12.2 C-Style Enumerations

The declaration

```
enum Color {RED, ORANGE, YELLOW, GREEN, BLUE, INDIGO, VIOLET};
```

creates a new type named `Color` whose values are the seven colors listed between the curly braces. Because the valid values are explicitly listed or *enumerated* in the declaration, this kind of type is called an **enumeration.**

ENUMERATION DECLARATIONS

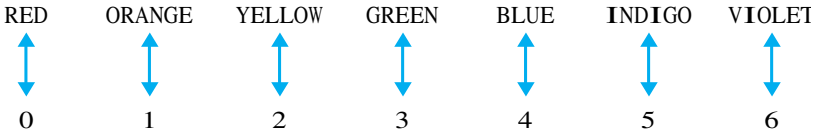
The declaration of an enumeration must:

1. Provide a name for the enumeration, which becomes the name of a new type
2. Explicitly list all of the values (called **enumerators**) of this new type

In the example above, `Color` is the name of the enumeration, and its enumerators are the identifiers

```
RED, ORANGE, YELLOW, GREEN, BLUE, INDIGO, VIOLET
```

When the compiler encounters such a declaration, it performs an object-to-integer mapping, associating the integer 0 with the first identifier in this list, the integer 1 with the second, and so on. Thus, for the preceding declaration, the compiler makes the following associations:



As another example, the declaration

```
enum Gender {FEMALE, MALE};
```

declares a new type `Gender` whose values are the identifiers `FEMALE` and `MALE`; the compiler will associate the integer 0 with `FEMALE` and the integer 1 with `MALE`. Similarly, the declaration

```
enum HandTool {HAMMER, PLIERS, SAW, SCREWDRIVER};
```

constructs a new type `HandTool` whose values are `HAMMER`, `PLIERS`, `SAW`, and `SCREWDRIVER`, and associates the integers 0, 1, 2, and 3 with these identifiers, respectively. By contrast, neither of the declarations

```
enum Zipcodes {12531, 14405, 21724, 30081};     // ERROR!
enum LetterGrades {A, A-, B+, B, B-, C+, C,     // ERROR!
                   C-, D+, D, D-, "FAIL" };
```

is a valid enumeration, because each contains items that are not valid identifiers.

C++ also allows the programmer to specify explicitly the values given to the enumerators. For example, the declaration

```
enum NumberBase {BINARY = 2,
                 OCTAL = 8,
                 DECIMAL = 10,
                 HEX = 16, HEXADECIMAL = 16};
```

associates the identifiers `BINARY`, `OCTAL`, `DECIMAL`, `HEX`, and `HEXADECIMAL` with the values 2, 8, 10, 16, and 16, respectively. Because each enumerator is a power of 2, each has a 1 at a different position in its binary representation. Such enumerators are called **bit masks,** and make it possible to efficiently store a boolean value such as an `iostream` status attribute using only a single bit of memory.

Similarly, if we wished to have the values 1, 2, . . . , 7 associated with the seven colors given earlier (instead of 0 through 6), we could use the declaration

```
enum Color {RED = 1, ORANGE = 2, YELLOW = 3, GREEN = 4,
            BLUE = 5, INDIGO = 6, VIOLET = 7};
```

or more compactly,

```
enum Color {RED = 1, ORANGE, YELLOW, GREEN, BLUE, INDIGO, VIOLET};
```

because the integer associated with an enumerator is, by default, one more than the integer associated with the preceding enumerator. The `iostream` library uses an enumeration declaration something like

```
enum Flag {GOOD_BIT = 1, BAD_BIT, FAIL_BIT = 4, EOF_BIT = 8};
```

which associates `1` with `GOOD_BIT`, `2` with `BAD_BIT`, `4` with `FAIL_BIT`, and `8` with `EOF_BIT`.[1]

These examples illustrate the flexibility of C++—the integers associated with the names need not be distinct nor must they be given in ascending order, although it is good programming style to do so.

The general form of an enumeration declaration is as follows:

Enumeration Declaration Statement

Form:

```
enum TypeName { List };
```

where:

TypeName is an identifier naming a new type; and

List is a list of the values for the new type, separated by commas, each of which is a valid

IDENTIFIER

or an initialization expression of the form

IDENTIFIER = integer_constant

Purpose:

Define a new data type whose values are the identifiers in *List*. Each identifier is associated with an integer as follows:

If an item in *List* has the form *IDENTIFIER = integer_constant*, then
    integer_constant is associated with *IDENTIFIER*;

otherwise if it is the first item in the list,
    0 is associated with the *IDENTIFIER*;

otherwise,
    1 + (the integer associated with the preceding identifier) is associated with the *IDENTIFIER*.

Because the compiler essentially treats an enumeration as a series of constant integer declarations, we use the same uppercase naming convention for enumerators that we use for constant objects.

DEFINING ENUMERATION OBJECTS

To illustrate how enumerations are used, consider the following expansion of enumeration `Color`:

```
enum Color {COLOR_UNDERFLOW = -1,          // too-low indicator
            RED, ORANGE, YELLOW, GREEN,    // 0-3
            BLUE, INDIGO, VIOLET,          // 4-6
            COLOR_OVERFLOW,                // too-high indicator
            NUMBER_OF_COLORS = 7};
```

Here, we added the identifiers `COLOR_UNDERFLOW` and `COLOR_OVERFLOW` as values to indicate out-of-range errors. These values can be used to keep from "falling off the ends of the list." We also added the identifier `NUMBER_OF_COLORS`, whose value is the number of values in the list, because this count is often useful.

If it is worthwhile to define a new type, it is usually worth taking the time to store that type in a library so that it can be easily reused. We thus store this declaration of type `Color` in a header file *Color.h* so that programs can include it and avoid reinventing the wheel.

Given this type, we can declare a `Color` object named `theColor`:

```
Color theColor;
```

Enumeration objects can also be initialized when they are declared:

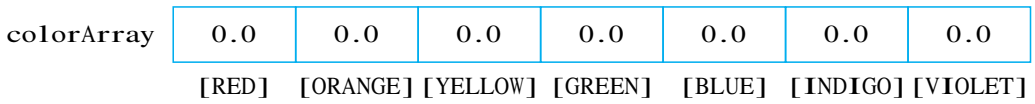
```
Color theColor = YELLOW;
```

USING ENUMERATIONS

In addition to defining enumeration objects, an enumeration can be used as the index of an array. For example, suppose we define `colorArray` as follows:

```
double colorArray[NUMBER_OF_COLORS] = {0.0};
```

This definition builds the object `colorArray` as a fixed-size array with index values 0 through 6. Because the C++ compiler treats the identifiers `RED` through `VIOLET` as the integer values 0 through 6, we can visualize `colorArray` as follows:



The `Color` enumerators can then be used with the subscript operator to access the array elements.

In the same way, an extra enumerator like `NUMBER_OF_COLORS` can be used to provide a `vector<T>` with an initial size:

```
vector<double> colorVector(NUMBER_OF_COLORS);
```

This defines `colorVector` as a varying-sized object, initially with `NUMBER_OF_COLORS` elements: