CS2313 Computer Programming

LT4 – Conditional Statements

Outlines

- `if` statement
  - Simple
  - Nested
- Boolean logic
- `switch` statement

Outcomes

- Work out the **boolean value** of a logic expression.
- Express decision making logic in **boolean logic**.
- Using **`if / switch`** statement to express **conditional** instruction.

Syntax Summary

- Keywords
  - `if, else, switch, case, default`.
- Punctuators
  - `(…)`
  - `{…}`
  - `:`
  - `? :`
- Operators

  `==, !, !=, >, >=, <, <=, &&, ||`

Comparative Operators

- **Binary operators** which accept two operands and compare them:

Relational operators	Syntax	Example
Less than	<	x<y
Greater than	>	z>1
Less than or equal to	<=	b<=1
Greater than or equal to	>=	c>=2

Equality operators	Syntax	Example
Equal to	==	a==b
Not equal to	!=	b!=3

Simplified Expression

Original Expression	Simplified Expression
`!(x<y)`	`x>=y`
`!(x>y)`	`x<=y`
`!(x!=y)`	`x==y`
`!(x<=y)`	`x>y`
`!(x>=y)`	`x<y`
`!(x==y)`	`x!=y`

Logical Operators

- Used for combining **logical values** and create new logical values.
- Logical **AND** (`&&`)
  - return `true` if both operands are `true`, `false` otherwise.
- Logical **OR** (`||`)
  - return `false` if both operands are `false`, `true` otherwise.
- Logical **NOT** (`!`)
  - Invert the Boolean value of the operand.

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

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

x	!x
true	false
false	true

Do not mix == and =

```
x=0;
y=1;
if (x = y){
    cout << "x and y are equal";
}
else
    cout << "unequal";
```

Output: x and y are equal.

The expression **x = y** :

- Assign the value of y to x (x becomes 1).
- The value of this expression is the value of y, i.e. 1 (which represent true)
  - false is represented by 0 .
  - true is represented by non-zero.

Assignment (=) and Equality Operator (==)

- Example: `x = 1`
- Assignment operator
- Place the value of the variable on the right to the variable on the left.
- The value of this expression will always equal to the value on the right (`1` in this case).

- Example : `x==1`
- Equality operator
- `true` (evaluates to `1`)
  - the value of `x` is `1`.
- `false` (evaluates to `0`)
  - values of `x` is not `1`.
- No space between the two `'='`

Relational, Equality & Logical Operators (Summary)

- Relational operators
  - Less than `<`
  - Greater than `>`
  - Less than or equal to `<=`
  - Greater than or equal to `>=`
- Equality operators
  - Equal to `==`
  - Not equal to `!=`
- Logical operators
  - (Unary) negation (i.e., not) `!`
  - Logical **and** `&&`
  - Logical **or** `||`

PS: Expressions with above operators have a *true* or *false* value.

Decision and Action

Real life

We make decision almost everyday.
Decision will be followed by one or more actions.

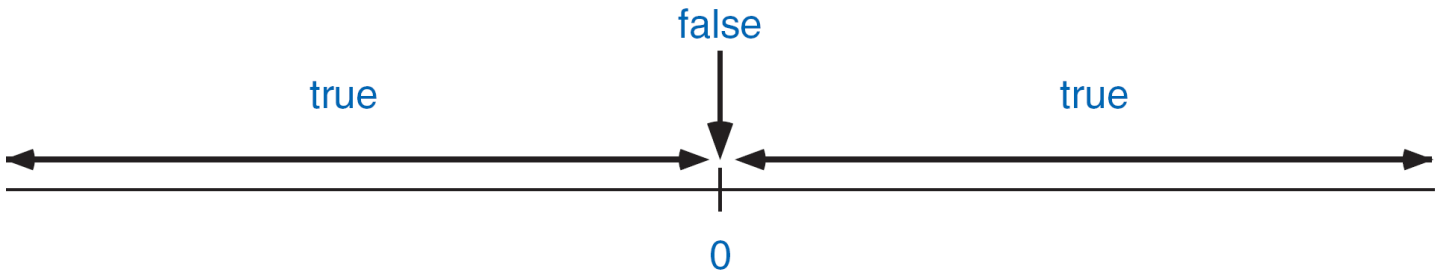
Programming

Decision is based on logical expression.
Action is in the form of program statement.

Logical Expression and Operators

- Logical expression can be true or false only.
  - `x==3`
  - `y==x`
  - `x>10`

- In C++, any **non-zero** expression will be treated as logical true.
  - `3-2` (`true`)
  - `1-1` (`false`)
  - `x=0` (`false`)
  - `X=1` (`true`)



Conditional Statements

- In decision making process, **logical** value can be used to determine the actions to take.

- E.g.
  - **If** it is raining, bring an umbrella.
  - **If** the canteen is too crowded, go to festival walk for lunch.

- In programming, certain statements will only be executed when certain condition is **fulfilled**. We call them **conditional statements**.

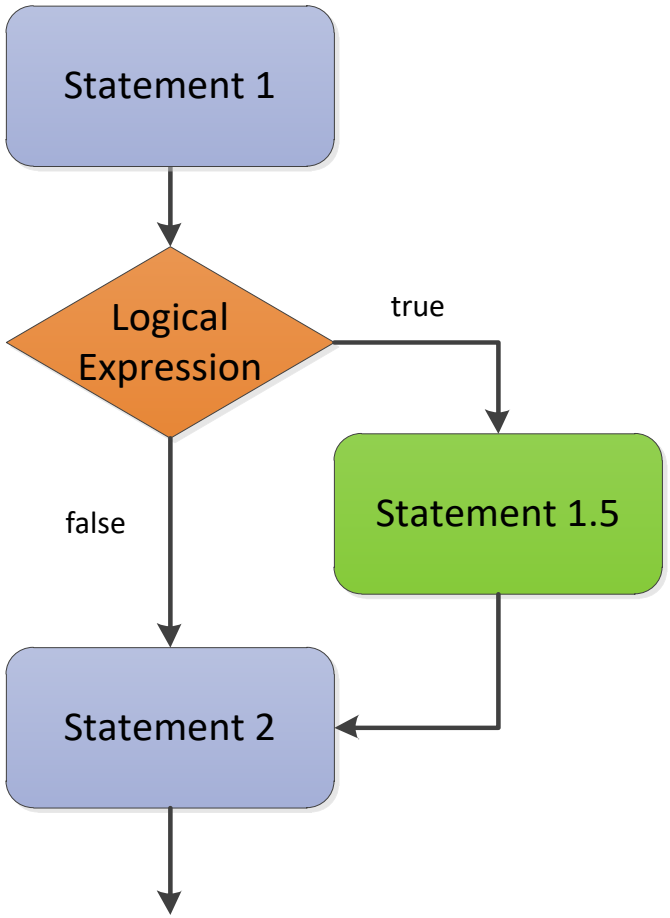
Conditional Statement: Simplest Form - if

- One or more statements will be executed if the condition is true.

```
……
Statement 1

if ( logical value 1)
     Statement 1.5

Statement 2
……
```

- C++ example:

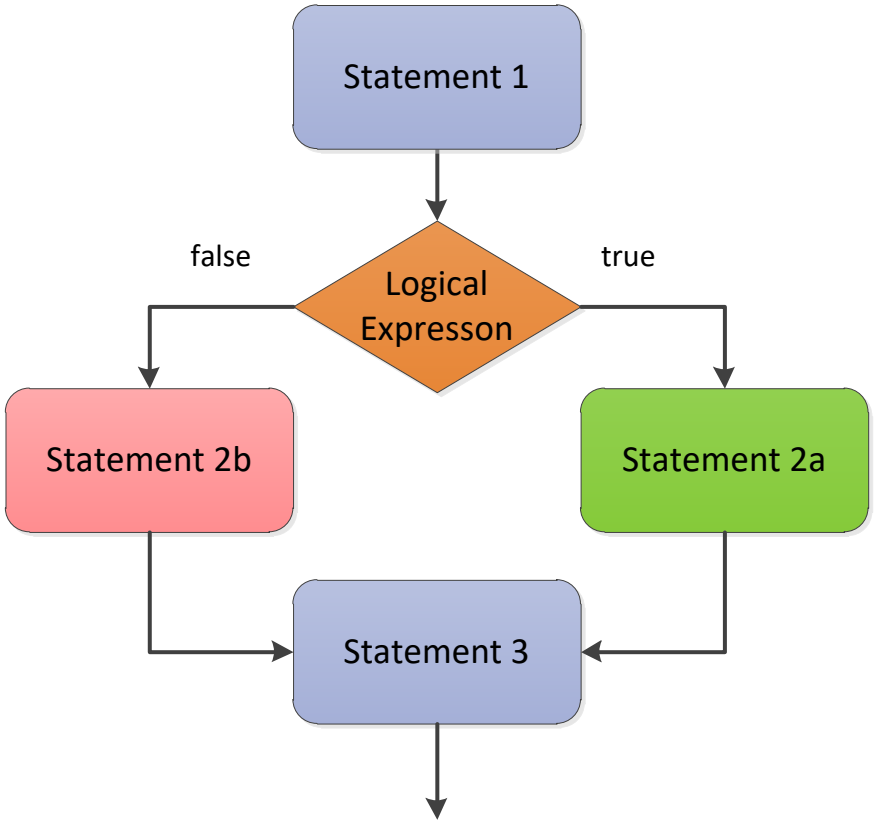
```
cin >>x;

if (x<0)
    x=-x;

cout << x << endl;
```



Two-way Selection

- If the condition is **true**, one or more statements will be executed.
- If the condition is **false**, another set of statements will be executed.

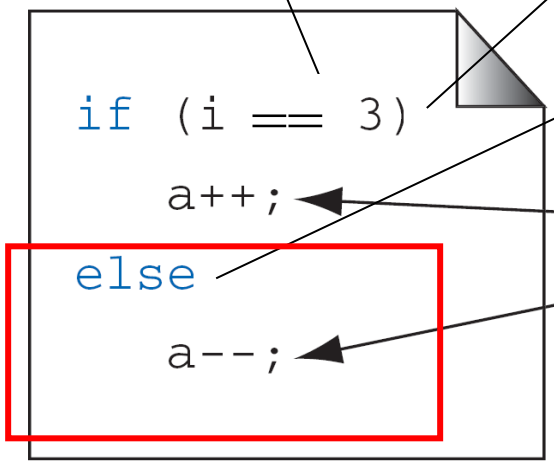
```
……
Statement 1

if (  Logical expression)
     statement 2a  //action for true
else
     statement 2b //action for false

Statement 3
……
```



Some Points to Note

The expression should be enclosed with parenthesis ()

No semi-colon after if or else



The semicolons belong to the expression statements, not to the *if … else* statement

The else part is optional

i == 3 evaluates to a non-zero value

i == 3 evaluates to zero

If i==3 is true, increment a by 1, otherwise (i==3 is false), decrement a by 1.

Compound Statement

- Group statements into an executable unit (a **block**):
  - if there are more than one statement to be executed for a particular `if`, `else if`, or `else` statement.

```
if (mark>=70){
        cout << "You get grade A.\n";
        cout << "Excellent!\n";
}
else if ......
else ......
```

Compound Statement

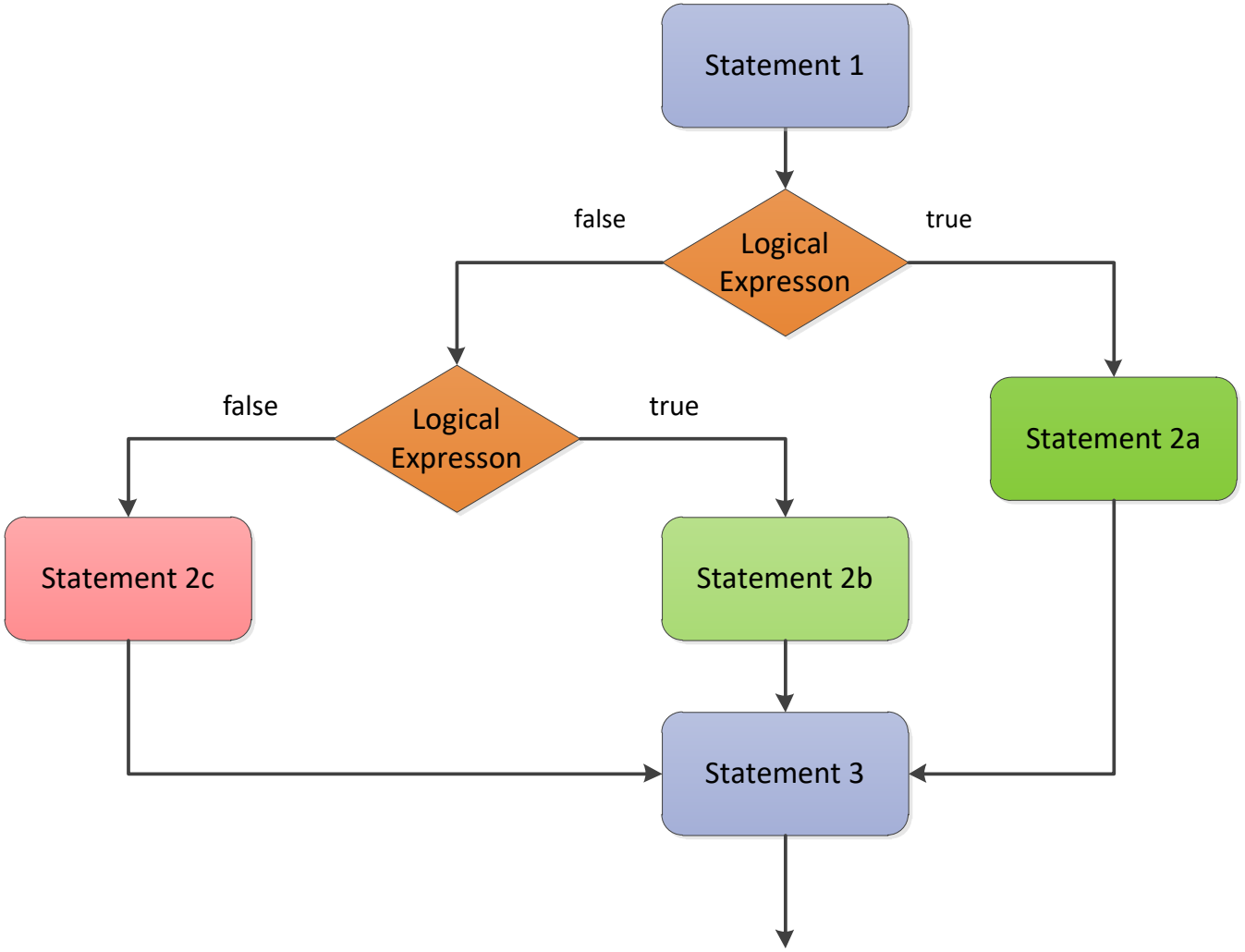
We may group multiple statements to form a compound statement using a pair of braces {}.

```
if (j!=3)
{
  b++;
  cout << b;
} //if
else
  cout < j;
```

Compound statements are treated as one statement.

```
if (j!=5 && d==2)
{
  j++;
  d--;
  cout << j <<d;
} //if
else
{
  j--;
  d++;
  cout << j << d;
} //end else
```

