VECTORS

Vector is a sequence of objects with direct access. It supports constant time for adding / deleting elements from the end of sequence and linear time for adding / deleting elements from middle or beginning. Size of vector varies dynamically, memory management is automatic. For using ***vector*** you need to include the following library:

```
#include <vector>
```

Constructors

Create an empty vector *v* (array of length 0, with no element):

```
vector<int> v;
```

v = ( )

Create a vector of length 5:

```
vector<int> v(5);
// v = (0, 0, 0, 0, 0)
```

Create a vector of length 5 with all elements equal to 2:

```
vector<int> v(5,2);
// v = (2, 2, 2, 2, 2)
```

Let *m* be an array of integers. To create a vector containing the same numbers as in *m* you need a ***copy constructor***:

```
int m[] = {1,2,3,4,5};
vector<int> v(m,m+5);
// v = (1, 2, 3, 4, 5)
```

Example. Create vector. Print the vector elements in a line.

```
#include <cstdio>
#include <vector>
using namespace std;

int m[] = {1,2,3,4,5};
vector<int> v(m,m+5);

int main(void)
{
  for(int i = 0; i < v.size(); i++)
    printf("%d ",v[i]);
  printf("\n");
  return 0;
}
```

After declaration

```
vector<int> v;
```

vector *v* is empty, it contains no element: *v* = ( ). Method ***resize*()** changes the number of vector elements and fills them with 0. For example, after

```
v.resize(5);
```

vector will looks like *v* = (0, 0, 0, 0, 0).

Method ***size*()** returns the number of elements in the vector.

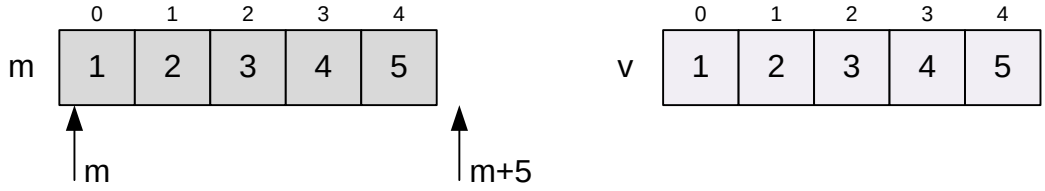
```
#include <cstdio>
#include <vector>
using namespace std;

vector<int> v;

int main(void)
{
  v.resize(5);
  for(int i = 0; i < v.size(); i++)
    printf("%d ",v[i]);
  printf("\n");
  return 0;
}
```

Following methods are created to work with vectors:

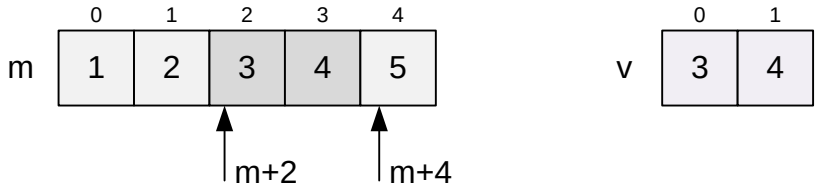
method	method description
void clear()	deleting all elements vector becomes empty
size_type size() const	calculates the size of vector
bool empty() const	returns true if vector is empty
reference operator[](size_type n)	indexation operator, returns n-th element of vector
reference front()	returns first element of vector
reference back()	returns last element of vector

Example. Let *m* be an array of integers. Let's create vector *v* by copying all data from *m* to vector *v*:

```
int m[] = {1,2,3,4,5};
vector<int> v(m,m+5);
// v = (1, 2, 3, 4, 5)
```




```
int m[] = {1,2,3,4,5};
vector<int> v(m+2,m+4);
// v = (3, 4)
```

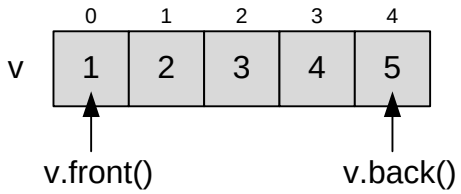


Let's find the size of vector *v*:

```
printf("Size: %d\n",v.size());
```

Let’s find the first and the last elements:

```
printf("First: %d, Last: %d\n",v.front(),v.back());
```



Example. Create vector and print its elements.

```
#include <cstdio>
#include <vector>
using namespace std;

int m[] = {1,2,3,4,5};
vector<int> v(m+1,m+4); // v = (2, 3, 4)

int main(void)
{
  printf("Size of array = %d\n",v.size());
  printf("First = %d, last = %d\n",v.front(),v.back());

  for(int i = 0; i < v.size(); i++)
    printf("%d ",v[i]);
  printf("\n");
  return 0;
}
```

method	method description
void push_back(const T& x)	add element to the end of vector
void pop_back()	delete last element

Example. Push and pop operations with vector.

```
#include <cstdio>
#include <vector>
using namespace std;

vector<int> v;

int main(void)
{
  v.push_back(3); v.push_back(6); // v = (3, 6)
  v.push_back(8); v.push_back(1); // v = (3, 6, 8, 1)

  for(int i = 0; i < v.size(); i++)
    printf("%d ",v[i]);
  printf("\n");

  v.pop_back(); // v = (3, 6, 8)

  for(int i = 0; i < v.size(); i++)
    printf("%d ",v[i]);
  printf("\n");
```

```
  return 0;
}
```

E-OLYMP **928. The sum of the largest and the smallest** Find the sum of the largest and the smallest element in array.

