CS32 Week 7 Worksheet

This worksheet is entirely **optional**, and meant for extra practice. Some problems will be more challenging than others and are designed to have you apply your knowledge beyond the examples presented in lecture, discussion or projects. All exams will be done on paper, so it is in your best interest to practice these problems by hand and not rely on a compiler.

Solutions are written in red. The solutions for **programming** problems are not absolute, it is okay if your code looks different; this is just one way to solve the specific problem.

If you have any questions or concerns, please go to any of the office hours.

Concepts

Templates, STL

1. What is the output of this program?

```
template <class T>
void foo(T input) {
      cout << "Inside the main template foo(): " <<input<< endl;
}

template<>
void foo(int input) {
      cout << "Specialized template for int: " << input << endl;
}

int main() {
      foo<char>('A');
      foo<int>(19);
      foo<double>(19.97);
}
```

```
Inside the main template foo(): A
Specialized template for int: 19
Inside the main template foo(): 19.97
```

Difficulty : Easy

2. The following code has 3 errors that cause either runtime or compile time errors. Find and fix all of the errors.

```
class Potato {
public:
  Potato(int in_size) : size(in_size) { };
  int getSize() const {
    return size;
  };
private:
  int size;
};

int main() {
  vector<Potato> potatoes;
  Potato p1(3);
  potatoes.push_back(p1);
  potatoes.push_back(Potato(4));
  potatoes.push_back(Potato(5));

  vector<~~int~~ Potato>::iterator it = potatoes.begin(); // 1
  while (it != potatoes.end()) {
    it = potatoes.erase(it);  // 2
    ~~it++;~~
  }

  for (it = potatoes.begin(); it != potatoes.end(); it++) {
    cout << it->getSize() << endl;  // 3
  }
}
```

1: potatoes.begin() gives iterator of potatoes, which is a vector<Potato>, so the iterator given will be of the type vector<Potato>::iterator

2: After calling erase with the iterator it, it is invalidated. Instead of incrementing it, the return value of potatoes.erase(it) should be assigned to it. The erase method returns the iterator of the element that is after the erased element.

3: Iterators use pointer syntax, so the last for loop should use it->getSize() instead of it.getSize().

Difficulty: Easy

3. Create a function that takes a container of integers and removes all zeros while preserving the ordering of all the elements. Do the operation in place, which means do not create a new container. Make sure to have the correct #include commands.

    a. Implement this function using STL list

```
void removeAllZeroes(list<int>& x){
      //Implement me
}
```

```
#include <list>
using namespace std;
void removeAllZeroes(list<int>& x) {
    list<int>::iterator it = x.begin();
    while (it != x.end()) {
      if (*it == 0)
          it = x.erase(it);
      else
          it++;
    }
}
```

    b. Implement the function using STL vectors

```
void removeAllZeroes(vector<int>& x){
      //Implement me
}
```

```
#include <vector>
using namespace std;
void removeAllZeroes(vector<int>& x) {
    vector<int>::iterator it = x.begin();
    while (it != x.end()) {
      if (*it == 0)
          it = x.erase(it);
      else
          it++;
    }
}
```

    c. Implement the function that takes a STL vector of pointers, and removes and deletes all pointers that point to integers of value zero

```
#include <vector>
using namespace std;
void removeAllZeroes(vector<int*>& x) {
    vector<int*>::iterator it = x.begin();
```

```
        while (it != x.end()) {
          if (*it != nullptr && *(*it) == 0) {
                delete *it; // call delete on the int pointer
                it = x.erase(it);
          } else
                it++;
        }
    }
```

Difficulty: Easy

4. Will this code compile? If so, what is the output? If not, what is preventing it from compiling?

   Note: We did not use `namespace std` because `std` has its own implementation of `max` and `namespace std` will thus confuse the compiler.

```
template <typename T>
T max(T x, T y)
{
      return (x > y) ? x : y;
}

int main()
{
      std::cout << max(3, 7) << std::endl;      // line 1
      std::cout << max(3.0, 7.0) << std::endl; // line 2
      std::cout << max(3, 7.0) << std::endl;    // line 3
}
```

   On Xcode, it gives the following error messages:

```
int main()
{
    std::cout << max(3, 7) << std::endl;
    std::cout << max(3.0, 7.0) << std::endl;
    std::cout << max(3, 7.0) << std::endl;      No matching function for call to 'max'
    return 0;
}
```

   For max, the compiler expects two arguments that are of the same type, as indicated in the template declaration T. In the third call, 3 is an integer and 7.0 is a double, so there is no matching function call for this instance.
   If we were to remove line 3, lines 1 and 2 would both output 7.

