

# **BRANCHING**

## **if-else statements**

# Conditional Statements

- ***A conditional statement*** lets us choose which statement will be executed next
- Therefore they are sometimes called ***selection statements***
- Conditional statements give us the power to make basic decisions
- The C conditional statements are the:
  - ***if statement***
  - ***if-else statement***
  - ***if-else if-else if-else ladder***
  - ***switch-case statement***
  - ***Conditional operator (?:)***

# The if Statement

- The *if statement* has the following syntax:

`if` is a C  
reserved word

The *condition* must be a  
boolean expression. It must  
evaluate to either true or false.



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

The diagram illustrates the syntax of an if statement. It features the code `if ( condition ) statement;` in the center. Three red arrows point to specific parts of the code: one from the text 'if is a C reserved word' to the keyword `if`, another from 'The condition must be a boolean expression...' to the word `condition`, and a third from 'If the condition is true...' to the word `statement`.

If the *condition* is true, the *statement* is executed.  
If it is false, the *statement* is skipped.

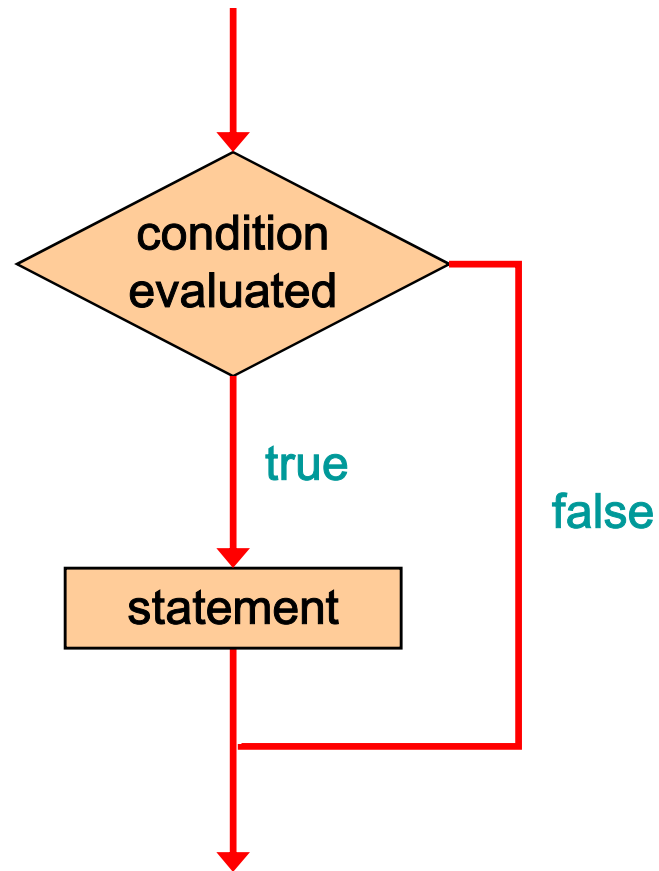
# The if Statement (Example)

- Selection structure:
  - Used to choose among alternative courses of action
  - Pseudocode: *If student's mark at least 40*  
*Print "Passed"*
- Pseudocode statement in C:

```
#include <stdio.h>

main() {
    int marks;
    printf("Enter your marks: ");
    scanf("%d", &marks);
    if ( marks >= 40 )
        printf( "Passed\n" );
}
```

# Logic of an if statement



# Relational Operators

- A condition often uses one of C's *equality operators* or *relational operators*

<	less than
>	greater than
<=	less than or equal to
>=	greater than or equal to

Higher  
Precedence

==	equal to
!=	not equal to

Lower  
Precedence

- Note the difference between the equality operator (==) and the assignment operator (=)

# The if-else Statement

- An *else clause* can be added to an `if` statement to make an *if-else statement*

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

- If the *condition* is true, *statement1* is executed; if the condition is false, *statement2* is executed
- One or the other will be executed, but not both

