

Control Flow

Outline

❖ Blocks and compound statements

❖ Conditional statements

- if - statement
- if-else - statement
- switch - statement
- ? : operator
- Nested conditional statements

❖ Repetitive statements

- for - statement
- while - statement
- do-while - statement
- Nested repetitive statements
- Break and continue statements

❖ Unconditional jump: goto

Blocks and Compound Statements

❑ A simple statement ends in a semicolon: `z = foo(x+y);`

❑ Consider the multiple statements:

```
temp = x+y ;
```

```
z = foo (temp) ;
```

- Curly braces – combine into compound statement/block
- Block can substitute for simple statement
- Compiled as a single unit
- Variables can be declared inside
- No semicolon at end

```
{  
    int temp = x+y;  
    z = foo(temp);  
}
```

❑ Block can be empty `{ }`

Blocks and Compound Statements

- ❑ Blocks nested inside each other

```
{  
    int temp = x+y ;  
    z = foo ( temp ) ;  
    {  
        float temp2 = x*y ;  
        z += bar ( temp2 ) ;  
    }  
}
```

- ❑ Variables declared inside a block are only visible within this block and its internal blocks

Conditional Statements

- ❑ **if** - Statement
- ❑ **if-else** - Statement
- ❑ **switch** - Statement
- ❑ **? :** Ternary operator
- ❑ No boolean type in ANSI C
 - introduced in C99
- ❑ Relational and logical expressions are evaluated to:
 - 1 if they are logically true
 - 0 if they are logically false
- ❑ Numeric expressions are considered false if they are evaluated to integer 0
- ❑ Pointer expressions are considered false if they are evaluated to null

if- Statement

❑ Syntax:

```
if (<condition>)  
    <statement>;
```

❑ Example:

```
if ( x % 2 == 0 )  
    y += x / 2 ;
```

- Evaluate condition: $(x \% 2 == 0)$
 - If true, execute inner statement: $y += x/2;$
 - Otherwise, do nothing
- Inner statements can be a block

if-else - Statement

❑ Syntax:

```
if (<condition>
    <statement1>;
else
    <statement2>;
```

❑ Example:

```
if ( x % 2 == 0)
    y += x / 2 ;
else
    y += ( x + 1 ) / 2;
```

- Evaluate condition: $(x \% 2 == 0)$
 - If true, execute first statement: $y += x/2;$
 - Otherwise, execute second statement: $y += (x + 1) / 2;$
- Either inner statements can be blocks

Nesting if/if-else Statements

- ❑ Can have additional alternative control paths by nesting if statements:

```
if (<condition>
    <statement1>; /* can be an if or if-else statement*/
else
    <statement2>; /* can be an if or if-else statement*/
```

- ❑ Conditions are evaluated in order until one is met; inner statement then executed
 - if multiple conditions true, only first executed

- ❑ Example:

```
if ( x % 2 == 0)
    y += x / 2 ;
else if ( x % 4 == 1)
    y += 2 * (( x + 3 ) / 4 );
else
    y += ( x + 1 ) / 2 ;
```


Nesting if/if-else Statements

❑ Dangling else , example:

```
if ( x % 4 == 0)
if ( x % 2 == 0)
y = 2;
else
y = 1;
```

```
if ( x % 4 == 0)
    if ( x % 2 == 0)
        y = 2;
    else
        y = 1;
```

```
if ( x % 4 == 0)
    if ( x % 2 == 0)
        y = 2;
else
    y = 1;
```

- To which `if` statement does the `else` keyword belong?
Belongs to the nearest `if` in the same block
- To associate `else` with outer `if` statement: use braces

```
if ( x % 4 == 0) {
    if ( x % 2 == 0)
        y = 2;
} else
    y = 1;
```

switch - Statement

❑ Syntax:

```
switch (<int or char expression>) {  
    case <literal1>:    <statements>  
        [break;  
    [more cases]  
    [default:    <statements>]  
}
```

❑ Provides multiple paths

❑ Case labels: different entry points into block

❑ Compares evaluated expression to each case:

- When match found, starts executing inner code until `break`; reached
- Execution “falls through” if `break`; is not included

switch - Statement

❑ Example:

```
switch ( ch ) {  
    case 'Y' : /* ch == 'Y ' */  
                /* do something */  
    case 'N' : /* ch == 'N ' */  
                /* do something else */  
                break ;  
    default : /* otherwise */  
                /* do a third thing */  
}
```

Loops (Iterative Statements)

- ❑ **while** - loop
- ❑ **for** - loop
- ❑ **do-while** - loop
- ❑ **break** and **continue** keywords

Loops: while - Statement

- ❑ Syntax:

```
while ( <condition> )  
    <loop body>
```

- ❑ Simplest loop structure – evaluate body as long as condition is true

- ❑ Condition evaluated first, so body may never be executed

- ❑ Example:

```
int x = 0;  
while ( x < 10 ) {      /* While x is less than 10 */  
    printf( "%d\n", x );  
    x++;                /* Update x so the condition breaks eventually */  
}
```

Loops: for - Statement

❑ Syntax:

```
for ( [<initialization>] ; [<condition>] ; [<modification>] )  
    <loop body>
```

❑ Example:

```
int i , j = 1;  
for ( i = 1; i <= n ; i ++)  
    j *= i ;  
printf("%d\n", j);
```

- A “counting” loop
- Inside parentheses, three expressions, separated by semicolons:
 - Initialization: `i = 1` , cannot declare variables here
 - Condition: `i <= n`
 - Modification: `i++`

Loops: for - Statement

- ❑ Any expression can be empty (condition assumed to be “true”):

```
for (;;) /* infinite loop */  
    <loop body>
```

- ❑ Compound expressions separated by commas

- Comma: operator with lowest precedence, evaluated left-to-right

- But the value of the expression is the value of the right-hand part only

```
for ( i = 1 , j = 1; i <= n , j % 2 != 0 ; j *= i , i ++ )  
    <loop body>
```

- ❑ Equivalent to while loop:

```
<initialization>  
while (<condition>) {  
    <loop body>  
    <modification>  
}
```

Loops: do-while - Statement

❑ Syntax:

```
do {  
    <loop body>  
} while( <condition> );
```

❑ Differs from while loop – condition evaluated after each iteration

- Body executed, at least, once
- Note semicolon at end

❑ Example:

```
char c ;  
do {  
    / * loop body * /  
    puts( "Keep going? (y/n) " ) ;  
    c = getchar();  
    / * other processing * /  
} while ( c == 'y' && /* other conditions */ );
```


Loops: Nested Loops

- ❑ A nested loop is a loop within a loop

- an inner loop within the body of an outer one.

```
for ([<initialization>]; [<condition>]; [<modification>])  
    <loop body> /* another loop here */
```

- ❑ Can nest any loop statement within the body of any loop statement
- ❑ Can have more than two levels of nested loops

Loops: break - Statement

- ❑ Sometimes want to terminate a loop early
 - break; exits innermost loop or switch statement to exit early
 - Consider the modification of the do-while example:

```
char c ;  
do {  
    /* loop body */  
    puts ( "Keep going? (y/n) " ) ;  
    c = getchar() ;  
    if ( c != 'y' )  
        break ;  
    /* other processing */  
} while ( /* other conditions */ ) ;
```

Loops: continue - Statement

❑ Use to skip an iteration

- continue; skips rest of innermost loop body, jumping to loop condition

❑ Example:

```
int i , ret = 1 , minval;
for ( i = 2; i <= (a > b? a:b); i++) {
    if ( a % i ) /* a not divisible by i */
        continue;
    if ( b % i == 0) /* b and a are multiples of i */
        ret = i;
}
printf("%d\n", ret);
```

Unconditional Jump

- ❑ `goto`: transfers program execution to a labeled statement in the current function
 - DISCOURAGED
 - easily avoidable
 - requires a label
- ❑ Label: a plain text, except C keywords, followed by a colon, prefixing a code line
 - may occur before or after the `goto` statement
- ❑ Example:

```
int main () {
    int a = 10;
    LOOP:do {
        if ( a == 15) {
            a = a + 1;
            goto LOOP;
        }
        printf("value of a: %d\n", a++);
    } while( a < 20 );
    return 0;
}
```