Problems

Checking Change 2
Dominoes 4
Shelves 5
Even Pairs 6
Aliens 7
Boats 8
False Coin 9
Formulas 10
Race Tracks 12
Burning Coins 15
Jump 16
Light Pattern 17
Longest Path 18
Ants 20
Bridges 21
Build The Graph 23
Deleted Entries 25
Shy Programmers 26
Algocoon Group 27
Buddies 28
Satellites 29
Kingdom Defence 30
Coin Tossing 31
Antenna 32
Almost Antenna 33
Hit 34
First Hit 35
Search Snippets 36
Bistro 37
Germs 38
Graypes 40
H1N1 41
HikingMaps 43
Maximize It! 45
Collisions 47
Diet 48
Porfolios 49
Inball 50
Monkey Island 51
Placing Knights 52
Shopping Trip 53
TheeV 54
Poker Chips 55
Portfolio Revisited 56
Stamp Exhibition 58
Tetris 60
Beach Bar 61
Cover 62
Divisor Distance 64
Tiles 65
Connecting Capitals 66
Deleted Entries Stike Back 70
Light The Stage 71
Radiation 73
Sweepers 75
The Bracelet 77
Knights 79
Next Path 81
Odd Route 83
Radiation 2 84

Checking Change

```
#include <vector>
#include <iostream>
#include <algorithm>
#include <string>
#include <sstream>
using namespace std;

vector<string> answers;

int main(int argc, char const *argv[])
{

    int currencies;
    cin >> currencies;

    for (int currency = 0; currency < currencies; currency++)
    {

        int coins_count;
        int testcases;

        cin >> coins_count >> testcases;

        vector<int> coins;
        for (int coins_it = 0; coins_it < coins_count; coins_it++)
        {
            int coin;
            cin >> coin;
            coins.push_back(coin);
        }

        vector<int> tests;
        for (int testcase = 0; testcase < testcases; testcase++)
        {
            int test;
            cin >> test;
            tests.push_back(test);
        }

        // find maximum of tests
        vector<int>::iterator max_test_it = max_element(tests.begin(), tests.end());
        int max_test = *max_test_it;
        int N = max_test + 1;

        vector<int>::iterator max_coin_it = max_element(coins.begin(), coins.end());
        int max_coin = *max_coin_it;

        vector<int>::iterator min_coin_it = min_element(coins.begin(), coins.end());
        int min_coin = *min_coin_it;

        // instantiate array with size max(tests)
        int arraysize = 2;
        vector<int> counts(arraysize);

        // fill indices we already know -> coins, set to zero where index smaller than index of smallest coin.
        for (int i = 0; i < min_coin; i++)
        {
            if (min_coin >= arraysize)
            {
                arraysize += min_coin + 10;
                counts.resize(arraysize);
                //cout << "vector size now " << arraysize;
            }
            counts[i] = 0;
        }

        for (vector<int>::iterator coins_it = coins.begin(); coins_it != coins.end(); coins_it++)
        {
            if (*coins_it <= max_coin)
            {
                if (*coins_it >= arraysize)
                {
                    arraysize += *coins_it + 1;
```

```
                    counts.resize(arraysize);
                    //cout << "vector size now " << arraysize;
                }
                counts[*coins_it] = 1;
            }
        }

        // iterate over counts, combine all minimums.
        for (int n = min_coin + 1; n < N; n++)
        {
            if (arraysize <= n)
            {
                arraysize += 1;
                counts.resize(arraysize);
                //cout << "vector size now " << arraysize;
            }

            signed int min = -1;
            for(int backward = n-1; backward >= min_coin; backward--) {

                if (counts[n] == 1)
                {
                    min = 1;
                } else {
                    if(counts[backward] != 0 && counts[n-backward] != 0) {
                        int new_min = counts[backward] + counts[n-backward];
                        //cout << n << ": counts[backward]: " << counts[backward] << " counts[n-backward]: " << ↙
                            ↳ counts[n-backward] << "new_min: "<< new_min << "\n";
                        if (min > new_min || min == -1)
                        {
                            min = new_min;
                        }
                    }
                }

            }
            if (min == -1)
            {
                min = 0;
            }
            counts[n] = min;
        }

        /*int i = 0;
        for (vector<int>::iterator elements = counts.begin(); elements != counts.end(); elements++)
        {
            cout << i++ << ": " << *elements << " \n";
        }*/

        for (vector<int>::iterator test = tests.begin(); test != tests.end(); test++)
        {
            int answer = counts[*test];

            stringstream ss;
            if (answer == 0)
            {
                ss << "not possible";
            } else {
                ss << answer;
            }

            answers.push_back(ss.str());
        }

    }

    for (vector<string>::iterator answer = answers.begin(); answer != answers.end(); answer++)
        cout << *answer << "\n";

    return 0;
}
```

Dominoes

```cpp
#include <vector>
#include <iostream>
using namespace std;

void testcase() {
    int N; cin >> N;
    vector<int> tiles;
    for(int i = 0; i < N; ++i) {
        int h; cin >> h;
        tiles.push_back(h);
    }

    int rightmost = 0;
    int sum = N;
    for(int i = 0; i < N; ++i) {
        int j = tiles[i] + i - 1;
        rightmost = max(rightmost, j);
        if(rightmost >= N-1) break;
        if(i >= rightmost) {
            sum = rightmost+1;
            break;
        }
    }
    cout << sum << "\n";
}

int main() {
    std::ios_base::sync_with_stdio(false);
    int TC; cin >> TC;
    while(TC--) testcase();
}
```

