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1 Basic

1.1 Syntax

```

1 #include <bits/stdc++.h>
2 using namespace std;
3 int main(int argc, char const *argv[])
4 {
5     // String to Integer
6     char str[30] = {'-', '1', '2', '3', '4', '5', '\0'};
7     printf("%d\n", stoi(str));
8     // Integer to String
9     int x = 185;
10    char temp[30];
11    int base = 10;
12    itoa(x, temp, base);
13    printf("%s\n", temp);
14    // String to Double
15    char strd[30] = {'0', '.', '6', '0', '2', '2', '2', '9', '\0'};
16    printf("%Lf\n", stod(strd));
17    // Double to String
18    double y = 3.1415926;
19    string dstr = to_string(y);
20    cout << dstr << endl;
21    // String initialize
22    char null[30] = {'\0'};
23    char A[30];
24    strcpy(A, null);
25    // String Length
26    char strl[30] = {'H', 'E', 'L', 'L', 'O', '\0'};
27    printf("%d\n", strlen(strl));
28    return 0;
29 }

```

1.2 BigInteger

```

1 import java.math.BigInteger;
2 import java.util.Scanner;
3 class Main {
4     public static void main(String[] args) {
5         Scanner input = new Scanner(System.in);
6         BigInteger n = input.nextBigInteger();
7         BigInteger m = input.nextBigInteger();
8         n.add(m); a.subtract(m); n.multiply(m); n.
9         divide(m); n.mod(m);
10        n.pow(m.intValue()); n.gcd(m); n.negate(); n.
11        abs();
12    }
13 }

```

2 Data Structure

2.1 Disjoint Set

```

4
4 1 const int n = 6; // number of nodes
2 int p[n+10];
4 3 void init()
4 4 {
5 5     for(int i = 0; i < n; i++){
5 6         p[i] = -1;
5 7     }
6 8 }
6 9 int find(int x){
7 10 int root, trail, lead;
7 11 for (root = x; p[root] >= 0; root = p[root]);
12 for (trail = x; trail != root; trail = lead) {
8 13     lead = p[trail];
8 14     p[trail] = root;
8 15 }
16 return root;
17 }
18 void uni(int x, int y)
19 {
20     int xRoot = find(x), yRoot = find(y);
21     if(xRoot != yRoot){
22         if(p[xRoot] > p[yRoot]){
23             p[xRoot] += p[yRoot];
24             p[yRoot] = xRoot;
25         }
26         else{
27             p[yRoot] += p[xRoot];
28             p[xRoot] = yRoot;
29         }
30     }
31 }

```

2.2 Segment Tree

```

1 #include <bits/stdc++.h>
2 using namespace std;
3 const int n = 8;
4 int B[n] = {18, 17, 13, 19, 15, 11, 20, 87};
5 typedef vector<int> vi;
6 vi A (B, B + 8);
7 vi ST;
8 void ST_Build(vi &ST, const vi &A, int vertex, int L,
9             int R)
9 {
10     if(L == R) ST[vertex] = L;
11     else
12     {
13         int nL = vertex * 2, nR = vertex * 2 + 1;
14         ST_Build(ST, A, nL, L, L + (R - L) / 2);
15         ST_Build(ST, A, nR, L + (R - L) / 2 + 1, R);
16         int indexL = ST[nL], indexR = ST[nR];
17         int valueL = A[indexL], valueR = A[indexR];

