Contents

1 Exgcd

```
void exgcd(int &x,int &y,int a,int b)
{
    if(!b)
    {
        x=1;
        y=0;
        return;
    }
    exgcd(x,y,b,a%b);
    int t=x;
    x=y;
    y=t-a/b*y;
}
```

2 Persist segtree on tree

```
// 1231
#include <cstdio>
#include <iostream>
#include <cstdlib>
#include <cmath>
#include <algorithm>

struct Node
{
        int low;
        int high;
        int count;
};

int  to   [200000  + 10];
int  pre  [200000  + 10];
int  last [100000  + 10];
int  V    [100000  + 10];
int  depth[100000 + 10];
int  lca  [100000  + 10][20];
int  root [100000  + 10];
Node tree [2000000 + 10];
int  nextId(1);

int increase(int oldNode, int low, int high, int value)
{
        int newNode(nextId);
        ++nextId;
        tree[newNode] = tree[oldNode];
        ++tree[newNode].count;
        if (low != high)
        {
                int mid((low + high) / 2);
                if (value <= mid)
                        tree[newNode].low = increase(tree[oldNode].low, low, mid, value);
                else
                        tree[newNode].high = increase(tree[oldNode].high, mid + 1, high,
↪   value);
        }
        return newNode;
}

void dfs(int father, int v, int d)
{
        depth[v] = d;
        lca[v][0] = father;
        for (int i(1); (1 << i) <= depth[v]; ++i)
                lca[v][i] = lca[lca[v][i - 1]][i - 1];
        root[v] = increase(root[father], 0, 100000, V[v]);
        for (int i(last[v]); i != 0; i = pre[i])
        {
                if (to[i] != father)
                        dfs(v, to[i], d + 1);
        }
}

int getLca(int u, int v)
{
        if (depth[u] < depth[v])
                std::swap(u, v);
        for (int i(19); i >= 0; --i)
        {
                if (depth[u] - (1 << i) >= depth[v])
                        u = lca[u][i];
        }
        if (u == v)
                return u;

        for (int i(19); i >= 0; --i)
        {
                if (lca[u][i] != lca[v][i])
                {
                        u = lca[u][i];
                        v = lca[v][i];
                }
        }
        return lca[u][0];
}

int query(int uNode, int vNode, int lcaNode, int faLcaNode, int low, int high, int k)
{
        if (low == high)
                return low;
        int mid((low + high) / 2);
        int lowCount(  tree[tree[uNode].low].count + tree[tree[vNode].low].count
                     - tree[tree[lcaNode].low].count - tree[tree[faLcaNode].low].count);
        if (k <= lowCount)
                return query(tree[uNode].low, tree[vNode].low, tree[lcaNode].low,
↪   tree[faLcaNode].low, low, mid, k);
        else
                return query(tree[uNode].high, tree[vNode].high, tree[lcaNode].high,
↪   tree[faLcaNode].high, mid + 1, high, k - lowCount);
}

int main()
{
        int N, M;
        std::cin >> N >> M;
        for (int i(1); i <= N; ++i)
                std::cin >> V[i];
        for (int i(1); i <= N - 1; ++i)
        {
                int x, y;
                std::cin >> x >> y;
                to[i * 2 - 1] = y;
                pre[i * 2 - 1] = last[x];
                last[x] = i * 2 - 1;

                to[i * 2] = x;
                pre[i * 2] = last[y];
                last[y] = i * 2;
        }
        dfs(0, 1, 0);

        int lastAns(0);
        for (int i(1); i <= M; ++i)
        {
                int u, v, k;
                std::cin >> u >> v >> k;
                u ^= lastAns;
                int ans(query(root[u], root[v], root[getLca(u, v)], root[lca[getLca(u,
↪  v)][0]], 0, 100000, k));
                std::cout << ans << std::endl;
                lastAns = ans;
        }

        return 0;
}
```

3 Ac automaton

```
#include <cstdio>
#include <cstring>
#include <queue>
#include <string>
#include <iostream>
#include <vector>

const int maxN   (10000000 + 10);
const int maxM   (100000 + 10);
const int maxLen (100 + 10);
const int maxCh  (256);
int       map    [maxCh];
char      in     [maxN];
int       orig   [maxN];
int       pattern[maxM][maxLen];
int       len    [maxM];
int       child  [maxN][5];
int       fail   [maxN];
bool      matched[maxN];
```

```
std::vector<int> sorted;

int N, M;

int lastNode(0);
void insert(int index)
{
        for (int i(1), node(0); i <= len[index]; ++i)
        {
                int &ch(child[node][pattern[index][i]]);
                if (!ch)
                {
                        ch = ++lastNode;
                }
                node = ch;
        }
}

void build()
{
        std::queue<int> queue;
        queue.push(0);

        while (!queue.empty())
        {
                int node(queue.front());
                queue.pop();
                sorted.push_back(node);

                for (int i(1); i <= 4; ++i)
                {
                        int &ch(child[node][i]);
                        if (ch)
                        {
                                if (node)
                                {
                                        fail[ch] = child[fail[node]][i];
                                }
                                queue.push(ch);
                        }
                        else
                        {
                                ch = child[fail[node]][i];
                        }
                }
        }
}

void match()
{
        for (int i(1), node(0); i <= N; ++i)
        {
                node = child[node][orig[i]];
                matched[node] = true;
        }

        for (int i(lastNode); i >= 0; --i)
        {
                int node(sorted[i]);
                matched[fail[node]] = (matched[fail[node]] || matched[node]);
        }
}

int main()
{
        map[int('E')] = 1;
        map[int('S')] = 2;
        map[int('W')] = 3;
        map[int('N')] = 4;

        scanf("%d %d", &N, &M);
        scanf("%s", in + 1);
        for (int i(1); i <= N; ++i)
        {
                orig[i] = map[int(in[i])];
        }
        for (int i(1); i <= M; ++i)
        {
                scanf("%s", in + 1);
                len[i] = strlen(in + 1);
                for (int j(1); j <= len[i]; ++j)
                {
                        pattern[i][j] = map[int(in[j])];
                }
                insert(i);
        }

        build();
        match();

        for (int i(1); i <= M; ++i)
        {
                int ans(0);
                int node(0);
                //printf("%d: ", i);
                for (int j(1); j <= len[i]; ++j)
                {
                        node = child[node][pattern[i][j]];
                        //printf("%d ", matched[node]);
                        if (matched[node])
                        {
                                ans = j;
                        }
                }
                //printf("\n");
                printf("%d\n", ans);
        }

        return 0;
}
```

4 Automata

```
// 5201

#include <cstdio>
#include <cstring>
#include <vector>
#include <algorithm>

int       lastNode  (0);
int       lastEdge  (0);
const int maxN      (1000000 + 10);
int       patternLen;
int       to        [maxN];
int       trans     [maxN];
int       pre       [maxN];
int       last      [maxN];
char      pattern   [maxN];
char      s         [maxN];

void addEdge(int u, int v, int t)
{
        ++lastEdge;
        to[lastEdge] = v;
        trans[lastEdge] = t;
        pre[lastEdge] = last[u];
        last[u] = lastEdge;
}

void addEdge(std::vector<int> &u, int v, int t)
{
        for (std::size_t i(0); i < u.size(); ++i)
        {
                addEdge(u[i], v, t);
        }
}

int build(int pred, int pos)
{
        std::vector<int> branch;
        while (pos <= patternLen && pattern[pos] != ']')
        {
```

```
        switch (pattern[pos])
        {
        case 'N':
        case 'S':
        case 'E':
        case 'W':
                ++lastNode;
                addEdge(pred, lastNode, pattern[pos]);
                addEdge(branch, lastNode, pattern[pos]);
                branch.clear();
                pred = lastNode;
                break;

        case '*':
                ++lastNode;
                addEdge(pred, lastNode, 0);
                addEdge(branch, lastNode, 0);
                addEdge(lastNode, lastNode, 0);
                branch.clear();
                branch.push_back(lastNode);
                break;

        case '?':
                ++lastNode;
                addEdge(pred, lastNode, 0);
                addEdge(branch, lastNode, 0);
                branch.clear();
                pred = lastNode;
                break;

        case '[':
                pos = build(pred, pos + 1);
                branch.push_back(lastNode);
                break;

        case '\0':
                ++lastNode;
                addEdge(pred, 2, 0);
                addEdge(branch, 2, 0);
                break;

        default:
                break;
        }

        ++pos;
    }

    return pos;
}
```

```
int main()
{
        scanf("%s", pattern);
        patternLen = strlen(pattern);
        ++lastNode; // S: 1
        ++lastNode; // T: 2
        build(1, 0);

        int n;
        scanf("%d", &n);
        for (int i(1); i <= n; ++i)
        {
                scanf("%s", s);
                int len(strlen(s));
                std::vector<int> queue;
                queue.push_back(1);
                for (int j(0); j <= len + 1; ++j)
                {
                        bool can(false);
                        std::vector<int> tmp;
                        for (std::size_t k(0); k < queue.size(); ++k)
                        {
                                if (queue[k] == 2)
                                {
                                        can = true;
                                }
                                for (int e(last[queue[k]]); e; e = pre[e])
                                {
                                        if (!trans[e] || trans[e] == s[j])
                                        {
                                                tmp.push_back(to[e]);
                                        }
                                }
                        }

                        std::sort(tmp.begin(), tmp.end());
                        tmp.erase(std::unique(tmp.begin(), tmp.end()), tmp.end());
                        std::swap(queue, tmp);

                        if (j > 1)
                        {
                                printf(can ? "1" : "0");
                        }
                }
                printf("\n");
        }

        return 0;
}
```

5 Backpack on tree

```
// 1826

#include <cstdio>
#include <vector>
#include <limits>

int n, m;

const int        maxN(100 + 10);
std::vector<int> edge[maxN];
int              dist[maxN];
int              w   [maxN];
int              f   [maxN][maxN][maxN];
int              g   [maxN];
int              size[maxN];

const int inf(std::numeric_limits<int>::max() / 2);

void dfs(int v)
{
        size[v] = 1;
        for (int i(0); i <= n; ++i)
        {
                f[v][i][0] = (dist[v] - dist[i]) * w[v];
        }

        for (size_t i(0); i < edge[v].size(); ++i)
        {
                int to(edge[v][i]);
                dist[to] += dist[v];
                dfs(to);
                for (int j(0); j <= n; ++j)
                {
                        for (int k(0); k <= size[v] + size[to] && k <= m; ++k)
                        {
                                g[k] = inf;
                        }
                        for (int k(0); k <= size[v] && k <= m; ++k)
                        {
                                for (int l(0); l <= size[to] && k + l <= m; ++l)
                                {
                                        g[k + l] = std::min(g[k + l], f[v][j][k] +
↪   f[to][j][l]);
                                }
                        }
                        for (int k(0); k <= size[v] && k <= m; ++k)
                        {
                                for (int l(0); l <= size[to] && k + l + 1 <= m; ++l)
                                {
                                        g[k + l + 1] = std::min(g[k + l + 1], f[v][j][k]
↪   + f[to][to][l]);
                                }
                        }
                        for (int k(0); k <= size[v] + size[to] && k <= m; ++k)
                        {
                                f[v][j][k] = g[k];
                        }
                }
                size[v] += size[to];
        }
}

int main()
{
        scanf("%d %d", &n, &m);
        for (int i(1); i <= n; ++i)
        {
                int v;
                scanf("%d %d %d", &w[i], &v, &dist[i]);
                edge[v].push_back(i);
        }

        dfs(0);

        printf("%d\n", f[0][0][m]);
        return 0;
}
```

6 Bigraph coloring

```
void dfs(int x, int color)
{
        v[x] = color
        for (int i = head[x]; i; i = Next[i])
        {
                if (v[y] == 0)
                {
                        dfs(y, 3 - color)
                }
                else if (v[y] != color)
                {
                        isBigraph = false;
                }
        }
}

for (int i = 1; i <= N; ++i)
{
        if (v[i] == 0)
        {
                dfs(i, 1);
        }
}
```

7 Bigraph matching

```
bool dfs(int x)
{
        for (int i = head[x], y; i; i = next[i])
        {
                if (!visit[y = ver[i]])
                {
                        visit[y] = 1;
                        if (!match[y] || dfs(match[y]))
                        {
                                match[y] = x; return true;
                        }
                }
        }
        return false;
}

for (int i = 1; i <= n; ++i)
{
        memset(visit, 0, sizeof(visit));
        if (dfs(i)) ++ans;
}
```

8 Bit decomposition

```
// 5093

#include <cstdio>
#include <vector>
#include <cctype>

struct Event
{
        int x1;
        int y1;
        int x2;
        int y2;
        int k;
};

const int len(4000000);
int n, m, T;
class Array
{
private:
        int data[len];
public:
        int& operator()(int x, int y)
        {
                return data[x * m + y];
        }
};

Array a;
Array map;
Array killed;
Array delta;
Event event[len];
int mapK[len];

int read()
{
        char ch(0);
        while (!isdigit(ch))
        {
                ch = getchar();
        }
        int x(0);
        while (isdigit(ch))
        {
                x = x * 10 + int(ch - '0');
                ch = getchar();
        }
        return x;
}

void kill(int color)
{
        for (int i(1); i <= n; ++i)
        {
                for (int j(1); j <= m; ++j)
                {
                        delta(i, j) = 0;
                }
        }
        for (int i(1); i <= T; ++i)
        {
                if (mapK[i] == color)
                {
                        ++delta(event[i].x1, event[i].y1);
                        --delta(event[i].x1, event[i].y2 + 1);
                        --delta(event[i].x2 + 1, event[i].y1);
                        ++delta(event[i].x2 + 1, event[i].y2 + 1);
                }
        }
        for (int i(1); i <= n; ++i)
        {
                for (int j(1); j <= m; ++j)
                {
                        //printf("%d ", delta[i][j]);
                        delta(i, j) += delta(i - 1, j) + delta(i, j - 1) - delta(i - 1, j
↪  - 1);

                        if (map(i ,j) != color && delta(i, j))
                        {
                                killed(i, j) = true;
                        }
                }
                //printf("\n");
        }
        //printf("\n");
}

int main()
{
        n = read(); m = read(); T = read();
        for (int i(1); i <= n; ++i)
        {
                for (int j(1); j <= m; ++j)
                {
                        a(i, j) = read();
                }
        }
        for (int i(1); i <= T; ++i)
        {
                event[i].x1 = read();
                event[i].y1 = read();
                event[i].x2 = read();
                event[i].y2 = read();
                event[i].k = read();
        }

        for (int digit(0); digit < 25; ++digit)
        {
                for (int i(1); i <= n; ++i)
                {
                        for (int j(1); j <= m; ++j)
                        {
                                map(i, j) = (a(i, j) >> digit & 1);
                        }
                }

                for (int i(1); i <= T; ++i)
                {
                        mapK[i] = (event[i].k >> digit & 1);
                }
                kill(0);
                kill(1);
        }

        int ans(0);
        for (int i(1); i <= n; ++i)
        {
                for (int j(1); j <= m; ++j)
                {
                        ans += killed(i, j);
                }
        }
        printf("%d\n", ans);
        return 0;
}
```

9 Bi dir search

```
#include <iostream>
#include <algorithm>

int N, M;
int p     [40 + 10];
int first [(1 << 20) + 10];
int firstLen;
int second[(1 << 20) + 10];
int secondLen;

void dfs(int pos, int end, int sum, int dst[], int &len)
{
        if (pos == end)
        {
                dst[len++] = sum;
        }
        else
        {
                dfs(pos + 1, end, sum, dst, len);
                if (sum + p[pos] <= M)
                        dfs(pos + 1, end, sum + p[pos], dst, len);
        }
}

int main()
{
        std::cin >> N >> M;
        for (int i(0); i < N; ++i)
                std::cin >> p[i];

        dfs(0, N / 2, 0, first, firstLen);
        dfs(N / 2, N, 0, second, secondLen);
        std::sort(first, first + firstLen, std::greater<int>());
        std::sort(second, second + secondLen);

        int ans(0);
        for (int i(0), j(0); i < firstLen; ++i)
        {
                while (j < secondLen - 1 && first[i] + second[j + 1] <= M)
                        ++j;
                ans = std::max(ans, first[i] + second[j]);
        }
        std::cout << ans << std::endl;
        return 0;
}
```

10 Bsgs

```
int baby_step_giant_step(int a, int b, int p)
{
        map<int, int> hash;
        hash.clear();
        b %= p;
        int t = (int)sqrt(p) + 1;
        for (int j = 0; j < t; ++j)
        {
                int val = (long long)b * power(a, j, p) % p;
                hash[val] = j;
        }
        a = power(a, t, p);
        if (a == 0) return b == 0 ? 1 : -1;
        for (int i = 0; i <= t; ++i)
        {
                int val = power(a, i, p);
                int j = hash.find(val) == hash.end() ? -1 : hash[val];
                if (j >= 0 && i * t  - j >= 0) return i * t - j;
        }
        return -1;
}
```

11 Catalan

```
//1276

#include <cstdio>

const int maxN(2000000 + 10);
long long fact[maxN];

const long long mod(20100403);

long long qPow(long long base, long long expo)
```

```
{
        long long prod(1);
        for (long long i(1); i <= expo; i *= 2)
        {
                if (i & expo)
                {
                        prod = prod * base % mod;
                }
                base = base * base % mod;
        }
        return prod;
}

long long inv(long long n)
{
        return qPow(n, mod - 2);
}

long long C(long long n, long long m)
{
        if (m > n) return 0;
        return fact[n] * inv(fact[m] * fact[n - m] % mod) % mod;
}

int main()
{
        fact[0] = 1;
        for (int i(1); i < maxN; ++i)
        {
                fact[i] = fact[i - 1] * i % mod;
        }
        long long n, m;
        scanf("%lld %lld", &n, &m);
        if (n < m)
        {
                printf("0\n");
        }
        else
        {
                printf("%lld\n", (C(n + m, n) - C(n + m, m - 1) + mod) % mod);
        }
        return 0;
}
```

