

Making Decisions

Fundamentals of Computer and Programming
Fall 2019

Bahador Bakhshi

CE & IT Department, Amirkabir University of Technology



What We Will Learn

- Introduction
- Conditions and Boolean operations
- **if-else** statement
- **switch-case** statement
- Conditional expressions



What We Will Learn

- Introduction
- Conditions and Boolean operations
- `if-else` statement
- `switch-case` statement
- Conditional expressions



Decision

- Decisions are based on *conditions*
 - If it is snowing → We will cancel the game
 - If the class is not canceled → I will attend
else → I will go to gym
- In programming
 - Do statements based on conditions
 - **True** → The statements will be done
 - **False** → The statement wont be done



Conditions

- Conditions by comparisons; e.g.,
 - Weather vs. snowing
 - Variable x vs. a value
- Comparing numbers: Relational Operators

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



Relations

- Relations are **not** a complete statement

```
int a, b;
```

```
a == b;          //ERROR
```

```
a <= b;          //ERROR
```

- Relations produce a boolean value

```
int a, b;
```

```
bool b1;          // #include <stdbool.h>
```

```
b1 = a == b;
```

```
b1 = a <= b;
```



Boolean operations

- Multiple conditions in decision making
- Logical relation between conditions
 - if you are student **and** you have the programming course
 - You should read the book
- C Boolean operators

➤ and **&&**

➤ or **||**

➤ not **!**

p	q	p && q	p q	!p
False	False	False	False	True
False	True	False	True	True
True	False	False	True	False
True	True	True	True	False



Boolean operations (cont'd)

➤ Examples

```
bool a = true, b = false, c;  
c = !a;           // c = false  
c = a && b;        // c = false  
c = a || b;       // c = true  
c = !a || b;      // c = false
```



Precedence

Operator	Operation
++ --	increment, decrement
+ -	unary plus, minus
!	boolean not
(<type>)	cast to <type>
* / %	multiplication, division, remainder
+ -	addition/concatenation, subtraction
< <= > >=	relational ordering
== !=	relational equality, inequality
&&	boolean and
	boolean or
= += -= *= /= %=	assignments



Relations, No type effect

```
int a = 10, b = 20;
float f = 54.677f;
double d = 547.775;
char c1 = 'A', c2 = 'a';
bool b1;

b1 = a == f;           // false
b1 = a <= d + 5;       // true
b1 = d < c1 * 10;      // true
b1 = c1 == c2;         // false
b1 = '1' < '2';        // true
b1 = c1 + f < d + a;   // true
```



Casting

- In logical operations
 - 0 → False, non-zero → True
- In mathematical & comparison operations
 - False → 0 , True → 1

```
bool b1, b2;  
int i = 0, j = 20;  
b1 = i && j;           // b1 = false  
b2 = j || j;           // b2 = true  
i = b1 + b2;           // i = 1  
j = (i < j) + (b1 && b2); // j = 1
```



Examples

➤ $x \in [10, 20]$

➤ Wrong Version

➤ $10 \leq x \leq 20$

➤ Let $x = 30$

➤ $10 \leq 30 \leq 20 \rightarrow (10 \leq 30) \leq 20$

$\rightarrow \text{true} \leq 20 \rightarrow 1 \leq 20 \rightarrow \text{true!!!}$

➤ Correct Version

➤ $(10 \leq x) \ \&\& \ (x \leq 20)$

➤ Let $x = 30$

➤ $(10 \leq 30) \ \&\& \ (30 \leq 20) \rightarrow \text{true} \ \&\& \ \text{false} \rightarrow \text{false}$



Examples

➤ $a, b > 0$

➤ Wrong version

➤ $a \ \&\& \ b > 0$

➤ Let $a = -10$, $b = 20$

➤ $-10 \ \&\& \ 20 > 0 \rightarrow -10 \ \&\& \ (20 > 0)$

$\rightarrow -10 \ \&\& \ \text{true} \rightarrow \text{true} \ \&\& \ \text{true} \rightarrow \text{true} !!!$

➤ Correct version

➤ $(a > 0) \ \&\& \ (b > 0)$

➤ Let $a = -10$, $b = 20$

➤ $(-10 > 0) \ \&\& \ (20 > 0) \rightarrow \text{false} \ \&\& \ \text{true} \rightarrow \text{false}$