**if statement analogy (Y-intersection)**





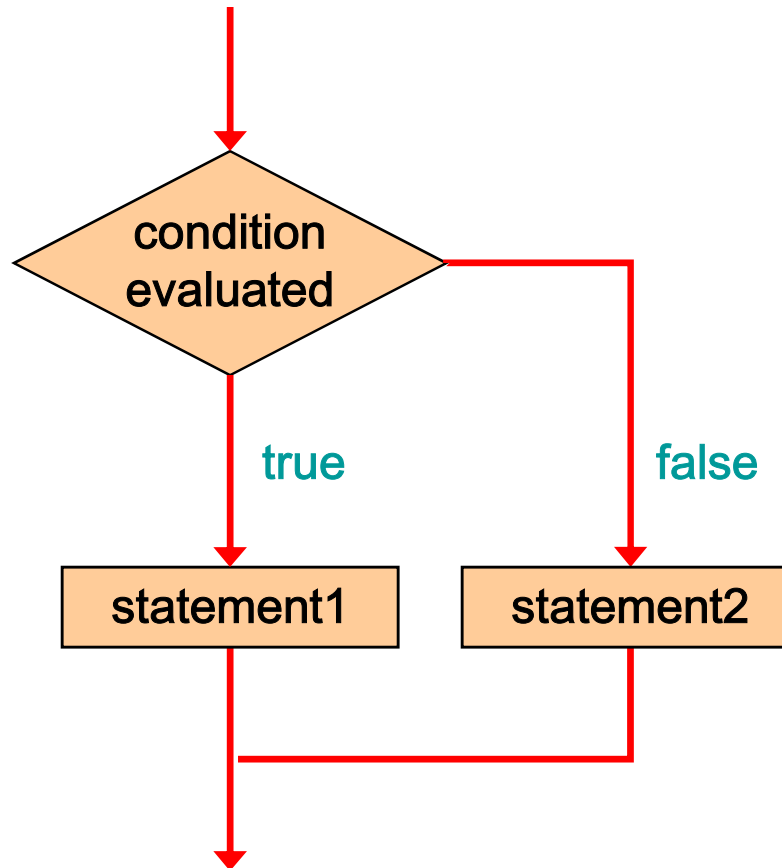
# The if-else Statement (Example)

- Selection structure:
  - Pseudocode: *If student's mark is at least 40*  
*Print "Passed"*  
*Otherwise*  
*Print "Failed"*

- Pseudocode statement in C:

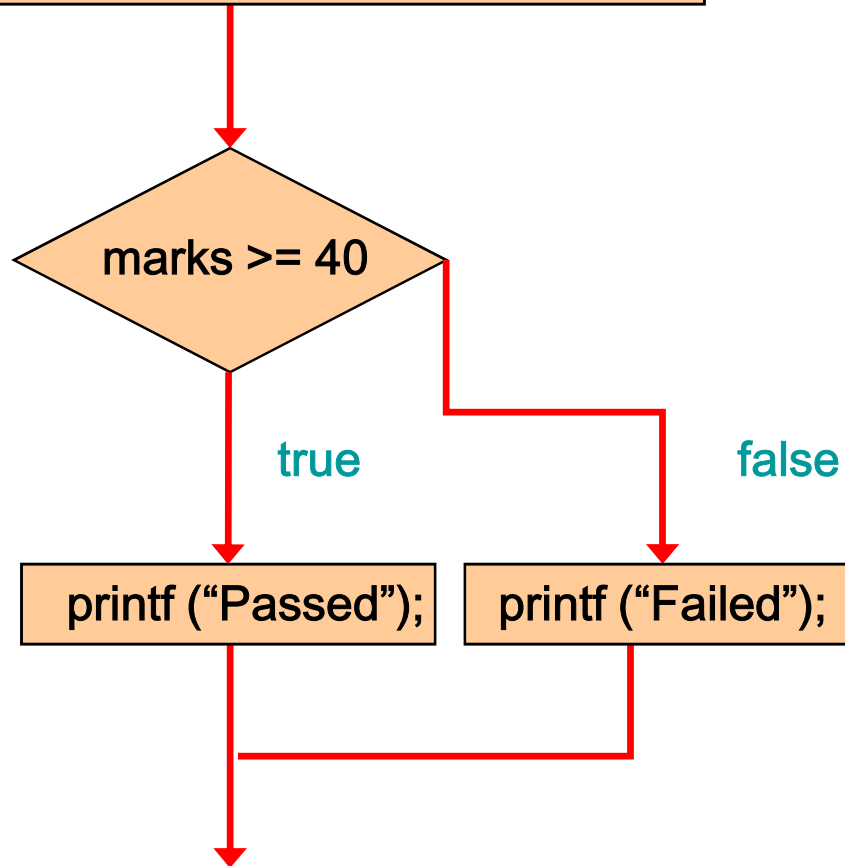
```
#include <stdio.h>
main()
{
    int marks;
    printf("Enter your marks: ");
    scanf("%d", &marks);
    if ( marks >= 40 )
        printf( "Passed\n" );
    else
        printf("Failed\n");
}
```