```

```

18     ST[vertex] = valueL <= valueR ? indexL : indexR;
19 }
20 }
21
22 void ST_Creation(vi &ST, const vi &A)
23 {
24     int len = 4 * A.size();
25     ST.assign(len, 0);
26     ST_Build(ST, A, 1, 0, A.size()-1);
27 }
28 int query(vi &ST, const vi &A, int vertex, int L, int R
    , int qL, int qR)
29 {
30     int temp, mid = (L + R) / 2;
31     if(qL <= L && R <= qR) return ST[vertex];
32     if(qR <= mid)
33     { //all we want at the left child
34         return query(ST, A, vertex * 2, L, mid, qL, qR);
35     }
36     if(qL > mid)
37     { // all we want at the right child
38         return query(ST, A, vertex * 2 + 1, mid + 1, R, qL,
39             qR);
40     }
41     return A[query(ST, A, vertex * 2, L, mid, qL, qR)] <=
42         A[query(ST, A, vertex * 2 + 1, mid + 1, R, qL,
43             qR)]
44         ? query(ST, A, vertex * 2, L, mid, qL, qR) :
45             query(ST, A, vertex * 2 + 1, mid + 1, R, qL,
46                 qR);
47 }
48
49 void update(vi &ST, vi &A, int x, int L, int R, int p,
    int v)
50 {
51     // p is the index where you want to update
52     // v is the value will be update in A[p];
53     int mid = L + (R - L) / 2;
54     if(L == R) A[ST[x]] = v;
55     else
56     {
57         if(p <= mid) update(ST, A, x*2, L, mid, p, v);
58         else update(ST, A, x*2+1, mid+1, R, p, v);
59         ST[x] = (A[ST[x*2]] <= A[ST[x*2+1]]) ? ST[x*2] : ST
60             [x*2+1];
61     }
62 }
63
64 int main(int argc, char const *argv[])
65 {
66     ST_Creation(ST, A);
67     printf("%d\n", query(ST, A, 1, 0, n-1, 3, 7));
68     // query return the index
69     printf("%d\n", A[query(ST, A, 1, 0, n-1, 3, 7)]);
70     update(ST, A, 1, 0, n-1, 5, 18);
71     // query and update first to fifth parameter dont
72     change
73     // ST, A, 1, 0, n-1
74     // last two would be
75     // query: the range(array index) you want to query
76     // update: first is the index you want to update,
77     second is the value will be
78     return 0;
79 }

```

3 Divide and Conquer

3.1 MaximumSubArray

```

1 #include <bits/stdc++.h>
2 using namespace std;
3 const int n = 16;
4 int arr[n] = {13, -3, -25, 20, -3, -16, -23,
5     18, 20, -7, 12, -5, -22, 15, -4, 7};
6

```

```

7 int findMaxCrossing(int left, int mid, int right){
8     int maxl = 0x80000000;
9     int sum = 0;
10    for(int i = mid; i >= left; i--){
11        sum += arr[i];
12        if(sum > maxl) maxl = sum;
13    }
14    int maxr = 0x80000000;
15    sum = 0;
16    for(int i = mid + 1; i <= right; i++){
17        sum += arr[i];
18        if(sum > maxr) maxr = sum;
19    }
20    return (maxl + maxr);
21 }
22
23 int findMaxSub(int left, int right)
24 {
25     if(left == right){
26         return arr[left];
27     }
28     else{
29         int mid = left + (right - left) / 2;
30         int maxl = findMaxSub(left, mid);
31         int maxr = findMaxSub(mid + 1, right);
32         int res = max(maxl, maxr);
33         res = max(res, findMaxCrossing(left, mid, right));
34         return res;
35     }
36 }
37
38
39
40 int main(int argc, char const *argv[])
41 {
42     printf("%d\n", findMaxSub(0, n-1));
43     return 0;
44 }

```

4 Dynamic Programming

4.1 LCS

```

1 const int maxn = 10000; // maxn is maximum length of
2   arrp and arrq
3 int arrp[maxn], arrq[maxn];
4 int dp[maxn+5][maxn+5];
5 int p, q; // p is the length of arrp, q is the length
6   of arrq
7 void LCS()
8 {
9     memset(dp, 0, sizeof(dp));
10
11     for(int i = 1; i <= p; i++){
12         for(int j = 1; j <= q; j++){
13             if(arrp[i] == arrq[j]){
14                 dp[i][j] = 1 + dp[i-1][j-1];
15             }
16             else{
17                 dp[i][j] = max(dp[i-1][j], dp[i][j-1]);
18             }
19         }
20     }
21     // dp[p][q] is the answer
22 }

```

4.2 LIS

```

1 int LIS(vector<int>& s)
2 {
3     if (s.size() == 0) return 0;
4

```

```

5 | vector<int> v;
6 | v.push_back(s[0]);
7 |
8 | for (int i = 1; i < s.size(); ++i)
9 | {
10 |     int n = s[i];
11 |
12 |     if (n > v.back())
13 |         v.push_back(n);
14 |     else
15 |         *lower_bound(v.begin(), v.end(), n) = n;
16 | }
17 |
18 | return v.size();
19 | }

