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Notes Made By

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

```
pair <int , int> p = {1, 2};
cout << p.first << " " << p.second;
```

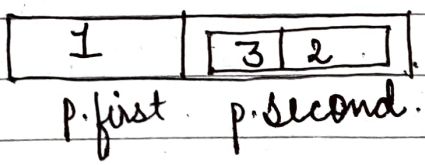
C++ STL

O/p → 1 3

pairs of pairs

```
pair <int, pair<int>> p = {1, {3, 2}};
cout << p.first << p.second.first << p.second.second;
```

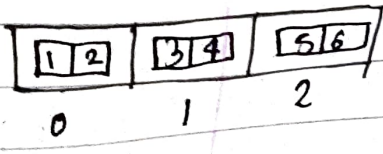
O/p → 1 3 2



pair of arrays.

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

O/p → 4



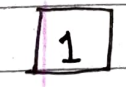
* Vectors

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);
```

↓ inserts an element in the empty vector



Size=1

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

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

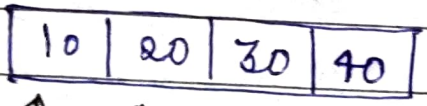
copying a vector

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

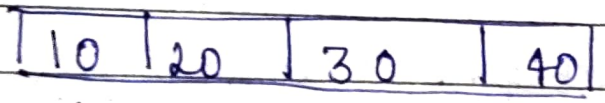
* Iterators → pointing to a given address location. Iterators can be pushed front or back using it++ & it--;

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

↓ to access the element at given itr



it it+1 it+2



v.rend() (points to memory address before 10)

v.begin()

v.rbegin() point to 40 exactly.

v.end() (memory address after 40)

If you don't want your iterator to change as 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 ~~[illegible]~~ 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 function
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(); o/p -> {10, 20}
o/p -> 2

Erasing the last element

10	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;

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}

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

// 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 operation's (St 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);
```

St 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 (min 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}.

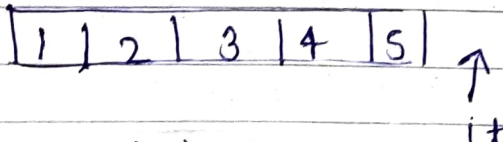
begin(), end(), rbegin(), rend(), size(), empty() & swap() are same as those of above

{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);



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);
```

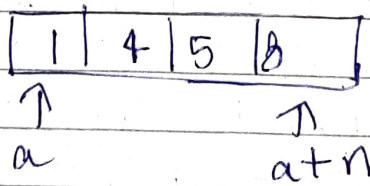
// after erase {1, 4, 5} [first, last);

* lower_bound() & upper_bound() functions

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

Check if x exists 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}
{2, 4} // stored in sorted order.

```
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 of given key value pair in unsorted manner. But collisions could take place.
[O(1)]

* 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);
```