# Logic of an if-else statement



# Logic of previous example

```
printf("Enter your marks: ");  
scanf("%f", &marks);
```



# Values on condition

- Zero (0) → False
- Anything nonzero → TRUE

```
if (40)
    printf(" Hi \n" );
else
    printf(" Bye \n" );
```

Output: Hi

```
if (-40)
    printf(" Hi \n" );
else
    printf(" Bye \n" );
```

Output: Hi

# Relational Operators

- Zero (0) → False
- Anything nonzero → TRUE

```
if (0)
    printf(" Hi \n" );
else
    printf(" Bye \n" );
```

Output: Bye

```
a = 40;
if (a)
    printf(" Hi \n" );
else
    printf(" Bye \n" );
```

Output: Hi

# Relational Operators

- Zero (0) → False
- Anything nonzero → TRUE

```
a = 0;  
if (a)  
    printf(" Hi \n" );  
else  
    printf(" Bye \n" );
```

Output: Bye

```
a = 30;  
if (a = 0)  
    printf(" Hi \n" );  
else  
    printf(" Bye \n" );
```

Output: Bye

# Relational Operators

- FALSE → Zero (0)
- TRUE → One (1)

```
a = 5;  
printf("%d ", a > 5 );
```

Output: 0

```
a = 5;  
printf("%d ", a == 5 );
```

Output: 1

# Little quiz for you

- FALSE → Zero (0)
- TRUE → One (1)

```
a = 6;  
b = 5;  
c = 2;  
if (a > b > c)  
    printf(" Hi \n" );  
else  
    printf(" Bye \n" );
```

Output

(a) Compilation Error

(b) Hi

(c) Bye



# Examples

- Write down a program that will take **two** integers as input and will print the maximum of two.
- Write down a program that will take **three** integers as input and will print the **maximum** of three.
- Write down a program that will take **three** integers as input and will print the **second largest of the three**.

# Logical NOT

- The *logical NOT* operation is also called *logical negation* or *logical complement*
- If some condition  $a$  is true, then  $!a$  is false; if  $a$  is false, then  $!a$  is true
- Logical expressions can be shown using a *truth table*

cond	! cond
true	false
false	true

# Example

- Selection structure:
  - Used to choose among alternative courses of action
  - Pseudocode: *If student's mark is at least 40*  
*Print "Passed"*
- Pseudocode statement in C:

```
#include <stdio.h>
main()
{
    int marks;
    printf("Enter your marks: ");
    scanf("%d", &marks);
    if ( marks >= 40 )
        printf( "Passed\n" );
}
```

# Example

- Selection structure:
  - Used to choose among alternative courses of action
  - Pseudocode: *If student's mark is at least 40*  
*Print "Passed"*
- Pseudocode statement in C:

```
#include <stdio.h>
main()
{
    int marks;
    printf("Enter your marks: ");
    scanf("%d", &marks);
    if ( marks < 40 )
        printf( "Passed\n" );
}
```

# Example

- Selection structure:
  - Used to choose among alternative courses of action
  - Pseudocode: *If student's mark at least 40 Print "Passed"*
  - *If student's mark not smaller than 40 Print "Passed"*
- Pseudocode statement in C:

```
#include <stdio.h>
main()
{
    int marks;
    printf("Enter your marks: ");
    scanf("%d", &marks);
    if ( !( marks < 40 ) )
        printf( "Passed\n" );
}
```

# Block Statements

- Several statements can be grouped together into a *block statement* delimited by braces
- A block statement can be used wherever a statement is called for in the C syntax rules

```
if (b == 0)
{
    printf ("divide by zero!!\n");
    errorCount++;
}
```

# Block Statements

- In an `if-else` statement, the `if` portion, or the `else` portion, or both, could be block statements

```
if (b == 0) {  
    printf("divide by zero!!");  
    errorCount++;  
}  
else{  
    result = a/b;  
    printf ("Result of division: %d", result);  
}
```

