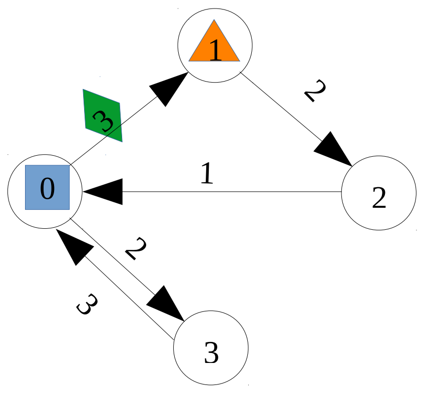
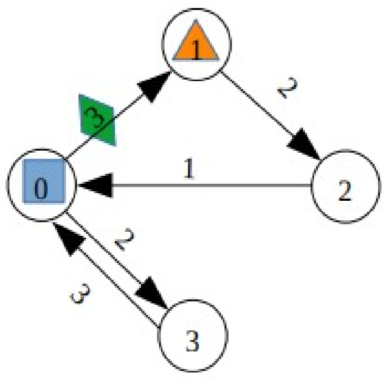
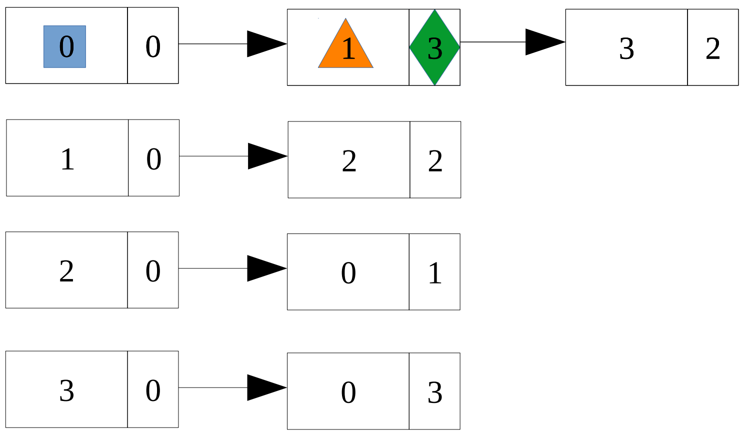
Grafos – Matriz de Adjacência



Vertices	0	1	2	3
0	0	3	0	2
1	0	0	2	0
2	1	0	0	0
3	3	0	0	0

Grafos – Lista Ligada





Algoritmo de Dijkstra

Pseudocódigo

```
Function Dijkstra(G,source, target):
    for each vertex v in G
        dist[v] = infinity
    dist[source] = 0
    Q has the set of all nodes in G
    while Q is not empty:
        u = vertex in Q with smallest dist
        remove u from Q
        if u = target
            break
        for each arc (v,u) in G
            if dist[v] > dist[u] + dist_between(v, u)
                dist[v] = dist[u] + dist_between(v, u)
    return dist
```

Código

```c
void dijkstra(int graph[][MAX_NODES], int num_nodes, int source, int target){
    for (int i=0; i<num_nodes; i++) graph[i][i] = __INT_MAX__;
    graph[source][source] = 0;


    int node_set[num_nodes];
    for (int i=0; i<num_nodes; i++) node_set[i] = 1;

    while (set_is_empty(node_set, num_nodes) != 1){
        int smallest = smallest_dist(graph, node_set, num_nodes);

        node_set[smallest] = -1;

        if (smallest == target) break;

        for (int i=0; i<num_nodes; i++){
            if (graph[smallest][i] != 0 && node_set[i] != -1){
                if(graph[i][i] > graph[smallest][smallest]+graph[smallest][i]
                     && graph[smallest][smallest] != __INT_MAX__
                     && graph[smallest][i] != __INT_MAX__){
                    graph[i][i]=graph[smallest][smallest] + graph[smallest][i];
                }
            }
        }
    }
}

int smallest_dist(int graph[][MAX_NODES], int node_set[], int num_nodes){
    int min = __INT_MAX__, node=-1;
    for (int i=0; i<num_nodes; i++){
        if (node_set[i] != -1){
            if (graph[i][i] < min){
                min = graph[i][i];
                node = i;
            }
        }
    }
    return node;
}

int set_is_empty(int node_set[], int num_nodes){
    int is_empty = 1;
    for (int i=0; i<num_nodes; i++){
        if (node_set[i] != -1){
            return -1;
        }
    }
    return is_empty;
}
```