Shelves

```cpp
#include <iostream>

using namespace std;

int main(void) {
    // speeds up read and write
    ios_base::sync_with_stdio(false);

    // number of testcases we need to run
    int nrCases;
    cin >> nrCases;

    for(int i = 0; i < nrCases; i++) {
        // read the input for the test case
        int l, m, n;
        cin >> l >> m >> n;

        // number of the two shelves and remaining length
        int cm = 0;
        int cn = 0;
        int r = l;

        for(int tmpCn = l/n; tmpCn >= 0 && r != 0; tmpCn--) {
            // calculate the number of the small shelves
            int tmpCm  = (l - tmpCn * n) / m;
            if(tmpCm >= n) {
                break;
            }

            // calculate the new remaining space and use it when smaller
            int tmpR = l - tmpCn * n - tmpCm * m;
            if(tmpR < r) {
                cn = tmpCn;
                cm = tmpCm;
                r = tmpR;
            }
        }

        // output the result
        cout << cm << "␣" << cn << "␣" << r << '\n';
    }

    return 0;
}
```

Even Pairs

```cpp
#include<iostream>

using namespace std;

/*
 * Dynamic programing. Running time O(n).
 */

int main() {
    int n, count, neven, nodd;

    // Read the input
    cin >> n;
    int x[n];
    for (int i = 0; i < n; i++) {
        cin >> x[i];
    }
    // Calculate the values S_i
    // S_i = sum of elements from x[1] to x[i]
    int S[n];
    S[0] = x[0];
    for (int i = 1; i < n; i++) {
        S[i] = x[i] + S[i-1];
    }

    // Calculate the result
    // If S[i] is even and there is k < i with S[k] is even,
    // then (k, i) is even pair. Similarly for odd S[i].
    count = 0;
    neven = 1;
    nodd = 0;
    for (int i = 0; i < n; i++) {
        if (S[i] % 2 == 0) {
            count += neven;
            neven++;
        } else {
            count += nodd;
            nodd++;
        }
    }
    cout << count << endl;

    return 0;
}
```

Aliens

```cpp
#include <iostream>
#include <vector>
#include <algorithm>
#include <climits>
using namespace std;

typedef vector<pair<int, int> > vii;      // sorted by left, right.
bool sortDescAsc(const pair<int, int>& lhs, const pair<int, int>& rhs) {
    if(lhs.first == rhs.first)
        return (lhs.second > rhs.second);
    else
        return lhs.first < rhs.first;
}

void testcase() {
    int n, m;
    cin >> n >> m;
    vii intervals;
    int superior = n;
    for(int i = 0; i < n; ++i) {
        int pi, qi;
        cin >> pi >> qi;
        if(pi == 0 && qi == 0) {
            --superior;
            continue;
        }
        pair<int, int> entry = make_pair(pi, qi);
        intervals.push_back(entry);
    }

    sort(intervals.begin(), intervals.end(), sortDescAsc);

    int left = 0;
    int right = 0;
    for(int i = 0; i < intervals.size(); ++i) {
        if(i+1 < intervals.size() && intervals[i+1].first == intervals[i].first && intervals[i+1].second == ↙
            ↳ intervals[i].second)
            --superior;
        else if(left == intervals[i].first && right == intervals[i].second)
            --superior;
        else if(right >= intervals[i].second)
            --superior;

        if(right < intervals[i].second) {
            left = intervals[i].first;
            if(right != 0 && left-right > 1) {
                cout << "0\n";
                return;
            }
            right = intervals[i].second;
        }
   }

    cout << superior << "\n";
}

int main() {
    int TC;
    cin >> TC;
    while(TC--) testcase();
}
```

Boats

```cpp
#include <vector>
#include <iostream>
#include <algorithm>
#include <climits>
using namespace std;

void testcase() {
    int N; cin >> N;
    vector<pair<int, int> > boats;  // sorted by ring position.
    for(int n = 0; n < N; ++n) {
        int l, p; cin >> l >> p;
        boats.push_back(make_pair(p, l));
    }
    sort(boats.begin(), boats.end());

    int counter = 1;
    int best_boat;
    int best_right = INT_MAX;
    int right = boats[0].first;
    int b = 1;
    while(b < N) {
        if(boats[b].first < right) { ++b; continue; }
        int temp = max(boats[b].first, boats[b].first + boats[b].second - (boats[b].first - right));

        if(temp < best_right) {
            best_boat = b;
            best_right = temp;
        }

        if((boats[b].first >= best_right) || (b + 1 == N && boats[b].first >= right)) {
            b = best_boat;
            right = best_right;
            best_right = INT_MAX;
            ++counter;
        }
        ++b;
    }
    cout << counter << "\n";
}

int main() {
    int TC; cin >> TC;
    while (TC--) testcase();
    return 0;
}
```