```

5 Search

5.1 Binary Search

```

1 | int L = 0; // left boundary
2 | int R = ans; // right boundary
3 | // check using L = 3, R = 4, ans = 4
4 | while(L < R){
5 |     int M = L + (R - L + 1) / 2; // Left + half distance
6 |     if(ok(M)) L = M; // ok() method is to find
7 |         whether the M can qualify the demand
8 |     else R = M - 1;
9 | }
10 | while(L < R){
11 |     int M = L + (R - L) / 2; // Left + half distance
12 |     if(ok(M)) R = M; // ok() method is to find
13 |         whether the M can qualify the demand
14 |     else L = M + 1;
15 | }

```

6 Sequence

6.1 RSQ(Prefix Sum)

```

1 | #include <bits/stdc++.h>
2 | using namespace std;
3 | const int maxn = 10;
4 | int arr[maxn] = {5, -2, 3, 10, -7, 1, -4, 8, -9};
5 | int query[maxn];
6 | void init()
7 | {
8 |     // every query is the sum of all previos element,
9 |     // include it self
10 |     // example query[3] = arr[0] + arr[1] + arr[2] + arr
11 |     [3]
12 |     query[0] = arr[0];
13 |     for(int i = 1; i < maxn; i++){
14 |         query[i] = arr[i];
15 |         query[i] += query[i-1];
16 |     }
17 | }
18 | int RangeSumQuery(int s, int e)
19 | {
20 |     //Prefix Sum Algorithm
21 |     if(s >= 1) return query[e] - query[s-1];
22 |     else return query[e];
23 | }
24 | int main(int argc, char const *argv[])
25 | {
26 |     init();
27 |     int start = 2, end = 5;
28 |     printf("RangeSumQuery(%d, %d): %d\n", start, end,
29 |         RangeSumQuery(start, end));

```

```

28 | return 0;
29 | }

```

6.2 RSQ(2DPrefix Sum)

```

1 | #include <bits/stdc++.h>
2 | using namespace std;
3 | int arr[110][110];
4 | int query[110][110];
5 | int n;
6 |
7 | int main(int argc, char const *argv[])
8 | {
9 |     while(cin >> n){
10 |         // input
11 |         for(int i = 0; i < n; i++){
12 |             for(int j = 0; j < n; j++){
13 |                 cin >> arr[i][j];
14 |             }
15 |             // bulid prefix query
16 |             for(int i = 0; i < n; i++){
17 |                 for(int j = 0; j < n; j++){
18 |                     query[i][j] = arr[i][j];
19 |                     if(i - 1 >= 0) query[i][j] += query[i-1][j];
20 |                     if(j - 1 >= 0) query[i][j] += query[i][j-1];
21 |                     if(i - 1 >= 0 && j - 1 >= 0) query[i][j] -=
22 |                         query[i-1][j-1];
23 |                 }
24 |             }
25 |             int temp;
26 |             int maximum = 0x80000000;
27 |             // find the maximum sum in any range
28 |             for(int i = 0; i < n; i++){
29 |                 for(int j = 0; j < n; j++){
30 |                     for(int k = i; k < n; k++){
31 |                         for(int t = j; t < n; t++){
32 |                             temp = query[k][t];
33 |                             if(i - 1 >= 0) temp -= query[i-1][t];
34 |                             if(j - 1 >= 0) temp -= query[k][j-1];
35 |                             if(i - 1 >= 0 && j - 1 >= 0) temp += query[
36 |                                 i-1][j-1];
37 |                             if(maximum < temp) maximum = temp;
38 |                         }
39 |                     }
40 |                 }
41 |             }
42 |             printf("%d\n", maximum);
43 |         }
44 |     }
45 |     return 0;
46 | }