12 Dijkstra

```
dist[src] = 0;
std::priority_queue<std::pair<int, int>,
                                        std::vector<std::pair<int, int> >,
                                        std::greater<std::pair<int, int> > > heap;
heap.push(std::make_pair(dist[src], src));
```

```
while (!heap.empty())
{
        int v(heap.top().second);
        heap.pop();
        if (visited[v])         continue;
        visited[v] = true;

        for (int nxt(last[v]); nxt; nxt = pre[nxt])
        {
                if (!visited[to[nxt]] && dist[to[nxt]] > dist[v] + cost[nxt])
                {
                        dist[to[nxt]] = dist[v] + cost[nxt];
                        heap.push(std::make_pair(dist[to[nxt]], to[nxt]));
                }
        }
}
```

13 Discretization

```
#include <algorithm>

int *end;
const int maxN(100000);

int a[maxN];

int get(int x)
{
        return std::lower_bound(a, end, x) - a + 1;
}

int main()
{
        int n;
        std::sort(a + 1, a + n + 1);
        end = std::unique(a + 1, a + n + 1);
}
```

14 Disjoint union

```
int find(int v)
{
        if (belong[v] == v)
        {
                return v;
        }
        else
        {
                return belong[v] = find(belong[v]);
        }
}
```

15 Dp on tree

```
// 5074

#include <cstdio>
#include <algorithm>

int        n, m;
int        ans;
const int maxN    (1000000 + 10);
const int maxLbN  (30);
const int maxM    (100000 + 10);
int        color   [maxN];
int        to      [maxN * 2];
int        pre     [maxN * 2];
int        last    [maxN];
int        jump    [maxN][maxLbN];
int        depth   [maxN];
int        max     [maxN];
int        sMax    [maxN];
int        colFirst[maxM];
int        colLast [maxM];
int        cnt     [maxN];
bool       dom     [maxN];

void addEdge(int u, int v)
{
        static int lastEdge(0);
        ++lastEdge;
        to[lastEdge] = v;
        pre[lastEdge] = last[u];
        last[u] = lastEdge;
}

void prep(int v, int pred)
{
        depth[v] = depth[pred] + 1;
        jump[v][0] = pred;
        for (int i(1); i < maxLbN; ++i)
        {
                jump[v][i] = jump[jump[v][i - 1]][i - 1];
        }

        for (int e(last[v]); e; e = pre[e])
        {
                if (to[e] != pred)
                {
                        prep(to[e], v);
                        if (max[to[e]] + 1 > max[v])
                        {
                                sMax[v] = max[v];
                                max[v] = max[to[e]] + 1;
                        }
                        else if (max[to[e]] + 1 > sMax[v])
                        {
                                sMax[v] = max[to[e]] + 1;
                        }
                }
        }
}

int lca(int l, int h)
{
        if (depth[l] < depth[h]) std::swap(l, h);

        for (int i(maxLbN - 1); i >= 0; --i)
        {
                if (depth[jump[l][i]] >= depth[h])
                {
                        l = jump[l][i];
                }
        }

        if (l == h) return l;

        for (int i(maxLbN - 1); i >= 0; --i)
        {
                if (jump[l][i] != jump[h][i])
                {
                        l = jump[l][i];
                        h = jump[h][i];
                }
        }

        return jump[l][0];
}

void count(int v, int pred)
{
        ++cnt[v];
        if (!colFirst[color[v]])
        {
                colFirst[color[v]] = v;
        }
        else
        {
                --cnt[lca(colLast[color[v]], v)];
        }
        colLast[color[v]] = v;

        for (int e(last[v]); e; e = pre[e])
        {
                if (to[e] != pred)
                {
                        count(to[e], v);
                }
        }
}

void solve(int v, int pred, int outDep)
{
        for (int e(last[v]); e; e = pre[e])
        {
                if (to[e] != pred)
                {
                        int curMax(max[to[e]] + 1 == max[v] ? sMax[v] : max[v]);
                        solve(to[e], v, std::max(curMax, outDep) + 1);
                        cnt[v] += cnt[to[e]];
                        dom[v] = (dom[v] || dom[to[e]]);
                }
        }

        if (cnt[v] == m) ans = std::max(ans, outDep + 1);
        if (!dom[v]) ans = std::max(ans, max[v] + 2);
}

int main()
{
        scanf("%d %d", &n, &m);
        for (int v(1); v <= n; ++v)
        {
                scanf("%d", &color[v]);
        }
        for (int e(1); e <= n - 1; ++e)
        {
                int u, v;
                scanf("%d %d", &u, &v);
                addEdge(u, v);
                addEdge(v, u);
        }

        prep(1, 0);
        count(1, 0);
        for (int i(1); i <= m; ++i)
        {
                dom[lca(colFirst[i], colLast[i])] = true;
        }

        solve(1, 0, 0);
```

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

16 Dsu merge

```
// 5287

#include <cstdio>
#include <unordered_map>
#include <queue>

const int maxN(300000 + 10);
int f    [maxN];
int size[maxN];
std::unordered_map<int, int> in[maxN];

int unionFind(int v)
{
	if (f[v] == v)
	{
		return v;
	}
	else
	{
		return f[v] = unionFind(f[v]);
	}
}

std::queue<std::pair<int, int> > queue;

void merge(int u, int v)
{
	u = unionFind(u);
	v = unionFind(v);
	if (u == v) return;
	if (size[u] > size[v]) std::swap(u, v);
	size[v] += size[u];
	f[u] = v;

	for (std::unordered_map<int, int>::iterator it(in[u].begin()); it != in[u].end();
↪   ++it)
	{
		if (in[v][it->first])
		{
			queue.push(std::make_pair(it->second, in[v][it->first]));
		}
		else
		{
			in[v][it->first] = it->second;
		}
```

```
        }
}

int main()
{
        int n, m, k;
        scanf("%d %d %d", &n, &m, &k);
        for (int v(1); v <= n; ++v)
        {
                f[v] = v;
                size[v] = 1;
        }
        for (int e(1); e <= m; ++e)
        {
                int u, v, w;
                scanf("%d %d %d", &u, &v, &w);
                if (in[v][w])
                {
                        queue.push(std::make_pair(u, in[v][w]));
                }
                else
                {
                        in[v][w] = u;
                }
        }

        while (!queue.empty())
        {
                std::pair<int, int> pair(queue.front());
                queue.pop();
                merge(pair.first, pair.second);
        }

        long long ans(0);
        for (int v(1); v <= n; ++v)
        {
                if (f[v] == v)
                {
                        ans += 1ll * size[v] * (size[v] - 1) / 2;
                }
        }
        printf("%lld\n", ans);
        return 0;
}
```

17 Du sieve

```
// 4658

#include <cstdio>
#include <map>
```

```
#include <vector>

const int maxPre(10000000);
bool      sieve [maxPre];
long long phiPre[maxPre];
long long muPre [maxPre];

std::map<int, long long> phiSum;
std::map<int, long long> muSum;

long long getPhiSum(long long n)
{
        if (n < maxPre) return phiPre[n];
        if (phiSum.count(n)) return phiSum[n];

        phiSum[n] = 1ll * n * (n + 1) / 2;
        for (long long l(2), r; l <= n; l = r + 1)
        {
                r = n / (n / l);
                phiSum[n] -= (r - l + 1) * getPhiSum(n / l);
        }
        return phiSum[n];
}

long long getMuSum(int n)
{
        if (n < maxPre) return muPre[n];
        if (muSum.count(n)) return muSum[n];

        muSum[n] = 1;
        for (long long l(2), r; l <= n; l = r + 1)
        {
                r = n / (n / l);
                muSum[n] -= (r - l + 1) * getMuSum(n / l);
        }
        return muSum[n];
}

int main()
{
        phiPre[1] = 1;
        muPre[1] = 1;
        std::vector<long long> prime;
        for (int i(2); i < maxPre; ++i)
        {
                if (!sieve[i])
                {
                        phiPre[i] = i - 1;
                        muPre[i] = -1;
                        prime.push_back(i);
                }
                for (std::size_t j(0); j < prime.size() && i * prime[j] < maxPre; ++j)
                {
                        sieve[i * prime[j]] = true;
                        if (i % prime[j] == 0)
                        {
                                phiPre[i * prime[j]] = phiPre[i] * prime[j];
                                muPre[i * prime[j]] = 0;
                                break;
                        }
                        else
                        {
                                phiPre[i * prime[j]] = phiPre[i] * phiPre[prime[j]];
                                muPre[i * prime[j]] = -muPre[i];
                        }
                }
        }

        for (int i(2); i < maxPre; ++i)
        {
                phiPre[i] += phiPre[i - 1];
                muPre[i] += muPre[i - 1];
        }

        int T;
        scanf("%d", &T);
        for (int ttt(1); ttt <= T; ++ttt)
        {
                int N;
                scanf("%d", &N);
                printf("%lld %lld\n", getPhiSum(N), getMuSum(N));
        }

        return 0;
}
```

18 Euler path

```
// Connected, exactly two odd vertices

int head[100010], ver[1000010], Next[1000010], tot;
int stack[1000010], ans[1000010];
bool vis[1000010];
int n, m, top, t;

void add(int x, int y)
{
        ver[++tot] = y, Next[tot] = head[x], head[x] = tot;
}

void euler()
```

```
{
        stack[++top] = 1;
        while (top > 0)
        {
                int x = stack[top], i = head[x];
                while (i && vis[i]) i = Next[i];
                if (i)
                {
                        stack[++top] = ver[i];
                        vis[i] = vis[i ^ 1] = true;
                        head[x] = Next[i];
                }
                else
                {
                        --top;
                        ans[++t] = x;
                }
        }
}

int main()
{
        cin >> n >> m;
        tot = 1;
        for (int i = 1; i <= m; ++i)
        {
                int x, y; scanf("%d%d", &x, &y);
                add(x, y), add(y, x);
        }
        euler();
        for (int i = t; i; --i) printf("%d\n", ans[i]);
}
```

19 Euler sieve

```
#include <iostream>
#include <vector>

const int maxN (1000000);

bool sieve[maxN];
int  mu   [maxN];
int  phi  [maxN];

int main()
{
        mu[1] = 1;
        phi[1] = 1;
        std::vector<int> prime;
        for (int i(2); i < maxN; ++i)
        {
                if (!sieve[i])
                {
                        prime.push_back(i);
                        mu[i] = -1;
                        phi[i] = i - 1;
                }

                for (std::size_t j(0); j < prime.size() && i * prime[j] < maxN; ++j)
                {
                        sieve[i * prime[j]] = true;
                        if (i % prime[j] == 0)
                        {
                                mu[i * prime[j]] = 0;
                                phi[i * prime[j]] = phi[i] * prime[j];
                                break;
                        }
                        else
                        {
                                mu[i * prime[j]] = -mu[i];
                                phi[i * prime[j]] = phi[i] * phi[prime[j]];
                        }
                }
        }

        for (int i(1); i <= 100; ++i)
                std::cout << phi[i] << ' ';
        std::cout << std::endl;

        return 0;
}
```

20 Euler tour

```
// 5380

#include <cstdio>
#include <algorithm>
#include <vector>

struct Node
{
        long long sum;
        long long diam;
        int end[2];
};

int n, m;

const int         maxN   (400000 + 10);
const int         maxLbN(30);
std::vector<int> edge   [maxN];
```

```
std::vector<int> cost  [maxN];
std::vector<int> goal  [maxN];
long long        in    [maxN];
long long        prefix[maxN];
int              depth [maxN];
int              euler [maxLbN][maxN * 2];
int              enter [maxN];
int              lb    [maxN * 2];
Node             data  [maxN * maxLbN];
int              lCh   [maxN * maxLbN];
int              rCh   [maxN * maxLbN];
int              root  [maxN];

inline int read()
{
    int x=0;
    char c=getchar();
    while(c<'0'||c>'9')c=getchar();
    while(c>='0'&&c<='9')x=x*10+c-'0',c=getchar();
    return x;
}

int curEuler(0);

void dfs(int v, int pred)
{
        depth[v] = depth[pred] + 1;
        euler[0][++curEuler] = v;
        enter[v] = curEuler;
        for (size_t i(0); i < edge[v].size(); ++i)
        {
                int to(edge[v][i]);
                prefix[to] = prefix[v] + cost[v][i];
                dfs(to, v);
                euler[0][++curEuler] = v;
        }
}

int lca(int a, int b)
{
        a = enter[a];
        b = enter[b];
        if (a > b) std::swap(a, b);
        int lbLen(lb[b - a + 1]);
        int x(euler[lbLen][a]), y(euler[lbLen][b - (1 << lbLen) + 1]);
        return depth[x] < depth[y] ? x : y;
}

long long dist(int a, int b)
{
        if (a == 0 || b == 0) return 0;
        int l(lca(a, b));
        return prefix[a] + prefix[b] - 2 * prefix[l];
}

Node operator+(const Node &a, const Node &b)
{
        if (!b.end[0]) return a;
        if (!a.end[0]) return b;

        Node cur;
        cur.sum = a.sum + b.sum;
        cur.diam = 0;
        cur.end[0] = cur.end[1] = 0;

        int end[4] = {a.end[0], a.end[1], b.end[0], b.end[1]};
        for (int i(0); i < 4; ++i)
        {
                for (int j(i + 1); j < 4; ++j)
                {
                        if (end[i] != 0 && end[j] != 0)
                        {
                                long long d(dist(end[i], end[j]));
                                if (d >= cur.diam)
                                {
                                        cur.diam = d;
                                        cur.end[0] = end[i];
                                        cur.end[1] = end[j];
                                }
                        }
                }
        }

        return cur;
}

int curNode(0);

void insert(int &node, int tl, int tr, int d, int v)
{
        if (!node) node = ++curNode;

        if (tl == tr)
        {
                data[node].sum = in[v] * 2;
                data[node].end[0] = data[node].end[1] = v;
        }
        else
        {
                int mid((tl + tr) / 2);
                if (d <= mid)
                {
```

```
				insert(lCh[node], tl, mid, d, v);
			}
			else
			{
				insert(rCh[node], mid + 1, tr, d, v);
			}
			data[node] = data[lCh[node]] + data[rCh[node]];
		}
}

int merge(int lNode, int rNode, int tl, int tr)
{
		if (!rNode) return lNode;
		if (!lNode) return rNode;

		if (tl == tr)
		{
			data[lNode] = data[lNode] + data[rNode];
			return lNode;
		}
		else
		{
			int mid((tl + tr) / 2);
			lCh[lNode] = merge(lCh[lNode], lCh[rNode], tl, mid);
			rCh[lNode] = merge(rCh[lNode], rCh[rNode], mid + 1, tr);
			data[lNode] = data[lCh[lNode]] + data[rCh[lNode]];
			return lNode;
		}
}

Node query(int node, int tl, int tr, int l, int r)
{
		if (!node || (l <= tl && tr <= r))
		{
			return data[node];
		}
		else
		{
			int mid((tl + tr) / 2);
			if (r <= mid)
			{
				return query(lCh[node], tl, mid, l, r);
			}
			else if (l >= mid + 1)
			{
				return query(rCh[node], mid + 1, tr, l, r);
			}
			else
			{
				return query(lCh[node], tl, mid, l, r) + query(rCh[node], mid +
↪ 1, tr, l, r);
```

```
                }
        }
}

long long ans(0);

void solve(int v)
{
        insert(root[v], 1, n, depth[v], v);
        for (size_t i(0); i < edge[v].size(); ++i)
        {
                int to(edge[v][i]);
                solve(to);
                root[v] = merge(root[v], root[to], 1, n);
        }

        for (size_t i(0); i < goal[v].size(); ++i)
        {
                Node result(query(root[v], 1, n, depth[v], std::min(depth[v] +
↪  goal[v][i], n)));
                ans ^= result.sum - result.diam - in[v] * 2;
        }
}

int main()
{
        n = read();
        m = read();
        for (int i(2); i <= n; ++i)
        {
                int p(read()), w(read());
                edge[p].push_back(i);
                cost[p].push_back(w);
                in[i] = w;
        }
        for (int i(1); i <= m; ++i)
        {
                int r, d;
                scanf("%d %d", &r, &d);
                goal[r].push_back(d);
        }

        dfs(1, 0);
        lb[0] = -1;
        for (int i(1); i <= curEuler; ++i)
        {
                lb[i] = lb[i / 2] + 1;
        }
        for (int i(1); i < maxLbN; ++i)
        {
                for (int j(1); j + (1 << i) - 1 <= curEuler; ++j)
                {
                        int a(euler[i - 1][j]), b(euler[i - 1][j + (1 << (i - 1))]);
                        euler[i][j] = (depth[a] <= depth[b] ? a : b);
                }
        }

        solve(1);
        printf("%lld\n", ans);
        return 0;
}
```

21 Fenwick

```
const int maxN(1000000);

long long BIT[maxN];

int lowbit(int x)
{
        return x & (-x);
}

void add(int pos, int value)
{
        while (pos <= maxN)
        {
                BIT[pos] += value;
                pos += lowbit(pos);
        }
}

int get(int pos)
{
        int sum(0);
        while (pos > 0)
        {
                sum += BIT[pos];
                pos -= lowbit(pos);
        }
        return sum;
}
```

22 Fft

```
// 1839

#include <iostream>
#include <complex>
#include <iomanip>
```

```cpp
std::complex<double> q      [400000 + 10];
std::complex<double> qRev   [400000 + 10];
std::complex<double> g      [400000 + 10];
std::complex<double> denom  [400000 + 10];
int                  reverse[400000 + 10];
const double pi(std::acos(-1.0));

int init(int len)
{
        len *= 2;
        int bitCount(0);
        int limit(1);
        while (limit < len)
        {
                ++bitCount;
                limit *= 2;
        }
        for (int i(0); i < limit; ++i)
                reverse[i] = (reverse[i >> 1] >> 1) | ((i & 1) << (bitCount - 1));
        return limit;
}

void FFT(std::complex<double> a[], int len, int inv)
{
        for (int i(0); i < len; ++i)
        {
                if (i < reverse[i])
                        std::swap(a[i], a[reverse[i]]);
        }

        for (int half(1); half < len; half *= 2)
        {
                std::complex<double> wn(std::cos(pi / half), inv * std::sin(pi / half));
                for (int i(0); i < len; i += half * 2)
                {
                        std::complex<double> w(1.0, 0.0);
                        for (int j(0); j < half; ++j)
                        {
                                std::complex<double> x(a[i + j]);
                                std::complex<double> y(w * a[i + half + j]);
                                a[i + j] = x + y;
                                a[i + half + j] = x - y;
                                w *= wn;
                        }
                }
        }
}

void FFT(std::complex<double> a[], int len)
{
        FFT(a, len, 1);
}

void invFFT(std::complex<double> a[], int len)
{
        FFT(a, len, -1);
        double invLen(1.0 / len);
        for (int i(0); i < len; ++i)
                a[i] *= invLen;
}

int main()
{
        int n;
        std::cin >> n;
        int limit(init(n));
        for (int i(0); i < n; ++i)
        {
                std::cin >> q[i];
                qRev[n - i - 1] = q[i];
                if (i != 0)
                        g[i] = 1.0 / i / i;
        }
        FFT(q, limit);
        FFT(qRev, limit);
        FFT(g, limit);
        for (int i(0); i < limit; ++i)
        {
                q[i] *= g[i];
                qRev[i] *= g[i];
        }
        invFFT(q, limit);
        invFFT(qRev, limit);

        for (int i(0); i < n; ++i)
                std::cout << std::fixed << std::setprecision(3) << q[i].real() - qRev[n -
↪   i - 1].real() << std::endl;

        return 0;
}
```