False Coin

```cpp
#include <vector>
#include <iostream>
using namespace std;

typedef vector<int> vi;
typedef vector<pair<vi, char> > vii;

bool evaluate(vi ineq, int var, char sign) {
    int left0 = 0;
    int left1 = 0;
    int right0 = 0;
    int right1 = 0;
    for(int l = 0, r = ineq.size()/2; l < ineq.size()/2; ++l, ++r) {
        int var_l = ineq[l];
        int var_r = ineq[r];
        left0 += (var_l == var) ? 0 : 1;
        left1 += (var_l == var) ? 1 : 0;
        right0 += (var_r == var) ? 0 : 1;
        right1 += (var_r == var) ? 1 : 0;
    }
    if(sign == '<') return (left0 < right0 || left1 < right1);
    else return (left0 > right0 || left1 > right1);
}

void testcase() {
    int N, K; cin >> N >> K;
    vi coins(N, 0);
    vii inequalities;

    for(int k = 0; k < K; ++k) {
        int C; cin >> C;
        vi equation(2*C);
        for(int i = 0; i < 2*C; ++i) {
            int c; cin >> c;
            equation[i] = c-1;
        }
        char sign; cin >> sign;
        if(sign == '<' || sign == '>') inequalities.push_back(make_pair(equation, sign));
        else for(int i = 0; i < 2*C; ++i) coins[equation[i]] = 1;
    }

    int knowns = 0;
    int unknown = -1;
    for(int i = 0; i < N; ++i) {
        knowns += coins[i];
        if(coins[i] == 1) continue;
        for(int ineq = 0; ineq < inequalities.size(); ++ineq) {
            vi inequality = inequalities[ineq].first;
            bool result = evaluate(inequality, i, inequalities[ineq].second);
            if(!result) {
                coins[i] = 1;
                ++knowns;
                break;
            }
        }
        if(coins[i] == 0) unknown = i;
    }
    if(N - knowns == 1) cout << unknown+1 << "\n";
    else cout << 0 << "\n";
}

int main() {
    int TC; cin >> TC;
    while (TC--) testcase();
    return 0;
}
```

Formulas

```cpp
#include <iostream>
#include <vector>
using namespace std;

void init_mergesort(vector<int> &racers, vector<int> &aux, int left, int right);
void sort(vector<int> &racers, vector<int> &aux, int left, int right);
void merge(vector<int> &racers, vector<int> &aux, int left, int pivot, int right);

vector<unsigned long> answers;

unsigned long overpasses;

int main(int argc, char const *argv[])
{

    int testcases;
    cin >> testcases;

    for (int testcase = 0; testcase < testcases; testcase++)
    {
        int size;
        cin >> size;

        vector<int> racers;
        vector<int> aux;

        for (int racer = 0; racer < size; racer++)
        {
            int pos;
            cin >> pos;
            racers.push_back(pos);
        }

        aux = racers;

        overpasses = 0;
        init_mergesort(racers, aux, 0, size-1);
        answers.push_back(overpasses % 10000);
    }

    for(vector<unsigned long>::iterator iter = answers.begin(); iter != answers.end(); iter++) {
        cout << *iter << "\n";
    }

    return 0;
}

void init_mergesort(vector<int> &racers, vector<int> &aux, int left, int right) {
    int pivot = (left + right) / 2;

    sort(racers, aux, left, pivot);
    sort(racers, aux, pivot + 1, right);
    merge(racers, aux, left, pivot, right);
}

void sort(vector<int> &racers, vector<int> &aux, int left, int right) {
    if (left < right)
    {
        int pivot = (left + right) / 2;
        sort(racers, aux, left, pivot);
        sort(racers, aux, pivot+1, right);
        merge(racers, aux, left, pivot, right);
    }
}

void merge(vector<int> &racers, vector<int> &aux, int left, int pivot, int right) {

    unsigned long local_overpasses = 0;
    int a = left;
    int i = left;
    int j = pivot + 1;

    // TODO: if left - right smaller than threshold, then use insertion sort!
```

```
74      while( (i <= pivot) && (j <= right) )
75      {
76          if (racers[i] == racers[j]) {
77              aux[a++] = racers[i++];
78          }
79          if (racers[i] < racers[j]) {
80              aux[a++] = racers[i++];
81          }
82          if (racers[i] > racers[j]) {
83              aux[a++] = racers[j++];
84              local_overpasses += (pivot + 1 - left) - (i - left);
85          }
86
87      }
88
89      if (i <= pivot) for (int k = i; k <= pivot; k++) { aux[a++] = racers[k]; i++; }
90      if (j <= right) for (int k = j; k <= right; k++) { aux[a++] = racers[k]; j++; }
91
92      //TODO: make it faster!
93      for (int k = left; k <= right; k++) {
94          racers[k] = aux[k];
95      }
96
97      overpasses += local_overpasses;
98  }
```