```

6.3 RSQ(Fenwick Tree)

```

1 | #include <bits/stdc++.h>
2 | using namespace std;
3 | const int maxn = 10;
4 | int arr[maxn] = {5, -2, 3, 10, -7, 1, -4, 8, -9};
5 | int FenwickTree[maxn];
6 | int ANDlowbit(int src)
7 | {
8 |     // src & -src will get the lowbit
9 |     // example: 6 & -6 = 0110 & 1010 = 0010 = 2
10 |     return src & -src;
11 | }
12 | void init()
13 | {
14 |     memset(FenwickTree, 0, sizeof(FenwickTree));
15 |     // Notice that we start in 1
16 |     for(int i = 1; i <= maxn; i++){
17 |

```

```

18     int index = i;
19     FenwickTree[i] += arr[i-1];
20     int temp = arr[i-1];
21     while(index + ANDlowbit(index) <= maxn){
22         index += ANDlowbit(index);
23         FenwickTree[index] += temp;
24     }
25 }
26 }
27 void Modify(int src, int val)
28 {
29     // Modify arr[src] to val
30     int gap = val - arr[src];
31     arr[src] = val;
32     int index = src + 1;
33     FenwickTree[index] += gap;
34     while(index + ANDlowbit(index) <= maxn){
35         index += ANDlowbit(index);
36         FenwickTree[index] += gap;
37     }
38 }
39 int SequenceQuery(int src)
40 {
41     //src is the index of the array which we want to know
42     //the Sequence Query
43     int res = FenwickTree[src];
44     int index = src;
45     while(index - ANDlowbit(index) > 0){
46         index -= ANDlowbit(index);
47         res += FenwickTree[index];
48     }
49     return res;
50 }
51 int RangeSumQuery(int s, int e)
52 {
53     return SequenceQuery(e) - SequenceQuery(s - 1);
54 }
55 int main(int argc, char const *argv[])
56 {
57     init();
58     int start = 2, end = 5;
59     // for Fenwick index is 3, 6 for array index is 2, 5
60     printf("RangeSumQuery(%d, %d): %d\n", start, end,
61         RangeSumQuery(start + 1, end + 1));
62     Modify(2, 5);
63     // Modify arr[2] from 3 to 5
64     printf("RangeSumQuery(%d, %d): %d\n", start, end,
65         RangeSumQuery(start + 1, end + 1));
66     return 0;
67 }

```

7 Sorting

7.1 Counting Sort

```

1 #include <bits/stdc++.h>
2 using namespace std;
3 const int maxn = 50;
4 const int maxDigit = 1050;
5 int unsorted[maxn] = {0, 3, 7, 6, 5}, sorted[maxn], aux
6 [maxDigit];
7 // aux size is depends on the max digit in sorting
8 int main(int argc, char const *argv[])
9 {
10     int n = 4;
11     // array index start with 1
12     memset(aux, 0, sizeof(aux));
13     for(int i = 1; i <= n; i++){
14         aux[unsorted[i]]++;
15     }
16     for(int i = 1; i < maxDigit; i++){
17         aux[i] += aux[i-1];
18     }
19     for(int i = n; i > 0; i--){

```

```

19     sorted[aux[unsorted[i]]] = unsorted[i];
20     aux[unsorted[i]]--;
21 }
22 for(int i = 1; i <= n; i++){
23     printf("%d ", sorted[i]);
24 }
25 return 0;
26 }

```

7.2 Topology Sort

```

1 #include <bits/stdc++.h>
2 using namespace std;
3 const int maxn = 100;
4 vector<int> ans;
5 vector<int> adj[maxn];
6 int refs[maxn];
7 int n = 5;
8
9 // refs 紀錄這個點被幾個邊連到
10 void TopologyOrder()
11 {
12     for(int i = 0; i < n; i++){
13         int s = 0;
14         while(s < n && refs[s] != 0) {
15             s++;
16         }
17         if(s == n) break;
18         refs[s] = -1;
19         ans.push_back(s);
20         for(auto j : adj[s]){
21             refs[j]--;
22         }
23     }
24 }
25 int main(int argc, char const *argv[])
26 {
27     memset(refs, 0, sizeof(refs));
28     ans.clear();
29     // adj[from].push_back(to); refs[to]++;
30     adj[4].push_back(1); refs[1]++;
31     adj[1].push_back(3); refs[3]++;
32     adj[1].push_back(0); refs[0]++;
33     adj[2].push_back(0); refs[0]++;
34     adj[3].push_back(0); refs[0]++;
35     TopologyOrder();
36     for(int i = 0; i < ans.size(); i++){
37         if(i == ans.size()-1) printf("%d\n", ans[i]);
38         else printf("%d ", ans[i]);
39     }
40     return 0;
41 }