Lazy evaluation

- When final result is found, does not evaluate remaining

```
int i;
```

```
bool a = true, b = false, c = true;
```

```
bool d = a || b || c
```

```
bool d = b && (a || c)
```

```
bool d = (i > 0) && (sqrt(i) > 5.6)
```



What We Will Learn

- Introduction
- Conditions and Boolean operations
- **if-else** statement
- `switch-case` statement
- Conditional expressions



Type of statements

➤ Expression statement (دستور عبارتی)

➤ Single statements

```
x = y + 10; scanf("%d", &i);
```

➤ Control statement (دستور کنترلی)

➤ Control the flow of program

➤ Decisions and loops

➤ Compound statement (دستور مرکب)

➤ Starts with { and ends with }

➤ All statements can be between { and }



if statement

➤ Decision making in C

```
if ( <expression> )  
    <statements1>  
  
else  
    <statements2>
```

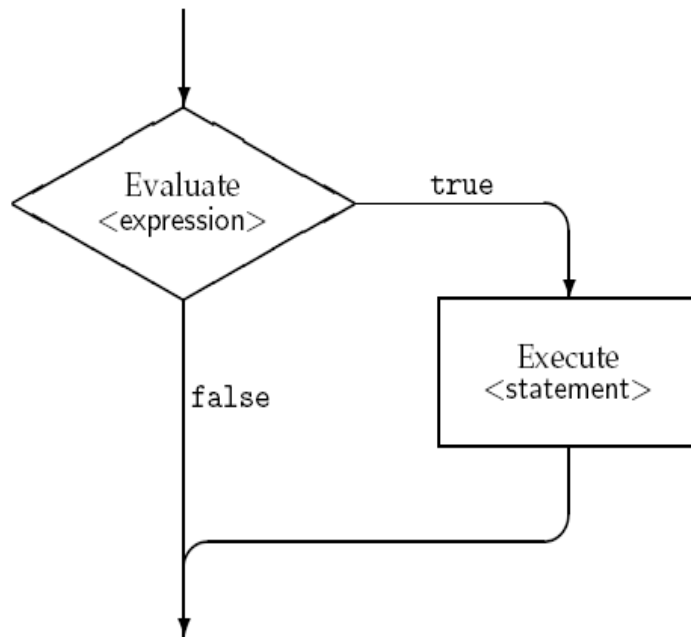
➤ Expression

- A boolean statement: $a \leq b$
- A mathematical statement: $a + b$ or a variable: a
 - zero \rightarrow false
 - Non-zero \rightarrow true