Algoritmo de Bellman-Ford

Pseudocódigo

```
Function BelmannFord(G,source):
    for each vertex v in G
        dist[v] = infinity
    d[source]=0;

    for(i=0; i<|V|-1; i++)
        for each arc (u,v) in G
            if dist[v] > dist[u]+ dist_between(u, v)
                d[v] = d[u] + dist_between(u, v)

    // Verificação de ciclos negativos
    for each arc (u,v) in G
        if dist[v] > dist[u]+ dist_between(u, v)
            return false   // Ciclo negativo!!
    return true
```

Código

```
int bellman_ford(int graph[][MAX_NODES], int num_nodes, int source, int target){
    for (int i=0; i<num_nodes; i++) graph[i][i] = __INT_MAX__;

    graph[source][source] = 0;

    /*Iterate |V| - 1, i.e, number of nodes - 1 */
    for (int i=0; i<num_nodes-1; i++){
        for (int j=0; j<num_nodes; j++){
            for (int k=0; k<num_nodes; k++){
                if (k==j || graph[j][k] == 0) continue;
                if (graph[k][k] > graph[j][j] + graph[j][k]
                    && graph[j][j] !=__INT_MAX__ && graph[j][k] != __INT_MAX__){
                    graph[k][k] = graph[j][j] + graph[j][k];
                }
            }
        }
    }

    /*Iteration number |V| serves to detect any negative cycles*/
    for (int j=0; j<num_nodes; j++){
        for (int k=0; k<num_nodes; k++){
            if (k==j || graph[j][k] == 0) continue;
            if (graph[k][k] > graph[j][j] + graph[j][k]
                && graph[j][j] !=__INT_MAX__ && graph[j][k] != __INT_MAX__){
                return -1;
            }
        }
    }

    return 1;
}
```

Algoritmo de Floyd-Warshall

Pseudocódigo

```
Function Floyd-Warshall(G)
    for each edge (u,v)
        dist[u][v] ← w(u,v)  // the weight of the edge (u,v)

    for each vertex v
        dist[v][v] ← 0

    for k from 1 to |V|
        for i from 1 to |V|
            for j from 1 to |V|
                if dist[i][j] > dist[i][k] + dist[k][j]
                    dist[i][j] ← dist[i][k] + dist[k][j]
```

Código

```
void floyd_warshall(int graph[][MAX_NODES], int num_nodes){
    /*Set the diagonal to 0*/
    for (int i=0; i<num_nodes; i++) graph[i][i] = 0;

    /*Set 0 values to infinity (INT_MAX)*/
    for(int i=0; i<num_nodes; i++){
        for(int j=0; j<num_nodes; j++){
            if (i!=j && graph[i][j] == 0) graph[i][j] = __INT_MAX__;
        }
    }

    for (int k=0; k<num_nodes; k++){
        for (int i=0; i<num_nodes; i++){
            for (int j=0; j<num_nodes; j++){
                /*Don't calculate if right side values are INT_MAX, overflow*/
                if (graph[i][j] > graph[i][k] + graph[k][j]
                   && graph[i][k]!=__INT_MAX__ && graph[k][j] != __INT_MAX__)
                    graph[i][j] = graph[i][k] + graph[k][j];
            }
        }
    }
}
```

Algoritmo BFS (Breadth-first Search)

Pseudocódigo

```
Function BFS(G, start_node):
    let S be a queue
    S.enqueue(start_node)
    while S is not empty
        v = S.dequeue()
        if v is the goal:
            return v
        for all edges from v to w in G.adjacentEdges(v) do
            if w is not labeled as discovered:
                label w as discovered
                w.parent = v
                S.enqueue(w)
```

Código

```
void bfs(int graph[][MAX_NODES], int num_nodes, int current, int target, int
visited[], int previous[]){
    /*Queue that holds neighbor nodes of current that haven't yet been visited*/
    queue <int> bfs_queue;
    /*Push the first node (the source node)*/
    bfs_queue.push(current);

    previous[0] = -1;

    /*While stack has nodes to visit*/
    while(!bfs_queue.empty()){
        /*Update current node and pop*/
        current = bfs_queue.front();
        bfs_queue.pop();

        /*We have visited this function node*/
        visited[current] = 1;

        /*For each edge that goes out of current node*/
        for (int j=0; j<num_nodes; j++){
            if (graph[current][j]!=0){
                /*If one of these nodes is our target*/
                if (j==target){
                    previous[j] = current;
                    return;
                }
                /*If we haven't visited node yet*/
                else if(visited[j]==0){
                    previous[j] = current;
                    bfs_queue.push(j);
                }
            }
        }
    }
}
```

Algoritmo DFS (Depth-first Search)

Pseudocódigo

```
Function DFS(G, v):
    if v is the goal:
        exit
    label v as visited
    for each neighbor u of v:
        if u is not labeled as discovered:
            u.parent = v
            DFS(G, u)
```

Código

```c
int dfs(int graph[][MAX_NODES], int num_nodes, int current, int target, int visited[],
int previous[]){
    previous[0] = -1;

    /*We have visited this node*/
    visited[current]=1;

    if (current==target){
        return 1;
    }
    else{
        /*For each edge*/
        for (int j=0; j<num_nodes; j++){
            /*If an edge exists*/
            if (graph[current][j]!=0)
            {
                /*Unvisited node and in recursion we found target,update previous*/
                if (dfs(graph, num_nodes, j, target, visited, previous)==1
                      && visited[j]!=1){
                    previous[j] = current;
                    return 1;
                }
            }
        }
    }

    /*Haven't found target in this recursive step*/
    return 0;
}
```

Algoritmo de Kruskal - Estrutura União-Busca (Disjoint-set)

Pseudocódigo – MakeSet

```
function MakeSet(x)
   if x is not already present:
     add x to the disjoint-set tree
     x.parent = x
     x.rank   = 0
     x.size   = 1
```

Pseudocódigo – Find

Path compression

```
function Find(x)
  if x.parent!= x
    x.parent:= Find(x.parent)
  return x.parent
```

Path halving

```
function Find(x)
  while x.parent!= x
    x.parent:= x.parent.parent
    x:= x.parent
  return x
```

Path splitting

```
function Find(x)
  while x.parent!= x
    next :=  x.parent
    x.parent := next.parent
    x := next
  return x
```

Pseudocódigo – Union

Union by rank

```
function Union(x, y)
  xRoot:= Find(x)
  yRoot:= Find(y)

  //x and y are already in the same set
  if xRoot == yRoot
      return

  //x and y are not in same set,so merge them
  if xRoot.rank < yRoot.rank
    // swap xRoot and yRoot
    temp := xRoot
    xRoot := yRoot
    yRoot := temp

  // merge yRoot into xRoot
  yRoot.parent:= xRoot
  if xRoot.rank == yRoot.rank:
    xRoot.rank:= xRoot.rank + 1
```

Union by size

```
function Union(x, y)
  xRoot:= Find(x)
  yRoot:= Find(y)

  //x and y are already in the same set
  if xRoot == yRoot
      return

  //x and y are not in same set,so merge them
  if xRoot.size < yRoot.size
    // swap xRoot and yRoot
    temp := xRoot
    xRoot := yRoot
    yRoot := temp

  // merge yRoot into xRoot
  yRoot.parent:= xRoot
  xRoot.size:= xRoot.size + yRoot.size
```

Algoritmo de Kruskal - Estrutura União-Busca (Disjoint-set)

Código

```
void make_set(int parent_set[], int rank_set[], int size_set[], int num_nodes){
    /*Create a new set with num_nodes nodes, all of them are their own parents*/
    for (int i=0; i<num_nodes; i++){
        parent_set[i] = i;
        rank_set[i] = 0;
        size_set[i] = 1;
    }
}
```

```
int find_compress(int parent_set[], int x){
    if (parent_set[x] ≠ x){
        parent_set[x] = find_compress(parent_set, parent_set[x]);
    }

    return parent_set[x];
}
```

```
int find_halve(int parent_set[], int x){
    while (parent_set[x] ≠ x){
        parent_set[x] = parent_set[parent_set[x]];
        x = parent_set[x];
    }

    return x;
}
```

```
int find_split(int parent_set[], int x){
    while (parent_set[x] ≠ x){
        int next = parent_set[x];
        parent_set[x] = parent_set[next];
        x = next;
    }

    return x;
}
```

Algoritmo de Kruskal - Estrutura União-Busca (Disjoint-set)

Código (cont.)

```c
void union_rank(int parent_set[], int rank_set[], int x, int y){
    int xRoot = find_compress(parent_set, x);
    int yRoot = find_compress(parent_set, y);

    /* x and y are already in the same set */
    if (xRoot == yRoot) return;

    /* x and y are not in same set, so we merge them */
    if (rank_set[xRoot] < rank_set[yRoot]){
        int temp = xRoot;
        xRoot = yRoot;
        yRoot = temp;
    }

    /*Merge yRoot into xRoot*/
    parent_set[yRoot] = xRoot;
    if (rank_set[xRoot]==rank_set[yRoot])
       rank_set[xRoot] = rank_set[xRoot] + 1;
}



void union_size(int parent_set[], int size_set[], int x, int y){

    int xRoot = find_compress(parent_set, x);
    int yRoot = find_compress(parent_set, y);

    /* x and y are already in the same set */
    if (xRoot == yRoot) return;

    /* x and y are not in same set, so we merge them */
    if (size_set[xRoot] < size_set[yRoot]){
        int temp = xRoot;
        xRoot = yRoot;
        yRoot = temp;
    }

    /*Merge yRoot into xRoot*/
    parent_set[yRoot] = xRoot;
    size_set[xRoot] = size_set[xRoot] + size_set[yRoot];
}



/******************************************
 * Structure that represents a graph edge.
 * u: node u;
 * v: node v;
 *
 ******************************************/
typedef struct Edge{
    int u, v;
    int weight;
} Edge;
```

Algoritmo de Kruskal - Algoritmo

Pseudocódigo

```
Function Kruskal(G):
    A = ∅
    foreach v ∈ G.V:
        MAKE-SET(v)

    foreach (u, v) in G.E ordered by weight(u, v), increasing:
        if FIND-SET(u) ≠ FIND-SET(v):
            A = A ∪ {(u, v)}
            UNION(u, v)

    return A
```

Código

```
void kruskal(int graph[][MAX_NODES], int num_nodes){
    /*Empty set of edges, will hold result*/
    Edge *spanning_tree = (Edge*) malloc(MAX_NODES*(MAX_NODES)-1 * sizeof(int));
    int spanning_tree_size = 0;

    /*Set that will hold all edges in graph sorted by weight*/
    Edge *sorted_edges = (Edge*)  malloc(MAX_NODES*(MAX_NODES)-1 * sizeof(int));
    int sorted_edges_size = 0;

    /*Create new set*/
    int parent_set[num_nodes]; int rank_set[num_nodes]; int size_set[num_nodes];
    make_set(parent_set, rank_set, size_set, num_nodes);

    /*Add the edges and sort them*/
    for (int i=0; i<num_nodes; i++){
        for (int j=0; j<num_nodes; j++){
            if (graph[i][j] != 0){
                sorted_edges[sorted_edges_size].u = i;
                sorted_edges[sorted_edges_size].v = j;
                sorted_edges[sorted_edges_size].weight = graph[i][j];
                sorted_edges_size+=1;
            }
        }
    }

    qsort(sorted_edges, sorted_edges_size, sizeof(struct Edge), comparator);

    /*For each sorted edge*/
    for (int i=0; i<sorted_edges_size; i++){
        int u = sorted_edges[i].u; int v = sorted_edges[i].v;
        if (find_compress(parent_set, u) != find_compress(parent_set, v)){
            /*Add the edge to the spanning tree*/
            spanning_tree[spanning_tree_size] = sorted_edges[i];
            spanning_tree_size+=1;
            union_rank(parent_set, rank_set, u, v);
        }
    }

    /*Print results*/
    printf("Spanning tree: \n");
    for (int i=0; i<spanning_tree_size; i++){
        printf("Edge (%d, %d): %d\n", spanning_tree[i].u, spanning_tree[i].v,
spanning_tree[i].weight);
    }

    /*Free allocated memory*/
    free(spanning_tree);
    free(sorted_edges);
}
```

