Learning Objectives: While Loops

- **Explain `while` loop syntax**
- **Identify the causes of an infinite `while` loop**
- **Describe the `break` statement as it relates to a `while` loop**

While Loops

While Loop Syntax

`while` loops, like `for` loops, use curly braces `{}` and indents for all commands that should be repeated. However, `for` loops generally contain 3 elements (an initialized variable, a boolean expression involving that variable, and a change in the value of that variable) while a `while` loop usually contains just a boolean expression. The `for` and `while` loops below produce the same results.

```
for (int i = 0; i < 5; i++) {
  cout << "Loop#: " << i <<
        endl;
}
```

```
int i = 0;
while (i < 5) {
  cout << "Loop# " << i <<
  i++;
}
```

Note that the variable declaration and initialization happen *before* the start of the `while` loop and any changes that occur to the variable happen *within* the body of the curly braces `{}`. On the other hand, everything happens in one step within parentheses `()` when using a `for` loop.

Here is another example of a `while` loop that prints `Hello` based on the value of the variable `count`.

```
int count = 5; // some random number set by user
while (count > 0) {
  cout << "Hello" << endl;
  count--;
}
```

Code Visualizer

challenge

What happens if you:

- Change the while statement to `while (count > -1 * count)`?
- Replace `count--` in the code above with `count = count - 2`?
- Change the while statement to `while (count < 10)`?

▼ **How does `while (count > -1 * count)` work?**

To understand how the loop works, it's best to substitute values in for the variable `count`. In the first iteration, we have `while (5 > -1 * 5)`, this statement is true so the print command is executed. Since `count` gets decremented by 1 with each iteration, the `while` loop condition changes slightly every time like as follow:

- `while (4 > -1 * 4)`
- `while (3 > -1 * 3)`
- `while (2 > -1 * 2)`
- `while (1 > -1 * 1)`

Once the condition gets to `while (0 > -1 * 0)`, it no longer holds true and the while loop ends. The result is 5 `Hello`s being printed to the screen.

Infinite Loops

Infinite loops are loops that do not have a test condition that causes them to stop. The following is a common mistake that results in an infinite loop:

```
int count = 5; // some random number set by user
while (count > 0) {
  cout << "Hello" << endl;
}
```

Since the variable `count` never gets decremented. It remains at 5, and 5 will forever be greater than 0, so the loop will never stop.

warning

Copy the code above and `TRY IT` to see what happens. C++ will eventually stop the loop due to an output limit, but it may take some time before this happens.

Why Use a While Loop?

If a `while` loop does the same thing as a `for` loop, then what is the purpose of having both? `while` loops are actually more useful when you are waiting for a certain event to occur. Imagine you are making a video game. The game should continue until the player loses all of their lives. You don't know how long this will take, so a `while` loop is more appropriate. On the other hand, if you have more specific loop parameters, a `for` loop will be better.

```
int player_lives = 3;

while (player_lives > 0) {
  // video game code
  // goes here
}
```

Turtle Coding: While Loop

Instead of a `for` loop, recreate the images below using a `while` loop.

▼ *Turtle Graphics Review*

- `tina.forward(n)` - Where `n` represents the number of pixels.
- `tina.backward(n)` - Where `n` represents the number of pixels.
- `tina.right(d)` - Where `d` represents the number of degrees.
- `tina.left(d)` - Where `d` represents the number of degrees.
- `tina.pencolor({"COLOR"})` - Where `COLOR` represents the track or line color you want tina to leave behind.
- `tina.width(W)` - Where `W` represents how wide (in pixels) tina's track is.
- `tina.shape("SHAPE")` - Where `SHAPE` represents the shape tina takes.
- `tina.speed(SPEED)` - Where `SPEED` represents how fast tina moves

Challenge 1

.guides/img/TurtleChallenge1

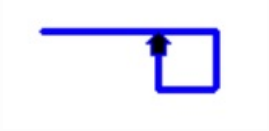
▼ **Hint**

The pattern is still the same:

1. Go forward (creating a long line).
2. Make a right turn.
3. Go forward (creating a small line).
4. Make a right turn.
5. Go forward (creating another small line).
6. Make a right turn.
7. Go forward (creating a final small line).
8. Repeat steps #1 through #7 three more times for a total of **four** iterations.

