If Statements

If statements are used to switch the flow of control between alternate paths.

The If-Then Statement

The formal syntax for the if-then statement is

if-then statement :

Form:

`if (` *Boolean Expression* `)` *Statement*$_T$

Example:

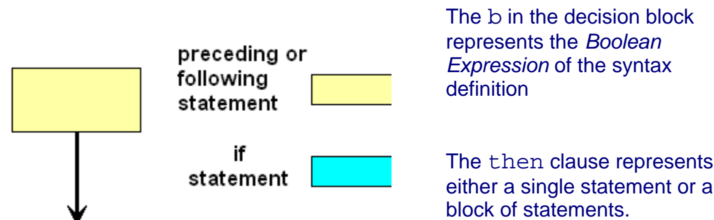
```
if (grade < 50)
    cout << "F!";
```

Interpretation: if the value of `grade` is less than `50` `"an F!"` is put into the output stream

Remember that *Statement*$_T$ can either be a *single statement* or a *statement block*.

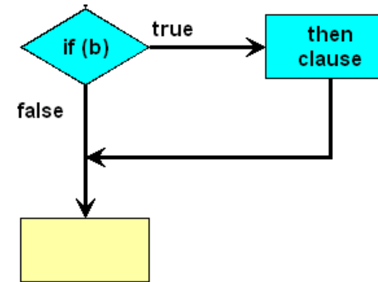
Note that there is no actual keyword for then. The T subscript on *Statement*$_T$ signifies it is the statement executed when the *boolean expression* is `true`—the *then clause*

The control flow looks like this.



The `b` in the decision block represents the *Boolean Expression* of the syntax definition

The `then` clause represents either a single statement or a block of statements.



If `b` is `true` the `then` clause is executed

If it is `false`, it is bypassed

In either case, *the flows of control come back together* and the same following statement is executed.

Let's use the `if-then` statement to determine the letter grade that should be assigned to a particular numeric mark. (Note, when the video was created, Memorial University reported grades to the nearest five marks. We've left the example to be as close to the video as possible.)

if_1.cpp

```
/*******  if demonstration ********

   In this demo we sort marks
   into letter grade bins

*******************************************/

#include <iostream>
using namespace std;

int main(){
    int mark;

    cout<< "Enter your mark: ";
    cin >> mark;

    cout << "\nThis is a";

    if (mark < 48) {
        cout << "n F.\n";
    }

    // if (48 <= mark < 52)    ***** NOT LEGAL
    if (mark >= 48 && mark < 52) {
        cout << " D.\n";
    }

    if (mark >= 52 && mark < 63) {
        cout << " C.\n";
    }

    if (mark >= 63 && mark < 78) {
        cout << " B.\n";
    }
```

```
    if (mark >= 78 ) {
        cout << "n A.\n";
    }
    return 0;
}
```

Code Notes

1. We don't bother to initialize `mark` because we know that data will be entered into it before it will be used.

2. The line

   ```
   cout << "\nThis is a" ;
   ```

   precedes all the `if` statements because we want to output it no matter what the letter grade is

3. When checking whether a mark is between boundaries, the perfectly well-formed *mathematical* condition `48 <= mark < 52` is not legal as a C++ expression and must be reformulated as two separate boolean conditions joined by an **and**

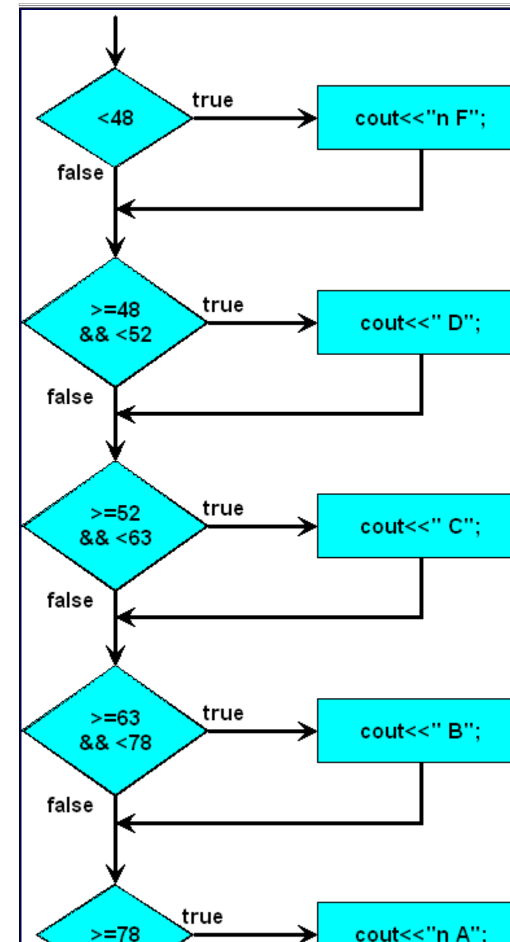
   ```
   if (mark >= 48 && mark < 52 )
   ```

4. Note that we have inserted the letter n before the A and the F. This is to make the output read correctly in English, i.e.

