

# Iterators

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## Begin/end iterator

# 1. Begin and end iterator

Use independent of looping:

Code:

```
vector<int> v{1,3,5,7};
auto pointer = v.begin();
cout << "we start at "
      << *pointer << '\n';
pointer++;
cout << "after increment: "
      << *pointer << '\n';

pointer = v.end();
cout << "end is not a valid
element: "
      << *pointer << '\n';
pointer--;
cout << "last element: "
      << *pointer << '\n';
```

Output

[stl] iter:

```
we start at 1
after increment: 3
end is not a valid
           element: 0
last element: 7
```

(Note: the auto actually stands for `vector::iterator`)

## 2. Containers have iterators

Containers such as *vector*, *map* have *begin/end* iterators.

'Pointer' (not in the technical sense) to first and one-beyond-last element.

### 3. (In case you know C)

This is not a C-style pointer dereference,  
but rather an overloaded operator.

## 4. Copy range

Copy a range at an iterator:

Code:

```
vector<int> counts{1,2,3,4};  
vector<int> copied(5);  
copy( counts.begin(),counts.end(),  
      copied.begin()+1 );  
cout << copied[0]  
      << ", " << copied[1]  
      << ".." << copied[4] << '\n';
```

Output

[iter] copy:

0, 1..4

(No bound checking, so be careful!)

## 5. Beyond begin/end

- An iterator is a little like a pointer (into anything iterable)
- *begin* / *end*
- pointer-arithmetic and 'dereferencing':

```
auto element_ptr = my_vector.begin();  
element_ptr++;  
cout << *element_ptr;
```

- allows operations (erase, insert) on containers

## 6. Erase at/between iterators

Erase from start to before-end:

Code:

```
vector<int> counts{1,2,3,4,5,6};  
vector<int>::iterator second =  
    counts.begin()+1;  
auto fourth = second+2; // easier  
    than 'iterator'  
counts.erase(second,fourth);  
cout << counts[0]  
    << "," << counts[1] << '\n';
```

Output

[iter] erase2:

1,4

(Also single element without end iterator.)



## 7. Insert at iterator

Insert at iterator: value, single iterator, or range:

Code:

```
vector<int>
counts{1,2,3,4,5,6},zeros{0,0};
auto after_one = zeros.begin()+1;
zeros.insert( after_one,

counts.begin()+1,counts.begin()+3
);
cout << zeros[0] << "," <<
zeros[1] << ","
    << zeros[2] << "," <<
zeros[3]
    << '\n';
```

Output

[iter] insert2:

0,2,3,0

## 8. Reconstruct index

Code:

```
vector<int> numbers{1,3,5,7,9};
auto it=numbers.begin();
while ( it!=numbers.end() ) {
    auto d =
        distance(numbers.begin(),it);
    cout << "At distance " << d
         << ": " << *it << '\n';
    it++;
}
```

Output

[loop] distance:

*At distance 0: 1*

*At distance 1: 3*

*At distance 2: 5*

*At distance 3: 7*

*At distance 4: 9*

# Algorithms

## 9. Reduction operation

Default is sum reduction:

Code:

```
#include <numeric>
using std::accumulate;
/* ... */
vector<int> v{1,3,5,7};
auto first = v.begin();
auto last  = v.end();
auto sum =
    accumulate(first,last,0);
cout << "sum: " << sum << '\n';
```

Output

[stl] accumulate:

sum: 16

## 10. Reduction with supplied operator

Supply multiply operator:

Code:

```
using std::multiplies;
/* ... */
vector<int> v{1,3,5,7};
auto first = v.begin();
auto last  = v.end();
first++; last--;
auto product =
    accumulate(first,last,2,
                multiplies<>());
cout << "product: " << product <<
    '\n';
```

Output

[stl] product:

product: 30

# 11. Use lambda to find any of

Here is an example using `any_of` to find whether there is any even element in a vector:

Code:

```
vector<int> integers{1,2,3,5,7,10};
auto any_even = any_of
    ( integers.begin(),integers.end(),
      [=] (int i) -> bool {
          return i%2==0; }
    );
if (any_even)
    cout << "there was an even" << '\n';
else
    cout << "none were even" << '\n';
```

Output

[range] anyof:

*there was an even*

## 12. For each, very simple example

Apply something to each array element:

Code:

```
#include <algorithm>
/* ... */
vector<int>
ints{2,3,4,5,7,8,13,14,15};
for_each( ints.begin(),ints.end(),
          [] ( int i ) -> void {
              cout << i << '\n';
          }
        );
```

Output

[iter] each:

2  
3  
4  
5  
7  
8  
13  
14  
15

# Exercise 1

Use `for_each` to sum the elements of a vector.

Hint: the problem is how to treat the sum variable. Do not use a global variable!