```

8 Graph

8.1 DFS

```

1 //implement by adjacent list
2 //functional dfs
3 void dfs(int now, int fa, int layer){
4     for (auto j : adj[now])
5         if(j != fa ) dfs(j, now, layer + 1);
6 }
7 //stack dfs
8 stack<int> st;
9 bool vis[maxn];
10 memset(vis, false, sizeof(vis));
11 int src;
12 st.push(src);
13 while(!st.empty())
14 {
15     int now = st.top(); st.pop();

```

```

16 vis[now] = true;
17 for(auto i : adj[now])
18     if(!vis[i]) st.push(i);
19
20 }
```

8.2 BFS

```

1 queue<int> st;
2 bool vis[maxn];
3 memset(vis, false, sizeof(vis));
4 int src;
5 st.push(src);
6 while(!st.empty())
7 {
8     int now = st.front(); st.pop();
9     vis[now] = true;
10    for(auto i : adj[now])
11        if(!vis[i]) st.push(i);
12 }
```

8.3 Dijkstra

```

1 int maxn = ;
2 int w[maxn][maxn], dis[maxn];
3 vector<int> v[maxn];
4 struct Node
5 {
6     int node, weight;
7     Node(int _n, int _w){
8         node = _n;
9         weight = _w;
10    }
11    bool operator<(Node const other) const{
12        return weight > other.weight;
13    }
14 };
15 void dijkstra(int src)
16 {
17     priority_queue<Node> pq;
18     pq.push(Node(src, 0));
19     while(!pq.empty())
20     {
21         auto top = pq.top();
22         pq.pop();
23         if(dis[top.node] != 1e9) continue;
24         for(auto i : v[top.node]){
25             pq.push(Node(i, top.weight + w[top.node][i]));
26         }
27         dis[top.node] = top.weight;
28     }
29 }
```

8.4 SPFA

```

1 #include <bits/stdc++.h>
2 using namespace std;
3
4 #define INF 0x3f3f3f3f;
5 const int maxn = 10000+5;
6
7 int n, m;
8 int dist[maxn], vis[maxn], out[maxn];
9 vector<pair<int, int>> adj[maxn];
10
11 void init()
12 {
13     memset(dist, INF, sizeof(dist));
14     memset(vis, 0, sizeof(vis));
15     memset(out, 0, sizeof(out));
16     for(int i = 0; i <= n; i++){
```

```

17     adj[i].clear();
18 }
19 }
20
21 bool spfa(int sp, int n)
22 {
23     queue<int> q;
24     q.push(sp);
25
26     while(!q.empty())
27     {
28         int u = q.front(); q.pop();
29         vis[u] = 0;
30         out[u]++;
31         if(out[u] > n) return false; // negative cycle
32                                     occurs
33
34         for(int j = 0; j < adj[u].size(); j++){
35             int v = adj[u][j].first;
36             if(dist[v] > dist[u] + adj[u][j].second){
37                 dist[v] = dist[u] + adj[u][j].second;
38                 if(vis[v]) continue;
39
40                 vis[v] = 1;
41                 q.push(v);
42             }
43         }
44     }
45     return true;
46 }
47
48 int main(int argc, char const *argv[])
49 {
50     // n nodes and m edges
51     scanf("%d%d", &n, &m);
52     init();
53     // make adjacent list
54     int a, b, w;
55     for(int i = 0; i < m; i++){
56         scanf("%d%d%d", &a, &b, &w);
57         E[a].push_back(make_pair(b, w));
58         E[b].push_back(make_pair(a, w));
59     }
60     int sp = 0; // start point
61     dist[sp] = 0; vis[sp] = 1;
62     if(spfa(sp, n)) printf("%d\n", dist[n-1]);
63     else printf("can't reach.\n");
64     return 0;
65 }
```

