Homework 2 — Counter<T>

See due date in canvas

(75 points)

Objectives:

- Implement generalized c++ functions/classes
- Use "mini" c++ topics that we have covered: const, overloading, unit testing
- Design and implement unit tests for a templated class

Turn in:

- Counter.hpp, test.cpp, Makefile. You are not required to turn in main.cpp though you are highly encouraged to write a main as you test your Counter object! You do not need to turn in catch.hpp.

Instructions:

Your job is to implement a templated Counter class in C++. A Counter is a specialized type of map (dictionary) that counts the occurrences of hashable objects. You can think of it as a version of a std::map<T, int> with a fancy interface. For our Counter<T>, counts are allowed to be any positive integer value or 0. If you do not have experience working with c++ maps, see the end of this write-up for examples to get started.

If you find writing a main.cpp helpful, you may do so but this is not required.

Your Counter<T> class must provide the following interface:

Function Signatures Note: it is your job to determine which parameters and methods should be const!	Description of behavior
Counter(); Counter(std::vector<T> vals);	initialize an empty Counter<T> initialize a Counter<T> appropriately from a vector or array that contains type T

int Count();
 	
int Count(T key);
 	
int Count(T min, T max);
	access the total of all counts so far
	
	access the count associated with any object T, even for values of T that have not been counted
	
	access the total of all counts for objects T given a certain range (an inclusive minimum T and an exclusive maximum T element)

void Remove(T key)	remove the object T from the Counter
void Increment(T key); void Increment(T key, int n);	increment the count of an object T by one increment the count of an object T by n
void Decrement(T key);	decrement the count of an object T by one

void Decrement(T key, int n);	decrement the count of an object T by n
T MostCommon(); std::vector<T> MostCommon(int n);	get the most commonly occurring object of type T (the object with the highest count) If the Counter is empty, this method should throw a domain error get the n most commonly occurring objects of type T. If the Counter is empty, this method should return a vector of size 0. When breaking ties, your Counter should return the first element in the Counter at the given place. Example: if your Counter contains {"cat":2, "dog": 2, "kangaroo": 3, "salamander":1}, then MostCommon() -> returns "kangaroo" MostCommon(2) -> returns "kangaroo", "cat" (in any order) MostCommon(3) -> returns "kangaroo", "cat", "dog" (in any order) MostCommon(4) -> returns "kangaroo", "cat", "dog", "salamander" (in any order)
T LeastCommon(); std::vector<T> LeastCommon(int n);	get the least commonly occurring object of type T (the object with the highest count) If the Counter is empty, this method should throw a domain error get the n least commonly occurring objects of type T get the n most commonly occurring objects of type T. If the Counter is empty, this method should return a vector of size 0. When breaking ties, your Counter should return the first element in the Counter at the given place. Example: if your Counter contains {"cat":2, "dog": 2, "kangaroo": 3, "salamander":1}, then

	LeastCommon() -> returns "salamander" LeastCommon(2) -> returns "salamander", "cat" (in any order) LeastCommon(3) -> returns "salamander", "cat", "dog" (in any order) MostCommon(4) -> returns "salamander", "cat", "dog", "kangaroo" (in any order)
std::map<T, double> Normalized();	access normalized weights for all objects of type T seen so far ○ normalized weights means that each value of type T would be associated with the percentage of all items of type T that have been counted that are that value ○ it essentially converts each T, int pair to a T, double pair where the double is the percentage rather than the raw count ○ Say that you have a Counter<std::string> which contains the data: - {"cat": 8, "dog": 4, "hamster": 2, "eagle": 6} - a map of normalized weights would be: {"cat": 0.4, "dog": 0.2, "hamster": 0.1, "eagle": 0.3}
std::set<T> Keys();	access the set of all keys in the Counter
std::vector<int> Values();	access the collection of all values in the Counter
std::ostream& operator<<(std::ostream& os, const Counter<U> &b);	overload the << operator for Counter<T> This should print out the contents of the Counter in the format: {T: count, T: count, T: count, …, T:count}

Counter<T> and different types:
Your Counter<T> must work for types T that are new, custom types, such as programmer-defined structs and classes. Each method that you implement must be adequately tested. You do not need to test each method with a Counter<T> of every type that T could be (that would be impossible!), but your different TEST_CASEs should make use of Counters that hold a variety of different types.

See examples in the examples folder on github for how to write templated classes and functions, as well as the resources linked to in the resources document.

We are happy to clarify any methods/requirements that you'd like guidance on, so please, make sure to ask if you have any questions.

As always, your functions should be well documented. Since a main.cpp is not required, include your file comment with your name(s) and instructions for running your program in test.cpp.

Some thoughts on getting started:
Though you may have the inclination to start by writing a non-templated version of your Counter and then converting it, our experience has been that getting a templated class started in c++ can be difficult enough that this might make finding your compiler issues harder. Therefore, we recommend the following steps:

1) Define your Counter<T> class with just a constructor.
2) Make sure you can create a Counter<int> (or some other primitive/built in type).
3) Write unit tests for one of the Counter<T> methods
4) Implement the Counter<T> method
5) Run your tests
6) Go back to step 3 and repeat until complete

Rubric Outline

Counter<T>	- these will be roughly equally spread between all methods that we've asked you to implement	45 points total
Unit tests	- TEST_CASEs and SECTIONs used appropriately - each method appropriately tested - Note: no unit testing required for overloading the << operator	20 points
Style and comments	- const and overloading used appropriately (5 points) - follows style guidelines (2.5 points) - commented appropriately (2.5 points)	10 points

Using Maps in C++

A map is an associative array. It links unique keys to values. You can imagine it as a vector except instead of having integer indices from 0 to the vector's size - 1, the "indices" can be of whatever type you want.

```
std::map<std::string, double> words_to_numbers;
  // adding elements one by one
  words_to_numbers["cat"] = 3.5;
```

```
words_to_numbers["dog"] = 5.2;
words_to_numbers["mouse"] = -100.0;
// updating a value
words_to_numbers["mouse"] += 5;

// getting the value associated with a key
std::cout << words_to_numbers.at("mouse") << std::endl;

// creating a map with values
// std::map<int, bool> ints_seen{{1: true, 2: true, 5: false}};

// iterating through maps
// option 1: with an iterator directly
std::map<std::string, double> :: iterator it;
for (it = words_to_numbers.begin(); it != words_to_numbers.end(); it++) {
        // access the key with it->first
        // access the value with it->second
}
// option 2: with a "for each" loop
for (std::pair<std::string, double> pair : words_to_numbers) {
        // access the key with pair.first
        // access the value with pair.second
}

// testing to see if an element exists in a map
if (words_to_numbers.find("cat") != words_to_numbers.end()) {
        // this value exists in this map!
        std::cout << "found cat!" << std::endl;
}

// using the insert method to insert a pair
// empty map container
std::map<int, int> num_to_num;

// insert elements in random order
num_to_num.insert(std::pair<int, int>(1, 40));
num_to_num.insert(std::pair<int, int>(5, 30));
num_to_num.insert(std::pair<int, int>(3, 40));
num_to_num.insert(std::pair<int, int>(4, 20));

// erase an element
num_to_num.erase(num_to_num.find(5));
```