Template functions

Templates allow us to write function or class once:

```
template< typename T >
void fun(const T& input) { ... }
```

but get a whole family of overloaded specifications:

```
void fun(const int& input) { ... }
void fun(const float& input) { ... }
void fun(const char& input) { ... }
void fun(const MyClass& input) { ... }
...
```

Template functions

Recall: two functions are overloaded if they have same name & return type, but different parameter types

```
void print_array(const int* array, int count) {
    //                    ^^^
    for(int i = 0; i < count; ++i) {
        std::cout << array[i] << " ";
    }
}

void print_array(const double* array, int count) {
    //                    ^^^^^^
    for(int i = 0; i < count; ++i) {
        std::cout << array[i] << " ";
    }
}
```

Template functions

Q: When should you consider using function templates?

When you find yourself writing functions with essentially the same body, but different types.

Template functions

This function sums even-indexed elements in a `std::vector`:

```
int sum_every_other(const std::vector<int>& ls) {
    int total = 0;
    for(std::vector<int>::const_iterator it = ls.cbegin();
      it != ls.cend(); ++it) {
        total += *it;
        ++it;
    }
    return total;
}
```

Works for `const vector<int>&`, but similar code could be used for other containers, e.g. a `std::list`.

Template functions

```
int sum_every_other(const std::vector<int>& ls) {
    //                      ^^^^^^^^^^^^
    int total = 0;
    for(std::vector<int>::const_iterator it = ls.cbegin();
    //  ^^^^^^^^^^^^
      it != ls.cend(); ++it) { total += *it; ++it; }
    return total;
}

int sum_every_other(const std::list<int>& ls) {
    //                      ^^^^^^^^^^
    int total = 0;
    for(std::list<int>::const_iterator it = ls.cbegin();
    //  ^^^^^^^^^^
      it != ls.cend(); ++it) { total += *it; ++it; }
    return total;
}
```

Template functions

```
// template1.cpp

#include "sum_every_other.h"

int main() {
    std::vector<int> vec = {10, 7, 10, 7, 10, 7};
    int sum = sum_every_other(vec);
    std::cout << "sum of every-other (vector): " << sum << std::endl;

    std::list<int> lis;
    lis.assign(vec.begin(), vec.end());
    sum = sum_every_other(lis);
    std::cout << "sum of every-other (list): " << sum << std::endl;
    return 0;
}
```

```
$ g++ -o template1 template1.cpp -std=c++11 -pedantic -Wall -Wextra
```

```
$ ./template1
```

```
sum of every-other (vector): 30
sum of every-other (list): 30
```

Template functions

Repetitive code is a sign of bad design

e.g. a correction or modification for one of them also has to be made for any others we've made

In fact, we do have an error in our `sum_every_other` function.

Have you spotted it?

Template functions

Extra `++it` skips over `ls.cend()` when the container has odd number of elements. We need another check:

```
int sum_every_other(const std::vector<int>& ls) {
    int total = 0;
    for(std::vector<int>::const_iterator it = ls.cbegin();
      it != ls.cend(); ++it) {
        total += *it;
        ++it;
        // now we can't skip over ls.cend()
        if (++it == ls.cend()) break; // that's better
    }
    return total;
}
```

Template functions

```
template< typename T >
int sum_every_other(const T& ls) {
    int total = 0;
    for(typename T::const_iterator it = ls.cbegin();
      it != ls.cend(); ++it) {
        total += *it;
        if(++it == ls.cend()) break;
    }
    return total;
}
```

If we pass `std::vector<int>`, compiler **instantiates** an appropriate function overload

- Same if we pass `std::list<int>`, `std::vector<double>`, ...

Template functions

```
// template2.cpp
#include "sum_every_other_template.h"
#include <iostream>
#include <vector>
#include <list>

int main() {
    std::vector<int> vec = {10, 7, 10, 7, 10, 7};
    int sum = sum_every_other(vec);
    std::cout << "sum of every-other (vector): " << sum << std::endl;

    std::list<int> lis;
    lis.assign(vec.begin(), vec.end());
    sum = sum_every_other(lis);
    std::cout << "sum of every-other (list): " << sum << std::endl;
    return 0;
}
```

```
$ g++ -o template2 template2.cpp -std=c++11 -pedantic -Wall -Wextra
$ ./template2
sum of every-other (vector): 30
sum of every-other (list): 30
```

Quiz - answers

Which definition of the `print` function is correct?

A.

```
template<class T> void print (const T &a) {
    for (typename T::const_iterator it = a.cbegin(); it != a.cend(); it++) { cout << *it << endl; }
}
```

B.

```
template<class T> void print (const T &a) {
    for (T::const_iterator it = a.cbegin(); it != a.cend(); it++) { cout << *it << endl; }
}
```

C.

```
template<typename T> void print (const T &a) {
    for (T::const_iterator it = a.cbegin(); it != a.cend(); it++) { cout << *it << endl; }
}
```

D.

```
template<typename T> void print (const typename T &a) {
    for (T::const_iterator it = a.cbegin(); it != a.cend(); it++) { cout << *it << endl; }
}
```

E. None of the above