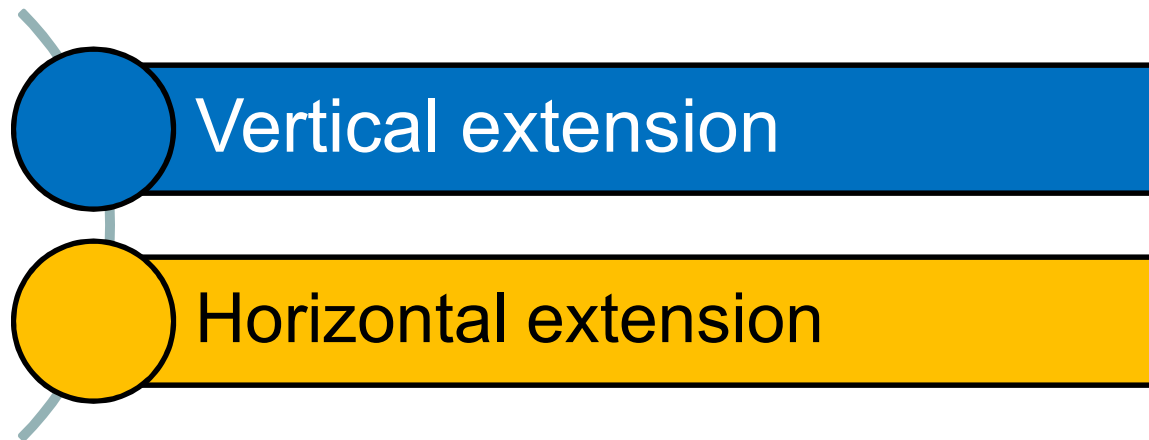
# Examples

- Write down a program that will take **two** integers as input and will print the maximum of two.
- Write down a program that will take **three** integers as input and will print the **maximum** of three.
- Write down a program that will take **three** integers as input and will print the **second largest of the three**.