23 Heavy path decomposition

```
// 2409

#include <cstdio>
#include <iostream>
#include <cstring>

int n;
const int maxN(131072);
char op[16];
```

```
bool test(false);

class Segtree
{
private:
        const int opInstall = 1;
        const int opUninstall = 2;

        int count[maxN * 4 + 10];
        int lazy [maxN * 4 + 10];

        void pushDown(int node, int left, int right);
        void pushUp(int node);

public:
        int install(int node, int left, int right, int oLeft, int oRight);
        int uninstall(int node, int left, int right, int oLeft, int oRight);
        int query(int node, int left, int right, int pos);
};

void Segtree::pushDown(int node, int left, int right)
{
        if (lazy[node] == opInstall)
        {
                lazy[node] = 0;
                lazy[node * 2] = opInstall;
                lazy[node * 2 + 1] = opInstall;

                int mid((left + right) / 2);
                int lSize(mid - left + 1);
                int rSize(right - mid);
                count[node * 2] = lSize;
                count[node * 2 + 1] = rSize;
        }

        if (lazy[node] == opUninstall)
        {
                lazy[node] = 0;
                lazy[node * 2] = opUninstall;
                lazy[node * 2 + 1] = opUninstall;

                count[node * 2] = 0;
                count[node * 2 + 1] = 0;
        }
}

void Segtree::pushUp(int node)
{
        count[node] = count[node * 2] + count[node * 2 + 1];
}
```

```
int Segtree::install(int node, int left, int right, int oLeft, int oRight)
{
        pushDown(node, left, right);
        int sum(0);
        if (left >= oLeft && right <= oRight)
        {
                int size(right - left + 1);
                sum += size - count[node];
                lazy[node] = opInstall;
                count[node] = size;
        }
        else
        {
                int mid((left + right) / 2);
                if (oLeft <= mid) sum += install(node * 2, left, mid, oLeft, oRight);
                if (oRight >= mid + 1) sum += install(node * 2 + 1, mid + 1, right,
↪  oLeft, oRight);
                pushUp(node);
        }
        return sum;
}

int Segtree::uninstall(int node, int left, int right, int oLeft, int oRight)
{
        pushDown(node, left, right);
        int sum(0);
        if (left >= oLeft && right <= oRight)
        {
                sum += count[node];
                lazy[node] = opUninstall;
                count[node] = 0;
        }
        else
        {
                int mid((left + right) / 2);
                if (oLeft <= mid) sum += uninstall(node * 2, left, mid, oLeft, oRight);
                if (oRight >= mid + 1) sum += uninstall(node * 2 + 1, mid + 1, right,
↪  oLeft, oRight);
                pushUp(node);
        }
        return sum;
}

int Segtree::query(int node, int left, int right, int pos)
{
        pushDown(node, left, right);
        if (left == right)
        {
                return count[node];
        }
        else
        {
                int mid((left + right) / 2);
                if (pos <= mid) return query(node * 2, left, mid, pos);
                else return query(node * 2 + 1, mid + 1, right, pos);
        }
}

Segtree seg;

int to    [maxN * 2 + 10];
int pre   [maxN * 2 + 10];
int last  [maxN     + 10];

void addEdge(int x, int y)
{
        static int e(1);
        to[e] = y;
        pre[e] = last[x];
        last[x] = e;
        ++e;
}

int father[maxN     + 10];
int depth [maxN     + 10];
int size  [maxN     + 10];
int heavy [maxN     + 10];
int top   [maxN     + 10];
int dfn   [maxN     + 10];

void dfsInfo(int v, int f, int d)
{
        father[v] = f;
        depth[v] = d;
        size[v] = 1;
        for (int e(last[v]); e; e = pre[e])
        {
                if (to[e] != f)
                {
                        dfsInfo(to[e], v, d + 1);
                        if (heavy[v] == -1 || size[to[e]] > size[heavy[v]])
                                heavy[v] = to[e];
                        size[v] += size[to[e]];
                }
        }
}

int currentDfn(0);
void dfsChain(int v, int begin)
{
        top[v] = begin;
        dfn[v] = currentDfn++;
        if (heavy[v] == -1)
                return;

        dfsChain(heavy[v], begin);
        for (int e(last[v]); e; e = pre[e])
        {
                if (to[e] != father[v] && to[e] != heavy[v])
                        dfsChain(to[e], to[e]);
        }
}

int install(int v)
{
        int sum(0);
        while (v != -1)
        {
                sum += seg.install(1, 0, n - 1, dfn[top[v]], dfn[v]);
                v = father[top[v]];
        }
        return sum;
}

int uninstall(int v)
{
        int sum(0);
        sum += seg.uninstall(1, 0, n - 1, dfn[v], dfn[v] + size[v] - 1);
        return sum;
}

int main()
{
        scanf("%d", &n);
        for (int v(1); v <= n - 1; ++v)
        {
                int f;
                scanf("%d", &f);
                addEdge(f, v);
        }

        memset(heavy, -1, sizeof(heavy));
        dfsInfo(0, -1, 0);
        dfsChain(0, 0);

        int q;
        scanf("%d", &q);
        for (int i(1); i <= q; ++i)
        {
                int v;
                scanf("%s %d", op, &v);
                if (op[0] == 'i')
                {
```

```
				if (seg.query(1, 0, n - 1, dfn[v]) == 1)
					printf("0\n");
				else
					printf("%d\n", install(v));
			}
			else
			{
				if (seg.query(1, 0, n - 1, dfn[v]) == 0)
					printf("0\n");
				else
					printf("%d\n", uninstall(v));
			}
	}

	return 0;
}
```

24 Inverse dp

```
#include <cstdio>

const int       maxN(2000000 + 10);
const long long mod (1000000007);
long long       inv [maxN];

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

	inv[1] = 1;
	for (int i(2); i <= n; ++i)
	{
		inv[i] = (mod - mod / i) * inv[mod % i] % mod;
	}

	return 0;
}
```

25 Km

```
const int N = 105;
int w[N][N];
int la[N], lb[N];
bool va[N], vb[N];
int match[N];
int n, delta;

bool dfs(int x)
{
        va[x] = 1;
        for (int y = 1; y <= n; ++y)
        {
                if (!vb[y])
                {
                        if (la[x] + lb[y] - w[x][y] == 0)
                        {
                                vb[y] = 1;
                                if (!match[y] || dfs(match[y]))
                                {
                                        match[y] = x;
                                        return true;
                                }
                        }
                }
                else delta = min(delta, la[x] + lb[y] - w[x][y]);
        }
        return false;
}

int KM()
{
        for (int i = 1; i <= n; ++i)
        {
                la[i] = -(1 << 30);
                lb[i] = 0;
                for (int j = 1; j <= n; ++j)
                        la[i] = max(la[i], w[i][j]);
        }
        for (int i = 1; i <= n; ++i)
        {
                while (true)
                {
                        memset(va, 0, sizeof(va));
                        memset(vb, 0, sizeof(vb));
                        delta = 1 << 30;
                        if (dfs(i)) break;
                        for (int j = 1; j <= n; ++j)
                        {
                                if (va[j]) la[j] -= delta;
                                if (vb[j]) lb[j] += delta;
                        }
                }
        }
        int ans = 0;
        for (int i = 1; i <= n; ++i) ans += w[match[i]][i];
        return ans;
}
```

26 Kmp

```cpp
#include <iostream>
#include <fstream>
#include <string>

const int   maxN {1000000};
int         fail [maxN];
int         match[maxN];

void build(std::string &pat)
{
        fail[0] = -1;
        for (int i{1}, j{-1}; i < pat.length(); ++i)
        {
                while (j >= 0 && pat[i] != pat[j + 1]) j = fail[j];
                if (pat[i] == pat[j + 1]) ++j;
                fail[i] = j;
        }
}

int find(std::string &str, std::string &pat)
{
        int cnt{0};
        for (int i{0}, j{-1}; i < str.length(); ++i)
        {
                while (j >= 0 && (j == pat.length() - 1 || str[i] != pat[j + 1]))
                {
                        j = fail[j];
                }
                if (str[i] == pat[j + 1]) ++j;
                match[i] = j;
                if (j == pat.length() - 1) ++cnt;
        }
        return cnt;
}

int main()
{
        std::string T{"anana"};
        std::string S{"banananban"};

        build(T);
        find(S, T);

        for (int i{0}; i < T.length(); ++i) std::cout << T[i] << ' ';
        std::cout << std::endl;
        for (int i{0}; i < T.length(); ++i) std::cout << fail[i] << ' ';
        std::cout << std::endl;
        for (int i{0}; i < S.length(); ++i) std::cout << S[i] << ' ';
        std::cout << std::endl;
        for (int i{0}; i < S.length(); ++i) std::cout << match[i] << ' ';
        std::cout << std::endl;

        return 0;
}
```

27 Kruskal smin span tree

```
#include <iostream>
#include <cstring>
#include <algorithm>

long long n, m;
const long long inf(0x7f7f7f7f);

struct Edge
{
        long long from;
        long long to;
        long long cost;
};
Edge edge  [300000     + 10];
bool inMst [300000     + 10];
long long  father[100000     + 10];

long long  to    [300000 * 2 + 10];
long long  pre   [300000 * 2 + 10];
long long  last  [100000     + 10];
long long  cost  [300000 * 2 + 10];

long long  depth [100000     + 10];
long long  lca   [100000     + 10][20];
long long  max1  [100000     + 10][20];
long long  max2  [100000     + 10][20];

bool operator<(const Edge &a, const Edge &b)
{
        return a.cost < b.cost;
}

void addEdge(long long x, long long y, long long z)
{
        static long long index(0);
        to[index] = y;
        pre[index] = last[x];
        last[x] = index;
        cost[index] = z;
        ++index;
}

long long getFather(long long vertex)
{
        if (father[vertex] == vertex)
                return vertex;
        else
                return father[vertex] = getFather(father[vertex]);
}

long long kruskal()
{
        for (long long i(1); i <= n; ++i)
                father[i] = i;
        std::sort(edge + 1, edge + m + 1);
        long long sum(0);
        for (long long i(1); i <= m; ++i)
        {
                long long fatherA(getFather(edge[i].from));
                long long fatherB(getFather(edge[i].to));
                if (fatherA != fatherB)
                {
                        inMst[i] = true;
                        sum += edge[i].cost;
                        father[fatherA] = fatherB;
                        addEdge(edge[i].from, edge[i].to, edge[i].cost);
                        addEdge(edge[i].to, edge[i].from, edge[i].cost);
                }
        }

        return sum;
}

void dfs(long long vertex, long long pred, long long d)
{
        depth[vertex] = d;
        lca[vertex][0] = pred;
        for (long long i(last[vertex]); i != -1; i = pre[i])
        {
                if (to[i] != pred)
                {
                        max1[to[i]][0] = cost[i];
                        max2[to[i]][0] = -inf;
                        dfs(to[i], vertex, d + 1);
                }
        }
}

long long getLca(long long v1, long long v2)
{
        if (depth[v1] < depth[v2])
                std::swap(v1, v2);
        for (long long i(19); i >= 0; --i)
        {
                if (depth[v1] - (1 << i) >= depth[v2])
```

```
                        v1 = lca[v1][i];
        }
        if (v1 == v2)
                return v1;
        for (long long i(19); i >= 0; --i)
        {
                if (lca[v1][i] != lca[v2][i])
                {
                        v1 = lca[v1][i];
                        v2 = lca[v2][i];
                }
        }
        return lca[v1][0];
}

long long calc(long long v, long long f, long long replace)
{
        long long m1(-inf), m2(-inf);
        for (long long i(19); i >= 0; --i)
        {
                if (depth[v] - (1 << i) >= depth[f])
                {
                        if (max1[v][i] > m1)
                        {
                                m2 = m1;
                                m1 = max1[v][i];
                        }
                        m2 = std::max(m2, max2[v][i]);
                        v = lca[v][i];
                }
        }

        if (m1 == replace)
                return replace - m2;
        else
                return replace - m1;
}

int main()
{
        std::cin >> n >> m;
        memset(last, -1, sizeof(last));
        for (long long i(1); i <= m; ++i)
                std::cin >> edge[i].from >> edge[i].to >> edge[i].cost;

        long long sum(kruskal());

        dfs(to[0], 0, 0);
        for (long long i(1); (1 << i) <= n; ++i)
        {
                for (long long j(1); j <= n; ++j)
                {
                        lca[j][i] = lca[lca[j][i - 1]][i - 1];
                        max1[j][i] = std::max(max1[j][i - 1], max1[lca[j][i - 1]][i -
↪  1]);
                        if (max1[j][i - 1] == max1[lca[j][i - 1]][i - 1])
                                max2[j][i] = std::max(max2[j][i - 1], max2[lca[j][i -
↪  1]][i - 1]);
                        else if (max1[j][i - 1] < max1[lca[j][i - 1]][i - 1])
                                max2[j][i] = std::max(max1[j][i - 1], max2[lca[j][i -
↪  1]][i - 1]);
                        else
                                max2[j][i] = std::max(max2[j][i - 1], max1[lca[j][i -
↪  1]][i - 1]);
                }
        }

        long long ans(inf);
        for (long long i(1); i <= m; ++i)
        {
                if (!inMst[i])
                {
                        long long f(getLca(edge[i].from, edge[i].to));
                        ans = std::min(ans, calc(edge[i].from, f, edge[i].cost));
                        ans = std::min(ans, calc(edge[i].to, f, edge[i].cost));
                }
        }
        std::cout << sum + ans << std::endl;

        return 0;
}
```

28 Lca

```
void dfs(int father, int v, int d)
{
        depth[v] = d;
        lca[v][0] = father;
        for (int i(1); (1 << i) <= depth[v]; ++i)
                lca[v][i] = lca[lca[v][i - 1]][i - 1];
        root[v] = increase(root[father], 0, 100000, V[v]);

        for (int i(last[v]); i != 0; i = pre[i])
        {
                if (to[i] != father)
                        dfs(v, to[i], d + 1);
        }
}

int getLca(int u, int v)
{
        if (depth[u] < depth[v])
```

```
                std::swap(u, v);
        for (int i(19); i >= 0; --i)
        {
                if (depth[u] - (1 << i) >= depth[v])
                        u = lca[u][i];
        }
        if (u == v)
                return u;

        for (int i(19); i >= 0; --i)
        {
                if (lca[u][i] != lca[v][i])
                {
                        u = lca[u][i];
                        v = lca[v][i];
                }
        }
        return lca[u][0];
}
```

29 Leftist tree

```
#include<bits/stdc++.h>
using namespace std;
#define file(a) freopen(#a".in","r",stdin),freopen(#a".out","w",stdout)
#define LL long long
#define N 200010
struct llt{
        int val,lc,rc;
        int fa,d;
}t[N];
#define fa(x) t[x].fa
#define lc(x) t[x].lc
#define rc(x) t[x].rc
int find(int x){
        return x==fa(x)?x:fa(x)=find(fa(x));
}
inline void Swap(int &x,int &y){
        int tmp=x;x=y;y=tmp;
}
int merge(int x,int y){
        if(!x||!y) return x|y;
        if(t[x].val>t[y].val||(t[x].val==t[y].val&&x>y)) Swap(x,y);
        rc(x)=merge(rc(x),y);
        if(t[rc(x)].d>t[lc(x)].d) Swap(lc(x),rc(x));
        fa(x)=fa(lc(x))=fa(rc(x))=x;
        t[x].d=t[rc(x)].d+1;
        return x;
}
void pop(int x){
        t[x].val=-1;
        fa(rc(x))=rc(x);fa(lc(x))=lc(x);
        t[x].fa=merge(lc(x),rc(x));
}
int n,m;
int main(){
        scanf("%d%d",&n,&m);
        t[0].d=-1;
        for(int i=1;i<=n;++i){
                int x;scanf("%d",&x);
                t[i].val=x;t[i].fa=i;
        }
        while(m--){
                int opt;
                scanf("%d",&opt);
                if(opt==1){
                        int x,y;
                        scanf("%d%d",&x,&y);
                        int xx=find(x),yy=find(y);
                        if(t[x].val==-1||t[y].val==-1) continue;
                        if(xx==yy) continue;
                        merge(xx,yy);
                }
                if(opt==2){
                        int x;scanf("%d",&x);
                        int xx=find(x);
                        if(t[x].val==-1) printf("%d\n",-1);
                        else{
                                printf("%d\n",t[xx].val);
                                pop(xx);
                        }
                }
        }
        return 0;
}
```