Race Tracks

```cpp
#include <vector>
#include <set>
#include <queue>
#include <sstream>
#include <string>
#include <iostream>
using namespace std;

vector<string> answers;

int main(int argc, char const *argv[])
{

    int testsets;
    cin >> testsets;

    for (int testset = 0; testset < testsets; testset++) {

        int m, n;
        cin >> m >> n;

        int s1, s2;
        cin >> s1 >> s2;

        int f1, f2;
        cin >> f1 >> f2;

        int numberObstacles;
        cin >> numberObstacles;

        vector< vector<bool> > obstacles (m, vector<bool>(n));
        for (int o = 0; o < numberObstacles; o++)
        {
            int x1, y1, x2, y2;
            cin >> x1 >> y1 >> x2 >> y2;

            for (int x = x1; x <= x2; x++)
            {
                for (int y = y1; y <= y2; y++) {
                    obstacles[x][y] = true;
                }
            }
        }

        if (obstacles[f1][f2] == true)
        {
            answers.push_back("No solution.");
            continue;
        }

        // visited states
        vector< vector< set<pair<int,int> > > > visited(m, vector<set<pair<int,int> > >(n) );

        // fifo queue for BFS
        queue<pair< pair< pair<int, int>, int>, pair<int, int> > > fifo;

        // adding starting point to fifo queue
        pair<pair< pair<int, int>,int>, pair<int, int> > start_point = make_pair( make_pair( make_pair(s1,s2) , 0), ↙
            ↳ make_pair(0,0));
        fifo.push(start_point);
        visited[s1][s2].insert(make_pair(0,0));

        bool success = false;

        while (!fifo.empty()) {
            pair<
                pair<
                    pair<int, int>, int>,
                    pair<int,int>
                > current_element = fifo.front();

            // remove current element
            fifo.pop();
```

```
73
74              // add to visited
75              int current_x = current_element.first.first.first;
76              int current_y = current_element.first.first.second;
77              int current_hops = current_element.first.second;
78              int current_xv = current_element.second.first;
79              int current_yv = current_element.second.second;
80
81              if ( (current_x == f1) && (current_y == f2) )
82              {
83                  stringstream ss;
84                  ss << "Optimal solution takes " << current_hops << " hops.";
85                  answers.push_back(ss.str());
86                  success = true;
87                  break;
88              }
89
90              // get children, add to queue
91              for (int xv = -1; xv <= 1; xv++)
92              {
93                  for (int yv = -1; yv <= 1; yv++) {
94
95                      // updated velocity
96                      int new_vx = current_xv + xv;
97                      int new_vy = current_yv + yv;
98
99                      // potential x and y coordinates
100                     int new_x = current_x + new_vx;
101                     int new_y = current_y + new_vy;
102
103                     // check for velocity range (-3,3), grid range (m,n) and obstacles
104                     if ((new_vx <= 3) && (new_vy <= 3)
105                         && (new_vx >= -3) && (new_vy >= -3)
106                         && (new_x < m) && (new_y < n)
107                         && (new_y >= 0) && (new_x >= 0)
108                         && obstacles[new_x][new_y] != true)
109                     {
110                         pair<int, int> child_velocity = make_pair(new_vx, new_vy);
111                         if (visited[new_x][new_y].find(child_velocity) == visited[new_x][new_y].end())
112                         {
113
114                             if ( (new_x == f1) && (new_y == f2) )
115                             {
116                                 stringstream ss;
117                                 ss << "Optimal solution takes " << current_hops + 1 << " hops.";
118                                 answers.push_back(ss.str());
119                                 success = true;
120                                 goto loopend;
121                             }
122
123                             pair< pair<int, int>, int> child_position = make_pair(make_pair(new_x, new_y), ↙
                                    ↳ current_hops + 1);
124                             pair< pair< pair<int, int>, int>, pair<int,int> > fifo_element = ↙
                                    ↳ make_pair(child_position, child_velocity);
125                             fifo.push(fifo_element);
126
127                             // add to visited nodes
128                             visited[new_x][new_y].insert(child_velocity);
129                         }
130                     }
131                 }
132             }
133
134             if(success == true) {
135                 loopend:
136                     break;
137             }
138
139         }
140
141         if (success == false) answers.push_back("No solution.");
142     }
143
144
145     for (vector<string>::iterator iter = answers.begin(); iter != answers.end(); iter++)
146     {
```

```
147             cout << *iter << "\n";
148         }
149 
150         return 0;
151     }
```

Burning Coins

```cpp
#include <vector>
#include <iostream>
using namespace std;

#define UNDEFINED -1
typedef vector<int> vi;
typedef vector<vi> vii;

int subsequence(int left, int right, vi& coins, vii& dp_table) {
    if(dp_table[left][right] != UNDEFINED) return dp_table[left][right];

    if(left > right) left = right;
    if(left == right) return dp_table[left][right] = coins[left];
    if(right - left == 1) return dp_table[left][right] = max(coins[left], coins[right]);

    int min_left = min(subsequence(left+2, right, coins, dp_table), subsequence(left+1, right-1, coins, dp_table));
    int min_right = min(subsequence(left, right-2, coins, dp_table), subsequence(left+1, right-1, coins, dp_table));
    return dp_table[left][right] = max(coins[left]+min_left, coins[right]+min_right);
}

void testcase() {
    int n; cin >> n;
    vi coins(n);
    for(int i = 0; i < n; ++i) {
        int input; cin >> input;
        coins[i] = input;
    }

    vii dp_table(n, vi(n, UNDEFINED));
    subsequence(0, n-1, coins, dp_table);
    cout << dp_table[0][n-1] << "\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Jump

```cpp
#include <vector>
#include <iostream>
#include <queue>
using namespace std;

typedef vector<unsigned long int> vi;

void testcase() {
    int n, k; cin >> n >> k;
    int input; cin >> input; // ignore first input.