   `This is a B` but
   `This is an F`

You might consider point 4 fussy, but remember, *though you write the code just once it gets used many times*. This example exemplifies another important principle:

Programs are for people. Get the details right and make them people friendly



Here's how our program looks diagrammatically.

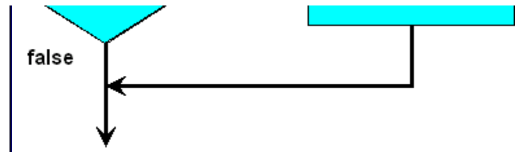
Competent C++ programmers would complain about the program.

The larger decision diamonds were made bigger to hold the bigger expressions

They demonstrate graphically that each of these require two tests to be made

Note that a lot of the tests are redundant

if the result of `mark<48` is false then we know it must be `>=48`. Why retest it?



The `if-then-else` Statement

With the `if-then-else` statement we add a second clause for the `false` case called the `else` clause.

if-then-else statement :

Form:

if (*Boolean Expression*) *Statement*$_T$
else *Statement*$_F$

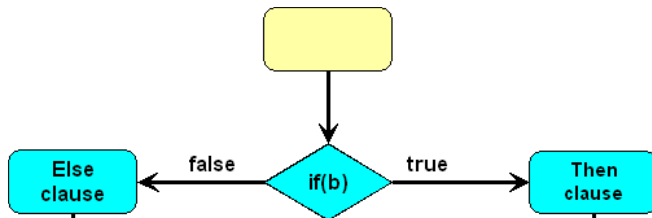
Example:

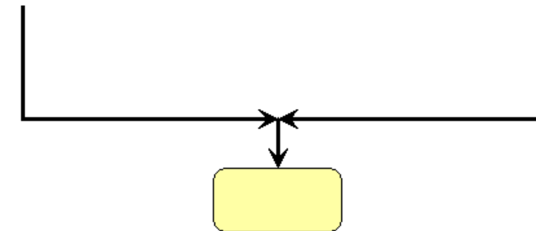
```
if (number < 0)
    cout << -number;
else
    cout << number;
```

Interpretation: if `number` is negative it outputs `-number` (a positive quantity) otherwise it ouputs `number`. i.e., outputs the absolute value of `number`

The Statement subscripts signify the statements to be executed when the *boolean expression* is `true` and `false`. So *Statement*$_T$ is the *then clause* and *Statement*$_F$ the *else clause*.

Here's the control flow:





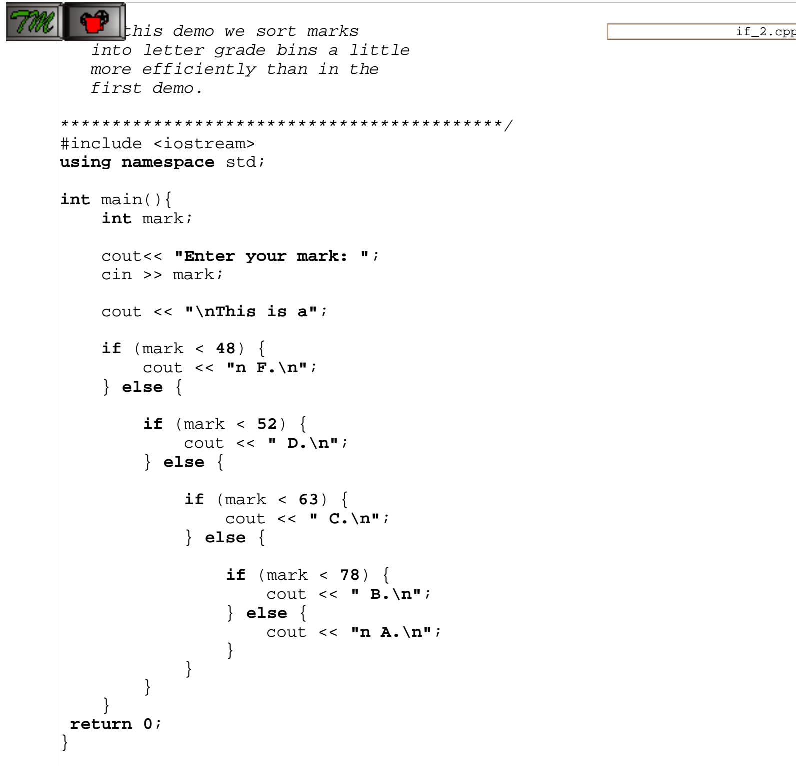
Both the then clause and the `else` clause can be either single statements or a block of statements

if the *boolean expression* `b` is `true` the then clause is executed

if it's `false` the else clause is executed

Either clause can be a single statement or a block of statements.

Let's see how we can use the if-then-else form of the if statement to improve our first example.



```
this demo we sort marks                                    if_2.cpp
   into letter grade bins a little
   more efficiently than in the
   first demo.

******************************************/
#include <iostream>
using namespace std;

int main(){
    int mark;

    cout<< "Enter your mark: ";
    cin >> mark;

    cout << "\nThis is a";

    if (mark < 48) {
        cout << "n F.\n";
    } else {

        if (mark < 52) {
            cout << " D.\n";
        } else {

            if (mark < 63) {
                cout << " C.\n";
            } else {

                if (mark < 78) {
                    cout << " B.\n";
                } else {
                    cout << "n A.\n";
                }
            }
        }
    }
 return 0;
}
```

Here, by using the `else` clause, and *by nesting each subsequent `if` statement in its preceding statement's `else` clause*, we have eliminated the double testing

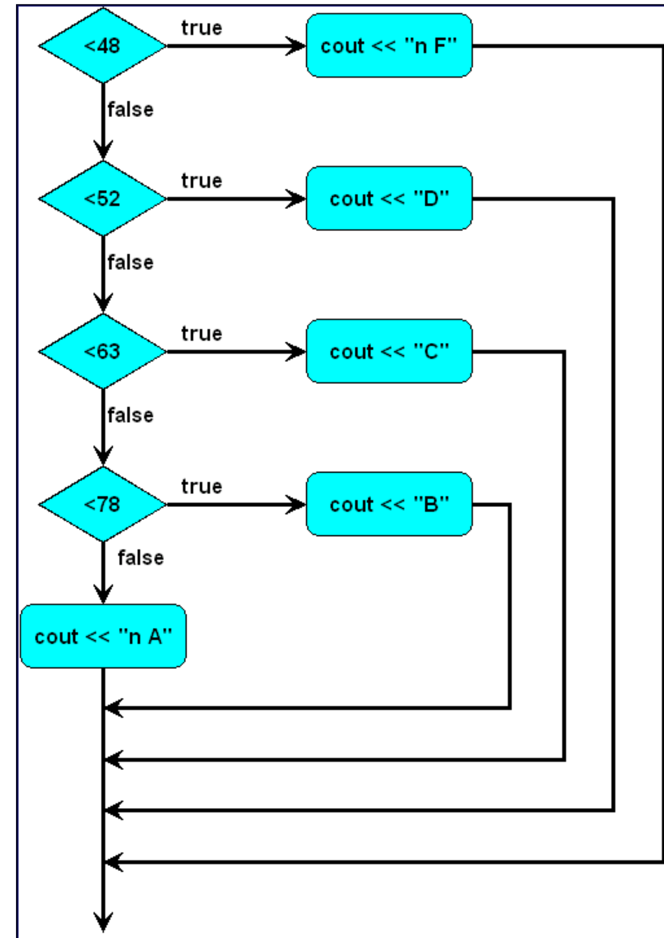
The strategy is actually very simple. In essence what we're doing is

if the mark is less than 48

then the grade is an F

otherwise go on to further testing

Here's what the control flow looks like



If you look back at our first example you will see we used five decision blocks, three of which were "big" ones—i.e., contained two separate tests

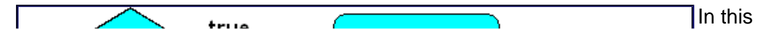
That's a total of eight tests!