30 Linear basis

```
const int maxBits{32};
int       basis  [maxBits];
bool      failed {false};

void add(int x)
{
        for (int i{maxBits - 1}; i >= 0; --i)
        {
                if ((x >> i) & 1)
                {
                        if (basis[i])
                        {
                                x ^= basis[i];
                        }
                        else
                        {
                                basis[i] = x;
                                return;
                        }
                }
        }

        failed = true;
}

int getMax()
{
        int ans{0};
        for (int i{maxBits - 1}; i >= 0; --i)
        {
                if ((ans ^ basis[i]) > ans) ans ^= basis[i];
        }
        return ans;
}

int getMin()
{
        if (failed) return 0;
        for (int i{0}; i < maxBits; ++i)
        {
                if (basis[i]) return basis[i];
        }
        return -1;
}

void reduce()
{
        for (int i{1}; i < maxBits; ++i)
        {
                for (int j{0}; j < i; ++j)
                {
                        if ((basis[i] >> j) & 1) basis[i] ^= basis[j];
                }
        }
}

// Must call reduce() before calling getKth()
int getKth(int k)
{
        if (k == 1 && failed) return 0;
        if (failed) --k;

        int ans{0};
        for (int i{0}; i < maxBits; ++i)
        {
                if (basis[i])
                {
                        if (k % 2 == 1) ans ^= basis[i];
                        k /= 2;
                }
        }
        return ans;
}
```

31 Li chao segtree

```
// 1363

#include <cstdio>
#include <algorithm>

struct Frac
{
        int y;
        int x;

        Frac() : y(0), x(1)
        {
        }

        Frac(int y, int x) : y(y), x(x)
        {
        }
};

bool operator<(const Frac &a, const Frac &b)
{
        return 1ll * a.y * b.x - 1ll * b.y * a.x < 0;
}

bool operator==(const Frac &a, const Frac &b)
{
        return 1ll * a.y * b.x - 1ll * b.y * a.x == 0;
}

bool operator<=(const Frac &a, const Frac &b)
{
        return a < b || a == b;
}

const int maxN(100000 + 10);
Frac      a   [maxN * 4];
Frac      max [maxN * 4];
int       ans [maxN * 4];

int pushUp(int node, int tl, int tr, const Frac &f)
```

```
{
        if (max[node] <= f)
        {
                return 0;
        }
        else if (f < a[tl])
        {
                return ans[node];
        }
        else
        {
                int mid((tl + tr) / 2);
                if (max[node * 2] < f)
                {
                        return pushUp(node * 2 + 1, mid + 1, tr, f);
                }
                else
                {
                        return pushUp(node * 2, tl, mid, f) + ans[node] - ans[node * 2];
                }
        }
}

void insert(int node, int tl, int tr, const Frac &f)
{
        if (tl == tr)
        {
                a[tl] = f;
                max[node] = f;
                ans[node] = 1;
        }
        else
        {
                int mid((tl + tr) / 2);
                if (f.x <= mid) insert(node * 2, tl, mid, f);
                else insert(node * 2 + 1, mid + 1, tr, f);
                max[node] = std::max(max[node * 2], max[node * 2 + 1]);
                ans[node] = ans[node * 2] + pushUp(node * 2 + 1, mid + 1, tr, max[node *
↪  2]);
        }
}

int main()
{
        int N, M;
        scanf("%d %d", &N, &M);
        for (int i(1); i <= M; ++i)
        {
                Frac f;
                scanf("%d %d", &f.x, &f.y);
                insert(1, 1, N, f);
                printf("%d\n", ans[1]);
        }

        return 0;
}
```

32 Main

```
#include <bits/stdc++.h>

int main()
{
        std::ios::sync_with_stdio(false);
        std::cin.tie(0);
        std::cout.tie(0);
        return 0;
}
```

33 Manacher

```
#include <cstdio>
#include <cstring>
#include <algorithm>

const int maxN(2000000 + 10);
char      in  [maxN];
char      str [maxN];
int       cnt [maxN];

int main()
{
        scanf("%s", in + 1);
        int len(strlen(in + 1));
        str[0] = '$';
        for (int i(1); i <= len; ++i)
        {
                str[i * 2 - 1] = in[i];
                if (i < len) str[i * 2] = '#';
        }
        len = len * 2 - 1;
        str[len + 1] = '\0';

        int mid(0);
        int r(0);
        for (int i(1); i <= len; ++i)
        {
                if (i <= r)
                {
                        cnt[i] = std::min(cnt[mid - (i - mid)], r - i + 1);
                }
                while (str[i - cnt[i]] == str[i + cnt[i]])
                {
                        //printf("%c + %d -> %c,%c\n", str[i], cnt[i], str[i - cnt[i]],
↪   str[i + cnt[i]]);
                        ++cnt[i];
                }

                if (i + cnt[i] - 1 > r)
                {
                        mid = i;
                        r = i + cnt[i] - 1;
                }
        }

        for (int i(1); i <= len; ++i)
        {
                if (str[i] == '#' && cnt[i] == 1)
                {
                        cnt[i] = 0;
                }
                if (str[i + cnt[i] - 1] == '#')
                {
                        --cnt[i];
                }
                printf("%d ", cnt[i]);
        }
        printf("\n");
        return 0;
}
```

34 Matrix

```
#include <iostream>

int N, T;
int map[9 * 10 + 10][9 * 10 + 10];
int ans[9 * 10 + 10][9 * 10 + 10];
int tmp[9 * 10 + 10][9 * 10 + 10];
const int mod(2009);

void mult(int a[9 * 10 + 10][9 * 10 + 10], int b[9 * 10 + 10][9 * 10 + 10], int c[9 * 10
↪   + 10][9 * 10 + 10])
{
        for (int i(1); i <= N * 9; ++i)
        {
                for (int j(1); j <= N * 9; ++j)
                {
                        tmp[i][j] = 0;
                        for (int k(1); k <= N * 9; ++k)
                        {
```

```
                    tmp[i][j] = (tmp[i][j] + a[i][k] * b[k][j]) % mod;
                }
            }
        }

        for (int i(1); i <= N * 9; ++i)
            for (int j(1); j <= N * 9; ++j)
                c[i][j] = tmp[i][j];
}

int main()
{
        std::cin >> N >> T;
        for (int i(0); i < N; ++i)
        {
                for (int j(0); j < N; ++j)
                {
                        char ch;
                        std::cin >> ch;
                        int cost(static_cast<int>(ch - '0'));
                        if (cost != 0)
                        {
                                for (int k(1); k <= cost - 1; ++k)
                                        map[i * 9 + k][i * 9 + k + 1] = 1;
                                map[i * 9 + cost][j * 9 + 1] = 1;
                        }
                }
        }

        for (int i(1); i <= N * 9; ++i)
                ans[i][i] = 1;

        for (int i(1); i <= T; i <<= 1)
        {
                if (i & T)
                        mult(ans, map, ans);
                mult(map, map, map);
        }

        std::cout << ans[0 * 9 + 1][(N - 1) * 9 + 1] << std::endl;
        return 0;
}
```

35 Min string

```
int k = 0, i = 0, j = 1;
while (k < n && i < n && j < n) {
  if (sec[(i + k) % n] == sec[(j + k) % n]) {
    ++k;
  } else {
    if (sec[(i + k) % n] > sec[(j + k) % n])
```

```
      ++i;
    else
      ++j;
    k = 0;
    if (i == j) i++;
  }
}
i = min(i, j);
```

36 Mono queue

```
// 2840

#include <deque>
#include <algorithm>
#include <iostream>

long long sum[2000000 + 10];

int main()
{
        std::ios::sync_with_stdio(false);
        int n, d;
        long long p;
        std::cin >> n >> p >> d;
        for (int i(1); i <= n; ++i)
        {
                int t;
                std::cin >> t;
                sum[i] = sum[i - 1] + t;
        }

        int ans(0);
        std::deque<int> deque;
        for (int i(d), j(0); i <= n; ++i)
        {
                while (!deque.empty() && sum[i] - sum[i - d] > sum[deque.back()] -
↪   sum[deque.back() - d])
                        deque.pop_back();
                deque.push_back(i);
                while (!deque.empty() && sum[i] - sum[j] - (sum[deque.front()] -
↪   sum[deque.front() - d]) > p)
                {
                        ++j;
                        while (!deque.empty() && deque.front() - d < j)
                                deque.pop_front();
                }
                ans = std::max(ans, i - j);
        }

        std::cout << ans << std::endl;
        return 0;
}
```

37 Mos

```
// https://zhuanlan.zhihu.com/p/115243708

const int MAXN = 30005, MAXQ = 200005, MAXM = 1000005;
int sq;
struct query
{
    int l, r, id;
    bool operator<(const query &o) const
    {
        if (l / sq != o.l / sq)
            return l < o.l;
        if (l / sq & 1)
            return r < o.r;
        return r > o.r;
    }
} Q[MAXQ];
int A[MAXN], ans[MAXQ], Cnt[MAXM], cur, l = 1, r = 0;
inline void add(int p)
{
    if (Cnt[A[p]] == 0)
        cur++;
    Cnt[A[p]]++;
}
inline void del(int p)
{
    Cnt[A[p]]--;
    if (Cnt[A[p]] == 0)
        cur--;
}
int main()
{
    int n = read();
    sq = sqrt(n);
    for (int i = 1; i <= n; ++i)
        A[i] = read();
    int q = read();
    for (int i = 0; i < q; ++i)
        Q[i].l = read(), Q[i].r = read(), Q[i].id = i;
    sort(Q, Q + q);
    for (int i = 0; i < q; ++i)
    {
        while (l > Q[i].l)
            add(--l);
        while (r < Q[i].r)
            add(++r);
        while (l < Q[i].l)
```

```
            del(l++);
        while (r > Q[i].r)
            del(r--);
        ans[Q[i].id] = cur;
    }
    for (int i = 0; i < q; ++i)
        printf("%d\n", ans[i]);
    return 0;
}
```

38 Mos modifiable

```
// https://blog.csdn.net/weixin_46870692/article/details/124654674

#include<stdio.h>
#include<math.h>
#include<algorithm>

using namespace std;
const int N = 1e6 + 10;
struct node{
        int l,r;
        int time,id;
}pen[4 * N];
struct Color{
        int p,c;
        int time;
}color[N];
int pos[N],a[N],res[N],cnt[N];
int n,m;

bool cmp(node a1,node a2) {
        if(pos[a1.l] != pos[a2.l]) return pos[a1.l] < pos[a2.l];
        else if(pos[a1.r] != pos[a2.r]) return pos[a1.r] < pos[a2.r];
        else return a1.time < a2.time;
}

void work() {
        int l = 0, r = 0,now = 0,time = 0;

        for(int i=1;i<=m;i++) {
                int ql = pen[i].l;
                int qr = pen[i].r;
                int qt = pen[i].time;

                while(l < ql) {
                        cnt[a[l]] --;
                        if(cnt[a[l]] == 0) now --;
                        l ++;
                }
                while(l > ql) {
                        l --;
                        cnt[a[l]] ++;
                        if(cnt[a[l]] == 1) now ++;
                }

                while(r < qr) {
                        r ++;
                        cnt[a[r]] ++;
                        if(cnt[a[r]] == 1) now ++;
                }

                while(r > qr) {
                        cnt[a[r]] --;
                        if(cnt[a[r]] == 0) now --;
                        r --;
                }

                while(time < qt) {
                        time ++;
                        int p = color[time].p;
                        int c = color[time].c;
                        if(p >= l && p <= r) {
                                cnt[a[p]] --;
                                if(cnt[a[p]] == 0) now --;

                                cnt[c] ++;
                                if(cnt[c] == 1) now ++;

                        }

                        swap(a[p],color[time].c);
                }

                while(time > qt) {
                        int p = color[time].p;
                        int c = color[time].c;
                        if(p >= l && p <= r) {
                                cnt[a[p]] --;
                                if(cnt[a[p]] == 0) now --;

                                cnt[c] ++;
                                if(cnt[c] == 1) now ++;
                        }

                        swap(a[p],color[time].c);
                        time --;
                }

                res[pen[i].id] = now;
        }
```

```
}

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

        int t = pow(n,2.0/3.0);

        int size = ceil((double)n / t);

        for(int i=1;i<=size;i++) {
                for(int j=(i-1)*t+1;j<=min(i*t,n);j++) {
                        pos[j] = i;
                }
        }

        for(int i=1;i<=n;i++) scanf("%d",&a[i]);

        int L = 0,k = 0;

        for(int i=1;i<=m;i++) {
                char s[2] = {0};
                scanf("%s",s);

                if(s[0] == 'Q') {
                        k ++;
                        scanf("%d %d",&pen[k].l,&pen[k].r);
                        pen[k].time = L;
                        pen[k].id = k;
                }
                else {
                        L ++;
                        scanf("%d %d",&color[L].p,&color[L].c);
                        color[L].time = L;
                }
        }

        sort(pen+1,pen+1+k,cmp);
        m = k;

        work();

        for(int i=1;i<=m;i++) printf("%d\n",res[i]);

        return 0;
}
```

39 Network flow

```
#include <iostream>
#include <cstring>
#include <queue>
```

```
#include <algorithm>

const int maxN(5000);

int to   [maxN];
int pre  [maxN];
int last [maxN];
int cap  [maxN];
int depth[maxN];

const int inf(0x3f3f3f3f);

bool bfs(int start, int end)
{
        memset(depth, 0, sizeof(depth));
        depth[start] = 1;

        std::queue<int> queue;
        queue.push(start);
        while (!queue.empty())
        {
                int v(queue.front());
                queue.pop();
                for (int e(last[v]); e; e = pre[e])
                {
                        if (!depth[to[e]] && cap[e])
                        {
                                depth[to[e]] = depth[v] + 1;
                                queue.push(to[e]);
                        }
                }
        }

        return depth[end];
}

int dfs(int v, int end, int flow)
{
        if (!flow) return 0;
        if (v == end) return flow;

        int sum(0);
        for (int e(last[v]); flow && e; e = pre[e])
        {
                if (depth[v] + 1 == depth[to[e]])
                {
                        int cur(dfs(to[e], end, std::min(flow, cap[e])));
                        cap[e] -= cur;
                        cap[e ^ 1] += cur;
                        flow -= cur;
                        sum += cur;
                }
        }

        if (!sum) depth[v] = 0;
        return sum;
}

void addEdge(int u, int v, int w)
{
        static int lastEdge(2);

        to[lastEdge] = v;
        pre[lastEdge] = last[u];
        last[u] = lastEdge;
        cap[lastEdge] = w;
        ++lastEdge;

        to[lastEdge] = u;
        pre[lastEdge] = last[v];
        last[v] = lastEdge;
        ++lastEdge;
}

int main()
{
        int m, n;
        std::cin >> m >> n;

        for (int i(1); i <= m; ++i)
                addEdge(0, i, 1);

        while (true)
        {
                int a, b;
                std::cin >> a >> b;
                if (a == -1)
                        break;
                addEdge(a, b, 1);
        }

        for (int i(m + 1); i <= n; ++i)
                addEdge(i, n + 1, 1);

        int sum(0);
        while (bfs(0, n + 1))
        {
                sum += dfs(0, n + 1, inf);
        }

        if (sum)
                std::cout << sum << std::endl;
        else
                std::cout << "No Solution!" << std::endl;

        return 0;
}
```

40 Network flow cost

```
// 5379

#include <cstdio>
#include <limits>
#include <cstdlib>
#include <cmath>
#include <queue>

struct Pig
{
        long long x;
        long long y;
        long long c;

        Pig() : x(0), y(0), c(0)
        {
        }

        Pig(long long x, long long y, long long c = 0) : x(x), y(y), c(c)
        {
        }
};

long long diff(const Pig &a, const Pig &b)
{
        return std::abs(a.x - b.x) + std::abs(a.y - b.y);
}

const int maxN (1000 + 10);
const int maxV (3 * maxN);
const int maxE (40 * maxN);
Pig       a    [maxN];
Pig       b    [maxN];
int       to   [maxE];
int       pre  [maxE];
long long cost [maxE];
long long cap  [maxE];
int       last [maxV];
long long flow [maxV];
long long dist [maxV];
bool      visit[maxV];
int       in   [maxV];
```

```
const long long inf(std::numeric_limits<long long>::max() / 10);

void addEdge(int u, int v, long long w, long long c)
{
        static int lastEdge(1);

        ++lastEdge;
        to[lastEdge] = v;
        pre[lastEdge] = last[u];
        last[u] = lastEdge;
        cost[lastEdge] = w;
        cap[lastEdge] = c;

        ++lastEdge;
        to[lastEdge] = u;
        pre[lastEdge] = last[v];
        last[v] = lastEdge;
        cost[lastEdge] = -w;
        cap[lastEdge] = 0;
}

bool SPFA(int S, int T)
{
        for (int i(0); i < maxV; ++i)
        {
                flow[i] = 0;
                dist[i] = -inf;
                visit[i] = false;
        }

        flow[S] = inf;
        dist[S] = 0;
        in[T] = -1;
        std::queue<int> queue;
        queue.push(S);
        visit[S] = true;

        while (!queue.empty())
        {
                int v(queue.front());
                queue.pop();
                visit[v] = false;
                for (int e(last[v]); e; e = pre[e])
                {
                        if (cap[e] && dist[to[e]] < dist[v] + cost[e])
                        {
                                dist[to[e]] = dist[v] + cost[e];
                                flow[to[e]] = std::min(flow[v], cap[e]);
                                in[to[e]] = e;
                                if (!visit[to[e]])
                                {
                                        queue.push(to[e]);
                                        visit[to[e]] = true;
                                }
                        }
                }
        }

        return in[T] != -1;
}

int main()
{
        int n;
        scanf("%d", &n);
        for (int i(1); i <= n; ++i)
        {
                scanf("%lld %lld %lld", &a[i].x, &a[i].y, &a[i].c);
        }
        for (int i(1); i <= n; ++i)
        {
                scanf("%lld %lld %lld", &b[i].x, &b[i].y, &b[i].c);
        }

        int S(2 * n + 1), T(2 * n + 2);
        int DL(2 * n + 3), UR(2 * n + 4), DR(2 * n + 5), UL(2 * n + 6);
        Pig cornerDL(0, 0), cornerDR(0, 1000000001);

        for (int i(1); i <= n; ++i)
        {
                addEdge(S, i, 0, a[i].c);
                addEdge(n + i, T, 0, b[i].c);

                addEdge(i, DL, diff(a[i], cornerDL), inf);
                addEdge(DL, n + i, -diff(cornerDL, b[i]), inf);

                addEdge(i, UR, -diff(a[i], cornerDL), inf);
                addEdge(UR, n + i, diff(cornerDL, b[i]), inf);

                addEdge(i, DR, diff(a[i], cornerDR), inf);
                addEdge(DR, n + i, -diff(cornerDR, b[i]), inf);

                addEdge(i, UL, -diff(a[i], cornerDR), inf);
                addEdge(UL, n + i, diff(cornerDR, b[i]), inf);
        }

        long long ans(0);
        while (SPFA(S, T))
        {
                ans += flow[T] * dist[T];
                for (int cur(T); cur != S; cur = to[in[cur] ^ 1])
                {
                        cap[in[cur]] -= flow[T];
                        cap[in[cur] ^ 1] += flow[T];
                }
        }
        printf("%lld\n", ans);
        return 0;
}
```