# When we have multiple conditions:

## if-else extension



Vertical extension

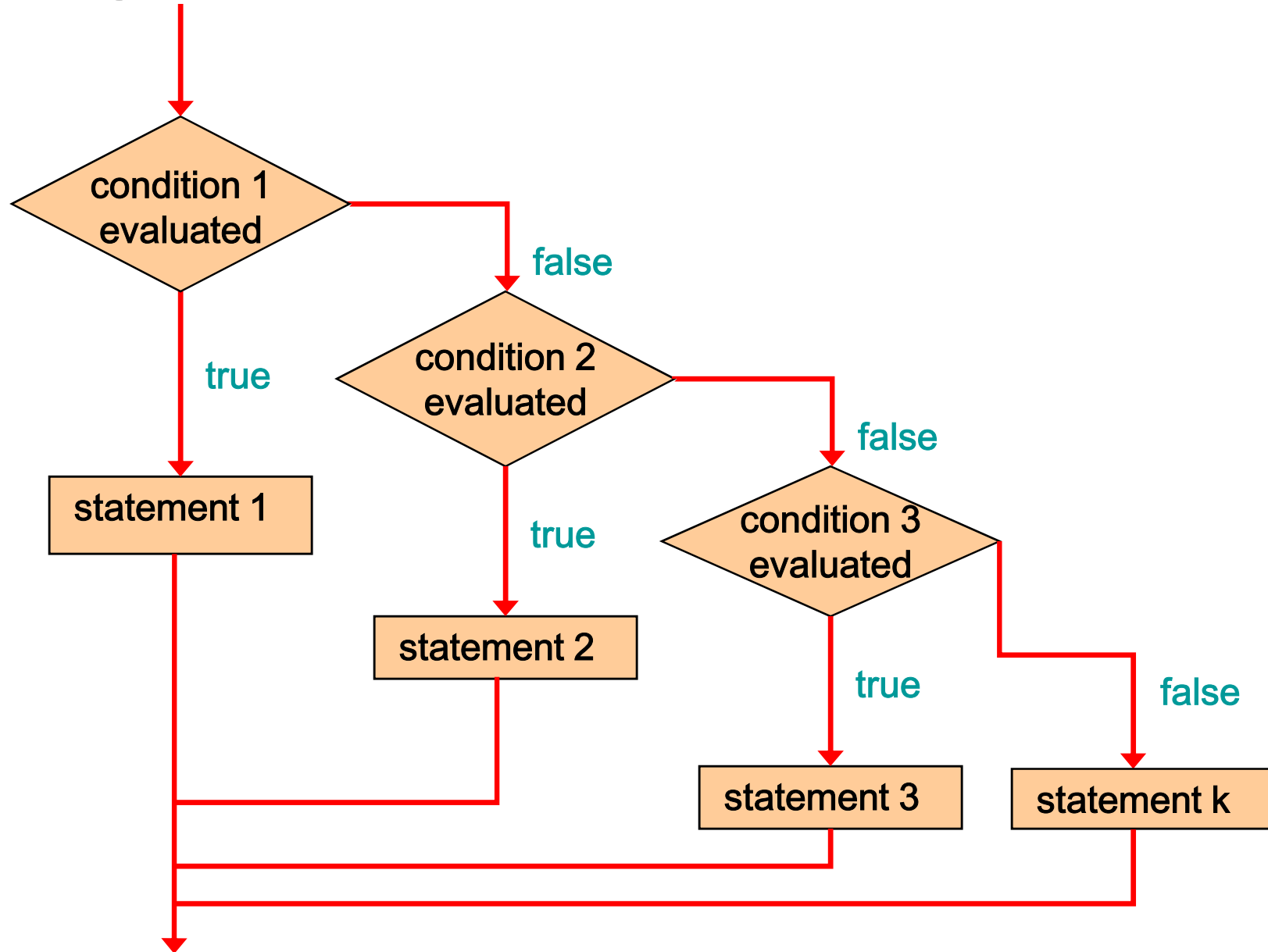
# The if-else if-else if –else ladder

- If-else if- else if –else can be used to select from multiple choices:

```
if ( condition1 )  
    statement1;  
else if ( condition2 )  
    statement2;  
...  
...  
else if ( conditionk )  
    statementk;  
else  
    statement;
```

- If the *condition1* is true, *statement1* is executed; if *condition2* is true, *statement2* is executed; and so on
- One or the other will be executed (i.e. those are mutually exclusive)

# Logic of an if-else if-else statement



# Example 1

The following chart will be used for a quick grade conversion in C programming language course:

90-100	A
80-89	B
70-79	C
60-69	D
0-59	F

Write down a program that will take a student's mark as input and will convert it to the corresponding letter grade.

```
scanf("%d", &m) ;  
if ( m >= 90 )  
    g = 'A';  
else if ( m >= 80 )  
    g = 'B';  
else if ( m >= 70 )  
    g = 'C';  
else if ( m >= 60 )  
    g = 'D';  
else  
    g = 'F';  
printf("Mark = %d Grade= %c", m, g) ;
```

```
scanf("%d", &m) ;  
if ( m >= 90 )  
    g = 'A' ;  
if ( m >= 80 )  
    g = 'B' ;  
if ( m >= 70 )  
    g = 'C' ;  
if ( m >= 60 )  
    g = 'D' ;  
else  
    g = 'F' ;  
printf("Mark = %d Grade= %c", m, g) ;
```

Wrong!!

```
scanf ("%d", &m) ;
```

```
g = 'F' ;
```

```
if ( m >= 60 )
```

```
    g = 'D' ;
```

```
if ( m >= 70 )
```

```
    g = 'C' ;
```

```
if ( m >= 80 )
```

```
    g = 'B' ;
```

```
if ( m >= 90 )
```

```
    g = 'A' ;
```

```
printf ("Mark = %d Grade= %c", m, g) ;
```

Correct but  
inefficient!!



Horizontal extension

# Combining multiple conditions: Logical Operators

- C defines the following *logical operators*:

!	Logical NOT
&&	Logical AND
	Logical OR

- Logical NOT is a unary operator (it operates on one operand). **We have already seen it before.**
- Logical AND and logical OR are binary operators (each operates on two operands)

# Logical AND and Logical OR

- The *logical AND* expression

`cond1 && cond2`

is true if both `a` and `b` are true, and false otherwise

- The *logical OR* expression

`cond1 || cond2`

is true if `a` or `b` or both are true, and false otherwise

# Logical Operators

- A truth table shows all possible true-false combinations of the terms
- Since `&&` and `||` each have two operands, there are four possible combinations of conditions a and b

cond1	cond2	cond1 && cond2	cond1    cond2
true	true	true	true
true	false	false	true
false	true	false	true
false	false	false	false

# Example 1

The following chart will be used for a quick grade conversion in C programming language course:

90-100	A
80-89	B
70-79	C
60-69	D
0-59	F

Write down a program that will take a student's mark as input and will convert it to the corresponding letter grade.

```
scanf("%d", &m);  
if ( m >= 90 && m <= 100 )  
    g = 'A';  
else if ( m >= 70 && m < 80 )  
    g = 'C';  
else if ( m >= 80 && m < 90 )  
    g = 'B';  
else if ( m >= 60 && m < 70 )  
    g = 'D';  
else  
    g = 'F';  
printf("Mark = %d Grade= %c", m, g);
```

```
scanf("%d", &m) ;  
    g = 'F' ;  
if ( m >= 90 && m <= 100 )  
    g = 'A' ;  
if ( m >= 70 && m < 80 )  
    g = 'C' ;  
if ( m >= 80 && m < 90 )  
    g = 'B' ;  
if ( m >= 60 && m < 70 )  
    g = 'D' ;  
  
printf("Mark = %d Grade= %c", m, g) ;
```

