";
         break;

 default : cout << "Neither One nor Two\n";
           break;
}
```

- evaluates to 1
- it is equal to this case-value (i.e. 1==1). So, execute the statements of the 'case 1'.
- Prints One
- No `break` statement here. So, no break out and move to the next line.
- Prints Two
- break out of the switch

switch statement

- The switch expression must be of integral type (i.e. `int`,`char`,`bool`).
- The following examples would be an error

```
void main()
{
 float point=4.0;
 int mark;

 switch (point)
 {
   case 4   : mark = 100;
              break;

   case 3.7 : mark = 80;
              break;

   default  : mark = 0;
              break;
 }

}
```

Error! The switch expression cannot be a `float` value

```
void main()
{
 char name[]="Ali";
 int mark;

 switch (name)
 {
   case "Ali"    : mark=95;
                   break;

   case "Aminah": mark=90;
                   break;

   default      : mark=50;
                   break;
 }
}
```

Error! The switch expression cannot be a `string` value

switch statement

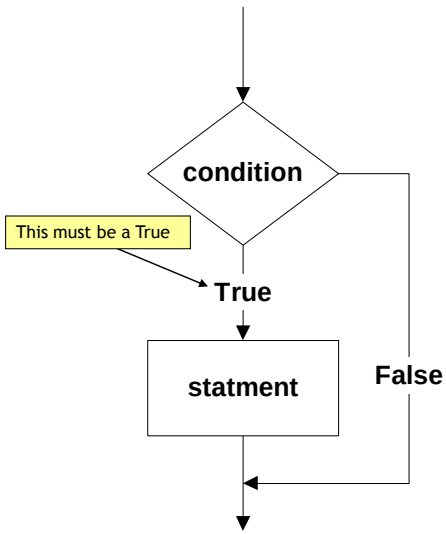
- The case-value must be a constant (literal, memory or defined constant)
- The following example would be an error

```
void main()
{
 #define DEFINE 1
 const int const2=2;
 int var3 = 3;
 int value;

 switch (value)
 { case 0        : cout << "Four";
                   break;

   case DEFINE   : cout << "One";
                   break;

   case const2   : cout << "Two";
                   break;

   case var3     : cout << "Three";
                   break;
 }
}
```

- a literal is OK
- a defined constant is OK
- a memory constant is OK
- **Error!** case-value cannot be a variable

Translating flowchart to C++ code

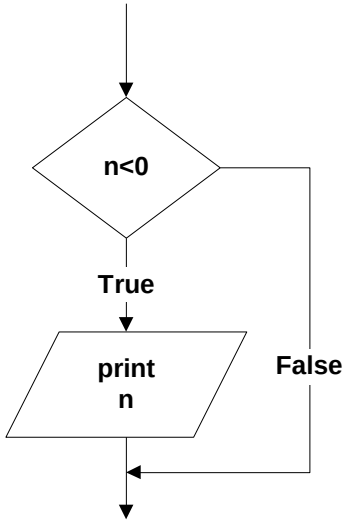
Pattern 1




```
if (condition)
{
 statement;
}
```

Translating flowchart to C++ code

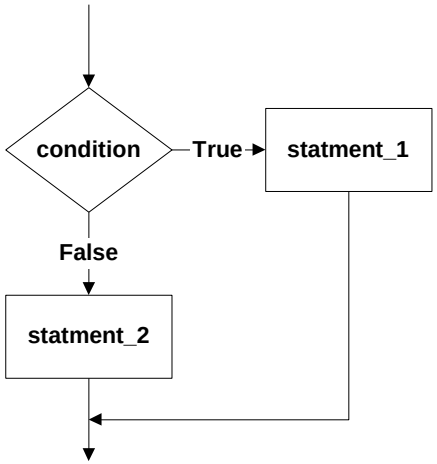
Example 1: *Printing a number only if it is a negative*




```
if (n<0)
{
 cout << n;
}
```


Translating flowchart to C++ code

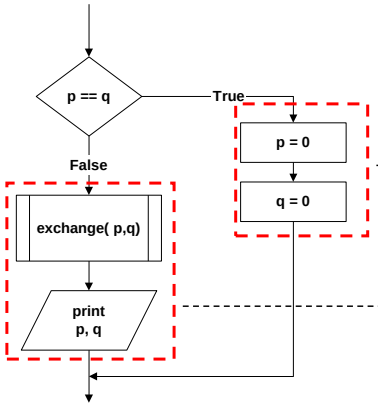
Pattern 2