41 Paren match

```
// 4652

#include <cstdio>
#include <vector>

const int        maxN (500000 + 10);
std::vector<int> edge [maxN];
char             in   [maxN];
bool             type [maxN];
int              stack[maxN];
int              match[maxN];
int              cnt  [maxN];
int              cons [maxN];
long long        sum  [maxN];

long long ans(0);

int top(0);

void dfs(int v, int pre)
{
        ++top;
        stack[top] = type[v];
        if (type[v] == 0 || stack[pre] == 1)
        {
                match[top] = top;
                cons[top] = 0;
                if (top > 0)
                {
                        sum[top] = sum[top - 1];
                }
                else
                {
                        sum[top] = 0;
                }
        }
        else
        {
                match[top] = match[pre - 1];
                cons[top] = cons[pre - 1] + 1;
                sum[top] = sum[top - 1] + cons[top];
        }
        ans ^= v * sum[top];

        for (size_t i(0); i < edge[v].size(); ++i)
        {
                dfs(edge[v][i], match[top]);
        }

        --top;
}

int main()
{
        int n;
        scanf("%d", &n);
        scanf("%s", in + 1);
        for (int i(1); i <= n; ++i)
        {
                type[i] = (in[i] == '(' ? 0 : 1);
        }
        for (int i(2); i <= n; ++i)
        {
                int f;
                scanf("%d", &f);
                edge[f].push_back(i);
        }

        stack[0] = 1;
        dfs(1, 0);
        printf("%lld\n", ans);
        return 0;
}
```

42 Parser

```
#include <iostream>
#include <string>
#include <cctype>
#include <limits>

std::string str;
int pos(0);
int lookup[256];

bool lessPower(char p0, char p1)
{
        if (p0 == '^' && p1 == '^')
                return true;
        else
                return lookup[p0] < lookup[p1];
}
```

```
int parse(char oldOp)
{
        int left(0);
        if (str[pos] == '(')
        {
                ++pos;
                left = parse(0);
                ++pos;
        }
        else
        {
                while (pos < str.size() && isdigit(str[pos]))
                {
                        left = left * 10 + static_cast<int>(str[pos] - '0');
                        ++pos;
                }
        }

        while (pos < str.size() && str[pos] != ')' && !isdigit(str[pos]) &&
↪   lessPower(oldOp, str[pos]))
        {
                char op(str[pos]);
                ++pos;
                int right(parse(op));
                switch (op)
                {
                case '+':
                        left += right;
                        break;

                case '-':
                        left -= right;
                        break;

                case '*':
                        left *= right;
                        break;

                case '/':
                        left /= right;
                        break;

                case '^':
                        {
                                int temp(left);
                                left = 1;
                                for (int i(0); i < right; ++i)
                                        left *= temp;
                        }
                        break;
                default:
                        break;
                }
        }

        return left;
}

int main()
{
        lookup[0]   = 0;
        lookup['+'] = 1;
        lookup['-'] = 1;
        lookup['*'] = 2;
        lookup['/'] = 2;
        lookup['^'] = 3;
        std::cin >> str;
        std::cout << parse(0) << std::endl;
        return 0;
}
```

43 Persist segtree

```
// 1231
#include <cstdio>
#include <cctype>
#include <algorithm>
#include <iostream>

struct Node
{
        int low;
        int high;
        int count;
};

int  number[100000 + 10];
int  sorted[100000 + 10];
int  root  [100000 + 10];
Node tree  [2000000 + 10];
int  nextId(0);

int read()
{
        char ch;
        while (ch = getchar(), !isdigit(ch) && ch != '-')
                ;
        int ret(0);
        int sign(ch == '-' ? -1 : 1);
        if (sign == -1)
```

```
                ch = getchar();
        while (isdigit(ch))
        {
                ret = ret * 10 + static_cast<int>(ch - '0');
                ch = getchar();
        }
        return sign * ret;
}

int increase(int oldNode, int low, int high, int value)
{
        int newNode(nextId);
        ++nextId;
        tree[newNode] = tree[oldNode];
        ++tree[newNode].count;
        if (low != high)
        {
                int mid((low + high) / 2);
                if (value <= mid)
                        tree[newNode].low = increase(tree[oldNode].low, low, mid, value);
                else
                        tree[newNode].high = increase(tree[oldNode].high, mid + 1, high,
↪   value);
        }
        return newNode;
}

int query(int leftNode, int rightNode, int low, int high, int k)
{
        if (low == high)
                return low;
        int mid((low + high) / 2);
        int lowCount(tree[tree[rightNode].low].count - tree[tree[leftNode].low].count);
        if (k <= lowCount)
                return query(tree[leftNode].low, tree[rightNode].low, low, mid, k);
        else
                return query(tree[leftNode].high, tree[rightNode].high, mid + 1, high, k
↪   - lowCount);
}

int main()
{
        int n(read()), m(read());
        for (int i(1); i <= n; ++i)
                sorted[i] = number[i] = read();

        std::sort(sorted + 1, sorted + n + 1);
        int *sortedEnd(std::unique(sorted + 1, sorted + n + 1));
        for (int i(1); i <= n; ++i)
                number[i] = std::lower_bound(sorted + 1, sortedEnd, number[i]) - sorted;
        int maxNumber(sortedEnd - sorted);
        ++nextId;
        for (int i(1); i <= n; ++i)
                root[i] = increase(root[i - 1], 1, maxNumber, number[i]);

        for (int i(1); i <= m; ++i)
        {
                int l, r, k;
                std::cin >> l >> r >> k;
                std::cout << sorted[query(root[l - 1], root[r], 1, maxNumber, k)] <<
↪   std::endl;
        }

        return 0;
}
```

44 Persist trie

```
// 1333

#include <iostream>
#include <algorithm>

const int maxN(300000);
int trie[maxN * 2 * 24][2];
int end [maxN * 2 * 24];
int sum [maxN * 2];
int root[maxN * 2];
int newNode;

int insert(int index, int pos, int node)
{
        int currentNode(++newNode);
        if (pos < 0)
        {
                end[currentNode] = index;
                return currentNode;
        }

        int digit((sum[index] >> pos) & 1);
        trie[currentNode][digit] = insert(index, pos - 1, trie[node][digit]);
        trie[currentNode][digit ^ 1] = trie[node][digit ^ 1];
        end[currentNode] = std::max(end[trie[currentNode][0]],
↪   end[trie[currentNode][1]]);
        return currentNode;
}

int query(int value, int pos, int limit, int node)
{
        int digit((value >> pos) & 1);
        if (pos < 0)
```

```
                return sum[end[node]] ^ value;
        if (end[trie[node][digit ^ 1]] >= limit)
                return query(value, pos - 1, limit, trie[node][digit ^ 1]);
        else
                return query(value, pos - 1, limit, trie[node][digit]);
}

int main()
{
        int N, M;
        std::cin >> N >> M;

        end[0] = -1;
        root[0] = insert(0, 23, 0);
        for (int i(1); i <= N; ++i)
        {
                int x;
                std::cin >> x;
                sum[i] = sum[i - 1] ^ x;
                root[i] = insert(i, 23, root[i - 1]);
        }

        for (int i(1); i <= M; ++i)
        {
                char op;
                std::cin >> op;
                if (op == 'A')
                {
                        int x;
                        std::cin >> x;
                        ++N;
                        sum[N] = sum[N - 1] ^ x;
                        root[N] = insert(N, 23, root[N - 1]);
                }
                else
                {
                        int l, r, x;
                        std::cin >> l >> r >> x;
                        std::cout << query(x ^ sum[N], 23, l - 1, root[r - 1]) << '\n';
                }
        }

        return 0;
}
```

45 Plug dp

```
// 5128

#include <cstdio>
#include <cmath>
```

```
#include <cstring>
#include <algorithm>
#include <vector>

const int maxN (12);
char      in    [maxN];
int       color[maxN][maxN];
int       w     [maxN][maxN];
int       dp    [1 << (2 * maxN)];
int       n;

struct Point
{
        int pos;
        int x;
        int y;
};

void print(int x)
{
        for (int i(0); i < 2 * n; ++i)
        {
                printf("%d", (x >> i) & 1);
        }
        printf("\n");
}

int main()
{
        scanf("%d", &n);
        for (int i(0); i < n; ++i)
        {
                scanf("%s", in);
                for (int j(0); j < n; ++j)
                {
                        if (in[j] == 'W')
                        {
                                color[i][j] = 1;
                        }
                        else if (in[j] == 'B')
                        {
                                color[i][j] = 2;
                        }
                        else
                        {
                                color[i][j] = 0;
                        }
                }
        }
        for (int i(0); i < n; ++i)
        {
                for (int j(0); j < n; ++j)
                {
                        scanf("%d", &w[i][j]);
                }
        }

        const int inf(0x3f3f3f3f);
        memset(dp, inf, sizeof(dp));
        dp[(1 << (2 * n)) - (1 << n)] = 0;

        for (int state(1 << (2 * n)); state; --state)
        {
                if (dp[state] != inf)
                {
                        std::vector<Point> corner;
                        {
                                Point p = {0, -1, 0};
                                while(p.pos < 2 * n - 1)
                                {
                                        p.x += (((state >> p.pos) & 1) == 0);
                                        p.y += (((state >> p.pos) & 1) == 1);
                                        if (0 <= p.x && p.x < n && 0 <= p.y && p.y < n &&
        ↪   ((state >> p.pos) & 3) == 2)
                                        {
                                                corner.push_back(p);
                                        }
                                        ++p.pos;
                                }
                        }

                        for (std::size_t i(0); i < corner.size(); ++i)
                        {
                                int nxt(state ^ (3 << corner[i].pos));
                                dp[nxt] = std::min(dp[nxt], dp[state] +
        ↪   w[corner[i].x][corner[i].y]);
                        }

                        for (std::size_t i(0); i < corner.size(); ++i)
                        {
                                if (color[corner[i].x][corner[i].y])
                                {
                                        for (std::size_t j(0); j < corner.size(); ++j)
                                        {
                                                if (color[corner[j].x][corner[j].y] &&
        ↪   color[corner[i].x][corner[i].y] != color[corner[j].x][corner[j].y])
                                                {
                                                        int nxt(state ^ (3 <<
        ↪   corner[i].pos) ^ (3 << corner[j].pos));
                                                        dp[nxt] = std::min(dp[nxt],
        ↪   dp[state] + std::abs(w[corner[i].x][corner[i].y] - w[corner[j].x][corner[j].y]));
                                                }
```

```
                                                }
                                        }
                                }
                        }
                }

                printf("%d\n", dp[(1 << n) - 1]);
                return 0;
}
```

46 Qpow

```
long long qpow(long long base, long long ex)
{
        long long prod(1);
        for (long long i(1); i <= ex; i *= 2)
        {
                if (i & ex) prod = prod * base % mod;
                base = base * base % mod;
        }
        return prod;
}

long long inv(long long n)
{
        return qpow(n, mod - 2);
}

long long C(long long n, long long m)
{
        return fact[n] * inv(fact[m] * fact[n - m] % mod) % mod;
}
```

47 Range dp

```
// 5274

#include <cstdio>
#include <limits>
#include <algorithm>
#include <cstring>

const int maxN(100 + 10);
int       a   [maxN];
int       f   [maxN][maxN][maxN];

void solve(int l, int r, int k, int zero)
{
        memset(f[l][r], 0, sizeof(f[l][r]));
        if (l > r) return;
        int min(l);
        for (int i(l); i <= r; ++i)
        {
                if (a[i] < a[min])
                {
                        min = i;
                }
        }

        solve(l, min - 1, k, zero);
        solve(min + 1, r, k, zero);
        for (int i(1); i <= k; ++i)
        {
                for (int j(0); j <= i; ++j)
                {
                        f[l][r][i] = std::max(f[l][r][i], f[l][min - 1][j] + f[min +
↪   1][r][i - j]);
                }
        }

        /*printf("[%d,%d] %d: ", l, r, zero);
        for (int i(1); i <= k; ++i)
        {
                printf("%d ", f[l][r][i]);
        }
        printf("\n"); //*/

        solve(l, min - 1, k, a[min]);
        solve(min + 1, r, k, a[min]);
        for (int i(1); i <= k; ++i)
        {
                for (int j(0); j <= i - 1; ++j)
                {
                        f[l][r][i] = std::max(f[l][r][i], f[l][min - 1][j] + f[min +
↪   1][r][i - j - 1] + (r - l + 1) * (a[min] - zero));
                }
        }

        /*printf("[%d,%d] %d: ", l, r, zero);
        for (int i(1); i <= k; ++i)
        {
                printf("%d ", f[l][r][i]);
        }
        printf("\n"); //*/
}

int main()
{
        int n, k;
        scanf("%d %d", &n, &k);
        for (int i(1); i <= n; ++i)
        {
                scanf("%d", &a[i]);
        }

        solve(1, n, k, 0);
        printf("%d\n", f[1][n][k]);
        return 0;
}
```

48 Rng

```
struct Rng
{
        uint64_t state;

        Rng(uint64_t state) : state(state)
        {
        }

        uint32_t getRaw()
        {
            uint64_t oldstate = state;
            state = oldstate * 6364136223846793005ULL + 1;
            uint32_t xorshifted = ((oldstate >> 18u) ^ oldstate) >> 27u;
            uint32_t rot = oldstate >> 59u;
            return (xorshifted >> rot) | (xorshifted << ((-rot) & 31));
        }

        int get(int min, int max)
        {
                return min + 1ll * getRaw() % (max - min + 1);
        }
};
```

49 Sa

```
#include <cstdio>
#include <cstring>
#include <algorithm>

int n;

const int maxN   (400000 + 10);
const int maxChar(26);
const int maxLbN (30);
char      S      [maxN];
int       sa     [maxN];
int       rank   [maxN];
int       cnt    [maxN];
int       second [maxN];
int       rankSec[maxN];
int       oldRank[maxN];
int       height [maxN];
int       st     [maxLbN][maxN];

void buildSa()
{
        int max(maxChar);
        memset(cnt + 1, 0, max * sizeof(int));
        for (int i(1); i <= n; ++i) ++cnt[rank[i] = int(S[i] - 'a' + 1)];
        for (int i(2); i <= max; ++i) cnt[i] += cnt[i - 1];
        for (int i(n); i >= 1; --i) sa[cnt[rank[i]]--] = i;

        for (int mid(1); mid < n; mid *= 2)
        {
                int front(0);
                for (int i(n - mid + 1); i <= n; ++i)
                {
                        second[++front] = i;
                }
                for (int i(1); i <= n; ++i)
                {
                        if (sa[i] >= mid + 1)
                        {
                                second[++front] = sa[i] - mid;
                        }
                }

                memset(cnt + 1, 0, max * sizeof(int));
                for (int i(1); i <= n; ++i) ++cnt[rankSec[i] = rank[second[i]]];
                for (int i(2); i <= max; ++i) cnt[i] += cnt[i - 1];
                for (int i(n); i >= 1; --i) sa[cnt[rankSec[i]]--] = second[i];

                memcpy(oldRank + 1, rank + 1, n * sizeof(int));

                int id(0);
                for (int i(1); i <= n; ++i)
                {
                        int x(sa[i - 1]), y(sa[i]);
                        if (oldRank[x] != oldRank[y] || oldRank[x + mid] != oldRank[y +
↪  mid])
                        {
                                ++id;
                        }
                        rank[y] = id;
                }

                max = id;
                if (max == n) break;
        }
        /*for (int i(1); i <= n; ++i)
    {
        printf("%d ", sa[i]);
    }
    printf("\n"); //*/
}

void calcHeight()
{
        for (int i(1); i <= n; ++i)
        {
                height[rank[i]] = std::max(height[rank[i - 1]] - 1, 0);
                while (S[i + height[rank[i]]] == S[sa[rank[i] - 1] + height[rank[i]]])
                {
                        ++height[rank[i]];
                }
        }

        for (int i(1); i <= n; ++i)
        {
                st[0][i] = height[i];
        }
        for (int i(1); i < maxLbN; ++i)
        {
                for (int j(1); j + (1 << i) - 1 <= n; ++j)
                {
                        st[i][j] = std::min(st[i - 1][j], st[i - 1][j + (1 << (i - 1))]);
                }
        }
}

int lb(int x)
{
        int y(0);
        while ((1 << y) <= x)
        {
                ++y;
        }
        return y - 1;
}

int get(int x, int y)
{
        x = rank[x];
        y = rank[y];
        if (x > y) std::swap(x, y);
        ++x;
        int l(lb(y - x + 1));
        return std::min(st[l][x], st[l][y - (1 << l) + 1]);
}
```

```
int main()
{
        int T;
        scanf("%d", &T);
        for (int ttt(1); ttt <= T; ++ttt)
        {
                scanf("%s", S + 1);
                n = strlen(S + 1);

                buildSa();
                calcHeight();

                /*for (int i(1); i <= n; ++i)
                {
                        printf("height %d: %d\n", i, height[i]);
                }//*/
                /*for (int i(1); i <= n; ++i)
                {
                        for (int j(i); j <= n; ++j)
                        {
                                printf("min [%d,%d]: %d\n", i, j, get(i, j));
                        }
                }//*/

                int ansPos(sa[1]), ansCnt(1), ansLen(1);
                for (int i(1); i <= n / 2; ++i)
                {
                        for (int j(1); j + i <= n; j += i)
                        {
                                int len(get(j, j + i));
                                if (len / i + 1 + 1 >= ansCnt)
                                {
                                        //printf("%d %d @@ £%d %s\n", i, j, len, S + j);
                                        for (int k(j); k >= 1 && j - k < i && S[k] == S[k
↪   + i]; --k)
                                        {
                                                  //printf("%d %d %d £%d %s\n", i, j, k,
↪   len, S + k);
                                                if (len / i + 1 > ansCnt || (len / i + 1
↪   == ansCnt && rank[k] < rank[ansPos]))
                                                {
                                                        ansPos = k;
                                                        ansCnt = len / i + 1;
                                                        ansLen = i;
                                                }
                                                ++len;
                                        }
                                }
                        }
                }
```

```
		for (int i(0); i < ansCnt * ansLen; ++i)
		{
			putchar(S[ansPos + i]);
		}
		puts("");
	}

	return 0;
}
```

50 Sam

```
#include <cstdio>
#include <cstring>

int n;

const int maxN (50000 + 10);
const int maxCh(256 + 10);
char      str  [maxN];
int       next [maxN * 2][maxCh];
int       link [maxN * 2];
int       len  [maxN * 2];

int lastNode;

void buildSam()
{
	lastNode = 0;
	int last(0);
	link[0] = -1;
	memset(next[0], 0, sizeof(next[0]));

	for (int i(1); i <= n; ++i)
	{
		int cur(++lastNode);
		len[cur] = i;
		memset(next[cur], 0, sizeof(next[cur]));

		int pre(last);
		while (pre != -1 && !next[pre][int(str[i])])
		{
			next[pre][int(str[i])] = cur;
			pre = link[pre];
		}

		if (pre != -1)
		{
			int suc(next[pre][int(str[i])]);
			if (len[suc] == len[pre] + 1)
```

```
                        {
                                link[cur] = suc;
                        }
                        else
                        {
                                int clone(++lastNode);
                                memcpy(next[clone], next[suc], sizeof(next[clone]));
                                link[clone] = link[suc];
                                len[clone] = len[pre] + 1;
                                link[suc] = clone;

                                while (pre != -1 && next[pre][int(str[i])] == suc)
                                {
                                        next[pre][int(str[i])] = clone;
                                        pre = link[pre];
                                }
                                link[cur] = clone;
                        }
                }
                else
                {
                        link[cur] = 0;
                }

                last = cur;
        }
}

int main()
{
        int T;
        scanf("%d", &T);
        for (int ttt(1); ttt <= T; ++ttt)
        {
                scanf("%s", str + 1);
                n = strlen(str + 1);

                buildSam();
                long long ans(0);
                for (int i(1); i <= lastNode; ++i)
                {
                        ans += len[i] - len[link[i]];
                }
                printf("%lld\n", ans);
        }

        return 0;
}
```

51 Search mem hash

```
// 5237

#include <cstdio>
#include <bitset>
#include <cstdlib>

int n, m;

const int maxN(9);

const int mod(10000007);

struct Bitset
{
        std::bitset<maxN * maxN> bs;
        std::bitset<maxN * maxN>::reference operator()(int x, int y)
        {
                return bs[x * m + y];
        }
        bool operator()(int x, int y) const
        {
                return bs[x * m + y];
        }

        const std::bitset<maxN * maxN>& data() const
        {
                return bs;
        }

        int hash() const
        {
                int h(0);
                int cur(1);
                for (int i(0); i < maxN * maxN; ++i)
                {
                        if (bs[i])
                        {
                                h = (h + cur) % mod;
                        }
                        cur = cur * 2 % mod;
                }
                return h;
        }
};

bool      used  [mod];
Bitset    belong[mod];
long long mem   [mod];

int hashFind(const Bitset &bs)
```

```
{
        int pos(bs.hash());
        while (used[pos] && belong[pos].data() != bs.data())
        {
                pos = (pos + 1) % mod;
        }
        if (!used[pos])
        {
                belong[pos] = bs;
        }
        return pos;
}

char in   [maxN + 10];

const int typeCnt(14);
int       dx     [typeCnt][4] = {
                                                                        {0,  1,  2,  3},
                                                                        {0,  0,  0,  0},
                                                                        {0,  0,  1,  2},
                                                                        {0,  1,  1,  1},
                                                                        {0,  1,  2,  2},
                                                                        {0,  0,  0,  1},
                                                                        {0,  0,  1,  2},
                                                                        {0,  0,  0,  1},

                                                                        {0,  1,  2,  2},
                                                                        {0,  1,  1,  1},
                                                                        {0,  1,  1,  1},
                                                                        {0,  1,  1,  2},
                                                                        {0,  0,  0,  1},
                                                                        {0,  1,  1,  2}
                                };
int       dy     [typeCnt][4] = {
                                                                        {0,  0,  0,  0},
                                                                        {0,  1,  2,  3},
                                                                        {0,  1,  1,  1},
                                                                        {0,  0, -1, -2},
                                                                        {0,  0,  0,  1},
                                                                        {0,  1,  2,  0},
                                                                        {0,  1,  0,  0},
                                                                        {0,  1,  2,  2},

                                                                        {0,  0,  0, -1},
                                                                        {0,  0,  1,  2},
                                                                        {0, -1,  0,  1},
                                                                        {0,  0,  1,  0},
                                                                        {0,  1,  2,  1},
                                                                        {0, -1,  0,  0}
                                };
```

```
bool can(const Bitset &bs, int x, int y, int type)
{
        for (int i(0); i < 4; ++i)
        {
                int xp(x + dx[type][i]), yp(y + dy[type][i]);
                if (xp < 0 || xp >= n || yp < 0 || yp >= m || bs(xp, yp))
                {
                        return false;
                }
        }
        return true;
}

void toggle(Bitset &bs, int x, int y, int type)
{
        for (int i(0); i < 4; ++i)
        {
                int xp(x + dx[type][i]), yp(y + dy[type][i]);
                bs(xp, yp) = !bs(xp, yp);
        }
}

void find(const Bitset &bs, int x, int y, int &xp, int &yp)
{
        xp = x;
        yp = y;
        while (xp < n && bs(xp, yp))
        {
                if (yp < m - 1)
                {
                        ++yp;
                }
                else
                {
                        yp = 0;
                        ++xp;
                }
        }
}

long long dfs(const Bitset &state, int x, int y)
{
        int id(hashFind(state));

        if (used[id])
        {
                return mem[id];
        }

        used[id] = true;
        if (x == n)
        {
                mem[id] = (int(state.data().count()) == n * m);
        }
        else
        {

                for (int i(0); i < typeCnt; ++i)
                {
                        Bitset cur(state);
                        if (can(cur, x, y, i))
                        {
                                toggle(cur, x, y, i);
                                int xp, yp;
                                find(cur, x, y, xp, yp);
                                mem[id] += dfs(cur, xp, yp);
                        }
                }
        }

        return mem[id];
}

int main()
{
        scanf("%d %d", &n, &m);
        Bitset empty;
        for (int i(0); i < n; ++i)
        {
                scanf("%s", in);
                for (int j(0); j < m; ++j)
                {
                        empty(i, j) = (in[j] == '*');
                }
        }

        int x, y;
        find(empty, 0, 0, x, y);
        printf("%lld\n", dfs(empty, x, y));
        return 0;
}
```

52 Segtree

```
// 3487

#include <cmath>

const     int maxN (300000);
constexpr int upN  (1 << int(std::ceil(std::log2(maxN)) + 1));
const     int inf  (0x3f3f3f3f);
```

```
int           min  [upN + 10];
int           cnt  [upN + 10];
int           delta[upN + 10];

void init(int node, int tl, int tr)
{
        min[node] = inf;
        cnt[node] = tr - tl + 1;
        if (tl != tr)
        {
                int mid((tl + tr) / 2);
                init(node * 2, tl, mid);
                init(node * 2 + 1, mid + 1, tr);
        }
}

void pushDown(int node, bool leaf)
{
        if (!leaf)
        {
                min[node * 2] += delta[node];
                delta[node * 2] += delta[node];
                min[node * 2 + 1] += delta[node];
                delta[node * 2 + 1] += delta[node];
        }
        delta[node] = 0;
}

void pushUp(int node)
{
        if (min[node * 2] == min[node * 2 + 1])
        {
                min[node] = min[node * 2];
                cnt[node] = cnt[node * 2] + cnt[node * 2 + 1];
        }
        else if (min[node * 2] < min[node * 2 + 1])
        {
                min[node] = min[node * 2];
                cnt[node] = cnt[node * 2];
        }
        else
        {
                min[node] = min[node * 2 + 1];
                cnt[node] = cnt[node * 2 + 1];
        }
}

void add(int node, int tl, int tr, int l, int r, int value)
{
        //if (node == 1) printf("ADD %d,%d %d\n", l, r, value);
        pushDown(node, tl == tr);
        if (l <= tl && tr <= r)
        {
                min[node] += value;
                delta[node] += value;
        }
        else
        {
                int mid((tl + tr) / 2);
                if (l <= mid) add(node * 2, tl, mid, l, r, value);
                if (r >= mid + 1) add(node * 2 + 1, mid + 1, tr, l, r, value);
                pushUp(node);
        }
}

void modify(int node, int tl, int tr, int l, int r, int value)
{
        //if (node == 1) printf("MODIFY %d,%d %d\n", l, r, value);
        pushDown(node, tl == tr);
        if (l <= tl && tr <= r)
        {
                min[node] = value;
        }
        else
        {
                int mid((tl + tr) / 2);
                if (l <= mid) modify(node * 2, tl, mid, l, r, value);
                if (r >= mid + 1) modify(node * 2 + 1, mid + 1, tr, l, r, value);
                pushUp(node);
        }
}
```

53 Segtree offline

```
// 1677

#include <cstdio>
#include <cstring>
#include <cmath>
#include <algorithm>
#include <map>
#include <list>

std::map<std::pair<int, int>, int> t;
std::list<std::pair<int, int> >    link  [200000 * 4 + 10];
std::pair<int, int>                query [200000     + 10];
int                                result[200000     + 10];
int                                father[10000 + 10];
int                                size  [10000 + 10];

int read()
{
        char ch;
        do ch = getchar();
        while (ch < '0' || ch > '9');

        int ret(0);
        while (ch >= '0' && ch <= '9')
        {
                ret = ret * 10 + static_cast<int>(ch - '0');
                ch = getchar();
        }
        return ret;
}

char readCmd()
{
        char ch;
        do ch = getchar();
        while (ch < 'A' || ch > 'Z');
        return ch;
}

void insert(int node, int left, int right, int oLeft, int oRight, const std::pair<int,
↪   int> &pair)
{
        //printf("%d %d %d %d\n", left, right, oLeft, oRight);
        //system("pause");
        if (left >= oLeft && right <= oRight)
        {
                link[node].push_back(pair);
                return;
        }

        int mid((left + right) / 2);
        if (oLeft <= mid)
                insert(node * 2, left, mid, oLeft, oRight, pair);
        if (oRight > mid)
                insert(node * 2 + 1, mid + 1, right, oLeft, oRight, pair);
}

int getFather(int index)
{
        while (father[index] != index)
                index = father[index];
        return index;
}

void simulate(int node, int left, int right, std::list<std::pair<int, int> >::iterator
↪   it)
{
        //printf("%d %d\n", left, right);
        int fa1, fa2;
        bool sameTree(true);
        if (it != link[node].end())
        {
                fa1 = getFather(it->second);
                fa2 = getFather(it->first);
                sameTree = (fa1 == fa2);
        }
        if (!sameTree)
        {
                if (size[fa1] < size[fa2])
                        std::swap(fa1, fa2);
                father[fa2] = fa1;
                  size[fa1] += size[fa2];
        }

        if (it != link[node].end() && ++it != link[node].end())
        {
                simulate(node, left, right, it);
        }
        else if (left < right)
        {
                int mid((left + right) / 2);
                simulate(node * 2, left, mid, link[node * 2].begin());
                simulate(node * 2 + 1, mid + 1, right, link[node * 2 + 1].begin());
        }
        else if (query[left].first != 0)
        {
                //printf("%d %d\n", getFather(query[left].first),
↪   getFather(query[left].second));
                result[left] = (getFather(query[left].first) ==
↪   getFather(query[left].second));
        }

        if (!sameTree)
        {
                father[fa2] = fa2;
                size[fa1] -= size[fa2];
        }
}

int main()
{
        int n(read()), m(read());
        for (int i(1); i <= m; ++i)
        {
                char cmd(readCmd());
                std::pair<int, int> pair;
                pair.first = read();
                pair.second = read();
                if (pair.first > pair.second)
                        std::swap(pair.first, pair.second);
```

```
			if (cmd == 'C')
			{
				t[pair] = i;
			}
			else if (cmd == 'D')
			{
				insert(1, 1, m, t[pair], i, pair);
				t[pair] = 0;
			}
			else
			{
				query[i] = pair;
			}
		}

		for (std::map<std::pair<int, int>, int>::iterator it(t.begin()); it != t.end();
↪	++it)
		{
			if (it->second != 0)
				insert(1, 1, m, it->second, m, it->first);
		}

		memset(result, -1, sizeof(result));
		for (int i(1); i <= n; ++i)
		{
			father[i] = i;
			size[i] = 1;
		}
		simulate(1, 1, m, link[1].begin());

		for (int i(1); i <= m; ++i)
		{
			if (result[i] == 0)
				printf("No\n");
			else if (result[i] == 1)
				printf("Yes\n");
		}
		return 0;
}
```

54 Segtree straddle

```
// 5276

#include <cstdio>
#include <algorithm>
#include <deque>

const int maxN(2000 + 10);
char      in  [maxN];
int       max [maxN];
int       lMin[maxN][maxN];
int       rMin[maxN][maxN];

int n, m, k;

void init(int tl, int tr)
{
        if (tl > tr) return;

        int mid((tl + tr) / 2);
        max[mid] = std::max(mid - tl + 1, tr - mid);
        for (int y(1); y <= m; ++y)
        {
                lMin[mid][y] = mid - tl + 1;
                rMin[mid][y] = tr - mid;
        }

        if (tl < tr)
        {
                init(tl, mid - 1);
                init(mid + 1, tr);
        }
}

void update(int tl, int tr, int x, int y)
{
        if (tl > tr) return;

        int mid((tl + tr) / 2);
        if (x == mid)
        {
                lMin[mid][y] = rMin[mid][y] = 0;
        }
        else if (x < mid)
        {
                lMin[mid][y] = std::min(lMin[mid][y], mid - x);
        }
        else
        {
                rMin[mid][y] = std::min(rMin[mid][y], x - mid - 1);
        }

        max[mid] = 0;
        if (x < mid)
        {
                update(tl, mid - 1, x, y);

        }
        else if (x > mid)
        {
                update(mid + 1, tr, x, y);
        }

        max[mid] = 0;
        if (tl <= mid - 1)
        {
                max[mid] = std::max(max[mid], max[(tl + mid - 1) / 2]);
        }
        if (mid + 1 <= tr)
        {
                max[mid] = std::max(max[mid], max[(mid + 1 + tr) / 2]);
        }

//        printf("update: [%d,%d]\n", tl, tr);

        std::deque<int> lQueue, rQueue;
        for (int l(1), r(1); r <= m; ++r)
        {
                while (!lQueue.empty() && lMin[mid][r] <= lMin[mid][lQueue.back()])
                {
                        lQueue.pop_back();
                }
                lQueue.push_back(r);

                while (!rQueue.empty() && rMin[mid][r] <= rMin[mid][rQueue.back()])
                {
                        rQueue.pop_back();
                }
                rQueue.push_back(r);

//                printf("(%d,%d)", lQueue.front(), rQueue.front());
                while (!lQueue.empty() && !rQueue.empty() && r - l + 1 >
↪   lMin[mid][lQueue.front()] + rMin[mid][rQueue.front()])
                {
                        ++l;
                        if (l > lQueue.front()) lQueue.pop_front();
                        if (l > rQueue.front()) rQueue.pop_front();
                }
//                printf("[%d,%d] ", l, r);
                max[mid] = std::max(max[mid], r - l + 1);
        }
//        printf("\n");
}

void print(int tl, int tr)
{
        if (tl > tr) return;

        printf("[%d,%d]\n", tl, tr);
        int mid((tl + tr) / 2);
        for (int x(1); x <= n; ++x)
        {
                for (int y(1); y <= m; ++y)
                {
                        if (x <= mid)
                        {
                                if (mid - x + 1 <= lMin[mid][y])
                                {
                                        printf("L");
                                }
                                else
                                {
                                        printf(".");
                                }
                        }
                        else
                        {
                                if (x - mid <= rMin[mid][y])
                                {
                                        printf("R");
                                }
                                else
                                {
                                        printf(".");
                                }
                        }
                }
                printf("\n");
        }

        if (tl < tr)
        {
                print(tl, mid - 1);
                print(mid + 1, tr);
        }
}

int main()
{
        scanf("%d %d %d", &n, &m, &k);
        init(1, n);
        for (int x(1); x <= n; ++x)
        {
                scanf("%s", in + 1);
                for (int y(1); y <= m; ++y)
                {
                        if (in[y] == 'X')
                        {
                                update(1, n, x, y);
                        }
                }
        }
        //print(1, n);
        for (int qqq(1); qqq <= k; ++qqq)
        {
                int x, y;
                scanf("%d %d", &x, &y);
                update(1, n, x, y);
                printf("%d\n", max[(1 + n) / 2]);
        }

        return 0;
}
```