Algoritmo para calcular pontos de articulação de um grafo

Pseudocódigo – DFS modificada

```
GetArticulationPoints(i, d)
    visited[i] = true
    depth[i] = d
    low[i] = d
    childCount = 0
    isArticulation = false
    for each ni in adj[i]
        if not visited[ni]
            parent[ni] = i
            GetArticulationPoints(ni, d + 1)
            childCount = childCount + 1
            if low[ni] ⩾ depth[i]
                isArticulation = true
            low[i] = Min(low[i], low[ni])
        else if ni ≠ parent[i]
            low[i] = Min(low[i], depth[ni])
    if (parent[i] ≠ null and isArticulation) or (parent[i] == null and childCount > 1)
        Output i as articulation point

Run GetArticulationPoints() for every unvisited node in main()
```

Código

```
void articulation_points(int graph[][MAX_NODES], int num_nodes, int current, int
depth, int visited[], int parent[], int depths[], int low[], int points[]){
    visited[current] = 1;
    depths[current] = depth;
    low[current] = depth;
    int child_count = 0;
    bool is_articulation = false;

    /*For each neighbor*/
    for (int j=0; j<num_nodes; j++){
        /*If a connection exists*/
        if (graph[current][j]!=0){
            if (visited[j]==0){
                parent[j] = current;
                articulation_points(graph, num_nodes, j, depth+1, visited,
parent, depths, low, points);
                child_count += 1;

                if (low[j] >= depths[current]) is_articulation = true;
                low[current] = min(low[current], low[j]);
            }
            else if (j != parent[current])
               low[current] = min(low[current], depths[j]);
        }
    }

    /*If node isn't the root node and is an articulation point, or it is root
node and has more than a child, mark it as an articulation point of graph*/
    if ((parent[current]!=-1 && is_articulation) || (parent[current]==-1 &&
           child_count>1))
        points[current] = 1;
}
```

Algoritmo de Tarjan para encontrar componentes fortemente conexas

Pseudocódigo

```
algorithm tarjan is
  input: graph G = (V, E)
  output: set of strongly connected components (sets of vertices)

  index = 0
  S = empty stack
  for each v in V do
    if (v.index is undefined):
      strongconnect(v)

  function strongconnect(v)
    // Set the depth index for v to the smallest unused index
    v.index = index
    v.lowlink = index
    index = index + 1
    S.push(v)
    v.onStack = true

    // Consider successors of v
    for each (v, w) in E:
      if (w.index is undefined):
        // Successor w has not yet been visited; recurse on it
        strongconnect(w)
        v.lowlink  = min(v.lowlink, w.lowlink)
      else if (w.onStack):
        // Successor w is in stack S and hence in the current SCC
        //If w isn't on stack,then(v,w) is cross-edge in DFS tree and ignored
        // Note: The next line may look odd - but is correct.
        // It says w.index not w.lowlink; that is deliberate
        v.lowlink  = min(v.lowlink, w.index)

    // If v is a root node, pop the stack and generate an SCC
    if (v.lowlink = v.index):
      start a new strongly connected component
      do
        w = S.pop()
        w.onStack = false
        add w to current strongly connected component
      while (w ≠ v)
      output the current strongly connected component
```