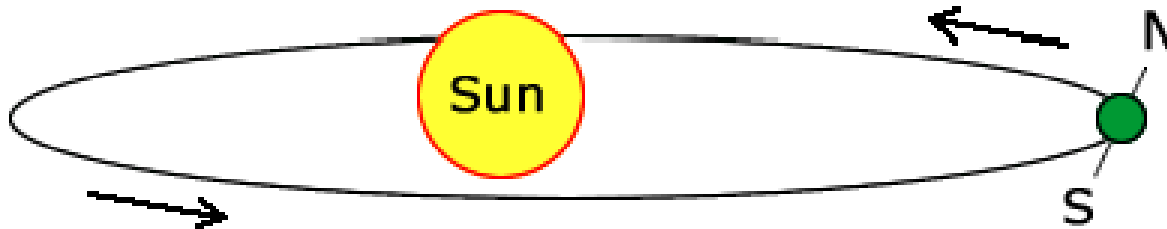
## Example 2

- Write down a program that will determine whether a year given as input is a **leap year** or not.



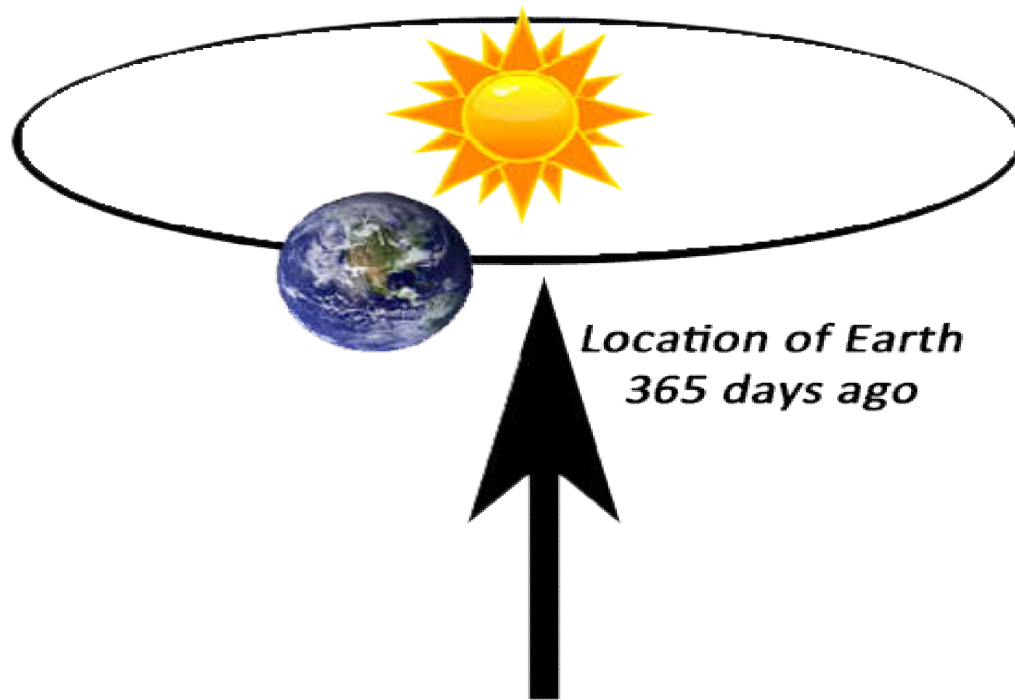
# Leap year explained

Precisely it takes 365.2425 days!



# Leap year explained





Adjustments are needed!



# Leap year explained

- Leap year condition

1, 2, 3, 4, 5, 6, 7, 8, ....., 96, 100, 104, ...., 200, ...., 300, ..., 400, ... 500, ..., 600, ..., 700, ....., 800, ..., 900, ... , 1000 .....