► Use ***vector*** to solve the problem. Use two ways:

- **resize** the vector according to the number *n* of its elements (if this value is known);
- use **push_back** to insert the values to the vector;

```
#include <cstdio>
#include <vector>
using namespace std;

int i, n, mn, mx, res;
vector<int> v;

int main(void)
{
  scanf("%d", &n);
  v.resize(n); // v = (0, 0, . . . , 0)

  for (i = 0; i < n; i++)
    scanf("%d", &v[i]);

  mn = 1e9; mx = -1e9; // 1e9 = 1000000000
  for (i = 0; i < v.size(); i++)
  {
    if (v[i] < mn) mn = v[i];
    if (v[i] > mx) mx = v[i];
  }

  res = mn + mx;
  printf("%d\n", res);
  return 0;
}
```

Use **push_back** to insert the values to the vector:

```
#include <cstdio>
#include <vector>
using namespace std;

int x, i, n, mn, mx, res;
vector<int> v;

int main(void)
{
  scanf("%d", &n);
  for (i = 0; i < n; i++)
  {
    scanf("%d", &x);
    v.push_back(x);
  }
```

```
  mn = 1e9; mx = -1e9;
  for (i = 0; i < v.size(); i++)
  {
    if (v[i] < mn) mn = v[i];
    if (v[i] > mx) mx = v[i];
  }

  res = mn + mx;
  printf("%d\n", res);
  return 0;
}
```

E-OLYMP **8685. Arithmetic mean** Find the arithmetic mean of the given sequence of integers.

► Read the given sequence into ***vector***. As we do not know the initial size of the sequence, read it till the end of file and use **push_back**.

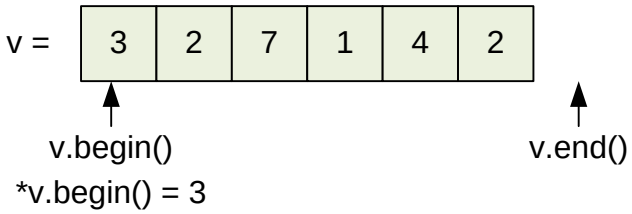
```
#include <cstdio>
#include <vector>
using namespace std;

int i, x, s;
vector<int> v;

int main(void)
{
  while (scanf("%d", &x) == 1)
    v.push_back(x);

  s = 0;
  for (i = 0; i < v.size(); i++)
    s = s + v[i];

  printf("%.4lf\n", 1.0 * s / v.size());
  return 0;
}
```

Iterator is a pointer to the object. It is created as following:

template_name<type>::iterator iterator_name

Vector class has the following iterators:

iterator	iterator description
const_iterator begin() const	pointer to the beginning of vector
const_iterator end() const	pointer to the end of vector, after the last element



Example. Print the first and the last element.

```
#include <cstdio>
#include <vector>
using namespace std;

vector<int> v;
vector<int>::iterator iter;
int i;

int main(void)
{
  for(i = 1; i < 10; i++)
    v.push_back(i*i);

  iter = v.begin();
  printf("%d\n",*iter);

  iter = v.end(); iter--;
  printf("%d\n",*iter);

  return 0;
}
```

E-OLYMP **904. Increase by 2** Increase by 2 each non-negative element of array.
► Print the resulting array using ***iterator***.

```
#include <cstdio>
#include <vector>
using namespace std;

int i, n;
vector<int> m;
vector<int>::iterator iter;

int main(void)
{
  scanf("%d", &n);
  m.resize(n);
  for (i = 0; i < n; i++)
    scanf("%d", &m[i]);

  for (i = 0; i < m.size(); i++)
    if (m[i] >= 0) m[i] = m[i] + 2;

  for (iter = m.begin(); iter != m.end(); iter++)
    printf("%d ", *iter);
  printf("\n");
  return 0;
```

```
}
```

The methods for adding and deleting elements take iterators as arguments:

method	method description
`iterator insert(iterator pos, const T& x)`	`insert element x in position pos`
`iterator erase(iterator pos)`	`delete element shown by iterator pos`
`iterator erase(iterator first, iterator last)`	`delete all elements in interval [first..last]`

Example. Let's create a vector v of squares of natural numbers from 1 to 10. Let's delete values 16, 25, 36, 49 from vector.

```
#include <cstdio>
#include <vector>
using namespace std;

vector<int> v;
int i;

int main(void)
{
  for(i = 1; i <= 10; i++)
    v.push_back(i*i);

  for(i = 0; i < v.size(); i++)
   printf("%d ",v[i]);
  printf("\n");

  v.erase(v.begin()+3,v.end()-3);

  for(i = 0; i < v.size(); i++)
    printf("%d ",v[i]);
  printf("\n");

  return 0;
}
```

Work with memory. In vector container description some functions as ***size*** and ***resize***, ***capacity*** and ***reserve*** can be encountered. Memory is allocated for the vector "in reserve", and must be able to control the number of vector elements, and the amount of memory it takes. size and resize are needed to work with real number of vector elements, capacity and reserve - to work with memory.

- ***size*** - returns number of vector elements
- ***resize*** - changes number of vector elements
- ***capacity*** - returns for how many elements the memory is reserved
- ***reserve*** - reserves memory

Example. Let's see how memory is allocated for a vector.

```cpp
#include <cstdio>
#include <vector>
using namespace std;

vector<int> v;

int main(void)
{
  v.push_back(5); v.push_back(7); v.push_back(10);
  printf("Vector size = %d, capacity = %d\n",v.size(),v.capacity());
  v.reserve(100);
  printf("Vector size = %d, capacity = %d\n",v.size(),v.capacity());
  v.resize(50);
  printf("Vector size = %d, capacity = %d\n",v.size(),v.capacity());
  v.erase(v.begin()+3,v.end());
  printf("Vector size = %d, capacity = %d\n",v.size(),v.capacity());
  vector<int>(v).swap(v);
  printf("Vector size = %d, capacity = %d\n",v.size(),v.capacity());
  return 0;
}
```