Algoritmo de Tarjan para encontrar componentes fortemente conexas

Código

```
void tarjan(int graph[][MAX_NODES], int num_nodes, int current, stack <int> *S,
int index[], int lowlink[], bool onStack[], set <int> strong_component[], int
*index_global, int *num_components){
    // Set the depth index for v to the smallest unused index
    index[current] = *index_global;
    lowlink[current] = *index_global;
    (*index_global) += 1;
    (*S).push(current);
    onStack[current] = true;

    // Consider successors of v
    for (int j=0; j<num_nodes; j++){
        /*If there's a connection*/
        if (graph[current][j] != 0){
            if (index[j] == -1){
                // Successor w has not yet been visited; recurse on it
                tarjan(graph, num_nodes, j, S, index, lowlink, onStack,
strong_component, index_global, num_components);
                lowlink[current] = min(lowlink[current], lowlink[j]);
            }
            else if (onStack[j]){
                // Successor w is in stack S and hence in the current SCC
                // If w is not on stack, then (v, w) is a cross-edge in the DFS
tree and must be ignored
                lowlink[current] = min(lowlink[current], index[j]);
            }
        }
    }

    // If v is a root node, pop the stack and generate an SCC
    int j;
    if (lowlink[current] == index[current]){
        do{
            j = (*S).top();
            (*S).pop();
            onStack[j] = false;
            strong_component[(*num_components)].insert(j);
        } while (j != current);

        (*num_components)+=1;
    }
}
```

Ordenação topológica

Pseudocódigo - DFS

```
L ← Empty list that will contain the sorted nodes
while exists nodes without a permanent mark:
    select an unmarked node n
    visit(n)

function visit(node n):
    if n has a permanent mark then return
    if n has a temporary mark then stop   (not a DAG)
    mark n with a temporary mark
    for each node m with an edge from n to m:
        visit(m)
    remove temporary mark from n
    mark n with a permanent mark
    add n to head of L
```

Código

```
int sort(int graph[][MAX_NODES], int num_nodes, int current, vector<int>
*sorted, int visited[]){
    /*If current node was already visited*/
    if (visited[current]==1) return 1;
    /*If current node is already being visited in another stack call*/
    if (visited[current]==-1) return -1;

    /*Mark the node with a temporary mark*/
    visited[current] = -1;

    /*For each neighbor of current node*/
    for (int j=0; j<num_nodes; j++){
        /*If a connection exists*/
        if (graph[current][j]!=0){
            if (sort(graph, num_nodes, j, sorted, visited)==-1) return -1;
        }
    }

    /*Mark this node as visited*/
    visited[current] = 1;
    /*Add the node to the list*/
    (*sorted).emplace_back(current);

    return 1;
}
```

Input

Exemplo – Um caso de teste

<source>
<target>
<matriz>

```
int main(int argc, char **argv){
    char temp[MAX_TEMP];
    int graph[MAX_NODES][MAX_NODES];
    int num_nodes=0, i=0, j=0;
    int source, target;
    int maxval; //For nice printing only, ignore

    /*Source and target nodes*/
    fgets(temp, MAX_TEMP, stdin);
    source = atoi(temp);
    fgets(temp, MAX_TEMP, stdin);
    target = atoi(temp);

    /*Read actual graph*/
    while(fgets(temp, MAX_TEMP, stdin) ≠ NULL){
        char *token = strtok(temp, " ");
        j=0;
        while (token ≠ NULL){
            if(atoi(token)>maxval) maxval=atoi(token); //For nice printing only,
ignore

            graph[i][j] = atoi(token); //Nodes updated here
            token = strtok(NULL, " ");
            j+=1;
        }
        i+=1;
        num_nodes+=1; //Count overall number of nodes
    }

    /*Print received input*/
    //int width = round(1+log(maxval)/log(10)); //Adjust for different sized
numbers in output
    //print_input(graph, num_nodes, source, target, width);

    /*Use algorithm*/
    something();

    return 0;
}
```