    priority_queue<pair<long unsigned int, int>, vector<pair<long unsigned int, int> >, greater<pair<long unsigned int, int> > > min_heap;

    vi dp_table;
    dp_table.push_back(0);

    for(int i = 1; i < n; ++i) {
        while((!min_heap.empty()) && (min_heap.top().second < max(0, i - k))) min_heap.pop();
        min_heap.push(make_pair(dp_table[i-1], i-1));

        int input; cin >> input;
        long unsigned int new_min = input + min_heap.top().first;
        dp_table.push_back(new_min);
    }
    cout << dp_table[n-1] << "\n";
}

int main() {
    ios_base::sync_with_stdio(false);
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Light Pattern

```cpp
#include <vector>
#include <iostream>
#include <cmath>
using namespace std;

#define SWAP 1
#define NO_SWAP 0
typedef vector<int> vi;
typedef vector<vi> vii;

void testcase() {
    int n, k, x; cin >> n >> k >> x;

    vi pattern;
    for(int i = k-1; i >= 0; i--) if(x - pow(2.0, i) >= 0) { x -= pow(2.0, i); pattern.push_back(1); } else { pattern.push_back(0); }

    vii changes(n/k, vi(2));
    for(int i = 0, p = 0, b = 0; i < n; ++i, ++p) {
        int input; cin >> input;
        (pattern[p] == input) ? changes[b][SWAP] += 1 : changes[b][NO_SWAP] += 1;
        if(p == k-1) { p = -1; ++b; }
    }

    vii dp_table(n/k, vi(2));
    dp_table[0][SWAP] = changes[0][SWAP] + 1;
    dp_table[0][NO_SWAP] = changes[0][NO_SWAP];
    for(int b = 1; b < (n/k); ++b) {
        dp_table[b][SWAP] = min(dp_table[b-1][SWAP] + changes[b][SWAP], dp_table[b-1][NO_SWAP] + 2 + changes[b][SWAP]);
        dp_table[b][NO_SWAP] = min(dp_table[b-1][NO_SWAP] + changes[b][NO_SWAP], dp_table[b-1][SWAP] + changes[b][NO_SWAP]);
    }

    cout << min(dp_table[(n/k)-1][SWAP], dp_table[(n/k)-1][NO_SWAP]) << "\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Longest Path

```cpp
#include <vector>
#include <queue>
#include <iostream>
#include <algorithm>
using namespace std;

typedef vector<int> vi;
typedef vector<vi> AdjacencyList;

void drill(int target, int comingFrom, AdjacencyList& adj, vi& max, vector<priority_queue<int> >& incomingPaths, vi& longest, bool start) {
    if(adj[target].size() == 1 && !start) {
        max[target] = 0;
        incomingPaths[comingFrom].push(1);
        return;
    }

    for(unsigned int outgoing = 0; outgoing < adj[target].size(); ++outgoing) {
        if(adj[target][outgoing] != comingFrom)
            drill(adj[target][outgoing], target, adj, max, incomingPaths, longest, false);
    }

    int first = incomingPaths[target].top(); incomingPaths[target].pop();
    int second = 0;
    if(!incomingPaths[target].empty()) {
        second = incomingPaths[target].top(); incomingPaths[target].pop();
    }

    max[target] = first;
    longest[target] = first + second;
    incomingPaths[comingFrom].push(first+1);
}

void testcase() {
    int vertices; cin >> vertices;

    if(vertices == 1) { int v1, v2; cin >> v1 >> v2; cerr << 1 << "\n"; return; }

    AdjacencyList adj(vertices);
    vi max(vertices, 0);
    vi longest(vertices, 0);
    vector<priority_queue<int> > incomingPaths(vertices);

    for(int input = 0; input < vertices-1; ++input) {
        int v1, v2; cin >> v1 >> v2;
        adj[v1].push_back(v2);
        adj[v2].push_back(v1);
    }

    drill(0, 0, adj, max, incomingPaths, longest, true);
    cout << *max_element(longest.begin(), longest.end())+1 << "\n";
}

int main() {
    ios_base::sync_with_stdio(false);
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

```cpp
#include <vector>
#include <iostream>
#include <queue>
#include <algorithm>
using namespace std;

typedef vector<int> vi;
typedef vector<vi> vii;
int N;

pair<int, int> DFS(int start, vii& adj, vi& dist, vi& visited) {
    queue<int> fifo;
    fifo.push(start);
```

```
    visited[start] = 1;

    while(!fifo.empty()) {
        int parent_id = fifo.front(); fifo.pop();
        for(int child = 0; child < adj[parent_id].size(); ++child) {
            int child_id = adj[parent_id][child];
            if(visited[child_id] == 0) {
                fifo.push(child_id);
                visited[child_id] = 1;
                dist[child_id] = dist[parent_id] + 1;
            }
        }
    }
    vi::iterator it = max_element(dist.begin(), dist.end());
    pair<int, int> val;
    val.first = it - dist.begin();
    val.second = *it;
    return val;
}

void testcase() {
    cin >> N;    // N vertices, by definition N-1 edges.
    vii adj(N);
    vi dist(N, 0);
    vi visited(N, 0);

    for(int n = 0; n < N-1; ++n) {
        int v1, v2; cin >> v1 >> v2;
        adj[v1].push_back(v2);
        adj[v2].push_back(v1);
    }
    if(N == 1) { cout << 0 << "\n"; return; }

    pair<int, int> pass1 = DFS(0, adj, dist, visited);
    dist.assign(N, 0); visited.assign(N, 0);
    pair<int, int> pass2 = DFS(pass1.first, adj, dist, visited);
    cout << pass2.second+1 << "\n";
}

int main() {
    cin.sync_with_stdio(false);
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Ants