- Blue numbers leap year  Multiple of 400
- Red numbers NOT leap year  Multiple of 100 but not of 400
- Green numbers leap year  Multiple of 4 but not of 100
- Black numbers NOT leap year  Not divisible by 4 at all

# Solution 1 (using vertical extension)

```
if ( year % 400 == 0 )  
    printf("Leap year");  
else if ( year % 100 == 0 )  
    printf("Not Leap year");  
else if ( year % 4 == 0 )  
    printf("Leap year");  
else  
    printf("Not a leap year");
```

# Solution 2: using horizontal extension

- Leap year condition

1, 2, 3, 4, 5, 6, 7, 8, .....,96, 100, 104, ....200, ....,300, ...,400,  
...500, ..., 600, ..., 700, ....., 800, ..., 900, ... ,1000.....

```
if ( ? )
```

```
    printf("Leap year");
```

```
else
```

```
    printf("Not a leap year");
```

# Solution 2: using horizontal extension

- Leap year condition

1, 2, 3, 4, 5, 6, 7, 8, .....,96, 100, 104, ....200, ....,300, ...,400,  
...500, ..., 600, ..., 700, ....., 800, ..., 900, ... ,1000.....

```
if ( blue or green )  
    printf("Leap year");  
else  
    printf("Not a leap year");
```

# Solution 2: using horizontal extension

- Leap year condition

1, 2, 3, 4, 5, 6, 7, 8, ....., 96, 100, 104, ...., 200, ...., 300, ..., 400,  
... 500, ..., 600, ..., 700, ....., 800, ..., 900, ... , 1000.....

```
if ( blue or (green but not red) )  
    printf("Leap year");  
else  
    printf("Not a leap year");
```

## Solution 2: using horizontal extension

```
if ( blue or (green but not red) )  
    printf("Leap year");  
else  
    printf("Not a leap year");
```



## Solution 2: using horizontal extension

```
if ((y%400 == 0) || ((y%4 == 0) && (y%100 != 0)))  
    printf("Leap year");  
else  
    printf("Not a leap year");
```

# Short-Circuited Operators

- The processing of logical AND and logical OR is “short-circuited”
- If the left operand is sufficient to determine the result, the right operand is not evaluated

```
if (count != 0 && total/count > MAX)
    printf ("Testing..");
```

- This type of processing must be used carefully

## Solution 2: using horizontal extension

```
if ((y%400 == 0) || ((y%4 == 0) && (y%100 != 0)))  
    printf("Leap year");  
else  
    printf("Not a leap year");
```

Most efficient solution:

```
if (black or (red but not blue))  
    printf("Not Leap year");  
else  
    printf("Leap year");
```

## Solution 2: using horizontal extension

```
if ((y%400 == 0) || ((y%4 == 0) && (y%100 != 0)))  
    printf("Leap year");  
else  
    printf("Not a leap year");
```

Most efficient solution:

```
if ((y%4 != 0) || ((y%100 == 0) && (y%400 != 0)))  
    printf("Not Leap year");  
else  
    printf("Leap year");
```

## **Example 2**

**Take a character as input. If it is uppercase letter convert it to lowercase, if it is lowercase letter convert it to uppercase. If it is neither lower case nor uppercase leave it unchanged.**

# Boolean Expressions in C

- **C does not have a boolean data type.**
- **Therefore, C compares the values of variables and expressions against 0 (zero) to determine if they are true or false.**
- **If the value is 0 then the result is implicitly assumed to be false.**
- **If the value is different from 0 then the result is implicitly assumed to be true.**
- **C++ and Java have boolean data types.**

# Example:

- **Write a C program that calculates weekly wages for hourly employees.**
  - **Regular hours 0-40 are paid at \$10/hours.**
  - **Overtime (> 40 hours per week) is paid at 150%**

# The Conditional Operator

- C has a *conditional operator* that uses a boolean condition to determine which of two expressions is evaluated

- Its syntax is:

*condition* ? *expression1* : *expression2*

- If the *condition* is true, *expression1* is evaluated; if it is false, *expression2* is evaluated
- The value of the entire conditional operator is the value of the selected expression



# The Conditional Operator

- The conditional operator is similar to an `if-else` statement, except that it is an expression that returns a value

- For example:

```
larger = ((num1 > num2) ? num1 : num2);
```

- If `num1` is greater than `num2`, then `num1` is assigned to `larger`; otherwise, `num2` is assigned to `larger`
- The conditional operator is *ternary* because it requires three operands

# **Example:**

- **Write a C program that will find the absolute value of a number. You can use only the ternary operator.**
- **Second largest of three numbers revisited.**

# The switch Statement

- The *switch statement* provides another way to decide which statement to execute next
- The *switch* statement evaluates an expression, then attempts to match the result to one of several possible cases
- Each case contains a value and a list of statements
- The flow of control transfers to statement associated with the first case value that matches