However, a `while` loop usually contains only a boolean expression(s) in its header. Thus, you must initialize a **counting variable** *before* the start of the `while` loop. Also, that counting variable should be **incremented** *inside* the

body of the loop. The pattern you are trying to iterate is still the same:



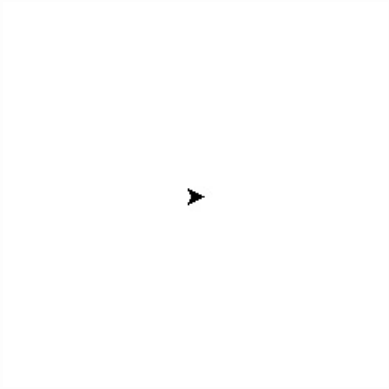
Challenge 2

.guides/img/TurtleChallenge2

▼ **Hint**

Since a circle has 360 degrees, you will need a loop that repeats 360 times. Be careful about how far the turtle moves forward and turns. The circle can get very big, very quickly.

Challenge 3



.guides/img/TurtleChallenge3

▼ **Hint**

The pattern here is to move forward and make a right turn.

The trick lies within the fact that the distance the turtle moves has to get larger as the loop advances. Think of some operators that you can use to make the loop iterator variable get bigger during each iteration.

▼ **Sample Solutions**

Here are some sample solutions using `while` loops:

```
tina.pencolor({"blue"});
tina.width(2);
tina.shape("arrow");
tina.speed(TS_SLOWEST);

int i = 0;
while (i < 4) {
  tina.forward(75);
  tina.right(90);
  tina.forward(25);
  tina.right(90);
  tina.forward(25);
  tina.right(90);
  tina.forward(25);
  i++;
}
```

```
tina.pencolor({"red"});
tina.width(2);
tina.shape("square");
tina.speed(TS_FASTEST);

int i = 0;
while (i < 360) {
  tina.forward(1);
  tina.right(1);
  i++;
}
```

```
tina.pencolor({"green"});
tina.width(2);
tina.shape("triangle");
tina.speed(TS_NORMAL);

int i = 10;
while (i <= 200) {
  tina.forward(i);
  tina.right(90);
  i+=10;
}
```

info

NOTE

In **most** cases, `for` loops and `while` loops can be used interchangeably. It is up to you to decide which one is better suited for your task.

Break Statement

Infinite Loops Are Bad, Right?

Well, that depends. If an infinite loop is caused because the counting variable isn't incremented, then it's a bug. However, some programmers purposely create a condition that will always evaluate to true. Therefore, the loop will always run. In such cases, a `break` statement is used to stop the loop at a particular point in the program.

Take a look at the following program (also shown in the text editor on the left).

```
#include <iostream>
using namespace std;

int main() {

  srand(time(NULL)); // start randomizer every time program runs
  while (true) {
    cout << "This is an infinite loop" << endl;
    int randNum = rand() % 100 + 1; // generate random number
        between 1 and 100

    if (randNum > 75) {
      cout << "The loop ends" << endl;
      break; // stop the loop
    } // end if condition
  } // end while loop

  cout << "The program ends" << endl;

  return 0;

}
```

Then click on the `TRY IT` button below *a few times* to run the code and see the resulting outputs. You can also click on the ++Code Visualizer++ link below to see how the code runs behind-the-scenes.

Code Visualizer

Even though `while (true)` will always evaluate as a true statement, the loop never becomes infinite because of the `break` statement.

challenge

What happens if you:

- Remove `break;` from the program?
- Add `break;` to the line before `cout << "The loop ends" << endl;`?

Code Visualizer

Comparing While Loops

The `while` loops introduced on the previous pages look different from the `while` loop covered on this page; however, they both have the same components and behave similarly.

```
int count = 5;
while (count > 0) {
  cout << "Hello" << endl;
  count--;
}
```

```
srand(time(NULL));
while (true) {
  cout << "This is an infinite loop" << endl;
  int randNum = rand() % 100 + 1;

  if (randNum > 75) {
    cout << "The loop ends" << endl;
    break;
  }
}

cout << "The program ends" << endl;
```

Variable to be tested

Test to end the loop

Change the variable

.guides/img/WhileLoopComparison