Beyond Two Way Condition…Nested

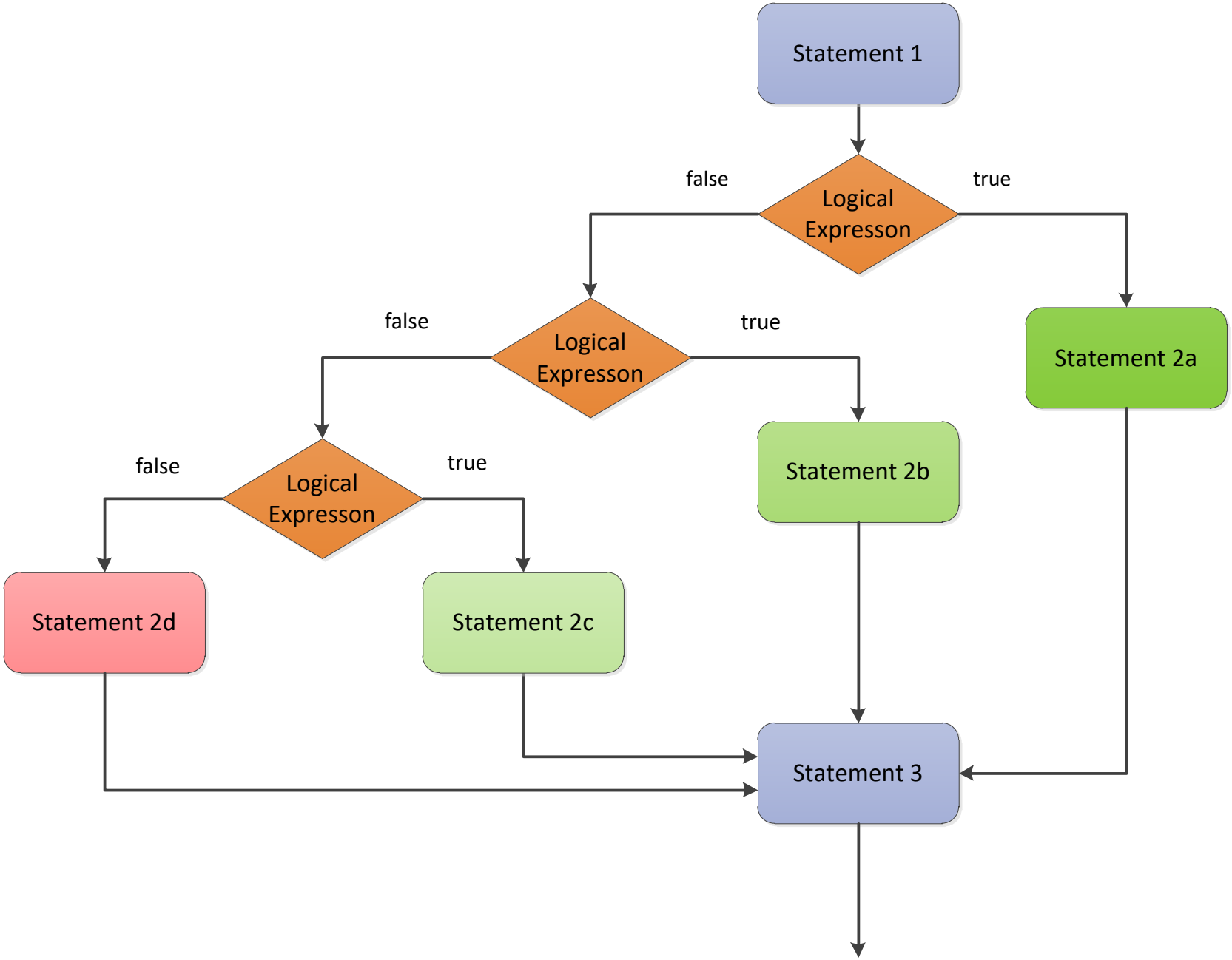


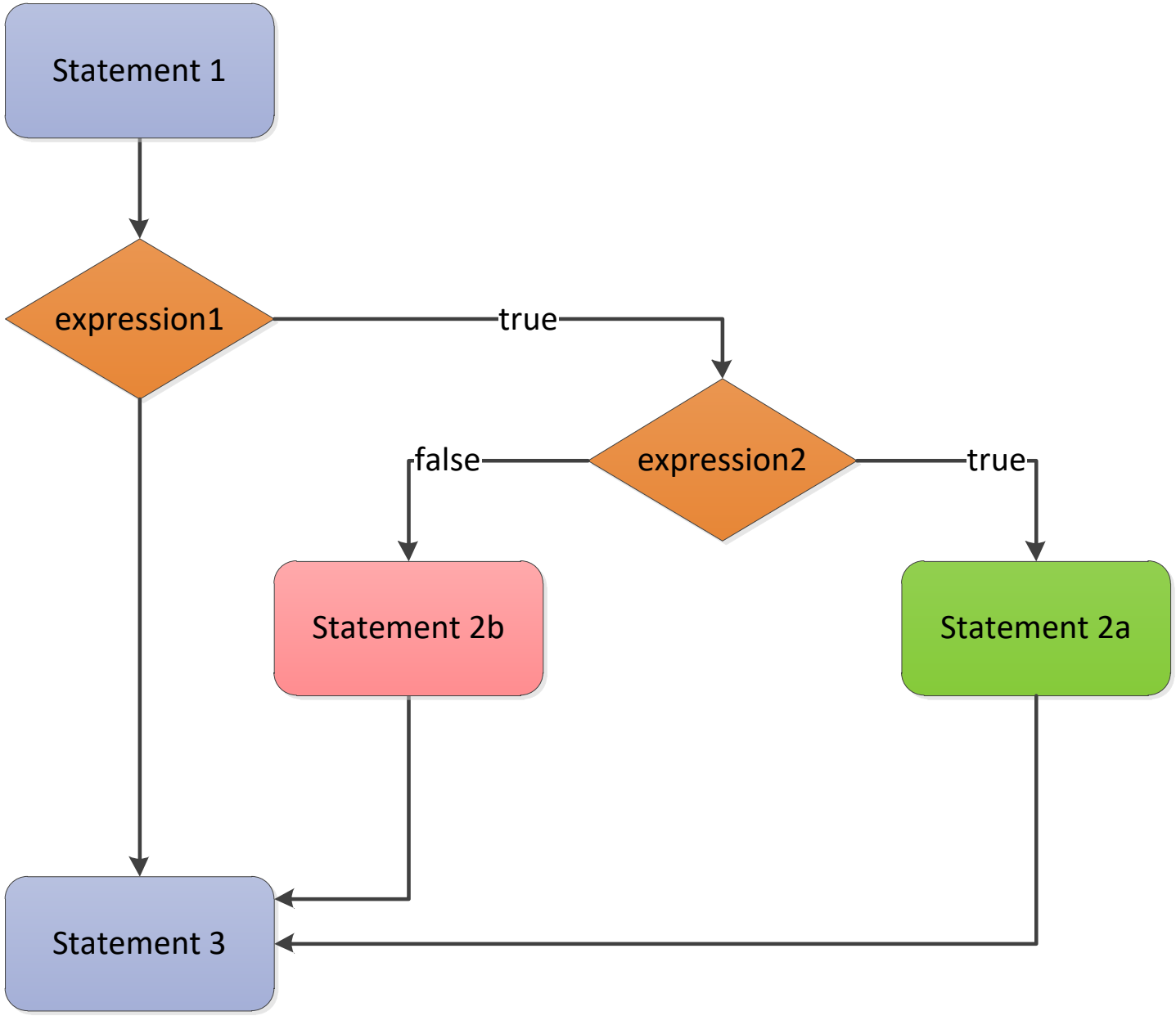
Beyond Two Way Condition…

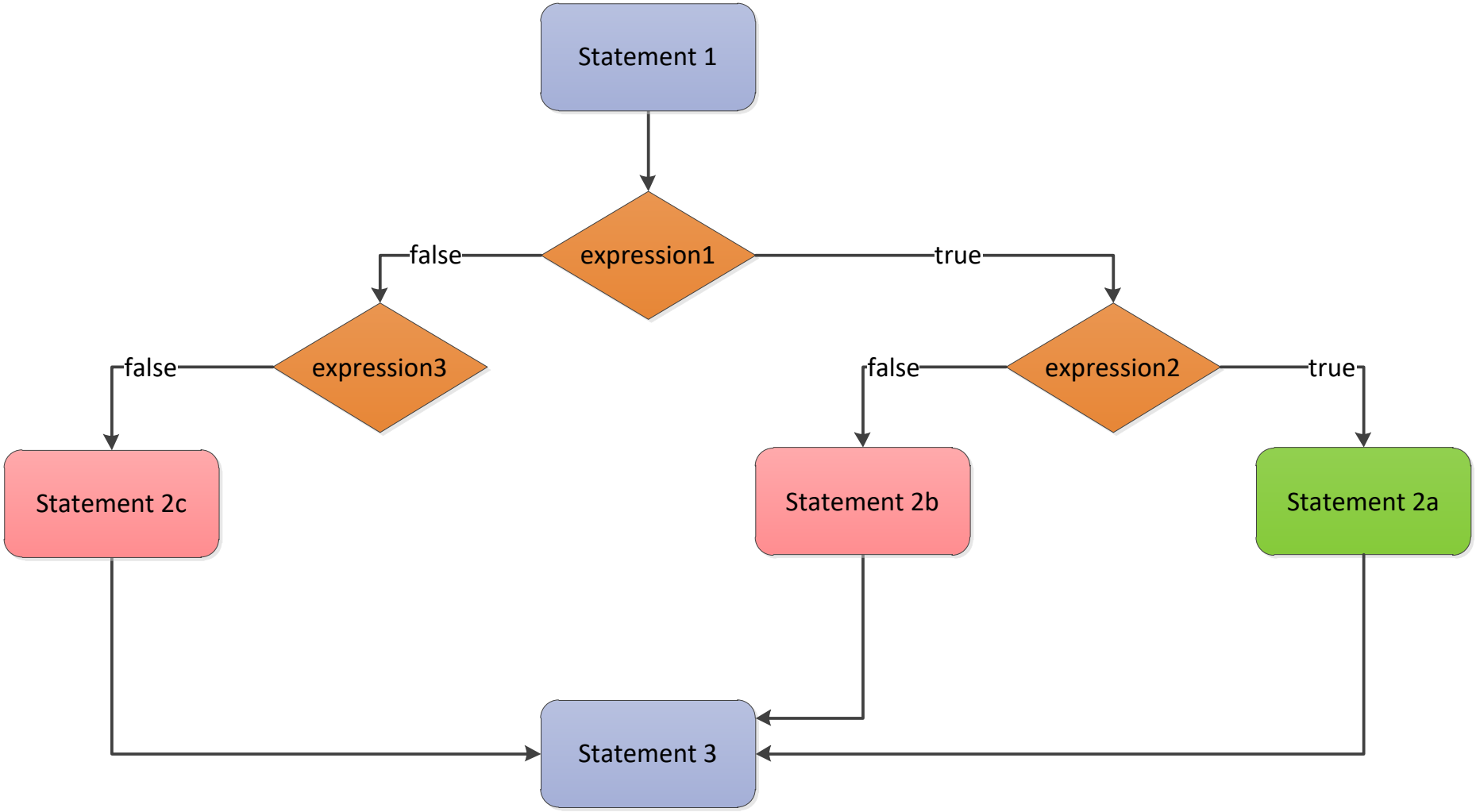
- In C++, **conditional statements** has the following format:

```
if (  logical value 1) {
    statements for logical value 1 is true
} else if (logical value 2) {
    statements for logical value 1 is false but logical value 2 is true
} else if (…)
…
} else {
    statements for all the logical values are false
}
```

- The `else if` and `else` part are optional.
- The braces can be omitted if the block contains only **one** statement.


Statement 1
false
Logical Expresson
true
false
Logical Expresson
true
Statement 2a
false
Logical Expresson
true
Statement 2b
Statement 2d
Statement 2c
Statement 3


Statement 1
expression1
true
expression2
false
true
Statement 2b
Statement 2a
Statement 3


Statement 1
expression1
false
true
expression3
expression2
false
false
true
Statement 2c
Statement 2b
Statement 2a
Statement 3

Examples – Single Statement

```
if (x>5){
  cout << " x is too large';
}
```

```
if (x>5)
  cout <<" x is too large";
else if (x<3)
  cout << " x is too small";
