Notes Made By

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1. Pairs (to store value in form of pairs)

pair <int , int> p = {1, 2}.

C++ cout << p.first << " " << p. second;

STL O/p → 1 3

pairs of pairs

pair <int, pair<int>> p = {1, {3, 2}};

cout << p.first << p.second.first << p.second.second;

O/p → 1 3 2.

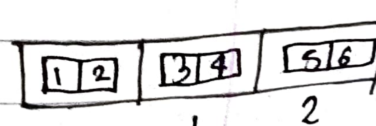

p.first p.second.

pair of arrays.

pair <int, int > arr [ ] = { {1,2}, {3,4} , {5,6} };

cout << arr[1]. second;

}




O/p → 4

## * Vectors

Array - doesn't provide dynamic allocation. After declaring the size, the size can't be increased or decreased.

```
vector <int> v;        // It defines a null vector.
```

```
v.push_back(1);
```
$\boxed{1}$ size=1

↓ inserts an element in the empty vector

```
v.emplace_back(2);
```
$\boxed{1}\boxed{2}$ size=2

Vector of pairs

```
vector <pair <int, int>> vec;

vec.push_back({1, 2});   // push_back uses curly bracket

vec.emplace_back(1, 2);  // In emplace_back curly
                         braces is not used but
                         in case of pair of pairs
```

Declare a vector of given size with every element having some value.

```
vector <int> v(5);      // A vector of size 5 is created
                        {0, 0, 0, 0, 0};

vector <int> v(5, 20);
                        {20 20 20 20 20};
```

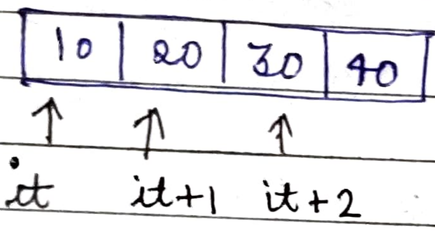
Copying a vector

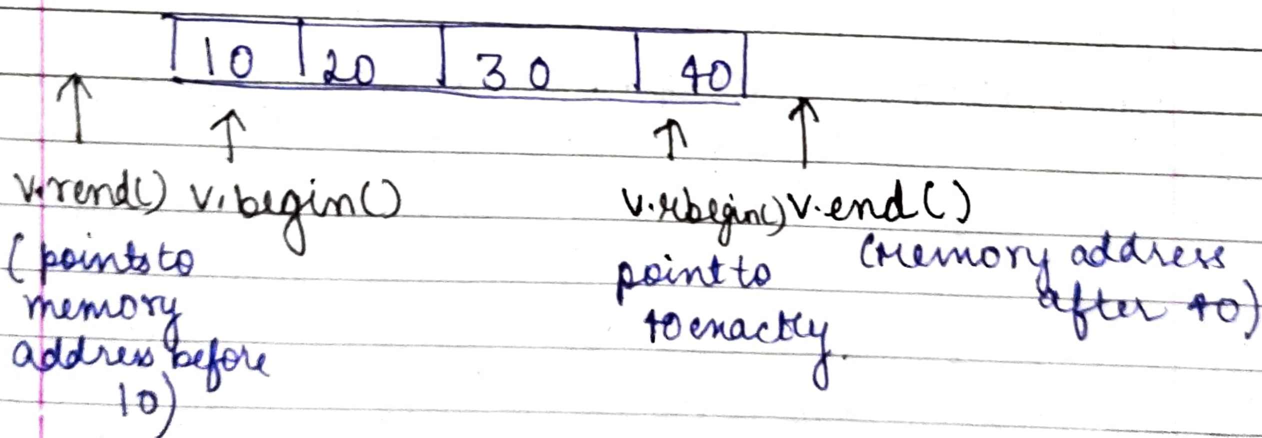
```
vector <int> v2(v1);
```

* Iterators → pointing to a given address location. Iterators can be pushed front or back using it++ & it--.

```
vector <int> :: iterator it = v.begin();
it++;
cout << *(it) << " ";          // o/p = 20.
```

*(it) → to access the element at given itr




If you don't want your iterator to change or it++ we use

v.cbegin() → constant

Accessing elements without iterators.

Indexing is similar as that of array.

v[0] v.at(0);

for the last element we ~~~~ use [10|20|30]

cout << v.back(); << " "; o/p → 30

Ways to print the vector

1)
```
for( vector<int>::iterator it= v.begin() ; it != v.end();
                                              it++) {
    cout << *(it) << " ";
}
```

2)
```
for (auto it = v.begin() ; it != v.end() ; it++) {
    cout << *(it) << " ";
}
```

3)
```
for (auto it : v) {              // for each loop
    cout << it << " ";
```

// It moves through the element & not the iterator.

auto = automatically converts to the given datatype

erase

vector_name.erase (iterator)

| 10 | 20 | 30 | 40 |
|---|---|---|---|

v.erase(v.begin())    O/p = 10

for a range

| 10 | 20 | 12 | 23 | 35 |
|---|---|---|---|---|

v.erase(v.begin()+2, v.begin()+4);

O/p = 10, 20, 30

// Insert functions
helps in inserting element at a given place.

vector <int> v(2, 100);    {100, 100}

v.insert (v.begin(), 300);    {300, 100, 100}.
v.insert (v.begin()+1, 2, 10);
{300, 10, 10, 100, 100};

// Inserting a copy vector in vector v.

vector <int> copy (2, 50);    // {50, 50}
v.insert (v.begin(), copy.begin(), copy.end());

// {50, 50, 300, 10, 10, 100, 100}

Size
cout << v.size();    I/p -> {10, 20}
O/p -> 2

Erasing the last element $\boxed{10 \mid 20}$

v.pop_back(); {10}.

Swapping 2 vectors.

$v_1 = \{10, 20\}$ $v_2 \rightarrow \{30, 40\}$.

V1.swap(v2);

$v_1 = \{30, 40\}$ $v_2 \rightarrow \{10, 20\}$.

Erase the entire vector

v.clear();

cout << v.empty(); // checks if an array is empty or not.

* List → stores the element in the dynamic fashion as vector does. You can push at front but in vector only at back.

list <int> ls ;

push_front()
pop_front()
push_back()
pop_back()

ls.push_back(2); // {2}
ls.emplace_back(4); // {2, 4}
ls.push_front(5); // {5, 2, 4}
ls.emplace_front(6); // {6, 5, 2, 4}

// rest functions are same as vector
begin   clear   swap.
end   insert
rbegin   erase.
rend.   size

* Deque - deque is a container where elements could be pushed front as well as in the back.

Access the front element directly by dq.front();

```
deque <int> dq;

dq.push_back(1);          // {1}
dq.emplace_back(2);       // {1,2}
dq.push_front(4);         // {4,1,2}.
dq.emplace_front(3);      // {3,4,1,2}.
dq.pop_back();            // {3,4,1}
dq.pop_front();           // {4,1}

dq.back();     // last element
dq.front();    // first element
```

Rest func are same as vector
(begin, end, rbegin, rend, clear, insert
size, swap)

* Stack (LIFO) last in first out.

push / pop operⁿ's (It pushes elements in front)

```
stack <int> st;
st.push(1);   // {1}
st.push(2);   // {2, 1}
st.push(3);   // {3, 2, 1}
st.push(3);   // {3, 3, 2, 1}
st.emplace(5); // {5, 3, 3, 2, 1}

cout << st.top();
// prints 5
```

No random access is allowed   st[5] → invalid

```
st.pop();      // {3, 3, 2, 1}

cout << st.size();    // 4

cout << st.empty();  // stack is empty or not

stack <int> st1;
stack <int> st2;

st1.swap(st2);
```

It doesn't have iterators like begin, end, erase etc.

Queue → FIFO (first in first out)

1) Same as stack
2) limited functionalities
3) Dynamic in size
4) But it doesn't stores the last inserted element at the top rather it stores the first inserted element at the top.

```
queue <int> q;
 q.push (1);          // {1}
 q.push(2);           // {1, 2}
 q.emplace (4);       // {1,2,4}.
```

last element

```
cout<<q.back();    // 4
```

front element

```
cout << q.front();    // 1
```

(q.top() doesn't work)

size, swap, empty are same as stack.

Priority_queue → Stores the element in a sorted fashion. (In descending order)
Max$^{m}$ heap.
greater the value, at the top.

```
priority_queue <int> pq;

pq.push(5);           // {5}.
pq.push(2);           // {5, 2}.
pq.push(8);           // {8, 5, 2}.
pq.push(10);          // {10, 8, 5, 2}
cout << pq.top()      // 10

pq.pop();             // {8, 5, 2}

cout << pq.top();     // 8
```

size swap empty function are same as stack & queue.