```
if (condition)
{
 statement_1;
}
else
  {
    statement_2;
  }
```


Translating flowchart to C++ code

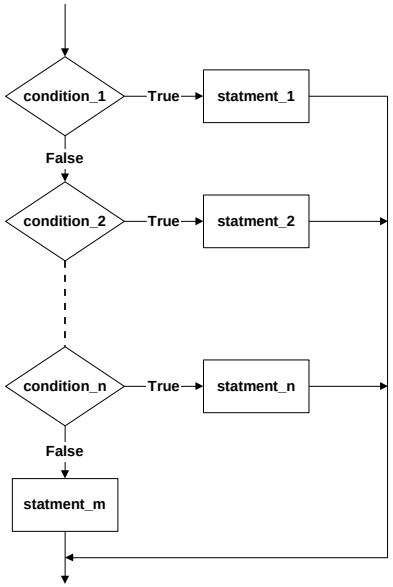
Example 2: *If two numbers (p and q) are equivalent reset them to zero, otherwise exchange or swap their value each other and then print the new values.*




```
if (p==q)
{
  p = 0;
  q = 0;
}
else
{
  exchange(&p,&q);
  cout << p << q;
}
```


Translating flowchart to C++ code

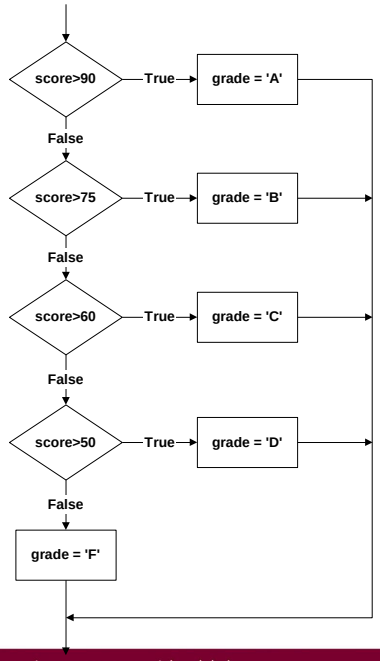
Pattern 3




```
if (condition_1)
{
 statement_1;
}
else if (condition_2)
{
 statement_2;
}
      .
      .
      .
else if (condition_n)
{
 statement_n;
}
else
{
 statement_m;
}
```

Translating flowchart to C++ code

Example 3: *Identifying the grade of a score*



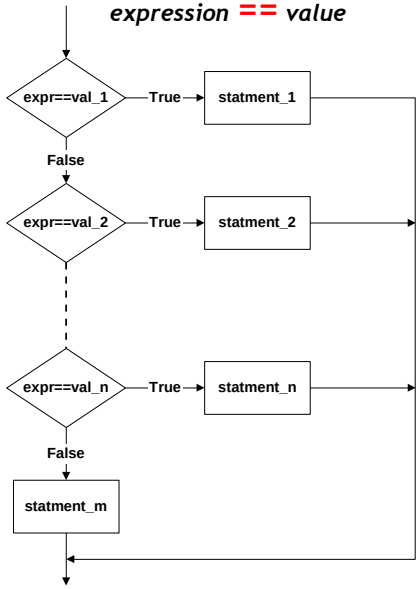

```
if (score > 90)
{
   grade  = 'A';
}
else if (score > 75)
{
   grade = 'B';
}
else if (score > 60)
{
   grade = 'C';
}
else if (score > 50)
{
   grade = 'D';
}
else
{
   grade = 'F';
}
```


Translating flowchart to C++ code

Pattern 4

- *The conditions must be in this form:*

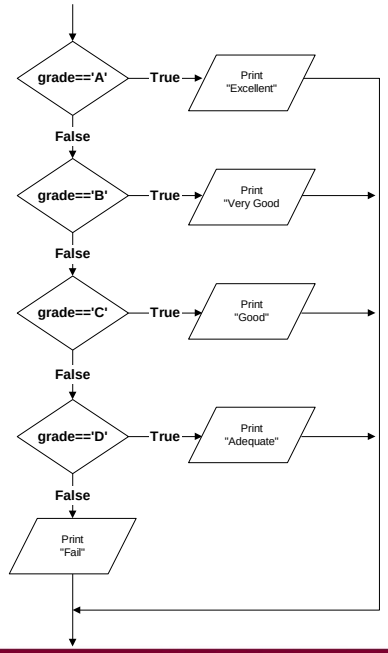
expression **==** *value*




```
switch (expr)
{
  case val_1 :   statement_1;
                 break;

  case val_2 :   statement_2;
                 break;
     .
     .
     .
  case val_n :   statement_n;
                 break;

  default:       statement_m;
                 break;
}
```


Translating flowchart to C++ code

Example 4: *Printing the description of a grade.*




```
switch (grade)
{
  case 'A' : cout << "Excellent!";
             break;

  case 'B' : cout << "Very good!";
             break;

  case 'C' : cout << "Good";
             break;

  case 'D' : cout << "Adequate";
             break;

  default  : cout << "Fail";
             break;
}
```