else
  cout << " x is a valid answer";
```

```
if (x>5)
  cout << " x is too large";
else if (x<3)
  cout << " x is too small";
```

Examples – Compound Statements

```
if (x==3)
  cout << "x is equal to 3";

if (x>y) {
  z=x-y;
  cout << "x is larger, the difference is " << z;
} else {
   z=y-x;
  cout << "y is larger, the difference is " << z;
}
```

Beware of Empty Statements!

```
int x=5;
if (x!=5);
  x=3;
  cout << x;
/*output is 3*/
```

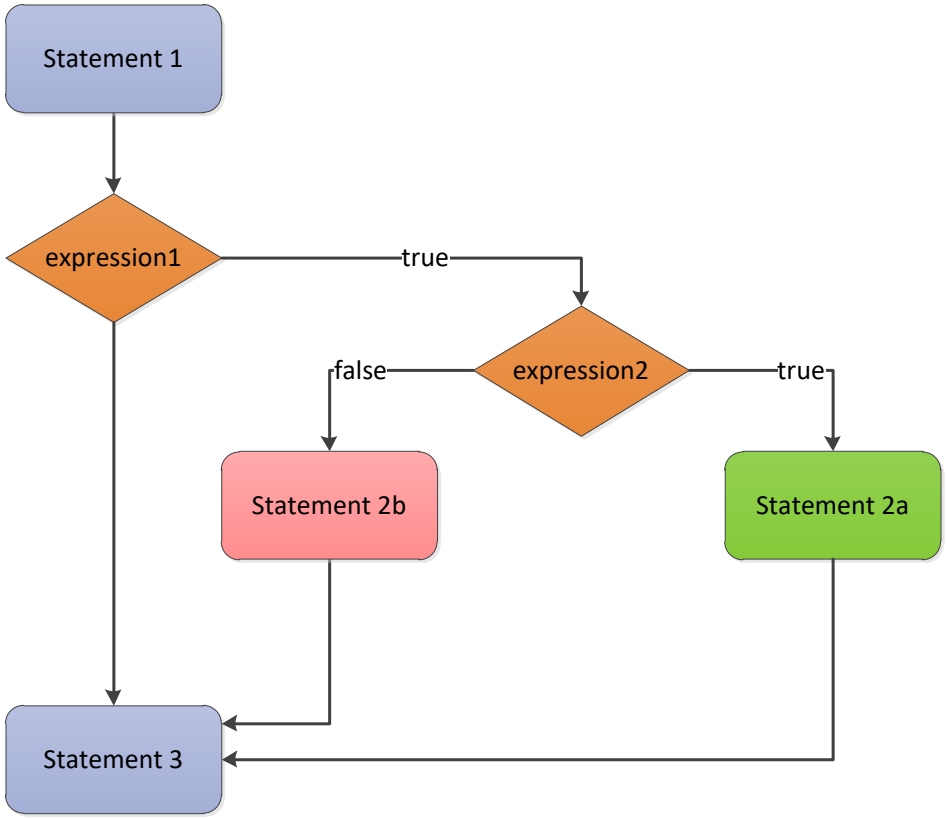
```
int x=5;
if (x!=5)
  x=3;
  cout << x;
/*output is 5*/
```

An empty statement can be specified by a semi-colon '`;`'. Empty statement specifies that no action should be performed.

For the second program, `x` is assigned `3` if `x` not equals to `5`.
For the first program, because of the extra semi colon at the end of the if statement, nothing is executed when `x!=5`.

Nested `if` Statement

An `if-else` statement is included by another `if-else` statement.




```
statement1
if (expression1)
    if (expression2)
        statement2a
    else
        statement2b
statement3
```

Dangling `else` Problem

- With which `if` the `else` part is associated?

