

## 4.9 — Boolean values

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In real-life, it's common to ask or be asked questions that can be answered with “yes” or “no”. “Is an apple a fruit?” Yes. “Do you like asparagus?” No.

Now consider a similar statement that can be answered with a “true” or “false”: “Apples are a fruit”. It's clearly true. Or how about, “I like asparagus”. Absolutely false (yuck!).

These kinds of sentences that have only two possible outcomes: yes/true, or no/false are so common, that many programming languages include a special type for dealing with them. That type is called a **Boolean** type (note: Boolean is properly capitalized in the English language because it's named after its inventor, George Boole).

### Boolean variables

Boolean variables are variables that can have only two possible values: true, and false.

To declare a Boolean variable, we use the keyword **bool**.

```
1 | bool  
   | b;
```

To initialize or assign a true or false value to a Boolean variable, we use the keywords **true** and **false**.

```
1 | bool b1 { true };  
   | bool b2 { false };  
   | b1 = false;  
   | bool b3 {}; // default initialize to  
   | false
```

Just as the unary minus operator (-) can be used to make an integer negative, the logical NOT operator (!) can be used to flip a Boolean value from true to false, or false to true:

```
1 | bool b1 { !true }; // b1 will be initialized with the value  
   | false  
   | bool b2 { !false }; // b2 will be initialized with the value  
   | true
```

Boolean values are not actually stored in Boolean variables as the words “true” or “false”. Instead, they are stored as integers: true becomes the integer 1, and false becomes the integer 0. Similarly, when Boolean values are evaluated, they don't actually evaluate to “true” or “false”. They evaluate to the integers 0 (false) or 1 (true). Because Booleans actually store integers, they are considered an integral type.

## Printing Boolean values

When we print Boolean values, `std::cout` prints 0 for false, and 1 for true:

```
1 #include <iostream>

int main()
{
    std::cout << true << '\n'; // true evaluates to 1
    std::cout << !true << '\n'; // !true evaluates to 0

    bool b{false};
    std::cout << b << '\n'; // b is false, which evaluates to
0
    std::cout << !b << '\n'; // !b is true, which evaluates to
1
    return 0;
}
```

Outputs:

```
1
0
0
1
```

If you want `std::cout` to print “true” or “false” instead of 0 or 1, you can use `std::boolalpha`. Here’s an example:

```
1 #include <iostream>

int main()
{
    std::cout << true << '\n';
    std::cout << false << '\n';

    std::cout << std::boolalpha; // print bools as true or
false

    std::cout << true << '\n';
    std::cout << false << '\n';
    return 0;
}
```

This prints:

```
1
0
true
false
```

You can use `std::noboolalpha` to turn it back off.

## Integer to Boolean conversion

You can’t initialize a Boolean with an integer using uniform initialization:

```
1 #include <iostream>

int main()
{
    bool b{ 4 }; // error: narrowing conversions
disallowed
    std::cout << b;

    return 0;
}
```

However, in any context where an integer can be converted to a Boolean, the integer 0 is converted to false, and any other integer is converted to true.

```

1  #include <iostream>

    int main()
    {
        std::cout << std::boolalpha; // print bools as true or false

        bool b1 = 4 ; // copy initialization allows implicit conversion from int to bool
        std::cout << b1 << '\n';

        bool b2 = 0 ; // copy initialization allows implicit conversion from int to bool
        std::cout << b2 << '\n';

        return 0;
    }

```

This prints:

```

true
false

```

Note: `bool b1 = 4;` may generate a warning. If so you'll have to disable treating warnings as errors to compile the example.

## Inputting Boolean values

Inputting Boolean values using `std::cin` sometimes trips new programmers up.

Consider the following program:

```

1  #include <iostream>

    int main()
    {
        bool b{}; // default initialize to false
        std::cout << "Enter a boolean value: ";
        std::cin >> b;
        std::cout << "You entered: " << b << '\n';

        return 0;
    }

```

```

Enter a Boolean value: true
You entered: 0

```

Wait, what?

It turns out that `std::cin` only accepts two inputs for boolean variables: 0 and 1 (not true or false). Any other inputs will cause `std::cin` to silently fail. In this case, because we entered true, `std::cin` silently failed. A failed input will also zero-out the variable, so `b` also gets assigned value false. Consequently, when `std::cout` prints a value for `b`, it prints 0.

To allow `std::cin` to accept “false” and “true” as inputs, the `std::boolalpha` option has to be enabled:

```

1  #include <iostream>

   int main()
   {
       bool b{};
       std::cout << "Enter a boolean value: ";

       // Allow the user to enter 'true' or 'false' for boolean
       values
       // This is case-sensitive, so True or TRUE will not work
       std::cin >> std::boolalpha;
       std::cin >> b;

       std::cout << "You entered: " << b << '\n';

       return 0;
   }

```

However, when `std::boolalpha` is enabled, "0" and "1" will no longer be treated as booleans.

## Boolean return values

Boolean values are often used as the return values for functions that check whether something is true or not. Such functions are typically named starting with the word `is` (e.g. `isEqual`) or `has` (e.g. `hasCommonDivisor`).

Consider the following example, which is quite similar to the above:

```

1  #include <iostream>

   // returns true if x and y are equal, false otherwise
   bool isEqual(int x, int y)
   {
       return (x == y); // operator== returns true if x equals y, and false
       otherwise
   }

   int main()
   {
       std::cout << "Enter an integer: ";
       int x{};
       std::cin >> x;

       std::cout << "Enter another integer: ";
       int y{};
       std::cin >> y;

2
3   std::cout << std::boolalpha; // print bools as true or false

       std::cout << x << " and " << y << " are equal? ";
       std::cout << isEqual(x, y); // will return true or false

       return 0;
   }

```

Here's output from two runs of this program:

```

Enter an integer: 5
Enter another integer: 5
5 and 5 are equal? true

```

```
Enter an integer: 6
Enter another integer: 4
6 and 4 are equal? false
```

How does this work? First we read in integer values for `x` and `y`. Next, the expression `isEqual(x, y)` is evaluated. In the first run, this results in a function call to `isEqual(5, 5)`. Inside that function, `5 == 5` is evaluated, producing the value `true`. The value `true` is returned back to the caller to be printed by `std::cout`. In the second run, the call to `isEqual(6, 4)` returns the value `false`.

Boolean values take a little bit of getting used to, but once you get your mind wrapped around them, they're quite refreshing in their simplicity! Boolean values are also a huge part of the language -- you'll end up using them more than all the other fundamental types put together!

We'll continue our exploration of Boolean values in the next lesson.



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