# The switch Statement

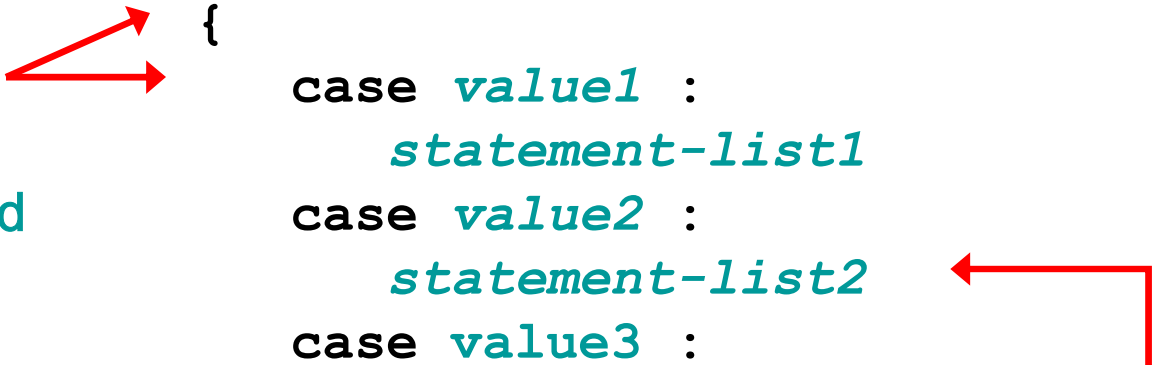
- Often a *break statement* is used as the last statement in each case's statement list
- A *break* statement causes control to transfer to the end of the *switch* statement
- If a *break* statement is not used, the flow of control will continue into the next case
- Sometimes this may be appropriate, but often we want to execute only the statements associated with one case

# The switch Statement

- The general syntax of a switch statement is:

```
switch ( expression )  
{  
    case value1 :  
        statement-list1  
    case value2 :  
        statement-list2  
    case value3 :  
        statement-list3  
    case ...  
}
```

switch  
and  
case  
are  
reserved  
words



If *expression*  
matches *value2*,  
control jumps  
to here

# The switch Statement

- A `switch` statement can have an optional *default case*
- The default case has no associated value and simply uses the reserved word `default`
- If the default case is present, control will transfer to it if no other case value matches
- If there is no default case, and no other value matches, control falls through to the statement after the switch

# The switch Statement example

- Write down a program using switch-case structure that will take an integer as input and will determine whether the number is odd or even.

```
switch (n%2)
{
    case 0:
        printf("It is Even");
        break;
    case 1:
        printf("It is ODD");
        break;
}
```

# The switch Statement example

- Write down a program using switch structure that will take an integer as input and will determine whether the number is multiple of 3 or not.

```
switch (n%3)
{
    case 0:
        printf("It is Multiple of 3");
        break;
    default:
        printf("No it's not");
        break;
}
```



# **This is deliberate and beneficial....**

**Write down a program that will take a character as input and will determine whether it is a vowel or consonant.**

# This is deliberate and beneficial....

```
scanf ("%c", &ch) ;
switch (ch)
{
    case 'a' : printf("It is Vowel") ;
                break;
    case 'e' : printf("It is Vowel") ;
                break;
    .....
    case 'u' : printf("It is Vowel") ;
                break;
    default: printf("It is consonant") ;
}
}
```

# This is deliberate....

```
scanf ("%c", &ch) ;
switch (ch)
{
    case 'a' :
    case 'e' :
        .....
    case 'u' : printf("It is Vowel") ;
                break;
    default: printf("It is consonant") ;
}
}
```

# The switch Statement example

- Write down a program using switch-case structure that will take two integers as input and will determine the maximum of two.

```
switch (a > b)
{
    case 0:
        max = b;
        break;
    case 1:
        max = a;
        break;
}
```

# Limitations of the switch Statement

- The expression of a `switch` statement must result in an *integral type*, meaning an integer (`byte`, `short`, `int`,) or a `char`
- It cannot be a floating point value (`float` or `double`)
- The implicit test condition in a `switch` statement is equality
- You cannot perform relational checks with a `switch` statement

# **Can we work around with switches limitations? One example.....**

**The following chart will be used for a quick grade conversion in C programming language course:**

<b>90-100</b>	<b>A</b>
<b>80-89</b>	<b>B</b>
<b>70-79</b>	<b>C</b>
<b>60-69</b>	<b>D</b>
<b>0-59</b>	<b>F</b>

**Write down a program that will take a student's mark as input and will convert it to the corresponding letter grade. Assume that marks are integers.**

**THE END**