```cpp
#include <vector>
#include <iostream>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/graph_traits.hpp>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/kruskal_min_spanning_tree.hpp>
#include <boost/graph/dijkstra_shortest_paths.hpp>
using namespace std;
using namespace boost;

typedef property<edge_weight_t, int, property<edge_index_t, int> > EdgeProperties;
typedef property<vertex_index_t, int> VertexProperties;
typedef adjacency_list<vecS, vecS, undirectedS, VertexProperties, EdgeProperties> Graph;
typedef graph_traits<Graph>::vertex_descriptor Vertex;
typedef graph_traits<Graph>::edge_descriptor Edge;
typedef property_map<Graph, edge_weight_t>::type WeightMap;
typedef property_map<Graph, edge_index_t>::type EIndexMap;
typedef property_map<Graph, vertex_index_t>::type VIndexMap;
typedef graph_traits<Graph>::edge_iterator EdgeIterator;
typedef vector<int> vi;
typedef vector<vi> vii;
typedef vector<Edge> ve;

void testcase() {
    int N, M, S, a, b; cin >> N >> M >> S >> a >> b;

    Graph g;
    WeightMap weightMap = get(edge_weight, g);
    EIndexMap eIndexMap = get(edge_index, g);
    vii weights(M);

    for(int e = 0; e < M; ++e) {
        int t1, t2; cin >> t1 >> t2;
        for(int s = 0; s < S; ++s) {
            int s_weight; cin >> s_weight;
            weights[e].push_back(s_weight);
        }

        Edge edge; bool success;
        tie(edge, success) = add_edge(t1, t2, g);
        eIndexMap[edge] = e;
    }

    Graph final;
    WeightMap weightMapFinal = get(edge_weight, final);

    for(int s = 0; s < S; ++s) {
        int hive; cin >> hive;

        EdgeIterator eit, eend;
        for(tie(eit, eend) = edges(g); eit != eend; ++eit) weightMap[*eit] = weights[eIndexMap[*eit]][s];

        ve mst(num_vertices(g)-1);
        kruskal_minimum_spanning_tree(g, mst.begin());
        for(ve::iterator edge = mst.begin(); edge != mst.end(); ++edge) {
            Edge newEdge; bool success;
            tie(newEdge, success) = add_edge(source(*edge, g), target(*edge, g), final);
            weightMapFinal[newEdge] = weightMap[*edge];
        }
    }

    vi d(num_vertices(final));
    dijkstra_shortest_paths(final, vertex(a, final), distance_map(&d[0]));
    cout << d[b] << "\n";
}

int main() {
    ios_base::sync_with_stdio(false);
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Bridges

```cpp
#include <vector>
#include <iostream>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/biconnected_components.hpp>
using namespace std;
using namespace boost;

typedef property<vertex_index_t, int> VertexProperties;
typedef adjacency_list< vecS, vecS, undirectedS, VertexProperties, no_property> Graph;
typedef property_map<Graph, vertex_index_t>::type VIndexMap;
typedef graph_traits<Graph>::vertex_descriptor Vertex;
typedef graph_traits<Graph>::edge_descriptor Edge;
typedef graph_traits<Graph>::adjacency_iterator AIter;
typedef vector<int> vi;
typedef vector<Vertex> vv;
typedef pair<int, int> pi;

void testcase() {
    int N, M; cin >> N >> M;

    if(N == 0 || M == 0) { cout << "0\n"; return; }

    Graph g(N);
    VIndexMap index = get(vertex_index, g);

    for(int m = 0; m < M; ++m) {
        int v1, v2; cin >> v1 >> v2;
        add_edge(v1, v2, g);
    }

    vv art_points;
    vi discover_time(num_vertices(g));
    vi low_point(num_vertices(g));
    vector<pi> bridges;
    articulation_points(g,
                        back_inserter(art_points),
                        discover_time_map(&discover_time[0]).lowpoint_map(&low_point[0]));

    // workaround for "root not chosen as articulation point if only one child".
    if(out_degree(vertex(1, g), g) == 1) {
        Vertex root = vertex(1, g);
        art_points.insert(art_points.begin(), root);
    }
    for(int v = 0; v < art_points.size(); ++v) {
        Vertex art_point = art_points[v];
        AIter neighbour, neighbour_end;
        for(tie(neighbour, neighbour_end) = adjacent_vertices(art_point, g); neighbour != neighbour_end; ++neighbour) {
            if(low_point[*neighbour] > discover_time[art_point]) {
                //cout << "bridge found between: " << index[art_point] << "-" << index[*neighbour] << "\n";
                bridges.push_back(make_pair(min(index[art_point], index[*neighbour]), max(index[art_point], ↙
                    ↳ index[*neighbour])));
            }
        }
    }

    sort(bridges.begin(), bridges.end());
    cout << bridges.size() << "\n";
    for(int b = 0; b < bridges.size(); ++b) {
        cout << bridges[b].first << "␣" << bridges[b].second << "\n";
    }
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