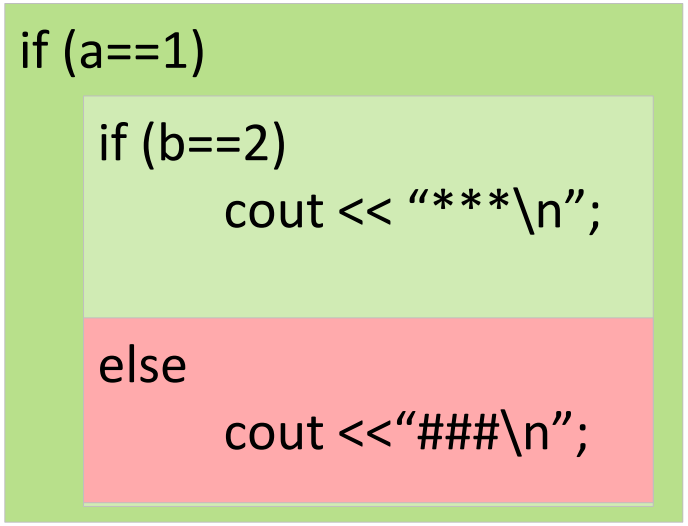
```
if (a==1)
    if (b==2)
        cout << "***\n";
    else
        cout << "###\n";
```

```
if (a==1)
    if (b==2)
        cout << "***\n";
else
    cout << "###\n";
```

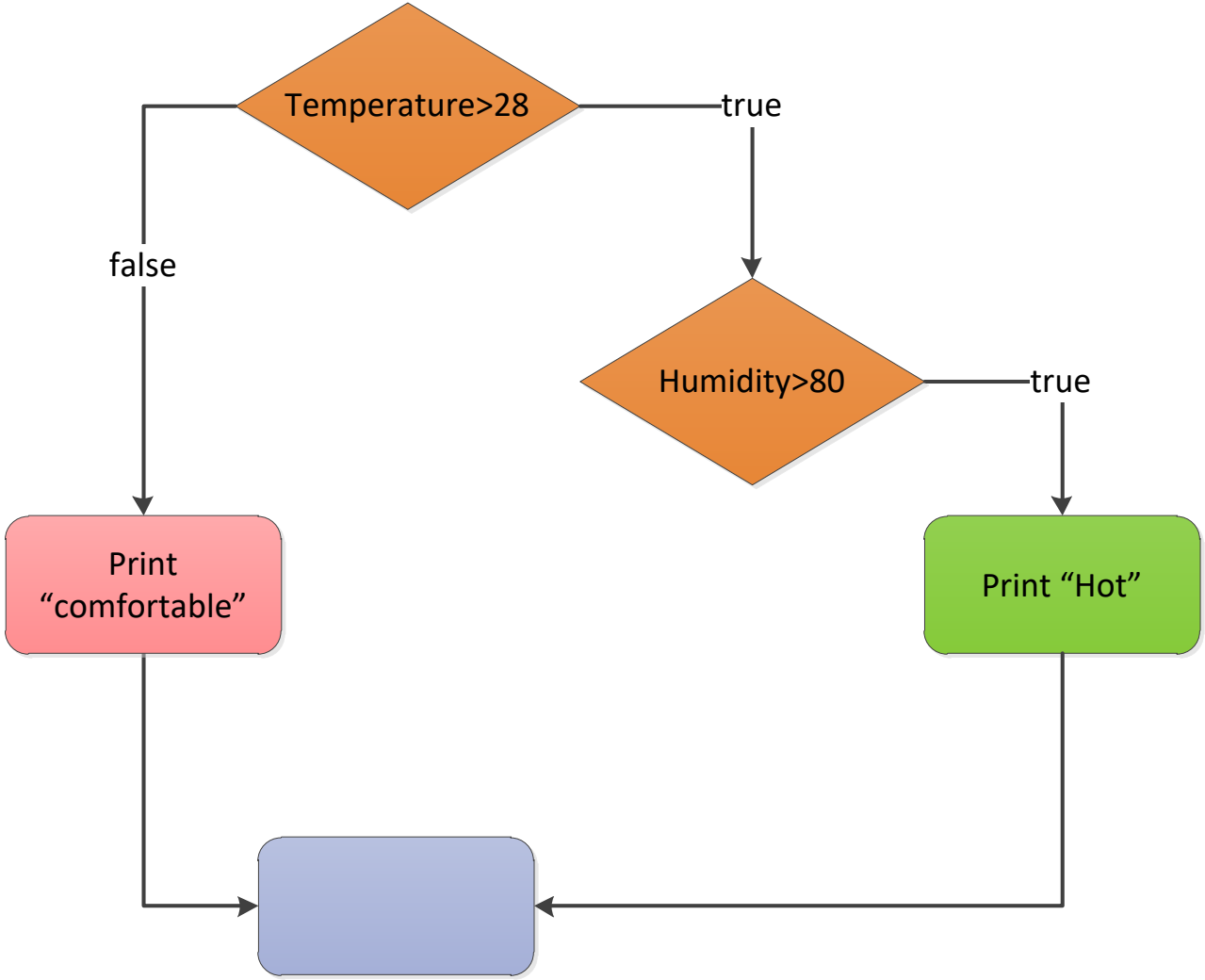
Dangling `else` Problem

- An `else` attached to the nearest `if`.

```
if (a==1)
    if (b==2)
        cout << "***\n";
    else
        cout << "###\n";
```



Suppose We Want to Implement the Following Logic



Condition

- Certain portion of code is executed when certain condition is `true`.

- The condition is specified by an **expression**, which evaluates to `true` or `false`.

Example: Passing CS2313

- If you get a total mark greater than or equal to `34`. You will pass the course.
  - *This is just an example!*
- Otherwise, you will fail.

Greater than or equal to is a kind of "relational operator".
Represented by the operator **>=** in C++.
How to represent the above logic in C++?

Example 1a: Pass or Fail?

```
int mark;
cout << "What is your mark?\n";
cin >> mark;
if (mark>=34)
   cout << "You passed in CS2313!\n";
```

The condition should be enclosed within `()`.
If the input mark is greater than or equal to `34`, the blue statement is executed.

Example 1b: Pass or Fail?

```
int mark;
cout << "What is your mark?\n";
cin >> mark;
if (mark>=34){
   cout << "You passed in CS2313!\n";
   cout << "congratulations\n";
}
```

If more than one statements are specified within an `if` statement, group the statements in a pair of braces **{ }**.

Example 1c: Pass or Fail?

```
int mark;
cout << "What is your mark?\n";
cin >> mark;
if (mark>=34){
   cout << "You passed in CS2313!\n";
   cout << "Congratulations\n";
}
else
   cout << "You failed in CS2313!\n";
```

The else statement is executed when the condition `mark>=34` is `false`.

Example 1c: Pass or Fail?

```
int mark;
cout << "What is your mark?\n";
cin >> mark;
if (mark>=34){
    cout << "You passed in CS2311!\n";
    cout << "Congratulations\n";
}
else
    cout << "You failed in CS2311!\n";
    cout << "You should retake the course\n";
```

Suppose the user inputs 35. The output:

```
You passed in CS2311!
Congratulations
You should retake the course
```

Why?

Example 1c: Pass or Fail?

```
int mark;
cout << "What is your mark?\n";
cin >> mark;
if (mark>=34){
    cout << "You passed in CS2311!\n";
    cout << "Congratulations\n";
}
else {
    cout << "You failed in CS2311!\n";
    cout << "You should retake the course\n";
}
```

Include a brace to group the statements in the else part!