Flowchart

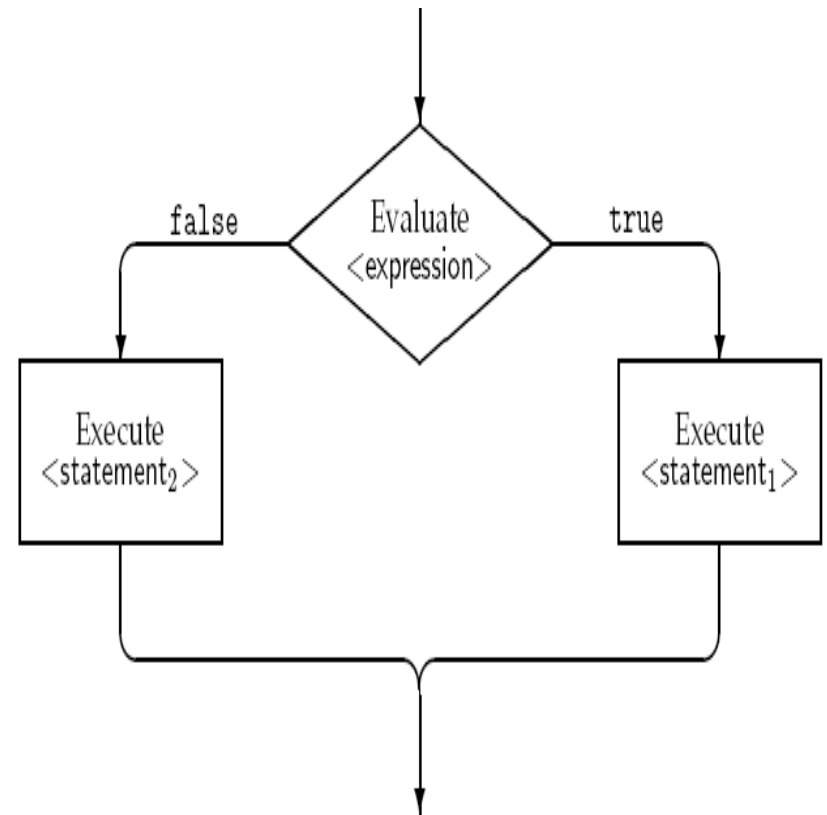
if(<expression>)
 <statement>



if(<expression>)
 <statement1>

else

<statement2>



برنامه‌ای که یک عدد را از کاربر می‌گیرد و مشخص می‌کند که این عدد فرد است یا زوج

```
#include <stdio.h>

int main(void) {
    int number_to_test, remainder;

    printf("Enter your number to be tested: ");
    scanf("%d", &number_to_test);

    remainder = number_to_test % 2;
    if(remainder == 0)
        printf ("The number is even.\n");
    else
        printf ("The number is odd.\n");

    return 0;
}
```



Statements in if-else

➤ Empty statement

```
if(a > b)
    Printf("A is larger \n");
else
    ;
```

➤ Block statements

```
if(a <= b) {
    printf("A is less than b or ");
    printf("A is equal b\n");
}

else
    printf("A is greater than b\n");
```



```
#include <stdio.h>
```

```
int main(void){
```

```
    int i;
```

```
    char c;
```

```
    printf("Enter a char: ");
```

```
    scanf(" %c", &c);
```

```
    printf("Enter an int: ");
```

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

```
    if(i > 0)
```

```
        printf("Your number is larger than 0\n");
```

```
    else
```

```
        printf("Your number is less than or equal 0\n");
```

```
    if((c >= '0') && (c <= '9'))
```

```
        printf("Your char is Numeric \n");
```

```
    return 0;
```

```
}
```

برنامه‌ای که یک حرف و یک عدد را می‌گیرد. در مورد عدد مشخص می‌کند که آیا بزرگتر صفر است یا نه. در مورد حرف اگر حرف عددی باشد پیغام چاپ می‌کند.

More than two choices

- If statement: 2 choices
 - If conditions are true → if statements
 - If conditions are false → else statements
- How to make decisions when there are multiple choices?



Map numeric grade to alphabetic

```
int numg;  
char alphag;  
if ( (numg < 25)  
    alphag = 'D';  
if ( (numg >= 25) && (numg < 50) )  
    alphag = 'C';  
if ( (numg >= 50) && (numg < 75) )  
    alphag = 'B';  
if (numg >= 75)  
    alphag = 'A';
```



More than two choices

- To avoid repeating conditions in if statements
- To avoid running unnecessary statements
- **Nested** if: check multiple conditions
 - <Statements 1> becomes an if-else statement
 - <Statements 2> becomes an if-else statement
 - Repeat it as many as needed



Nested if-else

```
if (c1 && c2)
    s1
if (c1 && !(c2))
    s2
if (!(c1) && c3)
    s3
if (!(c1) && !(c3))
    s4
```

```
if (c1)
    if (c2)
        s1
    else
        s2
else
    if (c3)
        s3
    else
        s4
```



Map numeric grade to alphabetic

```
int numg;  
char alphag;  
if(numg < 25)  
    alphag = 'D';  
else{  
    if(numg < 50)  
        alphag = 'C';  
    else{  
        if(numg < 75)  
            alphag = 'B';  
        else  
            alphag = 'A'  
    }  
}
```



Nested if-else

```
if (<condition 1>
    <statement 1>
else {
    if (<condition 2>)
        <statement 2>
    else
        <statement 3>
}
```

```
if (<condition 1>)
    <statement 1>
else if (<condition 2>)
    <statement 2>
else
    <statement 3>
```



Map numeric grade to alphabetic

```
int numg;  
char alphag;  
if(numg < 25)  
    alphag = 'D';  
else if(numg < 50)  
    alphag = 'C';  
else if(numg < 75)  
    alphag = 'B';  
else  
    alphag = 'A';
```