5. Implement a stack class *Stack* that can be used with any data type using templates. This class should use a linked list (not an STL `list`) to store the stack and implement the functions *push()*, *pop()*, *top()*, *isEmpty()*, a default constructor, and a destructor that deletes the linked list nodes.

```
template<typename Item>
class Stack {
 public:
  Stack() : m_head(nullptr) {}

  bool isEmpty() const {
    return m_head == nullptr;
  }

  Item top() const {
    // We'll return a default-valued Item if the Stack is empty,
    // because you should always check if it's empty before
    // calling top().
    if (m_head != nullptr)
      return m_head->val;
    else
      return Item();

  }

  void push(Item item) {
    Node* new_node = new Node;
    new_node->val = item;
    new_node->next = m_head;
    m_head = new_node;
  }

  void pop() {
    // We'll simply do nothing if the Stack is already empty,
    // because you should always check if it's empty while
    // popping.
    if (m_head == nullptr) {
      return;
    }
    Node* temp = m_head;
    m_head = m_head->next;
    delete temp;
  }
```

```
  ~Stack() {
    while (m_head != nullptr) {
      Node* temp = m_head;
      m_head = m_head->next;
      delete temp;
    }
 }

 private:
  struct Node {
    Item val;
    Node* next;
  };
  Node* m_head;
};
```

6. Implement a vector class *Vector* that can be used with any data type using templates. Use a dynamically allocated array to store the data. Implement only the *push_back()* function, default constructor, and destructor.

```
template <typename T>
class Vector {
  public:
    Vector();
    ~Vector();
    void push_back(const T& item);
  private:
    // Total capacity of the vector -- doubles each time
    int m_capacity;
    // The number of elements in the array
    int m_size;
    // Underlying dynamic array
    T* m_buffer;
};

template <typename T>
Vector<T>::Vector()
: m_capacity(0), m_size(0), m_buffer(nullptr)
{}

template <typename T>
Vector<T>::~Vector() {
     delete[] m_buffer;
}
```

```
template <typename T>
void Vector<T>::push_back(const T& item) {
  // if space is full, allocate more capacity
  if (m_size == m_capacity)
  {
    // double capacity; special case for capacity 0
    if (m_capacity == 0)
      m_capacity = 1;
    else
      m_capacity *= 2;

    // allocate an array of the new capacity
    T* newBuffer = new T[m_capacity];

    // copy old items into new array
    for(int i = 0; i < m_size; i++)
      newBuffer[i] = m_buffer[i];

     // delete original array (harmless if m_buffer is null)
     delete [] m_buffer;

     // install new array
     m_buffer = newBuffer;
  }

  // add item to the array, update m_size
  m_buffer[m_size] = item;
  m_size++;
}
```

7. The following code has 3 errors that cause either runtime or compile time errors. Find all of the errors.

```
class Potato {
public:
  Potato(int in_size) : size(in_size) { };
  int getSize() const {
    return size;
  };
private:
  int size;
};
```

```
int main() {
  set<Potato> potatoes;  // 1
  Potato p1(3);
  Potato p2(4);
  Potato p3(5);
  potatoes.insert(p1);
  potatoes.insert(p2);
  potatoes.insert(p3);

  set<Potato>::iterator it = potatoes.begin();
  while (it != potatoes.end()) {
    it = potatoes.erase(it);  // 2
    it++;
  }

  for (it = potatoes.begin(); it != potatoes.end(); it++) {
    cout << it->getSize() << endl;  // 3
  }
}
```

1: The type set<Potato> requires that Potato object cts can be compared with operator<. Here's an example of how to define <:

```
bool operator<(const Potato& a, const Potato& b) {
  return a.getSize() < b.getSize();
}
```

2: After calling erase with the iterator it, it is invalidated. Instead of incrementing it, the return value of potatoes.erase(it) should be assigned to it.

3: Iterators use pointer syntax, so the last for loop should use it->getSize() instead of it.getSize().

8. You are given an STL `set<list<int>*>`. In other words, you have a set of pointers, and each pointer points to a list of ints. Consider the sum of a list to be the result of adding up all elements in the list. If a list is empty, treat its sum as zero.
   Write a function that removes the lists with odd sums from the set. The lists with odd sums should be deleted from memory and their pointers should be removed from the set. This function should return the number of lists that are removed. You may assume that none of the pointers is null.

   ```
   int deleteOddSumLists(set<list<int>*>& s);
   ```

```
int deleteOddSumLists(set<list<int>*>& s) {
   int numDeleted = 0;

   // iterate over the set
   set<list<int>*>::iterator set_it = s.begin();
   while (set_it != s.end())
   {
      // iterate over each list and get the sum
      int sum = 0;
      list<int>::iterator list_it = (*set_it)->begin();
      list<int>::iterator list_end = (*set_it)->end();
      while (list_it != list_end)
      {
         sum += *list_it;
         list_it++;
      }

      // delete list and remove from set if sum is odd
      // otherwise, proceed to check the next list
      if (sum % 2 == 1)
      {
         delete *set_it;
         set_it = s.erase(set_it);
         numDeleted++;
      }
      else
         set_it++;
   }

   return numDeleted;
}

// Sample driver code:
int main()
{
    set<list<int>*> s;
    list<int>* l1 = new list<int>;
    l1->push_back(1);
    l1->push_back(2);
    list<int>* l2 = new list<int>;;
    l2->push_back(1);
    l2->push_back(1);
    list<int>* l3 = new list<int>;;
    l3->push_back(1);
    l3->push_back(0);
```

```
    s.insert(l1);
    s.insert(l2);
    s.insert(l3);
    cout << deleteOddSumLists(s) << endl;
}
```