Example 2a: Mark to Grade Conversion

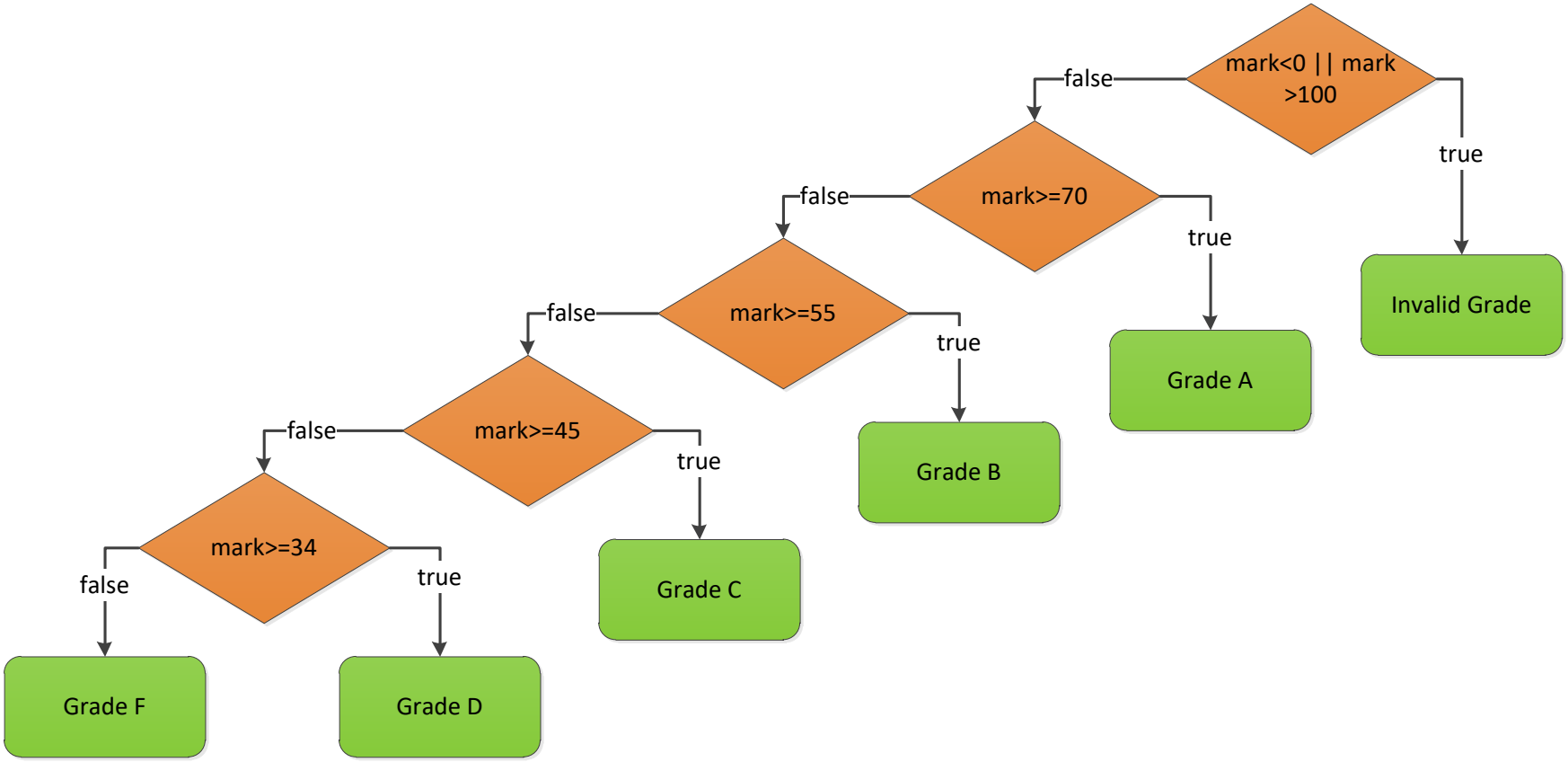
```
if (mark>=70 && mark<=100)
      cout << "A";
if (mark>=55 && mark<70)
      cout << "B";
if (mark>=45 && mark<55)
      cout << "C";
if (mark>=34 && mark<45)
      cout << "D";
if (mark<34 && mark>0)
      cout << "F";
if (mark<0 || mark>100)
      cout << "Invalid Grade";
```

Mark to Grade Conversion (`else-if` version)

```
if (mark<0 || mark>100)
   cout << "Invalid Grade";
else if (mark>=70)
   cout << "A";
else if (mark>=55)
   cout << "B";
else if (mark>=45)
   cout << "C";
else if (mark>=34)
   cout << "D";
else
   cout << "F";
```

The `else if` or `else` part is executed only if all the preceding conditions are `false`.

Mark to Grade Conversion



C++ Syntax Is Different from the Math Syntax

```
if (mark>=70 && mark<=100)
   ……
```

Can we express the above condition as follows?

```
if (70<=mark<=100)
   ……
```

Ans: No, the above statement is syntactically correct (can be compiled), but the meaning is **different** (contains a logical error).

Nested `if`

An `if` statement can be nested within another `if` statement.

```
if (mark>=70 && mark <=100){
        if (mark>90)
                cout << "You get grade A+.\n";
        else if (mark>80)
                cout << "You get grade A.\n";
        else
                cout << You get grade A-.\n";
}
else if ……
```

This statement is executed if `mark>=70` and `mark<=100` and `mark<=90` and `mark>80`.

Example 2b

Modify the previous program such that if the mark is `100`, the statement `"Full mark!”` should be printed (in addition to the grade).

Example 2b

```
if (mark>=70 && mark <=100){
        if (mark>90){
                cout << "You get grade A+.\n";
                if (mark==100)
                        cout << "\nFull mark!\n";
        }
        else if (mark>80)
                cout << "You get grade A.\n";
        else
                cout << "You get grade A-.\n";
}
else if ……
```

Short-Circuit Evaluation

- Evaluation of expressions containing `&&` and `||` **stops** as soon as the outcome `true` or `false` is known and this is called ***short-circuit evaluation*.**

- Short-circuit evaluation can improve program efficiency.

- Short-circuit evaluation exists in some other programming languages too, e.g., C and Java.

Short-Circuit Evaluation

Given integer variable `i`, `j` and `k`, what are the **outputs** when running the program fragment below?

```
k = (i=2) && (j=2);
cout << i << j << endl; /* 2  2 */
k = (i=0) && (j=3);
cout << i << j << endl; /* 0  2 */
k = i || (j=4);
cout << i << j << endl; /* 0  4 */
k = (i=2) || (j=5);
cout << i << j << endl; /* 2  4 */
```

`switch` Statement

General format of `switch` statement (*selection* statement).

```
switch (expression) {
   case constant-expr1: statement1
   case constant-expr2: statement2
   …
   …
   case constant-exprN: statementN
   default: statement
}
```

Example

```
#include <iostream>
using namespace std;

int main(){
    int x;
    cin >> x;

    switch (x){
          case 0:
            cout << "Zero";
            break;
          case 1:
            cout << "One";
            break;
          case 2:
            cout << "Two";
            break;
          default:
            cout << "Greater than two";
    }  //end switch
    return 0;
}
```

`switch` Statement (cont'd)

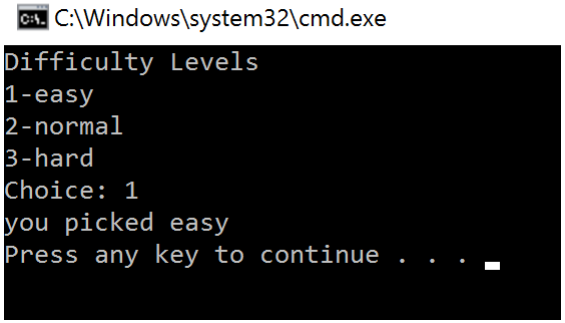
Semantics

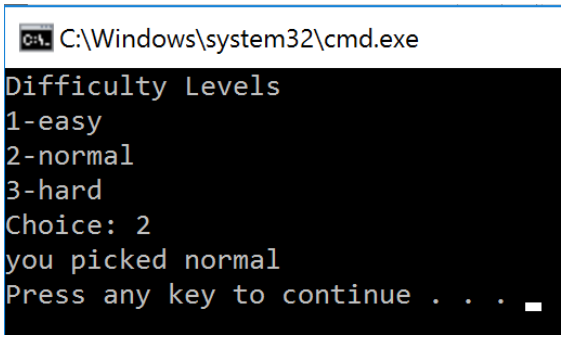
- Evaluating the `switch` expression returns an integer type (`int`, `long`, `short`, `char`).
- Go to the `case` label having the constant value that matches the value of the `switch` expression; if a match is not found, go to the `default` label; if `default` label does not exist, terminate the `switch`.
- Terminate the switch when a `break` statement is encountered.
- If there is no `break` statement, execution "*falls through*" to the next statement in the succeeding case.