55 Seg intersect

```
// 2470

#include <cstdio>
#include <utility>
#include <cmath>
#include <algorithm>
#include <set>
#include <iostream>
#include <cstdlib>

struct Vec
{
        long long x;
        long long y;
};

Vec operator-(const Vec &a, const Vec &b)
{
        Vec t = {a.x - b.x, a.y - b.y};
        return t;
}

long long cross(const Vec &a, const Vec &b)
{
        return a.x * b.y - a.y * b.x;
}

const int maxN(100010);
typedef std::pair<Vec, Vec>  Seg;
typedef std::pair<int, bool> EndPoint;
typedef std::set<int>::iterator It;
Seg      seg     [maxN    ];
EndPoint endpoint[maxN * 2];

bool cmpEndpoint(const EndPoint &a, const EndPoint &b)
{
        Vec p1(a.second == 0 ? seg[a.first].first : seg[a.first].second);
        Vec p2(b.second == 0 ? seg[b.first].first : seg[b.first].second);
        //std::cout << '!' << p1.x << ' ' << p2.x  << '\n';
        if (p1.x != p2.x)
                return p1.x < p2.x;
        else if (a.second != b.second)
                return a.second < b.second;
        else
                return p1.y < p2.y;
}

bool intersect(int a, int b)
{
        if (a == b)
        {
                //std::cout << seg[endpoint[ttt].first].first.x << ',' <<
↪   seg[endpoint[ttt].first].first.y << ' '
                //            << seg[endpoint[ttt].first].second.x << ',' <<
↪   seg[endpoint[ttt].first].second.y << '\n';
                  std::cout << "WTF?\n";
          }

        long long d1(cross(seg[a].first - seg[b].first, seg[b].second - seg[b].first));
        long long d2(cross(seg[a].second - seg[b].first, seg[b].second - seg[b].first));
        long long d3(cross(seg[b].first - seg[a].first, seg[a].second - seg[a].first));
        long long d4(cross(seg[b].second - seg[a].first, seg[a].second - seg[a].first));

        //std::cout << "XXX " << d1 << ' ' << d2 << ' ' << d3 << ' ' << d4 << '\n';
        if (((d1 >= 0 && d2 <= 0) || (d1 <= 0 && d2 >= 0)) && ((d3 >= 0 && d4 <= 0) ||
↪   (d3 <= 0 && d4 >= 0)))
        {
                if (a > b) std::swap(a, b);
                printf("%d %d\n", a, b);
                return true;
        }
        else
        {
                return false;
        }
}

bool cmpSeg(int a, int b)
{
        if (a == b)
                return false;
        if (intersect(a, b))
                exit(0);

        if (seg[a].first.x < seg[b].first.x)
        {
                return cross(seg[a].first - seg[b].first, seg[a].second - seg[b].first)
↪   >= 0;
```

```
        }
        else
        {
                return cross(seg[b].first - seg[a].first, seg[b].second - seg[a].first) <
↪   0;
        }
}

std::set<int, bool(*)(int, int)> set(cmpSeg);

int main()
{
        int n;
        scanf("%d", &n);
        for (int i(1); i <= n; ++i)
        {
                scanf("%lld %lld %lld %lld", &seg[i].first.x, &seg[i].first.y,
↪   &seg[i].second.x, &seg[i].second.y);
                if (seg[i].first.x > seg[i].second.x) std::swap(seg[i].first,
↪   seg[i].second);
                endpoint[i * 2 - 1] = std::make_pair(i, 0);
                endpoint[i * 2] = std::make_pair(i, 1);
        }
        std::sort(endpoint + 1, endpoint + n * 2 + 1, cmpEndpoint);

        for (int i(1); i <= n * 2; ++i)
        {
                //std::cout << i << ' ' << endpoint[i].first << ' ' << endpoint[i].second
↪   << '\n';
                if (endpoint[i].second == 0)
                {
                        set.insert(endpoint[i].first);
                }
                else
                {
                        It it(set.find(endpoint[i].first));
                        if (it == set.end())
                                continue;
                        It pre(it);
                        set.erase(it);
                        if (pre != set.begin())
                        {
                                --pre;
                                It suc(pre);
                                ++suc;
                                //if (pre == suc)
                                //        std::cout << "XXX\n";
                                if (suc != set.end())
                                {
                                        if (intersect(*pre, *suc))
                                                return 0;
                                }
                        }
                }
        }

        return 0;
}
```

56 Spfa

```
#include <cstdio>
#include <iostream>
#include <algorithm>
#include <cstring>
#include <queue>

int       start[20 + 10];
int       to             [400000 + 10];
int       pre            [400000 + 10];
long long len            [400000 + 10];
int       last           [100000 + 10];
long long dist [20 + 10] [100000 + 10];
long long minDist        [100000 + 10];
bool      far            [100000 + 10];
bool      in             [100000 + 10];
bool      dp             [1 << 20];

int n, m, k;
const long long maxByte(0x30);
const long long mod(998244353);
std::queue<int> queue;

void spfa(int origin, long long d[100000 + 10])
{
        d[origin] = 0;
        queue.push(origin);
        in[origin] = true;
        while (!queue.empty())
        {
                for (int i(last[queue.front()]); i != 0; i = pre[i])
                {
                        if (d[to[i]] > d[queue.front()] + len[i])
                        {
                                d[to[i]] = d[queue.front()] + len[i];
                                if (!in[to[i]])
                                {
                                        queue.push(to[i]);
                                        in[to[i]] = true;
                                }
                        }
                }
                in[queue.front()] = false;
                queue.pop();
        }
}

int main()
{
        std::cin >> n >> m >> k;
        for (int i(0); i < k; ++i)
                std::cin >> start[i];

        for (int i(1); i <= m; ++i)
        {
                int x, y, l;
                std::cin >> x >> y >> l;
                to[i * 2 - 1] = y;
                len[i * 2 - 1] = l;
                pre[i * 2 - 1] = last[x];
                last[x] = i * 2 - 1;

                to[i * 2] = x;
                len[i * 2] = l;
                pre[i * 2] = last[y];
                last[y] = i * 2;
        }

        memset(minDist, maxByte, sizeof(minDist));
        for (int i(0); i < k; ++i)
        {
                memset(dist[i], maxByte, sizeof(dist[i]));
                spfa(start[i], dist[i]);
                for (int j(1); j <= n; ++j)
                        minDist[j] = std::min(minDist[j], dist[i][j]);
        }

        /*for (int i(0); i < k; ++i)
        {
                for (int j(1); j <= n; ++j)
                        std::cout << dist[i][j] << ' ';
                std::cout << std::endl;
        }// */

        long long max(0);
        for (int j(1); j <= n; ++j)
                max = std::max(max, minDist[j]);
        for (int j(1); j <= n; ++j)
        {
                int state(0);
                for (int i(0); i < k; ++i)
                {
                        if (dist[i][j] <= max)
                                state |= 1 << i;
                }
                dp[state] = true;
                //std::cout << state << std::endl;
        }

        int count(0);
        for (int i(0); i < (1 << k); ++i)
        {
                if (dp[i])
                        ++count;
                for (int j(0); j < k; ++j)
                        dp[i | (1 << j)] = dp[i | (1 << j)] || dp[i];
        }

        long long base(1 << k), power(mod - 2);
        long long denom(1);
        for (long long i(1), mult(base); i <= power; i *= 2, mult = mult * mult % mod)
        {
                if (power & i)
                        denom = denom * mult % mod;
        }

        //std::cout << count << std::endl;
        std::cout << ((1 << k) - count) * denom % mod << std::endl;
        return 0;
}
```

57 Splay

```
#include <iostream>
#include <cstdlib>
#include <vector>
#include <limits>
#include <set>
#include <ctime>

class Splay
{
public:
        static const std::size_t empty;

        struct Node
        {
                int         value;
                std::size_t parent;
                std::size_t child[2];
                Node(int value, std::size_t parent)        : value(value), parent(parent)
                {
                        child[0] = empty;
```

```
				child[1] = empty;
			}

			std::size_t& operator[](bool index)
			{
				return child[index];
			}
		};

	private:
		std::size_t       root;
		std::vector<Node> data;

		void print(std::size_t node, int depth)
		{
			for (int i(0); i < depth; ++i)
				std::cout << '\t';
			if (node == empty)
			{
				std::cout << "NULL\n";
			}
			else
			{
				std::cout << node << ": " << data[node].value << '\n';
				print(data[node][0], depth + 1);
				print(data[node][1], depth + 1);
			}
		}

		bool getSide(std::size_t node)
		{
			return node == data[data[node].parent][1];
		}

		void rotate(std::size_t node)
		{
			std::size_t parent(data[node].parent);
			bool side(getSide(node));
			bool sideParent(getSide(parent));
			data[parent][side] = data[node][!side];
			if (data[parent][side] != empty)
				data[data[parent][side]].parent = parent;
			data[node][!side] = parent;

			data[node].parent = data[parent].parent;
			if (data[node].parent != empty)
				data[data[node].parent][sideParent] = node;
			data[parent].parent = node;
		}

		void splay(std::size_t node)
	{
		std::size_t parent;
		std::size_t grandparent;
		while (parent = data[node].parent, parent != empty)
		{
			grandparent = data[parent].parent;
			if (grandparent != empty)
			{
				bool side(getSide(node));
				bool sideParent(getSide(parent));
				if (side == sideParent)
					rotate(parent);
				else
					rotate(node);
			}
			rotate(node);
		}
		root = node;
	}

public:
	Splay(std::size_t reserve = 1) : root(empty)
	{
		data.reserve(reserve);
	}

	const Node& operator[](std::size_t index)
	{
		return data[index];
	}

	void print()
	{
		print(root, 0);
	}

	std::size_t find(int value, bool getPred = false)
	{
		std::size_t node(root), pred(empty);
		while (node != empty && data[node].value != value)
		{
			pred = node;
			if (value < data[node].value)
				node = data[node][0];
			else
				node = data[node][1];
		}

		if (getPred)
		{
			return pred;
```

```
        }
        else
        {
                if (node != empty)
                        splay(node);
                return node;
        }
}

void insert(int value)
{
        std::size_t pred(find(value, true));
        if (pred != empty)
        {
                if (value < data[pred].value)
                {
                        if (data[pred][0] != empty)
                                return;
                        else
                                data[pred][0] = data.size();
                }
                else
                {
                        if (data[pred][1] != empty)
                                return;
                        else
                                data[pred][1] = data.size();
                }
        }
        else if (root != empty)
        {
                return;
        }
        data.push_back(Node(value, pred));
        splay(data.size() - 1);
}

void erase(int value)
{
        std::size_t node(find(value));
        if (node != empty)
        {
                splay(node);

                if (data[root][0] == empty)
                {
                        if (data[root][1] != empty)
                                data[data[root][1]].parent = empty;
                        root = data[root][1];
                }
                else
```

```
                        {
                                std::size_t oldRoot(root);
                                data[data[root][0]].parent = empty;
                                std::size_t max(data[root][0]);
                                while (data[max][1] != empty)
                                        max = data[max][1];
                                splay(max);
                                data[oldRoot][0] = root;
                                root = oldRoot;

                                if (data[root][1] != empty)
                                        data[data[root][1]].parent = data[root][0];
                                data[data[root][0]][1] = data[root][1];
                                root = data[root][0];
                        }
                }
        }
};

const std::size_t Splay::empty(std::numeric_limits<std::size_t>::max());

bool getRandBool()
{
        return static_cast<bool>(rand() & 1);
}

int getRand()
{
        int a(rand());
        int b(rand() % 53);
        int c(rand() << 3);
        int sign(getRandBool() ? 1 : -1);
        return ((a * b) ^ c) * sign;
}

int main()
{
        std::set<int> control;
        Splay test(100000000);

        srand(time(0));
        int task(1000);
        int taskSize(100000);

        double beg(std::clock());
        for (int t(0); t < task; ++t)
        {
                std::cout << t << '\n';
                for (int i(0); i < taskSize; ++i)
                {
                        int n0(getRand());
                        if (getRandBool())
                        {
                                control.insert(n0);
                                test.insert(n0);
                        }
                        else
                        {
                                control.erase(n0);
                                test.erase(n0);
                        }

                        int n1(getRand());
                        if (control.count(n1) != (test.find(n1) != Splay::empty))
                        {
                                std::cout << "Task Failed: " << i << " lookup=" << n1 <<
↪  ' ' << control.count(n1) << ' ' << test.find(n1) << std::endl;
                                //test.print();
                                goto fail;
                        }
                }
        }
        fail:
        double end(std::clock());

        std::cout << (end - beg) / CLOCKS_PER_SEC << std::endl;

        return 0;
}
```

58 Sqrt block

```
// 4343

#include <cstdio>
#include <cstdlib>
#include <cmath>
#include <algorithm>
#include <vector>
#include <cctype>
#include <iostream>

struct Question
{
        int type;
        int l;
        int r;
        long long v;
};

const int maxN (200000 + 10);
```

```
long long a    [maxN];
long long delta[maxN];
long long data [maxN];
Question  quest[maxN];

int n;
int size;

long long read()
{
        char ch(0), sign(0);
        do
        {
                sign = ch;
                ch = getchar();
        }
        while (!isdigit(ch));
        long long x(0);
        while (isdigit(ch))
        {
                x = x * 10 + int(ch - '0');
                ch = getchar();
        }
        return sign == '-' ? -x : x;
}

double cnt1, cnt2;
double sum1, sum2;

double f(double x)
{
        return 5 * cnt1 * x * std::max(std::log(x) / std::log(2), 1.0) + sum1 / x + 5 *
↪  cnt2  * x + sum2 / x * std::max(std::log(x) / std::log(2), 1.0);
}

void getSize()
{
        size = 1;
        for (int i(2); i <= n; ++i)
        {
                if (f(i) < f(size))
                {
                        size = i;
                }
        }
}

void rebuild(int block)
{
        for (int i(block * size); i <= n && i / size == block; ++i)
        {
                data[i] = a[i];
        }
        std::sort(&data[block * size], &data[(block + 1) * size]);
}

void add(int l, int r, long long v)
{
        int blkBeg(l / size), blkEnd(r / size);
        for (int i(l); i <= r && i / size == blkBeg; ++i)
        {
                a[i] += v;
        }
        rebuild(blkBeg);

        if (blkBeg < blkEnd)
        {
                for (int i(r); i >= l && i / size == blkEnd; --i)
                {
                        a[i] += v;
                }
                rebuild(blkEnd);
        }
        for (int block(blkBeg + 1); block <= blkEnd - 1; ++block)
        {
                delta[block] += v;
        }
}

int query(int l, int r, long long k)
{
        int ans(0);
        int blkBeg(l / size), blkEnd(r / size);

        for (int i(l); i <= r && i / size == blkBeg; ++i)
        {
                if (delta[blkBeg] + a[i] <= k)
                {
                        ++ans;
                }
        }
        if (blkBeg < blkEnd)
        {
                for (int i(r); i >= l && i / size == blkEnd; --i)
                {
                        if (delta[blkEnd] + a[i] <= k)
                        {
                                ++ans;
                        }
                }
        }
        for (int block(blkBeg + 1); block <= blkEnd - 1; ++block)
        {
                ans += std::upper_bound(&data[block * size], &data[(block + 1) * size], k
↪   - delta[block]) - &data[block * size];
        }
        return ans;
}

int main()
{
        //freopen("ds.in", "r", stdin);
        //freopen("ds.out", "w", stdout);

        n = read();
        for (int i(0); i < n; ++i)
        {
                a[i] = read();
        }

        int m(read());
        for (int qqq(1); qqq <= m; ++qqq)
        {
                quest[qqq].type = read();
                quest[qqq].l = read();
                quest[qqq].r = read();
                quest[qqq].v = read();
                if (quest[qqq].type == 1)
                {
                        ++cnt1;
                        sum1 += quest[qqq].r - quest[qqq].l + 1;
                }
                else
                {
                        ++cnt2;
                        sum2 += quest[qqq].r - quest[qqq].l + 1;
                }
        }

        getSize();

        std::cerr << size << '\n';

        for (int i(0); i <= (n - 1) / size; ++i)
        {
                rebuild(i);
        }

        for (int qqq(1); qqq <= m; ++qqq)
        {
                if (quest[qqq].type == 1)
                {
```

```
                                add(quest[qqq].l - 1, quest[qqq].r - 1, quest[qqq].v);
                        }
                        else
                        {
                                printf("%d\n", query(quest[qqq].l - 1, quest[qqq].r - 1,
↪   quest[qqq].v));
                        }
                }
                return 0;
}
```

59 Sqrt graph

```
// 5192

#include <cstdio>
#include <algorithm>
#include <vector>
#include <cmath>
#include <utility>

struct Query
{
        int x;
        int v;
};

const int               maxN        (2 * 100000 + 10);
int                     n, q;
int                     orderedSize;
int                     crit;
long long               ans;
int                     a           [maxN];
int                     cur         [maxN];
long long               ordered     [maxN];
int                     degree      [maxN];
Query                   query       [maxN];
std::vector<int>        edge        [maxN];
std::vector<int>        large       [maxN];
std::vector<int>        bitCnt      [maxN];
std::vector<long long> bitVal      [maxN];

int myLog2(int x)
{
        int cur(1), result(0);
        while (cur < x)
        {
                cur *= 2;
                ++result;
        }
        return result;
```

```
}

int getIndex(long long value)
{
        return std::lower_bound(ordered + 1, ordered + orderedSize + 1, value) - ordered;
}

int lowbit(int x)
{
        return x & (-x);
}

void add(int id, int pos, int cnt, long long value)
{
        if (pos == 0) return;

        while (pos <= orderedSize)
        {
                bitCnt[id][pos] += cnt;
                bitVal[id][pos] += value;
                pos += lowbit(pos);
        }
}

long long queryCnt(int id, int pos)
{
        long long sum(0);
        while (pos > 0)
        {
                sum += bitCnt[id][pos];
                pos -= lowbit(pos);
        }
        return sum;
}

long long queryVal(int id, int pos)
{
        long long sum(0);
        while (pos > 0)
        {
                sum += bitVal[id][pos];
                pos -= lowbit(pos);
        }
        return sum;
}

long long calc(int v)
{
        long long sum(0);
        if (degree[v] <= crit)
        {
                for (std::size_t e(0); e < edge[v].size(); ++e)
                {
                        int to(edge[v][e]);
                        sum += std::min(ordered[cur[v]], ordered[cur[to]]);
                }
        }
        else
        {
                sum += (queryCnt(v, orderedSize) - queryCnt(v, cur[v])) *
↪  ordered[cur[v]];
                sum += queryVal(v, cur[v]);
        }

        return sum;
}

void update(int v, int value)
{
        //printf("update: %d with %lld\n", v, ordered[cur[v]]);

        //printf("erase: %lld %lld\n", -ordered[cur[v]], calc(v));

        ans -= ordered[cur[v]];
        ans += calc(v);

        for (std::size_t e(0); e < large[v].size(); ++e)
        {
                int to(large[v][e]);
                add(to, cur[v], -1, -ordered[cur[v]]);
                add(to, value, 1, ordered[value]);
        }
        cur[v] = value;

        //printf("add: %lld %lld\n", ordered[cur[v]], -calc(v));

        ans += ordered[cur[v]];
        ans -= calc(v);
}

int main()
{
//        freopen("sorry.in", "r", stdin);
//        freopen("sorry.out", "w", stdout);

        scanf("%d %d", &n, &q);
        for (int v(1); v <= n; ++v)
        {
                scanf("%d", &a[v]);
                ordered[++orderedSize] = a[v];
        }
        for (int e(1); e <= n - 1; ++e)
```

```
{
        int u, v;
        scanf("%d %d", &u, &v);
        edge[u].push_back(v);
        edge[v].push_back(u);
        ++degree[u];
        ++degree[v];
}
for (int qqq(1); qqq <= q; ++qqq)
{
        scanf("%d %d", &query[qqq].x, &query[qqq].v);
        ordered[++orderedSize] = query[qqq].v;
}

std::sort(ordered + 1, ordered + orderedSize + 1);
orderedSize = std::unique(ordered + 1, ordered + orderedSize + 1) - ordered - 1;
for (int v(1); v <= n; ++v)
{
        a[v] = getIndex(a[v]);
}
for (int qqq(1); qqq <= q; ++qqq)
{
        query[qqq].v = getIndex(query[qqq].v);
}

crit = sqrt(2 * (n - 1) * myLog2(orderedSize));
for (int v(1); v <= n; ++v)
{
        for (std::size_t e(0); e < edge[v].size(); ++e)
        {
                int to(edge[v][e]);
                if (degree[to] > crit)
                {
                        large[v].push_back(to);
                }
        }
}
for (int v(1); v <= n; ++v)
{
        if (degree[v] > crit)
        {
                bitCnt[v].resize(orderedSize + 1);
                bitVal[v].resize(orderedSize + 1);
        }
}

for (int v(1); v <= n; ++v)
{
        update(v, a[v]);
}
```

```
        for (int qqq(1); qqq <= q; ++qqq)
        {
                update(query[qqq].x, query[qqq].v);
                printf("%lld\n", ans);
        }
        return 0;
}
```