8.5 BellmanFord

```

1 int main(int argc, char const *argv[])
2 {
3     //initialize dis[] with 1e9
4     //make an adjacent list
5     call bellman_ford(src);
6     return 0;
7 }
8
9 void bellman_ford(int src)
10 {
11     dis[src] = 0; //initialize source
12     //with distance 0
13     for (int k = 0; k < n - 1; ++k){ //do n-1
14         //times
15         for (int i = 0; i < n; ++i){
16             for(auto j : v[i]){
17                 if(dis[i] != 1e9) dis[j] = min(dis[j], dis[i] +
18                     w[i][j]);
19             }
20         }
21     }
```

```

22 for(i = 0; i < n; ++i){
23     for(auto j : v[i]){
24         if(dis[j] > dis[i] + w[i][j]) return true //has
            negative cycle
25     }
26 }
27 return false;
28 }

```

8.6 FloydWarshall

```

1 //dis[i][j] is the distance of node i to node j
2 int dis[n+5][n+5];
3 void init()
4 {
5     memset(dis, 0x3f, sizeof(dis));
6     for(int i = 0; i < n; i++) d[i][i] = 0;
7 }
8 void floyd(){
9     for (int k = 0; k < n; ++k)
10         for(int i = 0; i < n; ++i)
11             for(int j = 0; j < n; ++j)
12                 dis[i][j] = dis[j][i] = min(dis[i][j], dis[i][k] + dis[k][j]);
13 }
14 int main(int argc, char const *argv[])
15 {
16     //If we got n nodes, label from 0 to (n-1)
17     init();
18     //Set the dis
19     floyd();
20 }

```

8.7 Kruskal

```

1 const int maxn = 1000+5;
2 struct Edge
3 {
4     int from, to;
5     double cost;
6     bool operator<(const Edge other){
7         return cost < other.cost;
8     }
9 }E[maxn*maxn];
10 int p[maxn];
11 vector<Edge> G[maxn];
12 int find(int x){
13     int root, trail, lead;
14     for (root = x; p[root] >= 0; root = p[root]);
15     for (trail = x; trail != root; trail = lead) {
16         lead = p[trail];
17         p[trail] = root;
18     }
19     return root;
20 }
21 bool uni(int x, int y)
22 {
23     int xRoot = find(x), yRoot = find(y);
24     if(xRoot != yRoot){
25         if(p[xRoot] > p[yRoot]){
26             p[xRoot] += p[yRoot];
27             p[yRoot] = xRoot;
28         }
29         else{
30             p[yRoot] += p[xRoot];
31             p[xRoot] = yRoot;
32         }
33         return true;
34     }
35     else return false;
36 }
37 double kruskal(int n, int m)
38 {

```

```

39 // n is the numbers of node, m is the numbers of edge
40 for(int i = 0; i <= n; i++){
41     G[i].clear();
42     p[i] = -1;
43 }
44 sort(E, E + m);
45 double ans = 0;
46 int edge_cnt = 0;
47 for(int i = 0; i < m; i++){
48     if(uni(E[i].from, E[i].to)){
49         int from = E[i].from, to = E[i].to;
50         ans += E[i].cost;
51         G[from].push_back(Edge{from, to, E[i].cost});
52         G[to].push_back(Edge{to, from, E[i].cost});
53         if(++edge_cnt == n-1) break;
54     }
55 }
56 if(edge_cnt == n-1) return ans;
57 else return -1; // means can't found spanning tree
58 }
59 // find max segment in MST graph
60 int maxcost[maxn][maxn];
61 vector<int> visited;
62 void dfs(int pre, int now, int w){
63     for(auto x : visited){
64         maxcost[x][now] = maxcost[now][x] = max(w, maxcost[
65             pre][x]);
66     }
67     visited.push_back(now);
68     for(auto i : G[now]){
69         if(pre != i.to) dfs(i.from, i.to, i.cost);
70     }
71 }
72 void findMaxPtah(int sp, int ep){
73     memset(maxcost, 0, sizeof(maxcost));
74     visited.clear();
75     dfs(-1, sp, 0);
76 }

