for Loop Lesson 1 Outline

A `while` Loop That Counts #1

```
#include <stdio.h>
#include <stdlib.h>
int main ()
{ /* main */
    const int initial_sum          =  0;
    const int increment            =  1;
    const int program_success_code =  0;
    const int program_failure_code = -1;
    int initial_value, final_value;
    int count;
    int sum;
```

A `while` Loop That Counts #2

```
printf("What value would you like to ");
printf("start counting at?\n");
scanf("%d", &initial_value);
printf("What value would you like to ");
printf("stop counting at,\n");
printf("  which must be greater than ");
printf("or equal to %d?\n", initial_value);
scanf("%d", &final_value);
if (final_value < initial_value) {
    printf("ERROR: the final value %d is less\n",
        final_value);
    printf("  than the initial value %d.\n",
        initial_value);
    exit(program_failure_code);
} /* if (final_value < initial_value) */
```

A `while` Loop That Counts #3

```
    sum   = initial_sum;
    count = initial_value;
    while (count <= final_value) {
        sum = sum + count;
        count = count + increment;
    } /* while (count <= final_value) */
    printf("The sum of the integers from");
    printf(" %d through %d is %d.\n",
        initial_value, final_value, sum);
    return program_success_code;
} /* main */
```

A `while` Loop That Counts #4

```
% gcc -o whilecount whilecount.c
% whilecount
What value would you like to start counting at?
1
What value would you like to stop counting at,
  which must be greater than or equal to 1?
0
ERROR: the final value 0 is less
  than the initial value 1.
% whilecount
What value would you like to start counting at?
1
What value would you like to stop counting at,
which must be greater than or equal to 1?
5
The sum of the integers from 1 through 5 is 15.
```

Count-Controlled Loops #1

On the previous slide, we saw a case of a loop that:

- executes a specific number of ***iterations***,
- by using a counter variable,
- which is initialized to a particular ***initial value***
- and is ***incremented*** (increased by 1) at the end of each iteration of the loop,
- until it goes beyond a particular ***final value***:

```
sum   = initial_sum;
count = initial_value;
while (count <= final_value) {
    sum = sum + count;
    count = count + increment;
} /* while (count <= final_value) */
```

Count-Controlled Loops #2

```
sum   = initial_sum;
count = initial_value;
while (count <= final_value) {
    sum = sum + count;
    count = count + increment;
} /* while (count <= final_value) */
```

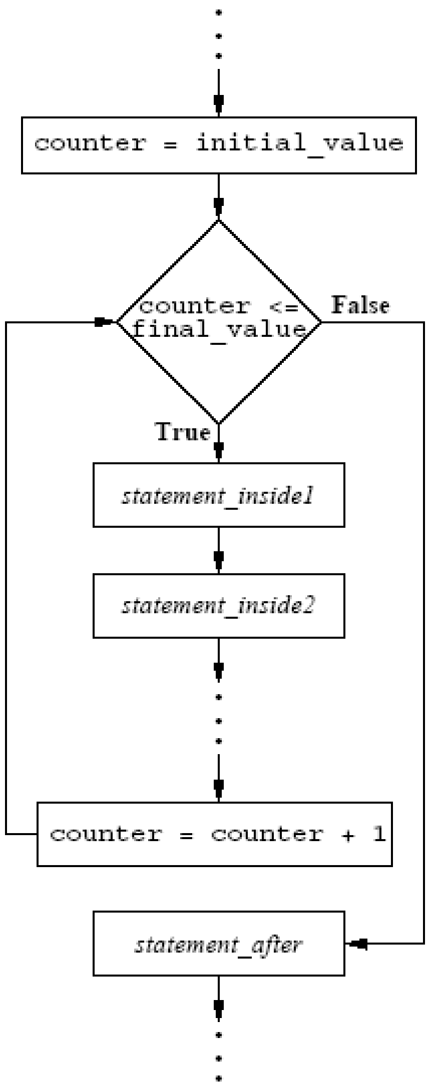
We call this kind of loop a ***count-controlled loop***.

If we express a count-controlled loop as a `while` loop, then the general form is:

```
counter = initial_value;
while (counter <= final value) {
    statement1;
    statement2;
    ...
    counter = counter + 1;
} /* while (counter <= final value) */
```

Count-Controlled Loop Flowchart

```
counter = initial_value;
while (counter <= final value) {
    statement1;
    statement2;
    …
    counter = counter + 1;
} /* while (counter <= final value) */
statement_after;
```



Arithmetic Assignment Operators #1

Some while back, we saw the following:

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

We learned that this statement increases the value of `x` by `y`.

That is, the statement takes the old value of `x`, adds `y` to it, then assigns the result of this addition to `x`.

This kind of statement is so common that the C language has a special operator for it, called the ***addition assignment operator***:

```
x += y;
```

Note that the two statements above **behave identically**.

Arithmetic Assignment Operators #2

C also has arithmetic assignment operators for the other arithmetic operations:

This:	Is identical to this:	Operation Name
`x += y;`	`x = x + y;`	Addition assignment
`x -= y;`	`x = x - y;`	Subtraction assignment
`x *= y;`	`x = x * y;`	Multiplication assignment
`x /= y;`	`x = x / y;`	Division assignment
`x %= y;`	`x = x % y;`	Remainder assignment (`int` operands only)

Jargon: Syntactic Sugar

Syntactic sugar is a programming language construct that doesn't add any new capability to the language, but makes the language a bit easier to use.

Arithmetic assignment operations are syntactic sugar.

Increment & Decrement Operators #1

One of the most common addition assignments is:

```
x = x + 1;
```

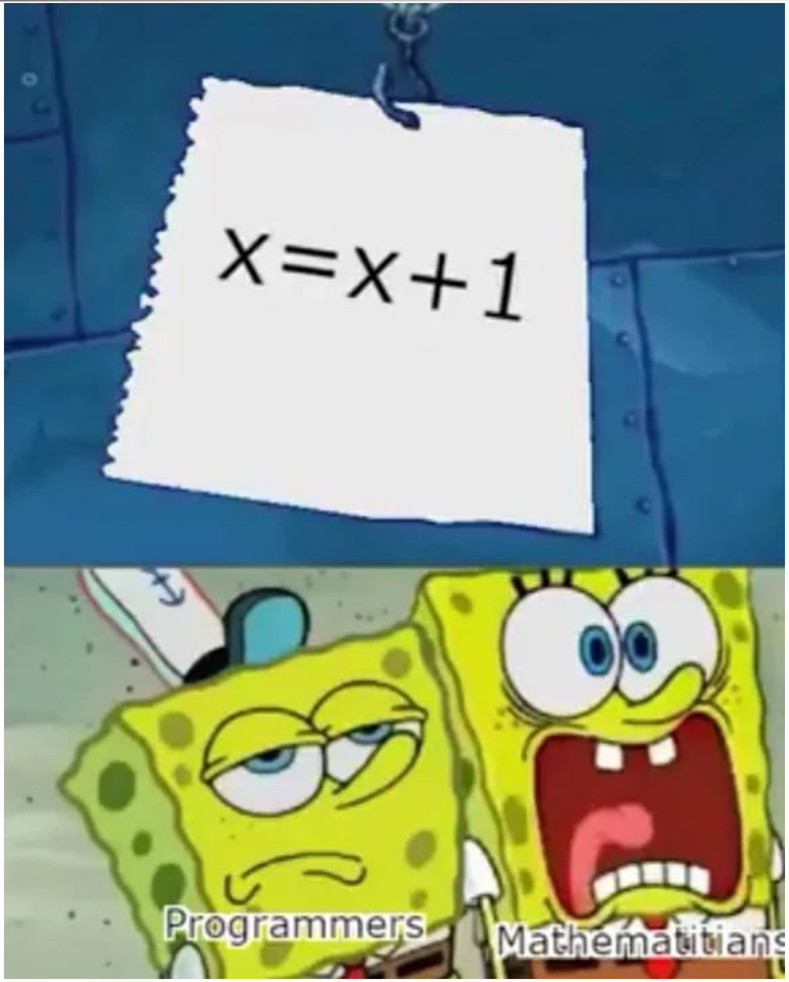
We learned that this statement increases the value of `x` by `1`.

That is, the statement takes the old value of `x`, adds `1` to it, then assigns the resulting sum to `x`.

For this statement, we could use the addition assignment operator:

```
x += 1;
```

`x = x + 1` : Programmers vs Mathematicians



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Increment & Decrement Operators #2

```
x = x + 1;
```

For this statement, we could use the addition assignment operator:

```
x += 1;
```

But this statement is **MUCH** more common than

```
x += y;
```

for generic `y`, so the C language has another special operator, called the ***increment operator***:

```
x++;
```

(This is also known as the ***autoincrement operator***.)

