EPL Spring 2016, Project 1, Phase C
Vector Container Extensions
Due April 8, 2016.

Add some new functionality to your Vector<T> template class, making it more compliant with the C++ standard, and applying some of the additional knowledge you've gained about templates.

In the requirements below, the asterisk characters indicate increased challenge/complexity of the requirement. All students enrolled in EPL are expected to be easily able to complete all of the non-asterisk requirements. In addition, students enrolled in EE379K are expected to complete most or all of the single-asterisk (*) requirements. Students enrolled in EE380L.5 are expected to complete all of the single-asterisk (*) requirements and most or all of the double-asterisk (**) requirements.

Requirements:

- Create a random-access iterator type for your Vector. Be sure that at least value_type and iterator_category work correctly for your iterator type (you can assume that iterator_traits is used to access value_type and iterator_category – do not change or specialize the standard iterator_traits template to make it work with your iterator, make your iterator work with iterator_traits).
    - Provide begin/end fuctions for your Vector.
    - (*) Provide both iterator and const_iterator (and begin/end for each).
    - (**) Ensure that an iterator can be converted (without warnings or type casts) to const_iterator. Ensure that const_iterator cannot be converted to iterator.
    - (*) Design your iterator so that it throws the exception epl::invalid_iterator whenever the value of an invalid iterator is used. "Using the value" of an iterator includes comparison operations (with other iterators), dereferencing the iterator, incrementing the iterator, etc. Assigning to an iterator, for example, is not "using the value" of the iterator, it is assigning a new value to the iterator (and should not throw an exception).
        - For this project, an iterator must be invalid if there are any push_back, pop_back, push_front or pop_front operations applied to the vector, or if the vector is assigned a new value, or if the vector is "moved". If the vector is destroyed (goes out of scope), then the behavior of iterators associated with that vector is undefined
    - (**) epl::invalid_iterator has three severity levels.

- If the iterator references a position that does not exist (i.e., the position is out-of-bounds), the exception you throw must use the level SEVERE.
- If the iterator reference a position that is in-bounds, but the memory location for that position may have been changed (e.g., a reallocation has been performed because of a push_back, or a new assignment has been performed to the Vector), then the exception you throw must have the level MODERATE.
- If the iterator is invalidated for any other reason, the exception must have the level MILD.
- Special notes on SEVERE exceptions and what is considered in range:
    1. The position x.end() for any epl::vector x is considered to be “in range”. Naturally, if an iterator pointing to x.end() is dereferenced, then undefined behavior results (although throwing std::out_of_range would be nice).
    2. As a special clarification, please note that our data structure is a vector (i.e., an array). Thus, the “positions” in the vector are equivalent to array indices. Specifically, the sequence:

```
epl::vector<int> x(10);
epl::vector<int>::iterator p = x.begin();
x.pop_front();
if (p == x.begin()) { // p is invalid and MILD
```

The reason that this exception is only MILD is because (1) no reallocation was required, and because p still references position #0 which is a perfectly valid position in the nine-element vector x.

- (*) Write an emplace_back variadic member template function for your vector that constructs the object in place.
- ~~Create a member template constructor that will initialize a Vector<T> using a Vector<T2> as an argument. This constructor must compile without warnings or errors when objects of type T can be constructed using objects of type T2. i.e., if T::T(T2) exists (even if its explicit), then your constructor member template must compile and produce the obvious behavior.~~
    - ~~If T cannot be constructed using T2, then your member template should fail with a compile time error.~~
- ~~Create a member template assignment operator with equivalent behavior to the constructor above.~~
- Please put some thought (we won’t grade this) into the question of whether the member template constructor and member template

assignment operator are good or bad things (see above requirements that have been struck out – not required Spring 2016).

- (*) Create a member template constructor that takes an iterator pair b and e and initializes the Vector to contain copies of the values from [b, e).
    - (**) Design your template constructor (using specialization/overloading if necessary) so that
        - When b and e are random-access iterators, only one allocation is necessary to construct the vector
        - When b and e are not random-access iterators, treat them as “input iterators”. That is, you must invoke ++b only once for each position in the range [b, e) – specifically, you cannot save a copy of b, increment b to e (counting the number of elements) and then expect your copy to still reference the first element of the source input.
- Create a constructor that will initialize a Vector from a std::initializer_list<T>
    - Please note that for Vector<int> this constructor conflicts with the explicit Vector::Vector(int) constructor. When testing, it may be worthwhile to know that:
      Vector x{42}; // uses Vector::Vector(std::initializer_list<int>)
      Vector x(42); // uses Vector::Vector(int)