```cpp
#include <vector>
#include <iostream>
#include <algorithm>
#include <set>
```

```cpp
using namespace std;

#define UNVISITED 0
#define VISITED 1
#define EXPLORED 2

typedef vector<int> vi;
typedef vector<vi> vii;
typedef pair<int, int> pi;

vi visited;
vi dfs_num;
vi dfs_low;

void dfs(int vertex, int parent, vii& adj, int counter) {
    for(signed int child = 0; child < adj[vertex].size(); ++child) {
        int child_vertex = adj[vertex][child];
        if(child_vertex != parent) {
            if(visited[child_vertex] == EXPLORED) {
                dfs_low[vertex] = min(dfs_num[child_vertex], dfs_low[vertex]);
            }

            if(visited[child_vertex] == UNVISITED) {
                visited[child_vertex] = EXPLORED;
                dfs_num[child_vertex] = ++counter;
                dfs_low[child_vertex] = dfs_num[child_vertex];
                dfs(child_vertex, vertex, adj, counter);
            }
        }
    }

    dfs_low[parent] = min(dfs_low[parent], dfs_low[vertex]);
    visited[vertex] = VISITED;
}

void testcase() {
    int N, M; cin >> N >> M;
    visited.clear(); dfs_low.clear(); dfs_num.clear();
    vii adj(N); visited.assign(N, UNVISITED); dfs_num.assign(N, 0); dfs_low.assign(N, 0);

    if(N == 0 || N == 0) { cout << "0\n"; return; }

    for(int m = 0; m < M; ++m) {
        int v1, v2; cin >> v1 >> v2;
        adj[(v1-1)].push_back(v2-1);
        adj[(v2-1)].push_back(v1-1);
    }

    dfs_num[0] = 0; dfs_low[0] = 0; visited[0] = EXPLORED;
    dfs(0, 0, adj, 0);

    vector<pi> bridges;
    set<int> art_points;
    for(int u = 0; u < N; ++u) {
        for(int v = 0; v < adj[u].size(); ++v) {
            if(dfs_low[adj[u][v]] > dfs_num[u]) {
                bridges.push_back(make_pair(min(u, adj[u][v]), max(u, adj[u][v])));
            }
            if(dfs_low[adj[u][v]] >= dfs_num[u]) {
                // if it is not root, or it is root but has more than 1 child:
                art_points.insert(u);
            }
        }
    }
    sort(bridges.begin(), bridges.end());
    cout << bridges.size() << "\n";
    for(signed int b = 0; b < bridges.size(); ++b) {
        cout << bridges[b].first+1 << "␣" << bridges[b].second+1 << "\n";
    }
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Build The Graph

```cpp
#include <iostream>
#include <boost/graph/adjacency_list.hpp>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/kruskal_min_spanning_tree.hpp>
#include <boost/graph/dijkstra_shortest_paths.hpp>
using namespace std;
using namespace boost;

// create internal properties
typedef property<vertex_index_t, int> IndexProperty;
typedef property<edge_weight_t, int> WeightProperty;

// adjacency list with properties
typedef adjacency_list<vecS, vecS, undirectedS, no_property, WeightProperty, IndexProperty> Graph;

// Vertex and edge type
typedef graph_traits<Graph>::vertex_descriptor Vertex;
typedef graph_traits<Graph>::edge_descriptor Edge;
typedef graph_traits<Graph>::edge_iterator EdgeIterator;

// Property maps for accessing the properties
typedef property_map<Graph, edge_weight_t>::type WeightMap;
typedef property_map<Graph, vertex_index_t>::type IndexMap;

int main() {
    ios_base::sync_with_stdio(false);
    int t; cin >> t;

    for(int i = 0; i < t; i++) {
        int m, n; cin >> n >> m;

        Graph G(n);
        WeightMap weightMap = get(edge_weight, G);

        for(int j = 0; j < m; j++) {
            int v1, v2, w;
            cin >> v1 >> v2 >> w;
            Edge e;
            tie(e, tuples::ignore) = add_edge(v1, v2, G);
            weightMap[e] = w;
        }

        vector<Edge> spanningTree;
        kruskal_minimum_spanning_tree(G, back_inserter(spanningTree));
        int sumOfWeights = 0;

        Graph mstGraph(n);
        WeightMap mstWeightMap = get(edge_weight, mstGraph);
        for (vector<Edge>::iterator ei = spanningTree.begin(); ei != spanningTree.end(); ++ei) {
            sumOfWeights += weightMap[*ei];
        }

        vector<int> distances(n);
        vector<Vertex> p_map(num_vertices(G));

        Vertex startVertex = vertex(0, G);
        dijkstra_shortest_paths(G, startVertex, predecessor_map(&p_map[0]).distance_map(&distances[0]));

        int longestDistance = 0;
        for(int k = 0; k < n; k++) {
            int distance = distances[k];

            if(distance > longestDistance) {
                longestDistance = distance;
            }
        }

        cout << sumOfWeights << "␣" << longestDistance << endl;

        /* Playing around with backtracking shortest path.
        IndexMap index;
        int target = 3;
        while(target != p_map[index[vertex(target, G)]]) {
```

```
74              cout << target << "-" << p_map[index[vertex(target, G)]] << "\n";
75              target = p_map[index[vertex(target, G)]];
76          }
77          */
78      }
79  }
```