Input

Exemplo – Vários casos de teste

<n> <n_v> Numero de vertices / Numero de ligações
n_v linhas
<v u> Conexao
<v u>
...

```c
int main(int argc, char **argv){
    char temp[MAX_TEMP];
    int graph[MAX_NODES][MAX_NODES];
    int num_nodes=0, num_connections;
    //int maxval; //For nice printing only, ignore

    /*Read actual graph*/
    while(fgets(temp, MAX_TEMP, stdin) != NULL){
        char *token = strtok(temp, " ");
        /*Number of nodes*/
        num_nodes = atoi(token); token = strtok(NULL, " ");

        /*Get number of connections*/
        num_connections = atoi(token);

        /*Set graph values to 0*/
        for (int i=0; i<num_nodes; i++){
            for (int j=0; j<num_nodes; j++){
                graph[i][j] = 0;
            }
        }

        /*Graph nodes*/
        for (int t=0; t<num_connections; t++){
            /*Get source and target node*/
            fgets(temp, MAX_TEMP, stdin);
            token = strtok(temp, " ");

            int source = atoi(token); token = strtok(NULL, " ");
            int target = atoi(token);

            /*Update the graph*/
            graph[source][target] = 1;
        }

        /*Print received input*/
        //int width = round(1+log(maxval)/log(10));
        //print_input(graph, num_nodes, width);

        /*Use algorithm*/
       something();
    }

    return 0;
}
```

C++ STL (Standard Template Library)

Iterators

<tipo>::iterator <nome>

```cpp
using namespace std;

int main(){

    vector<int>::iterator it1;
    set<int>::iterator it2;
    /*To print in reverse*/
    set<int>::reverse_iterator it3;

    set<int> list; list.insert(0); list.insert(2);

    /*To get an iterator*/
    it2 = list.begin(); //Pointing to the first element
    it3 = list.rbegin(); //Pointing to last element (r - reverse)

    /*Example*/
    for (it2 = list.begin(); it2 != list.end(); ++it2){
        printf("%d\n", *it2);
    }

    return 1;
}
```

Queue FIFO - #include <queue>

queue<tipo> <nome>

```cpp
using namespace std;

int main(){

    queue<int> queue1;

    /*Add elements*/
    queue1.push(1);
    queue1.push(10);

    /*Read the element at the front of the queue*/
    int number = queue1.front();

    /*Remove the element at the front of the queue*/
    queue1.pop();

    /*Check if it's empty*/
    while(!queue1.empty()){
         ...
    }

    return 1;
}
```

C++ STL (Standard Template Library)

Stack - #include <stack>

stack<tipo> <nome>

```
using namespace std;

int main(){

    stack<int> stack1;

    /*Insert elements*/
    stack1.push(1);
    stack1.push(10);

    /*Get element at the top of the stack*/
    int number = stack1.top();

    /*Remove the top element*/
    stack1.pop();

    /*Check if the stack is empty*/
    while(!stack1.empty()){
        ...
    }

    return 1;
}
```

Vector - #include <vector>

vector<tipo> <nome>

```
using namespace std;

int main(){

    vector<int> vector1;

    /*Add elements at beggining*/
    vector1.insert(vector1.begin(), 1);
    vector1.insert(vector1.begin(), 10);

    /*Add elements at specific index*/
    vector1.insert(vector1.begin() + index, 1);
    vector1.insert(vector1.begin() + index, 10);

    /*Add elements at the end*/
    vector1.push_back(1);

    /*Delete element at specific index*/
    vector1.erase(vector1.begin() + index);

    /*Check its size and if empty*/
    int size = vector1.size();
    vector1.empty();

    /*Swap two elements in the vector*/
    iter_swap(vector1.begin() + index1, vector1.begin() + index2);

    return 1;
}
```

Alocação dinãmica do grafo

```
#define MAX_NODES 5001

int main(){

    /*Matrix that contains adjacency matrix*/
    int **graph = (int**)malloc((MAX_NODES) * sizeof *graph);
    int *data = (int*)malloc((MAX_NODES) * (MAX_NODES) * sizeof *data);
    for (int i=0; i<MAX_NODES; i++, data+=MAX_NODES) graph[i] = data;


    while(1){
        ... //Use algorithm
    }

    /*Free memory*/
    free(*graph);
    free(graph);

    return 0;
}
```