* Min-heap → ascending order (minm element at top)

```
priority queue < int, vector<int >, greater <int>> pq;
pq.push(5);           // {5}
pq.push(2);           // {2, 5}
pq.push(8);           // {2, 5, 8}
pq.emplace(10);       // {2, 5, 8, 10}

cout << pq.top();     // prints 2.
```

* Set - stores element in a sorted order & unique elements only.

```
set <int> st;
st.insert(1);         // {1}
```

st.emplace(2); {1, 2}.
st.insert(2); → not takes this 2 as it has taken.
st.insert(4); {1, 2, 4}
st.insert(3); {1, 2, 3, 4}.

begin(), end(), rbegin(), rend(), size(), empty() & swap() are same as those of above

{1, 2, 3, 4, 5}.

auto it = st.find(3);

but when we find the element which is not present in set, it would point after the end element.
like
auto it = st.find(6);

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

↑ it

if st.find(x) != st.end()
element is present in set.

{1, 4, 5}

st.erase(5); // erases 5 O(logn)

int cnt = st.count(1);

if exsists cnt = 1 else cnt = 0.

to delete range of elements.

{1, 2, 3, 4, 5}.

```
auto it1 = st.find(2);
auto it2 = st.find(4);
st.erase(it1, it2);
```

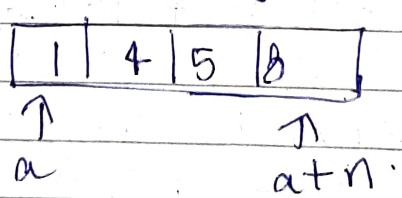
// after erase {1, 4, 5} [first, last);

* lower bound() & upper bound() functions

They work in the same way as in vector it does.

Check if x exsists in sorted array array or not

```
bool res = binary_search(a, a+n, 3);
```



* Multiset → similar as set but allows to store duplicate elements (but in sorted order)

```
multiset <int> ms;
 ms. insert(1);   // {1}
 ms. insert(1);   // {1,1}
 ms. insert(1);   // {1,1,1}

ms.erase(1);   // all the 1's get erased
```

only a single one erased.

```
 ms. erase(ms.find(1));
```

for 2 1's : ms. erase(ms. find(1), ms. find(1)+2);

To find the count the no in given set.

```
int cnt = ms.count(1)
```

rest all function are same as set.

* Unordered set → same functionality as set
1) stores unique elements
2) doesn't store in sorted order
3) lower bound & upper bound is not applicable

* Map - stores elements in key & value pair.

{key, value)
↓ ↓
name city

```
map <int, int> mpp;

map <int, pair<int, int>> mpp;

map <pair<int,int>, int> mpp;


mpp[1] = 2;     // to initialise value
mpp.insert ({2, 4});
```

O/P

{1, 2}     // stored in sorted order.
{2, 4}

```
for(auto it : mpp) {
    cout << it.first << " " << it.second;
}.
```

to access the value at given key.

```
cout << mp[1];     // 2.
```

map - O(logn)

find function works the same.

```
auto it = mpp.find(3);
cout << *(it).second ;
```

points to the position where 3 is found then prints the value.

lower bound & upper bound works as same.

```
auto it = mpp.lower_bound(2);
auto it = mpp.upper_bound(3);
```

// erase, swap, size empty are same as above.

* Multimap - Stores a given key twice or more times (multiple key value pairs)

* Unordered map - Stores elements or given $\boxed{O(1)}$ key value pair in unsorted manner. But collisions could take place.

* Sort Algorithm.

sort (a, a+n); // Sort in ascending order

for a given range

sort (a+2, a+4); [first, last)

sort ( a, a+n, greater<int>) // sort in descending order.

* Comparators

```
bool comp (pair <int, int> p1 , pair <int, int>p2){
    if (p1.second < p2.Second) { return true; }
    else if (p1.second == p2.second) { if(p1.first > p2.second) return true;
} return false;
pair <int , int > a[] = {{1, 2}, {2,1}, {4, 1}};
sort (a, a+n, comp);
```

Sorting it acc$^n$. to 2nd element

{{4, 1}, {2, 1}, {1, 2}}

1) If second element is same, then sort it according to the first element but in descending order.

* __builtin_popcount() - Counts the no. of set bits in binary representation of a no.
It only works for integers.

```
int num = 7;   // 111
int cnt = __builtin_popcount();

long long num = 165786578687;
int cnt = __builtin_popcount();
```

* next_permutation - It gives the next dictionary order. ↳(returns true or false)

```
string s = "123";
do {
    cout << s << endl;
} while (next_permutation(s.begin(), s.end()));

// 123
// 132
// 213
// 231
// 312
// 321
```

max element in a given range

```
int maxi = *max_element(a, a+n);
```