Map numeric grade to alphabetic

```
int numg;  
char alphag;  
if(numg < 50){  
    if(numg < 25)  
        alphag = 'D';  
    else  
        alphag = 'C';  
}  
else{  
    if(numg < 75)  
        alphag = 'B';  
    else  
        alphag = 'A';  
}
```



Nested if: Example 2

- Determine a char is alphabetic, Uppercase or not, numeric, less or greater than 5 or none of them

```
/* '0': 48, '9': 57, 'A': 65, 'Z': 90, 'a': 97, 'z': 122 */
```

```
char c;  
if(((c >= 'a') && (c <= 'z')) || ((c >= 'A') && (c <= 'Z'))){  
    if(c >= 'a')  
        printf("The char is Lowercase \n");  
    else  
        printf("The char is Uppercase \n");  
}  
else if((c >= '0') && (c <= '9')){  
    if(c > '5')  
        printf("The char is greater than 5\n");  
    else  
        printf("The char is less than or equal 5\n");  
}  
else  
    printf("The char is not either alphabetic or numeric");
```

This can be written
in other ways



Nested if: Incomplete branch

- 1) **else** part is optional
- 2) **else** always associates with the **nearest if**
 - 1 + 2 can be dangerous specially in incomplete branches
- Example: Tell user to move or game over

```
if(gameIsOver == 0)
    if(playerToMove == YOU)
        printf ("Your Move\n");
else
    printf ("The game is over\n");
```

- To avoid error you should
 - Close off you code or Use Empty statements



Nested if: close off & empty statement

```
if(gameIsOver == 0) {  
    if(playerToMove == YOU)  
        printf ("Your Move\n");  
}  
else  
    printf ("The game is over\n");  
//-----  
if(gameIsOver == 0)  
    if(playerToMove == YOU)  
        printf ("Your Move\n");  
    else  
        ;  
else  
    printf ("The game is over\n");
```

This one is better.



Duplicate zero, input is 3 digit

```
#include <stdio.h>
int main(void){
    int n, x1, x2, x3, q1, q2, result;
    printf("Enter a 3-digit number: ");
    scanf("%d", &n);
    if((n < 100) || (n > 999)){
        printf("Wrong input\n");
        return -1;
    }
    x1 = n / 100;
    x2 = (n % 100) / 10;
    x3 = n % 10;

    q1 = 100;
    q2 = 10;

    if(x3 == 0){
        q1 *= 10;
        q2 *= 10;
    }
    if(x2 == 0)
        q1 *= 10;

    result = (x1 * q1) + (x2 * q2) + x3;
    printf("result = %d\n", result);
    return 0;
}
```



Print in base-2, $0 \leq \text{input} < 16$



What We Will Learn

- Introduction
- Conditions and Boolean operations
- `if-else` statement
- **`switch-case`** statement
- Conditional expressions



switch-case: Multiple choices

- Multiple conditions
 - If-else if-else if-....
- Select from alternative **values** of a **variable**
 - switch-case
 - Values should be **constant** not expression: **i**, **i+j**,
 - Values & Variables should be **int** or **char**

```
switch(variable){  
    case value1:  
        <statements 1>  
    case value2:  
        <statements 2>  
  
}
```



How does switch-case work?

- Each switch-case can be rewritten by If-else
 - if-else version of switch-case in the previous slide

```
if(variable == value1) {  
    <statements 1>  
    <statements 2>  
}  
else if(variable == value2) {  
    <statements 2>  
}
```



switch-case: complete version

```
switch(variable) {  
    case value1:  
        <statements 1>  
        break;  
    case value2:  
        <statements 2>  
        break;  
    default:  
        <statements 3>  
}
```

```
If(variable == value1) {  
    <statements 1>  
}  
  
else if(variable == value2) {  
    <statements 2>  
}  
  
else {  
    <statements 3>  
}
```



```
#include <stdio.h>
#include <stdlib.h>
int main(void){
    int res, opd1, opd2;
    char opr;
    printf("Operand1 : ");
    scanf("%d", &opd1);
    printf("Operand2 : ");
    scanf("%d", &opd2);
    printf("Operator : ");
    scanf(" %c", &opr);
    switch(opr){
    case '+':
        res = opd1 + opd2;
        break;
```

