981. Minimum spanning tree

Find the weight of minimum spanning tree for a weighted undirected connected graph.

Input. The first line contains the numbers n and m ($1 \le n \le 100$, $1 \le m \le 6000$), where n is the number of vertices in the graph and m is the number of edges. In each of the next m lines the triple of numbers a, b, c are written, where a and b are the numbers of vertices connected by an edge and c is the weight of edge (a positive number not exceeding 30000).

Output. Print the weight of minimum spanning tree.

Sample input	Sample output
3 3 1 2 1 2 3 2 3 1 3	3

SOLUTION

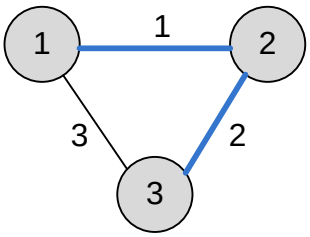
graphs – minimum spanning tree – Kruskal

Algorithm analysis

In this problem you must find the weight of the minimum spanning tree using Kruskal's algorithm.

Example

The graph given in the sample has a form:



Algorithm realization

Declare the structure of the graph edge (a pair of vertices and the weight of the edge). Declare the vector of edges e.

```
struct Edge
{
  int u, v, dist;
};

vector<Edge> e;
```

Declare an array *parent* used by the disjoint set system.

```
vector<int> parent;
```

The function ***Repr*** finds a representative of the set that contains vertex *n*.

```
int Repr(int n)
{
  while (n != parent[n]) n = parent[n];
  return n;
}
```

Function ***Union*** unites sets that contain elements *x* and *y*.

```
int Union(int x, int y)
{
  x = Repr(x); y = Repr(y);
  if (x == y) return 0;
  parent[y] = x;
  return 1;
}
```

The function ***lt*** is a comparator for sorting edges.

```
int lt(Edge a, Edge b)
{
  return (a.dist < b.dist);
}
```

The main part of the program. Initialize the *parent* array.

```
scanf("%d %d",&n,&m);
parent.resize(n + 1);
for (i = 1; i <= n; i++) parent[i] = i;
```

Read the edges of the graph.

```
e.resize(m);
for (i = 0; i < m; i++)
  scanf("%d %d %d", &e[i].u, &e[i].v, &e[i].dist);
```

Sort the edges in increasing order of their weights.

```
sort(e.begin(), e.end(), lt);
```

Start the Kruskal algorithm that constructs the minimum spanning tree.

```
res = 0;
for(i = 0; i < m; i++)
  if (Union(e[i].u,e[i].v)) res += e[i].dist;
```

Print the weight of the minimum spanning tree.

```
printf("%d\n",res);
```

Algorithm realization – heuristics

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

struct Edge
{
  int u, v, dist;
};

vector<Edge> e;
vector<int> parent, depth;
int i, n, m, res;

int Repr(int n)
{
  if (n == parent[n]) return n;
  return parent[n] = Repr(parent[n]);
}

int Union(int x, int y)
{
  x = Repr(x); y = Repr(y);
  if (x == y) return 0;
  if (depth[x] < depth[y]) swap(x, y);
  parent[y] = x;
  if (depth[x] == depth[y]) depth[x]++;
  return 1;
}

int lt(Edge a, Edge b)
{
  return a.dist < b.dist;
}

int main(void)
{
  scanf("%d %d", &n, &m);

  parent.resize(n + 1);
  depth.resize(n + 1);
  for (i = 1; i <= n; i++)
  {
    parent[i] = i;
    depth[i] = 0;
  }

  e.resize(m);
  for (i = 0; i < m; i++)
    scanf("%d %d %d", &e[i].u, &e[i].v, &e[i].dist);

  sort(e.begin(), e.end(), lt);

  res = 0;
  for (i = 0; i < m; i++)
    if (Union(e[i].u, e[i].v)) res += e[i].dist;
```

```
  printf("%d\n", res);
  return 0;
}
```

Java realization

```
import java.util.*;

class Edge
{
  int u, v, dist;
  Edge (int u, int v, int dist)
  {
    this.u = u;
    this.v = v;
    this.dist = dist;
  }
};

public class Main
{
  static int mas[];
  static int size[];

  static int Repr(int n)
  {
    if (n == mas[n]) return n;
    return mas[n] = Repr(mas[n]);
  }

  static int Union(int x,int y)
  {
    x = Repr(x); y = Repr(y);
    if(x == y) return 0;

    if (size[x] < size[y])
    {
      int temp = x; x = y; y = temp;
    }
    mas[y] = x;
    size[x] += size[y];
    return 1;
  }

  public static class MyFun implements Comparator<Edge>
  {
    public int compare(Edge a, Edge b)
    {
      return a.dist - b.dist;
    }
  }

  public static void main(String[] args)
  {
    Scanner con = new Scanner(System.in);
    int n = con.nextInt();
```

```
    int m = con.nextInt();
    mas = new int[n+1];
    size = new int[n+1];

    for(int i = 1; i <= n; i++)
    {
      mas[i] = i;
      size[i] = 1;
    }

    Vector<Edge> v = new Vector<Edge>();
    for(int i = 0; i < m; i++)
    {
      int x = con.nextInt();
      int y = con.nextInt();
      int dist = con.nextInt();
      v.add(new Edge(x,y,dist));
    }

    Collections.sort(v, new MyFun());

    int res = 0;
    for(int i = 0; i < m; i++)
      if (Union(v.get(i).u,v.get(i).v) == 1) res += v.get(i).dist;

    System.out.println(res);
    con.close();
  }
}
```