Increment & Decrement Operators #3

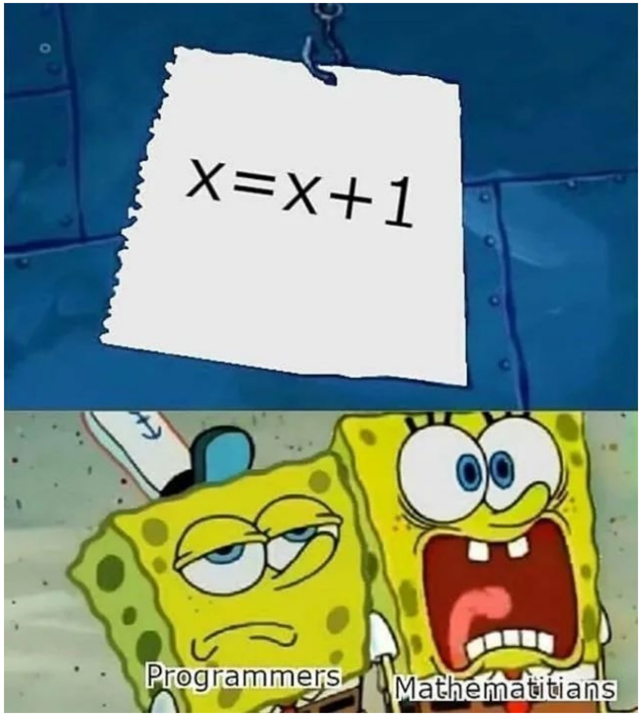
```
x = x + 1;
x += 1;
```

Increment operator:

```
x++;
```

Also:

```
x = x - 1;
x -= 1;
x--;
```



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This is known as the ***decrement operator*** (and also as the ***autodecrement operator***).

Increment & Decrement Operators #4

This:	is identical to this:	is identical to this:	Name
`x++;`	`x += 1;`	`x = x + 1;`	Increment (or autoincrement)
`x--;`	`x -= 1;`	`x = x - 1;`	Decrement (or autodecrement)

Note that the increment and decrement operators are syntactic sugar, just like the arithmetic assignment operators.

`for` Loop

A ***`for` loop*** has this form:

```
for (counter   = initial_value;
     counter <= final_value; counter++) {
    statement1;
    statement2;
    ...
} /* for counter */
```

`for` Loop vs `while` Loop

A ***`for` loop*** has this form:

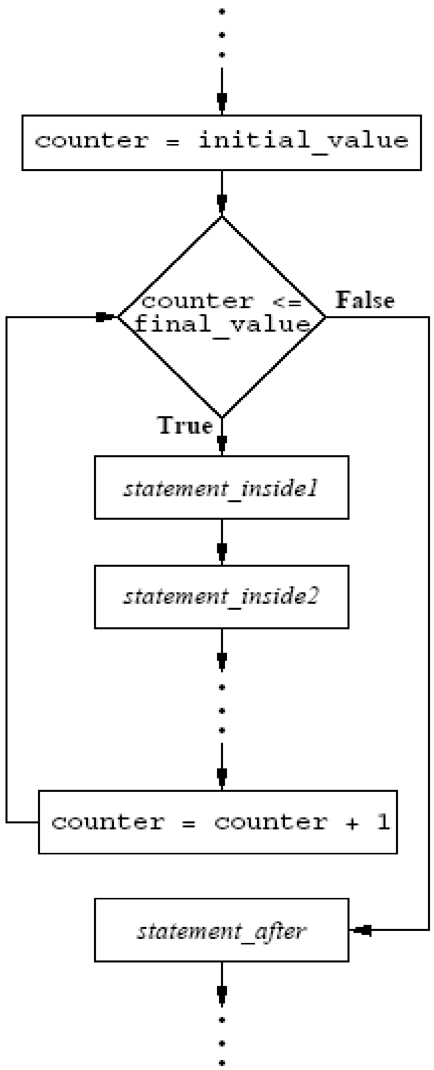
```
for (counter  = initial_value;
     counter <= final_value; counter++) {
    statement1;
    statement2;
    ...
} /* for counter */
```

A **`for` loop** behaves **exactly the same** as a count-controlled `while` loop:

```
counter = initial_value;
while (counter <= final value) {
    statement1;
    statement2;
    ...
    counter = counter + 1;
} /* while (counter <= final value) */
```

`for` Loop Flowchart

```
for (counter = initial_value;
     counter <= final_value;
     counter++) {
    statement1;
    statement2;
    ...
} /* for counter */
statement_after;
```



Notice that the `for` loop flowchart is **<u>identical</u>** to the `while` loop flowchart on slide 8 – **NOT A COINCIDENCE!**

Three Programs That Behave the Same #1

```
#include <stdio.h>

int main ()
{ /* main */
    int count;
    int sum;

    sum = 0;
    count = 1;
    sum = sum + count;
    count = count + 1;
    sum = sum + count;
    count = count + 1;
    sum = sum + count;
    count = count + 1;
    sum = sum + count;
    count = count + 1;
    sum = sum + count;
    count = count + 1;
    printf("count = %d\n", count);
    printf("sum   = %d\n", sum);
    return 0;
} /* main */
```

Three Programs That Behave the Same #2

```
#include <stdio.h>

int main ()
{ /* main */
    int count;
    int sum;

    sum = 0;
    count = 1;
    while (count <= 5) {
        sum = sum + count;
        count += 1;
    } /* while (count <= 5) */
    printf("count = %d\n", count);
    printf("sum   = %d\n", sum);
    return 0;
} /* main */
```