Here we only use four, single-test, decision blocks

Before we tested `mark` to see if it was `<48`, then turned around and tested it to see if it was `>=48`

Here we use `else` clause to take advantage of the fact that if it is not `<48`, *it must be* `>=48`

But haven't we generated spaghetti code? Not really. The flow of control is highly constrained and so very orderly



In this

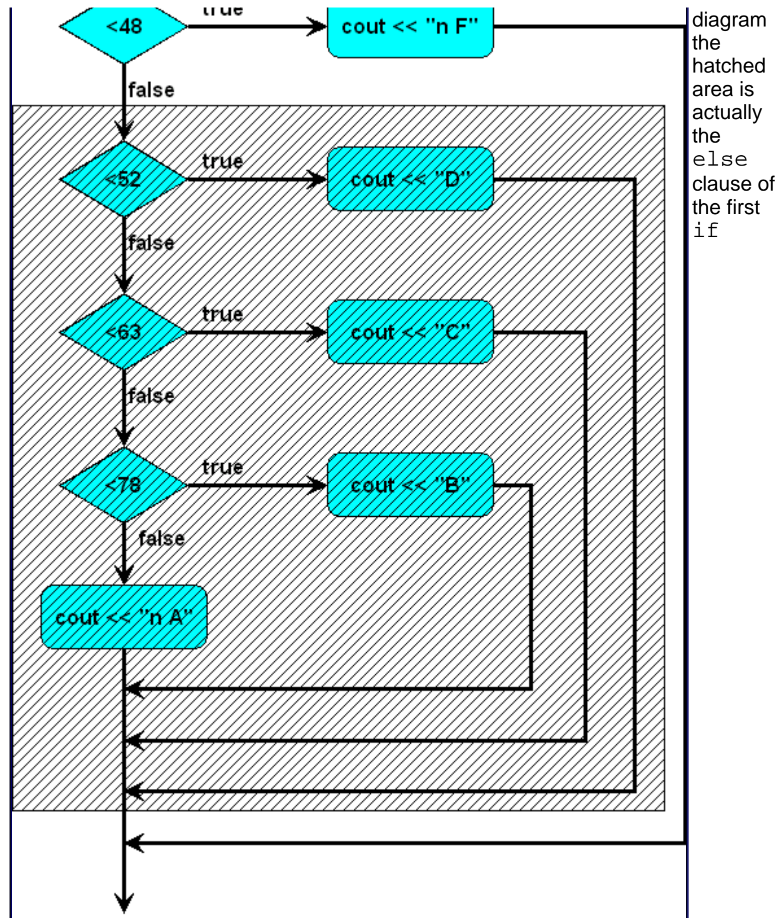


diagram the hatched area is actually the `else` clause of the first `if` statement.

All the rest of the `if` statements are wholly embedded within that `else` clause.

The power of control structures really stems from our ability to nest them, one inside the other, to build almost arbitrarily complex structures.

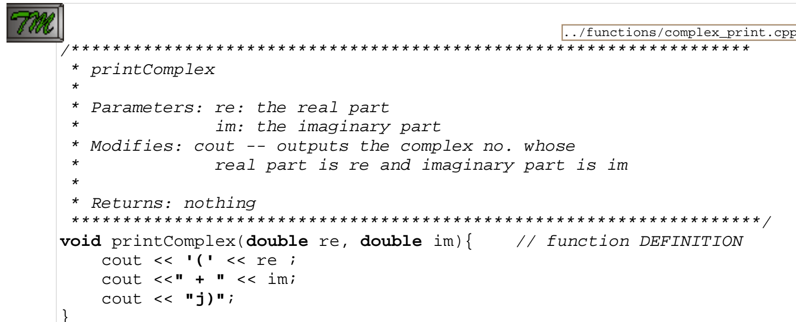
Of course, we don't want arbitrarily complex, just complex enough to do the job (and not one jot more).

One of the most basic design skills good programmers have is an ability to get their

control structures right.

A Complicated Example

Remember our complex number printing function?



../functions/complex_print.cpp

```
/*******************************************************************
 * printComplex
 *
 * Parameters: re: the real part
 *             im: the imaginary part
 * Modifies: cout -- outputs the complex no. whose
 *             real part is re and imaginary part is im
 *
 * Returns: nothing
 *******************************************************************/
void printComplex(double re, double im){    // function DEFINITION
    cout << '(' << re ;
    cout <<" + " << im;
    cout << "j)";
}
```