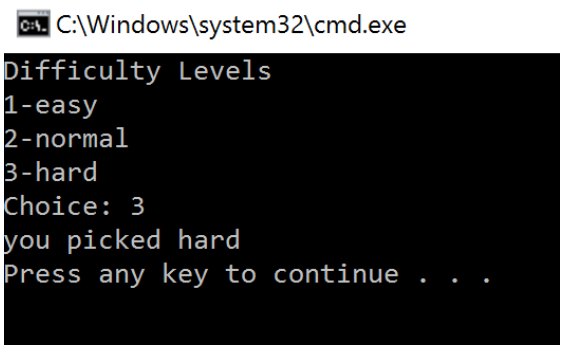
A Program Segment Using `switch`

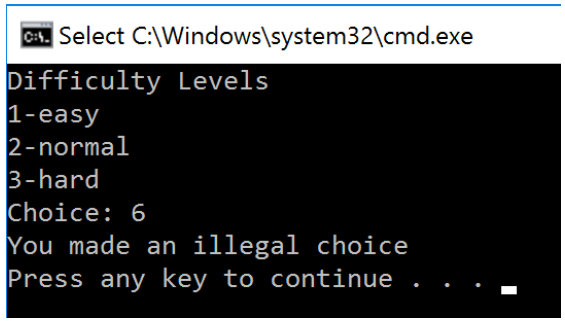
```
while ((c = getchar()) != EOF) {  /* get a char */
   switch (c) {
     case '0': case '1': case '2': case '3': case '4':
     case '5': case '6': case '7': case '8': case '9':
        digit_count++;   /* no braces is needed */
    break;
     case ' ': case '\n': case '\t':
    white_character_count++;
    break;
     default:
    other_character_count++;
    break;
   }
}
```

```cpp
#include <iostream>
using namespace std;

int main() {
    cout << "Difficulty Levels" << endl;
    cout << "1-easy"   << endl;
    cout << "2-normal" << endl;
    cout << "3-hard"   << endl;

    int choice;
    cout << "Choice: ";
    cin  >> choice;

    switch (choice)
    {
        case 1:
            cout << "you picked easy" << endl;
            break;
        case 2:
            cout << "you picked normal" << endl;
            break;
        case 3:
            cout << "you picked hard" << endl;
            break;
        default:
            cout << "You made an illegal choice" << endl;
    }

    return 0;
}
```









```cpp
#include <iostream>
using namespace std;

int main() {
    cout << "Difficulty Levels" << endl;
    cout << "1-easy"   << endl;
    cout << "2-normal" << endl;
    cout << "3-hard"   << endl;

    int choice;
    cout << "Choice: ";
    cin  >> choice;

    switch (choice)
    {
        case 1:
            cout << "you picked easy" << endl;
        case 2:
            cout << "you picked normal" << endl;
        case 3:
            cout << "you picked hard" << endl;
        default:
            cout << "You made an illegal choice" << endl;
    }

    return 0;
}
```

Without **break**

C:\Windows\system32\cmd.exe

```
Difficulty Levels
1-easy
2-normal
3-hard
Choice: 1
you picked easy
you picked normal
you picked hard
You made an illegal choice
Press any key to continue . . .
```

C:\Windows\system32\cmd.exe

```
Difficulty Levels
1-easy
2-normal
3-hard
Choice: 3
you picked hard
You made an illegal choice
Press any key to continue . . .
```

C:\Windows\system32\cmd.exe

```
Difficulty Levels
1-easy
2-normal
3-hard
Choice: 2
you picked normal
you picked hard
You made an illegal choice
Press any key to continue . . .
```

Conditional (`?:`) Operator

- General format of the ternary `?:` operator is

expr1 ? expr2 : expr3

- **Semantics**
  - **`expr1`** is evaluated.
  - If the above result is non-zero, then `expr2` is evaluated; else `expr3` is evaluated.
  - The value of the whole `?:` expression is the value of expression evaluated at the end.
  - Data type of the returning value is determined by both `expr2` and `expr3`, but not the one being evaluated ultimately.

- Example
  - `int min_x=(x>y)?y:x;`

Common Errors in Conditional Statements

Common Error 1: Forgetting Necessary Braces

```
if (radius >= 0)
  area = radius * radius * PI;
  cout << "The area "
    << " is " << area;
```

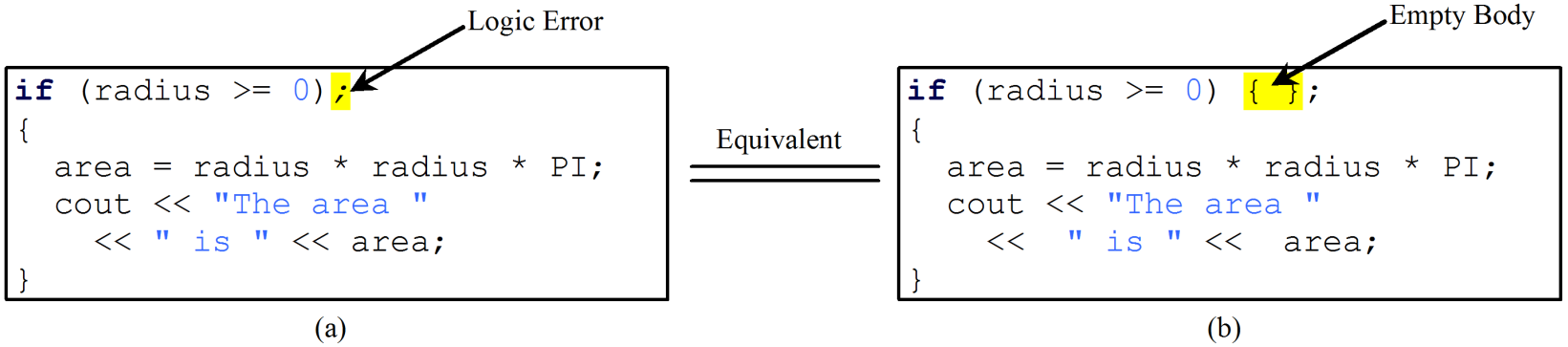
(a) Wrong

```
if (radius >= 0)
{
  area = radius * radius * PI;
  cout << "The area "
    <<  " is " <<  area;
}
```

(b) Correct

Common Errors in Conditional Statements

Common Error 2: Wrong Semicolon at the if Line



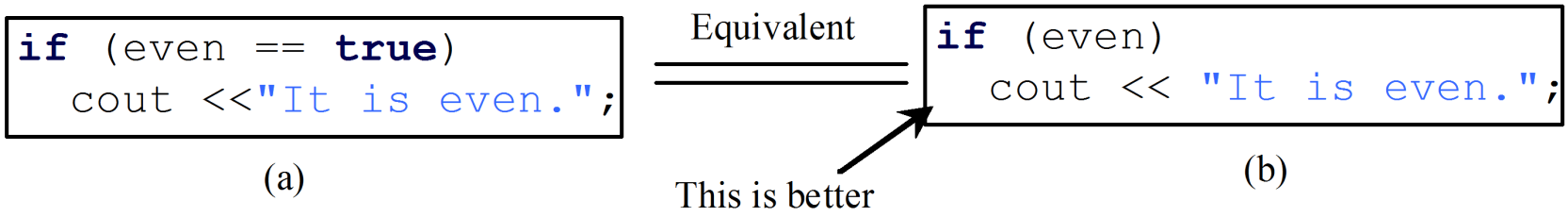
Common Errors in Conditional Statements

Common Error 3: Mistakenly Using = for ==

```
if (count = 1)
  cout << "count is zero" << endl;
else
  cout << "count is not zero" << endl;
```

Common Errors in Conditional Statements

Common Error 4: Redundant Testing of Boolean Values



This is not an error!

Trace if-else statement

Suppose score is 70.0

The condition is false

```
if (score >= 90.0)
  cout << “Grade is A";
else if (score >= 80.0)
  cout << “Grade is B";
else if (score >= 70.0)
  cout << “Grade is C";
else if (score >= 60.0)
  cout << “Grade is D";
else
  cout << “Grade is F";
```

This is just an example!

