Templates

Ch 17

Highlights

- Variable types

```
template <typename T>
void dostuff(T x)
{
    cout << x << endl;
}
```

```
template <typename T>
class holdinStuff {
public:
    T stuff;
};
```

Review: Types

A <u>type</u> is a container for a specific value

data value

data type

Review: Types

It is normally not good to mix these up...

Review: Types

C++ is fairly picky about most types, only certain values can be stored in a type

42	'x'	“hello world”
int	char	string

You can convert between types easily (such as from int to double)

But not others (hard to go int to string)

Templates

While C++ has no “I can hold any data” type, it does have a “I can be any type” variables

That is there is no “magic” type that can be both int and string simultaneously

Instead, you can specify that “magic” will be some type... you just don't know what yet

In C++ we call this a <u>template</u>

Templates

You can think of this not as “a type to hold all values” but as “a box to hold any type”

42

int

"hello world"

string

Templates

You have actually seen templates before, namely static_cast (a function)

You provide the type you wish to convert the data into, but outside of the normal parenthesis

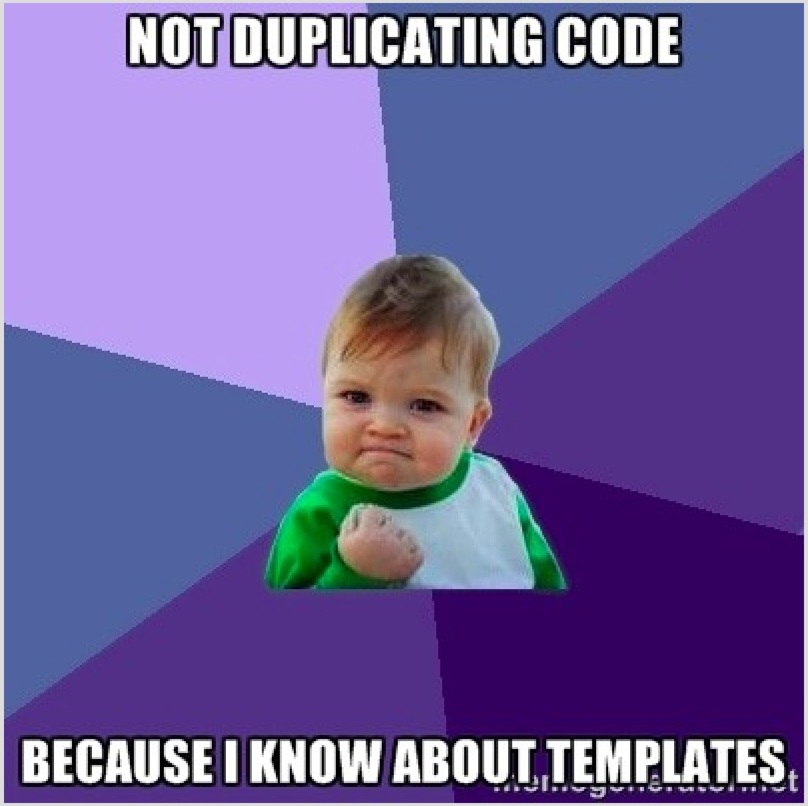
```
cout << static_cast<char>(100) << endl;
```

You can put any type you want here!

Templates

You can use a variable-type for both:

1. Functions
2. Classes



This allows you to make more general functions (thus less code)

However, this function should be generalizable (for example, factorial only works for ints...)

Function: templates

To use a variable-type, you put template before the function and specify the type variable

```
template <typename T>
void coutMe(T x)
{
    cout << x << endl;
}
```

T is a variable for the type

This lets you use "T" as a type anywhere in the function
(see: coutMe.cpp)   (see: goodSwap.cpp)

Function: templates

You can also use multiple types variables, just separate them with a comma:

```
template <typename T , typename T2>
void mswap(T& a, T2& b);
```

You can have as many different (or similar) types of input as you want

(Although this does not work well for swap)
(see: multipleTypes.cpp)

Function: templates

You can check to see if the input types are the same by doing this:

```
template <typename T1, typename T2>
void foo(T1 x, T2 y)
{
    if( is_same<T1,T2>::value) {
        cout << "Same types... doing something\n";
    }
    else {
        cout << "Different types\n";
    }
}
```

(see: checkSameType.cpp)

Function: notation

As C++ is rather old, there are a lot of ways to say the same thing (same with templates)

These both mean the same thing (mostly):

```
template <typename T>
template <class T>
```

Some compilers also see these as the same:

```
coutMe<int>(2);
coutMe(2);
```

Bad templates!

Templates are not magic that allow you to do anything with any type!

If an operation does not exist between types and you try and use it, computer will get angry

You also cannot ignore types completely by making everything a template (main must have real types at the very least)
(see: badTemplates.cpp)

Classes: templates

Templates for classes are very similar:

```
template <typename T>
class holdinStuff {
public:
    T stuff;
};
```

After using template, you can use “T” as a type inside the class anywhere

(see: classTemplate.cpp)

vector class

Normal arrays have multiple issues:
(1) cannot grow (have to do partially filled)
(2) cannot insert (have to shift)

However, there is a class that does these things for you automatically called “vector”

```
#include <vector>
```

It also uses templates so you can store any type (much like normal arrays)
(see: vector.cpp)

vector class

Useful vector functions:

- push_back(array_type) - adds this element to back of array
- at(int) or [int] - index into the array at this index
- size() - how many elements there are now
- insert(iterator, array_type) - inserts an element at iterator's spot (shifts current element and all later down one)
- erase(iterator) - removes an element