It isn't very good. Try it with -ve nos. or with one part set to zero. Here's a better version (it uses `i` instead of `j` because that's what we used in Math when the video was done).

```
/*******  if demonstration ********
                                                    if_3.cpp
   In this complex if demo we
   output properly formatted
   complex nos.

********************************************/

#include <iostream>   // info from standar
using namespace std;    // cout is in the          e

int main(){
    int real;
    int imag;

    cout << "Enter the real part: ";
    cin >> real;
    cout << "& the imaginary part: ";
    cin >> imag;

    cout << "\nThe complex no. is (";

    if (real == 0) {
        if (imag == 0) {
            cout << "0";
        } else {
            cout << imag << 'i';
        }
    } else {
        cout << real;
        if (imag < 0) {
            cout << " - ";
            cout << -imag << 'i';
        }
        if (imag > 0) {
            cout << " + ";
            cout << imag << 'i';
        }
    }
    cout << ")\n";
    return 0;
}
```

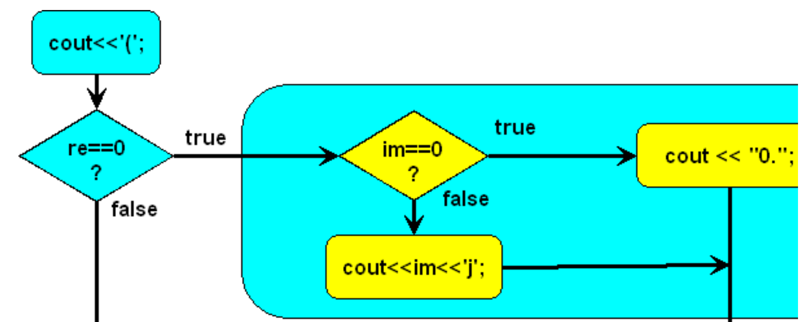
By our standards this isn't nice example. The specialised nature of the printing task should be embedded in a function as we did a few lectures back. We kept it because we do have a video, that will let you review the detailed programming issues at a later date.

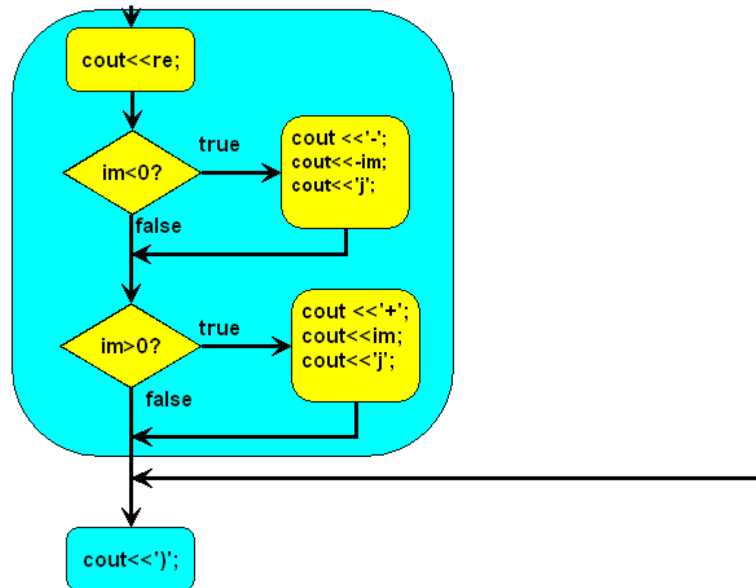
Here's an updated version that takes our earlier well-structured example and simply replaces the function with the better one from the video:

```
                                                    better_complex_print.cpp
/*********************************************************************
 * printComplex
 *
 * Parameters: re: the real part
 *             im: the imaginary part
 * Modifies: cout -- outputs the complex no. whose
 *             real part is re and imaginary part is im
 *
 * Returns: nothing
 *********************************************************************/
void printComplex(double re, double im){    // function DEFINITION
    cout << '(';
    if (re == 0) {
        if (im == 0) {
            cout << "0";
        } else {
            cout << im << 'j';
        }
    } else {
        cout << re;
        if (im < 0) {
            cout << " - ";
            cout << -im << 'j';
        }
        if (im > 0) {
            cout << " + ";
            cout << im << 'j';
        }
    }
    cout << ')';
}
```

Self-study: Try to identify each then and else clauses. Roll the mouse over each `if` to see its corresponding then clause and each `else` to see the else clause

Here they are diagrammed in the flow graph for the function





Notice how the other `if` statements are wholly nested with the then and else clauses of the first `if` statement.

Rounding

On the section on Expressions we briefly discussed rounding but said it was only good for positive numbers.

When C++ converts a `double` to an `int` it does it by *truncation*. Thus `3.7—>3, 3.4—>3, -3.7—>-3`, and `-3.3—>-3`

So while adding `.5` to a `double` before converting works for positive nos we need to add `-.5` to negative ones. Sounds like a good job for a function!

round.cpp

```
/**********************************************************************
 * round
 *
 * Parameters: x: a real number
 *
 * Modifies: nothing
 *
 * Returns: x rounded to the nearest integer
```



```
 **********************************************************************/
int round(double x){
    if (x < 0)
        return (int)(x-.5);
    return (int)(x+.5);
}
```

Code Notes

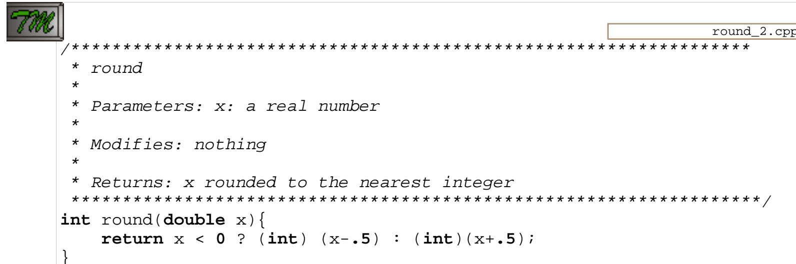
1. Our function has two separate `return` statements. Some programming shops forbid this because it can make larger functions hard to maintain.

2. Notice there is no `else` even though we only want to execute one of the two `returns`. This is because if `x < 0`, the then clause is executed and *it is a return*. Remember, `return` not only sends back a value it exits as well. So the only way the second `return` can be reached is if `x >= 0`.

3. The type cast `(int)` in the two `return` statements is not strictly necessary. The `round` function is contracted to return an `int` so the compiler will automatically insert a conversion into the object code even without the type cast.

   Professional programmers will often insert such type casts simply to flag maintenance programmers that they intended a conversion to take place

Here is another way to write the same function.



```
round_2.cpp
/*****************************************************************
 * round
 *
 * Parameters: x: a real number
 *
 * Modifies: nothing
 *
 * Returns: x rounded to the nearest integer
 *****************************************************************/
int round(double x){
    return x < 0 ? (int) (x-.5) : (int)(x+.5);
}
```

Style Issues

Placement of the {

There are two schools of thought on where to place the { (open block) operator

```
if (im > 0) {
   cout << " + ";
   cout << im;
}

if (im > 0)
{
   cout << " + ";
   cout << im;
}
```

The second one makes it easy to line up the } with its own {.

The first one is more compact, taking one less line vertically.

We accept either in this course but *you must be consistent*. Whichever one you decide on use it always.

Other aspects are consistent.

1. indent statements inside the block (most program editors try to automate this anyway—set the indent to 4 spaces)
2. Don't indent the }. It should line up with the start of its own `if` (or `else` if it terminates an else clause).

To Block or Not to Block

One of our bin examples above includes the following lines of code

```
if (mark < 48 ) {
    cout << "n F.\n";
}
```

This could equally well have been written

```
if (mark < 48 )
    cout << "n F.\n";
```

Some programming shops routinely insist upon the first. Others prefer the second as being more compact. We will accept either.

This line is also legal C++

```
if (mark < 48 )cout << "n F.\n";
```

We will not accept it. Always put (or start) then and else clauses on their own line.

The `else if` Construct

Remember this fragment of code taken from our second example?

```
int main(){
    int mark;                                          if_2.cpp

    cout<< "Enter your mark: ";
    cin >> mark;

    cout << "\nThis is a";

    if (mark < 48) {
        cout << "n F.\n";
    } else {

        if (mark < 52) {
            cout << " D.\n";
        } else {

            if (mark < 63) {
                cout << " C.\n";
            } else {

                if (mark < 78) {
                    cout << " B.\n";
                } else {
                    cout << "n A.\n";
                }
            }
        }
    }
```

All `if` statements subsequent to the first one are wholly embedded in the preceding else clause. In fact *they are the else clause*.

Some languages actually have a special `elseif` keyword.

There's no need of that, but many experienced programmers would simulate that by replacing `else {` *if statement* `}` by `else if` *statement* as below (we've actually removed all the brackets because the then clauses were also just single statements).

```
int main(){
    int mark;                                          if_4.cpp

    cout<< "Enter your mark: ";
    cin >> mark;

    cout << "\nThis is a";

    if (mark < 48)
        cout << "n F.\n";
    else if (mark < 52)
        cout << " D.\n";
    else if (mark < 63)
        cout << " C.\n";
    else if (mark < 78)
        cout << " B.\n";
    else
        cout << "n A.\n";
    return 0;
}
```

This page last updated on Monday, February 2, 2004