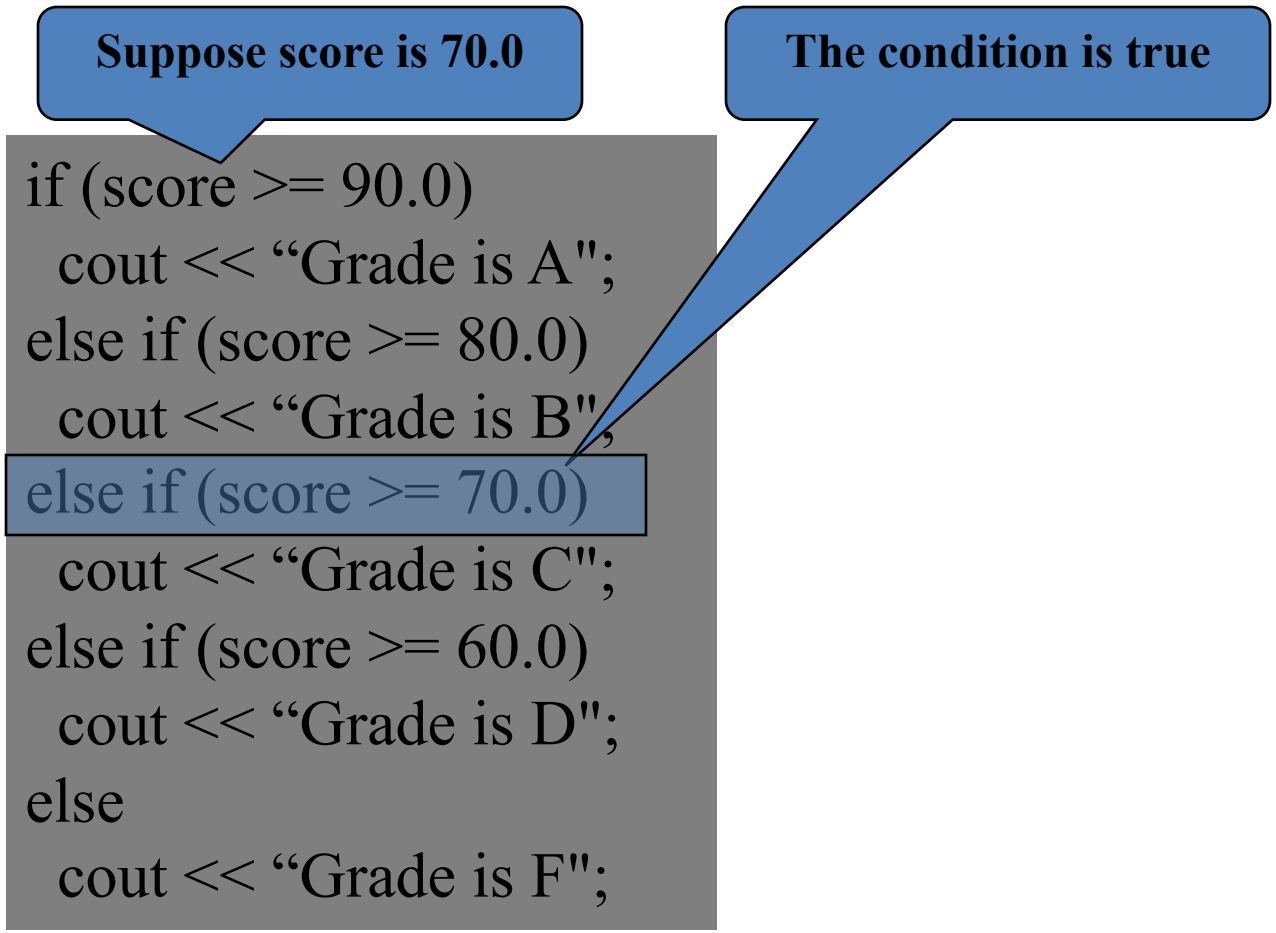
Trace if-else statement

Suppose score is 70.0

The condition is false

```
if (score >= 90.0)
  cout << “Grade is A";
else if (score >= 80.0)
  cout << “Grade is B";
else if (score >= 70.0)
  cout << “Grade is C";
else if (score >= 60.0)
  cout << “Grade is D";
else
  cout << “Grade is F";
```

Trace if-else statement



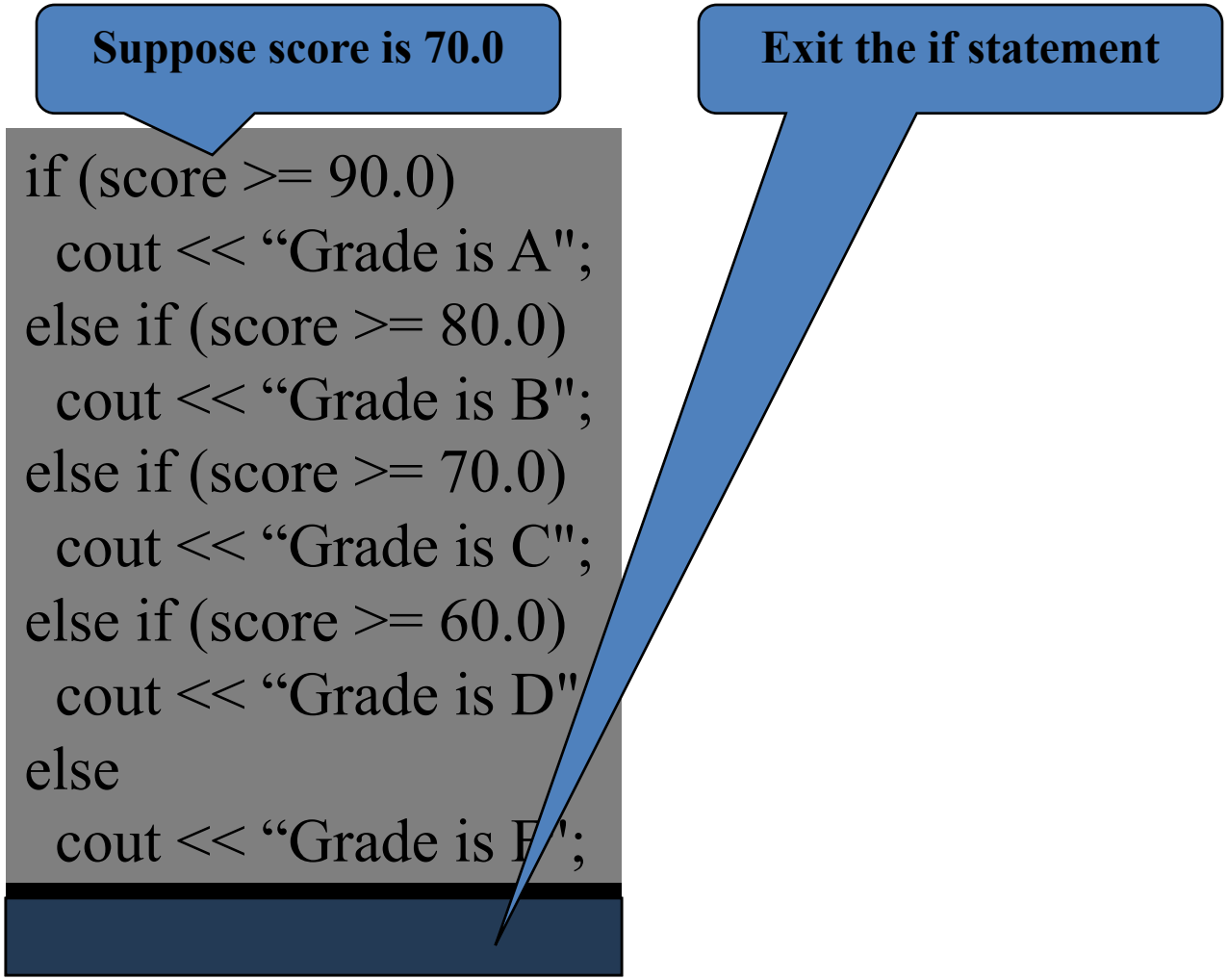
Trace if-else statement

Suppose score is 70.0

grade is C

```
if (score >= 90.0)
  cout << “Grade is A";
else if (score >= 80.0)
  cout << “Grade is B";
else if (score >= 70.0)
  cout << “Grade is C";
else if (score >= 60.0)
  cout << “Grade is D";
else
  cout << “Grade is F";
```

Trace if-else statement



Summary

- **Boolean** logic has two values only: `true` or `false`.
- **Conditional** statements are the statements will only be executed under certain condition.
- In C++, there are two approaches to construct conditional statement:
  - `If (…){…}else{…}`.
  - `switch(…){…case:break}`.