Three Programs That Behave the Same #3

```
#include <stdio.h>

int main ()
{ /* main */
    int count;
    int sum;

    sum = 0;
    for (count = 1; count <= 5; count++) {
        sum = sum + count;
    } /* for count */
    printf("count = %d\n", count);
    printf("sum   = %d\n", sum);
    return 0;
} /* main */
```

Three Programs That Behave the Same #4

```
% gcc -o manycountstmts manycountstmts.c
% manycountstmts
count = 6
sum   = 15

% gcc -o while_loop while_loop.c
% while_loop
count = 6
sum   = 15

% gcc -o for_loop for_loop.c
% for_loop
count = 6
sum   = 15
```

`for` Loop Example

```
% cat product_loop.c
#include <stdio.h>

int main ()
{ /* main */
    int count;
    int product;

    product = 1;
    for (count = 1; count <= 5; count++) {
        product = product * count;
    } /* for count */
    printf("After the loop: count = %d, ", count);
    printf("product = %d\n", product);
    return 0;
} /* main */
% gcc -o product_loop product_loop.c
% product_loop
After the loop: count = 6, product = 120
```

`for` Loop Behavior #1

```
for (count = 1; count <= 5; count++) {
    product = product * count;
} /* for count */
```

1. The ***loop initialization*** is performed; typically, the ***loop control variable*** (also known as the ***loop counter*** or the ***loop index***) is assigned an ***initial value*** (also known as the ***lower bound***).

NOTE: The loop initialization is performed only the **FIRST TIME** that the `for` statement is reached.

Once a loop is underway, that loop's initialization **DOESN'T** get executed again.

We refer to each trip through the body of the loop as an ***iteration***.

`for` Loop Behavior #2

```
for (count = 1; count <= 5; count++) {
    product = product * count;
} /* for count */
```

2. The loop ***continuation condition*** is evaluated, to check whether the **loop control variable** (or **loop counter** or **loop index**) hasn't yet passed the ***final value*** (also known as the ***upper bound***). If the loop continuation condition evaluates to false (`0`), then the `for` loop body is skipped, and the program continues on from the first statement after the `for` loop's block close. But, if the loop continuation condition evaluates to true (`1`), then enter the loop body.

We refer to each trip through the body of the loop as an ***iteration***.

`for` Loop Behavior #3

```
for (count = 1; count <= 5; count++) {
    product = product * count;
} /* for count */
```

3. Each statement inside the ***loop body*** is executed in sequence.

We refer to each trip through the body of the loop as an ***iteration***.

`for` Loop Behavior #4

```
for (count = 1; count <= 5; count++) {
    product = product * count;
} /* for count */
```

4. When the end of the loop body is reached (indicated by the block close associated with the block open of the `for` statement), the loop counter is changed by the ***loop change statement***, typically (though not always) by incrementing.

We refer to each trip through the body of the loop as an ***iteration***.

`for` Loop Behavior #5

```
for (count = 1; count <= 5; count++) {
    product = product * count;
} /* for count */
```

5. **REPEAT** from step 2.

(Step 1, the loop initialization, gets executed **<u>ONLY THE FIRST TIME</u>** that the `for` statement is reached.)

We refer to each trip through the body of the loop as an ***<u>iteration</u>***.

`for` Loop Behavior #6

```
int product = 1;
int count;
for (count = 1; count <= 5; count++) {
    product = product * count;
} /* for count */
```

The above program fragment behaves **<u>identically</u>** the same as:

```
                  /* Program Trace */
int product = 1;  /* product = 1 */
int count;        /* count is undefined */
count = 1;        /* count == 1, product == 1 */
product *= count; /* count == 1, product == 1 */
count++;          /* count == 2, product == 1 */
product *= count; /* count == 2, product == 2 */
count++;          /* count == 3, product == 3 */
product *= count; /* count == 3, product == 6 */
count++;          /* count == 4, product == 6 */
product *= count; /* count == 4, product == 24 */
count++;          /* count == 5, product == 24 */
product *= count; /* count == 5, product == 120 */
count++;          /* count == 6, product == 120 */
```

Why Have `for` Loops?

If a count-controlled loop can be expressed as a `while` loop, then why have `for` loops at all?

Imagine that a count-controlled loop has a very long loop body, for example longer than a screenful of source code text.

In that case, the change statement (for example, incrementing the loop counter variable) could be very far away from the initialization and the condition.

In which case, looking at the `while` statement, you couldn't immediately understand its count-controlled behavior.

But by putting all of the count-control code in a single `for` statement, you can look at just the `for` statement and immediately understand the count-control behavior.