برنامه‌ای که دو عدد و یک عملگر را
می‌گیرد، عملگر را بر روی اعداد
اعمال و نتیجه را چاپ می‌کند.

```
case '-':
    res = opd1 - opd2;
    break;
case '/':
    res = opd1 / opd2;
    break;
case '*':
    res = opd1 * opd2;
    break;
default:
    printf("Invalid operator \n");
    return -1;
}
printf("%d %c %d = %d\n", opd1, opr, opd2, res);
return 0;
}
```



switch-case (cont'd)

- All values used in case should be different

```
switch(i) {           //Error
```

```
case 1:
```

```
...
```

```
case 2:
```

```
...
```

```
case 1:
```



switch-case (cont'd)

- All values must be value, not expression of variables

```
switch(i) {           //Error
```

```
case j:
```

```
...
```

```
case 2:
```

```
...
```

```
case k+10:
```



switch-case: multiple matches

```
switch(variable) {  
    case value1:  
        <statements 1>  
        break;  
    case value3:  
        <statements 2>  
}
```

```
If (  
    (variable == value1) ||  
    (variable == value2)  
) {  
    <statements 1>  
}  
else if  
    (variable == value3)  
{  
    <statements 2>  
}
```



switch-case vs. if-else

- **if-else** is more powerful than **switch-case**
- **switch-case** is only for checking the **values of a variable** and the values must be **constant**
 - if-else is more suitable in some cases , e.g.,

```
double var1, var2;
```

```
if(var1 <= 1.1)  
    <statements 1>
```

```
if(var1 == var2)  
    <statements 2>
```



Nested switch-case

```
bool b;  //b = x && y
switch (x) {
    case 0:
        b = 0;
        break;
    case 1:
        switch(y) {
            case 0:
                b = 0;
                break;
            case 1:
                b = 1;
                break;
        }
        break;
}
```



What We Will Learn

- Introduction
- Conditions and Boolean operations
- `if-else` statement
- `switch-case` statement
- Conditional expressions



Conditional Expression

- Assign value according to conditions
- A ternary (سه تایی) operator

```
int i, j, k;
```

```
bool b;
```

```
...
```

```
i = b ? j : k;
```

```
/* if (b)
```

```
    *           i = j
```

```
    * else
```

```
    *           i = k;
```

```
*/
```



Conditional Expression: Examples

$$y = \text{abs}(x)$$

$$y = (x > 0) ? x : -x;$$

$$\text{signum}(x) = \begin{cases} -1 & \text{if } x < 0 \\ 0 & \text{if } x = 0 \\ 1 & \text{if } x > 0 \end{cases}$$

$$\text{signum} = (x < 0) ? -1 : (x > 0 ? 1 : 0)$$



Map Alphabetic Grade to Numeric

```
int d = numg / 25
```

```
charg = (d == 0) ? 'D' : ((d == 1) ? 'C' : (d ==  
    2) ? 'B' : 'A');
```



Common Bugs

- Equality of floating point numbers
 - Two float numbers may or may **NOT** be equal

```
double d1, d2;  
d1 = 1e20 + 1;  
d2 = 1e20 - 1;  
if(d1 == d2)  
    printf("They are equal :-o \n");  
else  
    printf("They are not equal :D \n");
```

They are equal :-o



Common Bugs

- Danger of empty statement
- Danger of assignment (=) and equality (==)

```
int a = 10;
```

```
int b = 20;
```

```
if(a=b) // logical but not compile error!!!
```

- Danger of similarity between C and mathematic
 - ```
if(a < b < c) // Logical Error
```
  - ```
if(a && b > 0) // Logical Error
```



Avoiding Bugs

➤ Precedence of operators

`if (!a && b)` or `if (! (a && b))`

➤ Use parenthesis in conditions

➤ Close-off code as much as you can



Debugging by assert

- The assert macro is defined in `assert.h`
- **assert** (an expression)
 - If the expression is true → nothing
 - If the expression is false → error message + halt

```
int x, y, z
```

```
...
```

```
assert(y != 0);
```

```
z = x / y;
```



Reference

- **Reading Assignment:** Chapter 3 of “C How to Program”



Homework

➤ Homework 3