60 St

```
#include <algorithm>

const int maxN  (1000000);
const int maxLbN(20);

int a [maxN];
int lb[maxN];
int f [maxLbN][maxN];

int n;

int query(int l, int r)
{
        int lbLen(lb[r - l + 1]);
        return std::max(f[lbLen][l], f[lbLen][r - (1 << lbLen) + 1]);
}

void init()
{
        lb[0] = -1;
        for (int i(1); i <= n; ++i)
        {
                lb[i] = lb[i / 2] + 1;
        }

        for (int i(1); i <= n; ++i)
        {
                f[0][i] = a[i];
        }
        for (int i(1); i < maxLbN; ++i)
        {
                for (int j(1); j + (1 << i) - 1 <= n; ++j)
                {
                        f[i][j] = std::max(f[i - 1][j], f[i - 1][j + (1 << (i - 1))]);
                }
        }
}
```

61 Tarjan cut edge

```
const int SIZE = 100010;
int head[SIZE], ver[SIZE * 2], Next[SIZE * 2];
int dfn[SIZE], low[SIZE], n, m, tot, num;
bool bridge[SIZE * 2];

void add(int x, int y)
{
        ver[++tot] = y, Next[tot] = head[x], head[x] = tot;
}

void tarjan(int x, int in_edge)
{
        dfn[x] = low[x] = ++num;
        for (int i = head[x]; i; i = Next[i])
        {
                int y = ver[i];
                if (!dfn[y])
                {
                        tarjan(y, i);
                        low[x] = min(low[x], low[y]);

                        if (low[y] > dfn[x])
                                bridge[i] = bridge[i ^ 1] = true;
                }
                else if (i != (in_edge ^ 1))
                        low[x] = min(low[x], dfn[y]);
        }
}

int main()
{
        cin >> n >> m;
        tot = 1;
        for (int i = 1; i <= m; ++i)
        {
                int x, y;
                scanf("%d%d", &x, &y);
                add(x, y), add(y, x);
        }
        for (int i = 1; i <= n; ++i)
                if (!dfn[i]) tarjan(i, 0);
        for (int i = 2; i < tot; i += 2)
                if (bridge[i])
                        printf("%d %d\n", ver[i ^ 1], ver[i]);
}
```

62 Tarjan cut vertex

```
const int SIZE = 100010;
int head[SIZE], ver[SIZE * 2], Next[SIZE * 2];
int dfn[SIZE], low[SIZE], stack[SIZE];
int n, m, tot, num, root;
bool cut[SIZE];

void add(int x, int y)
{
        ver[++tot] = y, Next[tot] = head[x], head[x] = tot;
}

void tarjan(int x)
{
        dfn[x] = low[x] = ++num;
        int flag = 0;
        for (int i = head[x]; i; i = Next[i])
        {
                int y = ver[i];
                if (!dfn[y])
                {
                        tarjan(y);
                        low[x] = min(low[x], low[y]);
                        if (low[y] >= dfn[x])
                        {
                                ++flag;
                                if (x != root || flag > 1) cut[x] = true;
                        }
                }
                else low[x] = min(low[x], dfn[y]);
        }
}

int main()
{
        cin >> n >> m;
        tot = 1;
        for (int i = 1; i <= m; ++i)
        {
                int x, y;
                scanf("%d%d", &x, &y);
                if (x == y) continue;
                add(x, y), add(y, x);
        }
        for (int i = 1; i <= n; ++i)
                if (!dfn[i]) root = i, tarjan(i);
        for (int i = 1; i <= n; ++i)
                if (cut[i]) printf("%d ", i);
        puts("are cut-vertexes");
}
```

63 Tarjan e dcc find

```
int c[SIZE], dcc;
void dfs(int x)
{
        c[x] = dcc;
        for (int i = head[x]; i; i = Next[i])
        {
                int y = ver[i];
                if (c[y] || bridge[i]) continue;
                dfs(y);
        }
}

for (int i = 1; i <= n; ++i)
{
        if (!c[i])
        {
                ++dcc;
                dfs(i);
        }
}
printf("There are %d e-DCCs. \n", dcc);
for (int i = 1; i <= n; ++i)
        printf("%d belongs to DCC %d.\n", i, c[i]);
```

64 Tarjan e dcc shrink

```
int hc[SIZE], vc[SIZE * 2], nc[SIZE * 2], tc;
void add_c(int x, int y)
{
        vc[++tc] = y, nc[tc] = hc[x], hc[x] = tc;
}

tc = 1;
for (int i = 2; i <= tot; ++i)
{
        int x = ver[i ^ 1], y = ver[i];
        if (c[x] == c[y]) continue;
        add_c(c[x], c[y]);
}

printf("Vertices %d, Edges %d\n", dcc, tc / 2);
for (int i = 2; i < tc; ++i)
        printf("%d %d\n", vc[i ^ 1], vc[i]);
```

65 Tarjan scc find

```
const int N = 100010, M = 1000010;
int ver[M], Next[M], head[N], dfn[N], low[N];
int stack[N], ins[N], c[N];
vector<int> scc[N];
int n, m, tot, num, top, cnt;

void add(int x, int y)
{
        ver[++tot] = y, Next[tot] = head[x], head[x] = tot;
}

void tarjan(int x)
{
        dfn[x] = low[x] = ++num;
        stack[++top] = x, ins[x] = 1;
        for (int i = head[x]; i; i = Next[i])
        {
                if (!dfn[ver[i]])
                {
                        tarjan(ver[i]);
                        low[x] = min(low[x], low[ver[i]]);
                }
                else if (ins[ver[i]])
                        low[x] = min(low[x], low[ver[i]]);
        }

        if (dfn[x] == low[x])
        {
                ++cnt; int y;
                do
                {
                        y = stack[top--], ins[y] = 0;
                        c[y] = cnt, scc[cnt].push_back(y);
                }
                while(x != y);
        }
}

int main()
{
        cin >> n >> m;
        for (int i = 1; i <= m; ++i)
        {
                int x, y;
                scanf("%d%d", &x, &y);
                add(x, y);
        }
        for (int i = 1; i <= n; ++i)
                if (!dfn[i]) tarjan(i);
}
```

66 Tarjan scc shrink

```
void add_c(int x, int y)
{
        vc[++tc] = y, nc[tc] = hc[x], hc[x] = tc;
}

for (int x = 1; x <= n; ++x)
{
        for (int i = head[x]; i; i = Next[i])
        {
                int y = ver[i];
                if (c[x] == c[y]) continue;
                add_c(c[x], c[y]);
        }
}
```

67 Tarjan v dcc find

```
void tarjan(int x)
{
        dfn[x] = low[x] = ++num;
        stack[++top] = x;
        if (x == root && head[x] == 0)
        {
                dcc[++cnt].push_back(x);
                return;
        }

        int flag = 0;
        for (int i = head[x]; i; i = Next[i])
        {
                int y = ver[i];
                if (!dfn[y])
                {
                        tarjan(y);
                        low[x] = min(low[x], low[y]);
                        if (low[y] >= dfn[x])
                        {
                                ++flag;
                                if (x != root || flag > 1) cut[x] = true;
                                ++cnt;
                                int z;
                                do
                                {
                                        z = stack[top--];
                                        dcc[cnt].push_back(z);
                                }
                                while (z != y);
                                dcc[cnt].push_back(x);
                        }
                }
                else low[x] = min(low[x], dfn[y]);
        }
}

for (int i = 1; i <= cnt; ++i)
{
        printf("e-DCC #%d:", i);
        for (int j = 0; j < dcc[i].size(); ++j)
                printf(" %d", dcc[i][j]);
        puts("");
}
```

68 Tarjan v dcc shrink

```
num = cnt;
for (int i = 1; i <= n; ++i)
        if (cut[i]) new_id[i] = ++num;

tc = 1;
for (int i = 1; i <= cnt; ++i)
{
        for (int j = 0; j < dcc[i].size(); ++j)
        {
                int x = dcc[i][j];
                if (cut[x])
                {
                        add_c(i, new_id[x]);
                        add_c(new_id[x], i);
                }
                else c[x] = i;
        }
}

printf("Vertices %d, Edges %d\n", num, tc / 2);
for (int i = 2; i < tc; i += 2)
        printf("%d %d\n", vc[i ^ 1], vc[i]);
```

69 Topo sort

```
// 4602

#include <cstdio>
#include <iostream>
#include <cstring>
#include <queue>
#include <utility>
#include <bitset>
#include <vector>
#include <cstdio>
```

```
int       n, m;
long long ans(0);
int       to  [1200000 + 10];
int       pre [1200000 + 10];
long long cost[1200000 + 10];
int       last[30000   + 10];
long long dist[30000   + 10];
bool      go  [30000   + 10];
long long deg [30000   + 10];

struct Cmp
{
        bool operator()(int a, int b)
        {
                return dist[a] > dist[b];
        }
};

std::bitset<30000 + 10> state[30000 + 10];
std::queue<int> queue;
std::priority_queue<int, std::vector<int>, Cmp> pqueue;

void dijkstra()
{
        memset(dist, 0x30, sizeof(dist));
        dist[1] = 0;
        pqueue.push(1);

        while (!pqueue.empty())
        {
                if (!go[pqueue.top()])
                {
                        go[pqueue.top()] = true;
                        for (int i(last[pqueue.top()]); i != -1; i = pre[i])
                        {
                                if (!go[to[i]] && dist[to[i]] > dist[pqueue.top()] +
↪   cost[i])
                                {
                                        dist[to[i]] = dist[pqueue.top()] + cost[i];
                                        pqueue.push(to[i]);
                                }
                        }
                }
                pqueue.pop();
        }
}

void init()
{
        memset(deg, -1, sizeof(deg));
        deg[n] = 0;
        queue.push(n);
        while (!queue.empty())
        {
                for (int i(last[queue.front()]); i != -1; i = pre[i])
                {
                        if (dist[queue.front()] == dist[to[i]] + cost[i])
                        {
                                if (deg[to[i]] == -1)
                                {
                                        deg[to[i]] = 1;
                                        queue.push(to[i]);
                                }
                                else
                                {
                                        ++deg[to[i]];
                                }
                        }
                }
                queue.pop();
        }
}

void topoSort()
{
        queue.push(n);
        while (!queue.empty())
        {
                ans += state[queue.front()].count();
                  state[queue.front()].set(queue.front());

                for (int i(last[queue.front()]); i != -1; i = pre[i])
                {
                        if (deg[to[i]] > 0)
                        {
                                --deg[to[i]];
                                state[to[i]] |= state[queue.front()];
                                if (deg[to[i]] == 0)
                                        queue.push(to[i]);
                        }
                }
                queue.pop();
        }
}

int main()
{
        memset(last, -1, sizeof(last));

        scanf("%d%d", &n, &m);
        for (int i(0); i < m; ++i)
        {
                int a, b;
                long long c;
                scanf("%d%d%lld", &a, &b, &c);
                to[i * 2] = b;
                pre[i * 2] = last[a];
                last[a] = i * 2;
                cost[i * 2] = c;

                to[i * 2 + 1] = a;
                pre[i * 2 + 1] = last[b];
                last[b] = i * 2 + 1;
                cost[i * 2 + 1] = c;
        }

        dijkstra();
        init();
        topoSort();

        printf("%lld\n", ans);
        return 0;
}
```

70 Tree center

```
void dfs(int x)
{
        v[x] = 1;
        size[x] = 1;
        int max_part = 0;
        for (int i = head[x]; i; i = next[i])
        {
                int y = ver[i];
                if (v[x]) continue;
                dfs(y);
                size[x] += size[y];
                max_part = max(max_part, size[y]);
        }
        max_part = max(max_part, n - size[x]);
        if (max_part < ans)
        {
                ans = max_part;
                pos = x;
        }
}
```

71 Tree diameter

```
// Or: DFS twice
```

```
void dp(int x)
{
        v[x] = 1;
        for (int i = head[x]; i; i = Next[i])
        {
                int y = ver[i];
                if (v[y]) continue;
                dp(y);
                ans = max(ans, d[x] + d[y] + edge[i]);
                d[x]= max(d[x], d[y] + edge[i]);
        }
}
```

72 Trie

```
#include <cstdio>
#include <algorithm>
#include <vector>
#include <limits>

const int        maxN    (100000 + 10);
const int        logW    (30);
int              lastNode(0);
int              to      [maxN * 2];
int              pre     [maxN * 2];
int              weight  [maxN * 2];
int              last    [maxN];
int              sum     [maxN];
int              son     [maxN * logW][2];
std::vector<int> sub     [maxN * logW];

void addEdge(int x, int y, int w)
{
        static int lastEdge(0);
        ++lastEdge;
        to[lastEdge] = y;
        pre[lastEdge] = last[x];
        weight[lastEdge] = w;
        last[x] = lastEdge;
}

void dfs(int v, int pred)
{
        for (int e(last[v]); e; e = pre[e])
        {
                if (to[e] != pred)
                {
                        sum[to[e]] = sum[v] ^ weight[e];
                        dfs(to[e], v);
                }
        }
```

```
}

void insert(int value)
{
        int node(0);
        for (int i(logW); i >= 0; --i)
        {
                int bit(value >> i & 1);
                if (!son[node][bit]) son[node][bit] = ++lastNode;
                node = son[node][bit];
                sub[node].push_back(value);
        }
}

int find(int node, int pos, int value)
{
        int delta(0);
        for (int i(pos); i >= 0; --i)
        {
                int bit(value >> i & 1);
                if (son[node][bit])
                {
                        node = son[node][bit];
                }
                else
                {
                        delta |= 1 << i;
                        node = son[node][bit ^ 1];
                }
        }
        return delta;
}

long long solve(int node, int pos)
{
        long long ans(0);
        int l(son[node][0]), r(son[node][1]);
        if (l && r)
        {
                if (sub[l].size() > sub[r].size()) std::swap(l, r);
                int min(std::numeric_limits<int>::max());
                for (std::size_t i(0); i < sub[l].size(); ++i)
                {
                        min = std::min(min, (1 << pos) | find(r, pos - 1, sub[l][i]));
                }
                ans += min;
        }

        if (l) ans += solve(l, pos - 1);
        if (r) ans += solve(r, pos - 1);
        return ans;
```

```
}

int main()
{
        int n;
        scanf("%d", &n);
        for (int i(1); i <= n - 1; ++i)
        {
                int x, y;
                int w;
                scanf("%d %d %d", &x, &y, &w);
                ++x, ++y;
                addEdge(x, y, w);
                addEdge(y, x, w);
        }

        dfs(1, 1);

        for (int i(1); i <= n; ++i)
        {
                insert(sum[i]);
        }

        printf("%lld\n", solve(0, logW));
        return 0;
}
```

73 Vec

```
#include <cmath>

struct Vec
{
        double x;
        double y;

        Vec()
        {
        }

        Vec(double x, double y) : x(x), y(y)
        {
        }

        double norm() const
        {
                return std::sqrt(x * x + y * y);
        }

        Vec normalize() const
        {
                double invNorm(1 / norm());
                return Vec(x * invNorm, y * invNorm);
        }
};

Vec operator+(const Vec &a, const Vec &b)
{
        return Vec(a.x + b.x, a.y + b.y);
}

Vec operator-(const Vec &a, const Vec &b)
{
        return Vec(a.x - b.x, a.y - b.y);
}

Vec operator*(double a, const Vec &b)
{
        return Vec(a * b.x, a * b.y);
}

double dot(const Vec &a, const Vec &b)
{
        return a.x * b.x + a.y * b.y;
}

double cross(const Vec &a, const Vec &b)
{
        return a.x * b.y - a.y * b.x;
}

double xtan2(double y, double x)
{
        double p(x / (std::abs(x) + std::abs(y)));
        return y < 0 ? p - 1 : 1 - p;
}

double diff(const Vec &a, const Vec &b)
{
        static const double pi(std::acos(-1));
        double angle(xtan2(cross(a, b), dot(a, b)));
        return angle >= 0 ? angle : pi * 2 + angle;
}

int quad(const Vec &v)
{
        if (v.x >= 0)
        {
                if (v.y >= 0)
                        return 3;
                else
                        return 2;
        }
        else
        {
                if (v.y >= 0)
                        return 4;
                else
                        return 1;
        }
}

bool operator<(const Vec &a, const Vec &b)
{
        Vec da(a - origin), db(b - origin);
        return quad(da) < quad(db) || (quad(da) == quad(db) && cross(da, db) > 0);
}
```