```

8.8 Bipartite Matching

```

1 const int maxn = 500+5;
2 int W[maxn][maxn], n;
3 int Lx[maxn], Ly[maxn];
4 int Lef[maxn];
5 bool S[maxn], T[maxn];
6 bool match(int i)
7 {
8     S[i] = true;
9     for (int j = 1; j <= n; ++j)
10     {
11         if(Lx[i] + Ly[j] == W[i][j] && !T[j])
12         {
13             T[j] = true;
14             if(!Lef[j] || match(Lef[j]))
15             {
16                 Lef[j] = i;
17                 return true;
18             }
19         }
20     }
21     return false;
22 }
23 void update()
24 {
25     int a = 0x3f3f3f3f;
26     for(int i = 1; i <= n; i++)
27     {
28         if(S[i])
29         {
30             for(int j = 1; j <= n; j++)
31             {
32                 if(!T[j]) a = min(a, Lx[i] + Ly[j] - W[i][j]);
33             }
34         }
35     }

```

```

35     }
36 }
37 for(int i = 1; i <= n; i++)
38 {
39     if(S[i]) Lx[i] -= a;
40     if(T[i]) Ly[i] += a;
41 }
42 }
43 void KM()
44 {
45     for (int i = 1; i <= n; ++i)
46     {
47         Lef[i] = Lx[i] = Ly[i] = 0;
48         for(int j = 1; j <= n; j++){
49             Lx[i] = max(Lx[i], W[i][j]);
50         }
51     }
52     for (int i = 1; i <= n; ++i)
53     {
54         for(;;){
55             for(int j = 1; j <= n; j++){
56                 S[j] = T[j] = 0;
57             }
58             if(match(i)) break;
59             else update();
60         }
61     }
62 }
63 }
64 }
65 int main(int argc, char const *argv[])
66 {
67     for(int i = 1; i <= n; i++){
68         for(int j = 1; j <= n; j++){
69             scanf("%d", &W[i][j]);
70         }
71     }
72 }
73 KM();
74 int ans = 0;
75
76 for(int i = 1; i <= n; i++){
77     ans += Ly[i];
78     ans += Lx[i];
79 }
80
81 for(int i = 1; i <= n; i++){
82     if(i != n) printf("%d ", Lx[i]);
83     else printf("%d\n", Lx[i]);
84 }
85
86 for(int i = 1; i <= n; i++){
87     if(i != n) printf("%d ", Ly[i]);
88     else printf("%d\n", Ly[i]);
89 }
90
91 printf("%d\n", ans);
92 return 0;
93 }

```

8.9 CLE Directed MST

```

1 const int maxn = 60+5;
2 const int INF = 0x3f3f3f3f;
3 struct Edge
4 {
5     int from, to, cost;
6 };
7 Edge E[maxn * maxn], e[maxn * maxn];
8 int n, m, c;
9 int in[maxn], pre[maxn], id[maxn], vis[maxn];
10 int CLE(int root, int n, int m)
11 {
12     int res = 0;
13     while(1)
14     {

```

```

15     for(int i = 0; i < n; i++){
16         in[i] = INF;
17     }
18     //Find in edge
19     for(int i = 0; i < m; i++){
20         int from = e[i].from, to = e[i].to;
21         if(from != to && e[i].cost < in[to]){
22             in[to] = e[i].cost;
23         }
24         pre[to] = from;
25     }
26     //Check in edge
27     for(int i = 0; i < n; i++){
28         if(i == root) continue;
29         if(in[i] == INF) return -1;
30     }
31
32     int num = 0;
33     memset(id, -1, sizeof(id));
34     memset(vis, -1, sizeof(vis));
35     in[root] = 0;
36
37     //Find cycles
38     for(int i = 0; i < n; i++){
39         res += in[i];
40         int v = i;
41         while(vis[v] != i && id[v] == -1 && v != root)
42         {
43             vis[v] = i;
44             v = pre[v];
45         }
46         if(v != root && id[v] == -1)
47         {
48             for(int j = pre[v]; j != v; j = pre[j]){
49                 id[j] = num;
50             }
51             id[v] = num++;
52         }
53     }
54     //No cycle
55     if(num == 0) break;
56     for(int i = 0; i < n; i++){
57         if(id[i] == -1) id[i] = num++;
58     }
59     //Grouping the vertices
60     for(int i = 0; i < m; i++){
61         int from = e[i].from, to = e[i].to;
62         e[i].from = id[from]; e[i].to = id[to];
63         if(id[from] != id[to]) e[i].cost -= in[to];
64     }
65     n = num;
66     root = id[root];
67 }
68 return res;
69 }
70 int main(int argc, char const *argv[])
71 {
72     int n, m;
73     // n nodes and m edges
74     scanf("%d%d", &n, &m);
75     for(int i = 0; i < m; i++){
76         scanf("%d%d%d", &E[i].from, &E[i].to, &E[i].cost);
77     }
78     int sp = 0; // start point
79     int ans = CLE(sp, n, m);
80     if(ans == -1) printf("No Directed Minimum Spanning Tree.\n");
81     else printf("%d\n", ans);
82     return 0;
83 }

```

8.10 Convex Hull

```

1 #include <bits/stdc++.h>
2 using namespace std;

```



```

3
4 struct point{
5     int x;
6     int y;
7     int d;
8 }p[600],ch[600];
9
10 int dist(point a, point b) {
11     return (a.x-b.x)*(a.x-b.x)+(a.y-b.y)*(a.y-b.y);
12 }//若點的angle一樣，則比較遠的點
13
14 bool find_small_vertex(point a, point b) {
15     return (a.y < b.y) || (a.y == b.y && a.x < b.x);
16 }
17
18 int cross(point o, point a, point b) {
19     return (a.x - o.x) * (b.y - o.y) - (a.y - o.y) * (b.x
        - o.x);
20 }
21
22 bool compare_angle(point a, point b){
23     double c = cross( p[0], a, b );
24     if ( !c ) return a.d < b.d;
25     else return c > 0;
26 }
27
28 void GrahamScan(int k){
29     sort(p+0, p+k, find_small_vertex);
30     for(int i=1; i<k; i++){
31         p[i].d = dist(p[0], p[i]);
32     }
33     sort(p+1, p+k, compare_angle);
34
35     int m=0;
36     for(int i=0; i<k; i++){
37         while(m>=2 && cross(ch[m-2], ch[m-1], p[i]) <= 0){
38             m--;
39         }
40         ch[m++] = p[i];
41     }
42     // Convex Hull find m nodes and print them out
43     printf("%d\n", m+1);
44     for(int j=0; j<m; j++){
45         printf("%d %d\n", ch[j].x, ch[j].y);
46     }
47     printf("%d %d\n", ch[0].x, ch[0].y);
48 }

```

9.2 Power

```

1 double Power(double x, int n)
2 {
3     if (n == 0) return 1.00;
4     if (n == 1) return x;
5     double ans = Power(x, n / 2);
6     if (n % 2 == 0) return ans * ans;
7     else if (n < 0) return ans * ans / x;
8     else return ans * ans * x;
9 }

```

9.3 Euler

```

1 const int maxn = 50000;
2 int F[maxn+5];
3 void Euler(){
4     memset(F, 0, sizeof(F));
5     F[1] = 1;
6     for(int i=2; i<maxn; i++){
7         if(!F[i]){
8             for(int j=i; j<maxn; j+=i){
9                 if(!F[j]) F[j] = j;
10                F[j] = F[j] / i*(i-1);
11            }
12        }
13    }
14 }

```

9 Number

9.1 Sieve

```

1 const int maxn = 500+10;
2 bool visit[maxn];
3 int primes[maxn];
4 int sieve(int src)
5 {
6     memset(visit, false, sizeof(visit));
7     for(int i = 2; i <= sqrt(src + 0.5); i++){
8         if(!visit[i]){
9             for(int j = i * i; j <= src; j += i){
10                visit[j] = true;
11            }
12        }
13    }
14    int cnt = 0;
15    for(int i = 2; i <= src; i++){
16        if(!visit[i]) primes[cnt++] = i;
17    }
18    return cnt;
19 }

```