Deleted Entries

```cpp
#include <vector>
#include <iostream>
#include <queue>
#include <algorithm>
using namespace std;

typedef vector<int> vi;
typedef vector<vi> vii;

int k;

void testcase() {
    int n, m, k;
    cin >> n >> m >> k;

    vii adj(n);
    vii groups(k);
    vi col(n, -1);

    for(int e = 0; e < m; ++e) {
        int v1, v2; cin >> v1 >> v2;
        adj[v1].push_back(v2);
        adj[v2].push_back(v1);
    }

    queue<int> q; // lifo
    int c = 0;
    q.push(0);
    col[0] = c;
    groups[c].push_back(0);

    while(!q.empty()) {
        const int v = q.front(); q.pop();
        for(int child = 0; child < adj[v].size(); ++child) {
            const int u = adj[v][child];
            if(col[u] != -1) continue;

            c = (c == k-1) ? 0 : ++c;
            if(col[v] == c) { c = (c == k-1) ? 0 : ++c; }
            col[u] = c;
            groups[c].push_back(u);
            q.push(u);
        }
    }

    if(n >= k && find(col.begin(), col.end(), -1) == col.end()) {
        cout << "yes\n";
        for(int g = 0; g < k; ++g) {
            cout << groups[g].size();
            for(int i = 0; i < groups[g].size(); ++i) {
                cout << "␣" << groups[g][i];
            }
            cout << "\n";
        }
    } else {
        cout << "no\n";
    }
    col.clear();
    adj.clear();
    groups.clear();
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
}
```

Shy Programmers

```cpp
#include <iostream>
#include <vector>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/boyer_myrvold_planar_test.hpp>
using namespace std;
using namespace boost;

typedef adjacency_list<vecS, vecS, undirectedS, no_property, no_property> Graph;

void testcase() {
    int N, M; cin >> N >> M;
    Graph g(N+1);
    vector<int> processed(N, 0);
    for(int m = 0; m < M; ++m) {
        int a, b; cin >> a >> b;
        add_edge(a, b, g);
        if(!processed[a]) { add_edge(a, N+1, g); processed[a] = 1; }
        if(!processed[b]) { add_edge(b, N+1, g); processed[b] = 1; }
    }

    if(boyer_myrvold_planarity_test(g))
        cout << "yes\n";
    else
        cout << "no\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Algocoon Group

```cpp
#include <iostream>
#include <vector>
#include <map>
#include <set>
#include <string>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/max_cardinality_matching.hpp>
using namespace std;
using namespace boost;

typedef adjacency_list<vecS, vecS, undirectedS, no_property, no_property> Graph;
typedef graph_traits<Graph>::vertex_descriptor Vertex;

void testcase() {
    int N, C, F; cin >> N >> C >> F;
    int counter = 0;
    map<string, int> stringMap;
    vector<set<int> > chars(N);
    for(int i = 0; i < N; ++i) {
        for(int c = 0; c < C; ++c) {
            string input; cin >> input;
            if(stringMap.count(input) == 0) stringMap[input] = counter++;
            chars[i].insert(stringMap[input]);
        }
    }

    Graph g(N);
    for(int i = 0; i < N; ++i) {
        for(int j = i+1; j < N; ++j) {
            int matchings = 0;
            for(set<int>::iterator it = chars[i].begin(); it != chars[i].end(); ++it) {
                if(chars[j].count(*it) == 1) {
                    ++matchings;
                    if(matchings > F) {
                        add_edge(i, j, g);
                        break;  // could be the culprit.
                    }
                }
            }
        }
    }

    vector<Vertex> mateMap(N, 0);
    checked_edmonds_maximum_cardinality_matching(g, &mateMap[0]);
    int matched = matching_size(g, &mateMap[0]);
    if(matched*2 == N) cout << "not␣optimal\n";
    else cout << "optimal\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Buddies

```cpp
#include <iostream>
#include <vector>
#include <map>
#include <set>
#include <string>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/max_cardinality_matching.hpp>
using namespace std;
using namespace boost;

typedef adjacency_list<vecS, vecS, undirectedS, no_property, no_property> Graph;
typedef graph_traits<Graph>::vertex_descriptor Vertex;

void testcase() {
    int N, C, F; cin >> N >> C >> F;
    int counter = 0;
    map<string, int> stringMap;
    vector<set<int> > chars(N);
    for(int i = 0; i < N; ++i) {
        for(int c = 0; c < C; ++c) {
            string input; cin >> input;
            if(stringMap.count(input) == 0) stringMap[input] = counter++;
            chars[i].insert(stringMap[input]);
        }
    }

    Graph g(N);
    for(int i = 0; i < N; ++i) {
        for(int j = i+1; j < N; ++j) {
            int matchings = 0;
            for(set<int>::iterator it = chars[i].begin(); it != chars[i].end(); ++it) {
                if(chars[j].count(*it) == 1) {
                    ++matchings;
                    if(matchings > F) {
                        add_edge(i, j, g);
                        break;  // could be the culprit.
                    }
                }
            }
        }
    }

    vector<Vertex> mateMap(N, 0);
    checked_edmonds_maximum_cardinality_matching(g, &mateMap[0]);
    int matched = matching_size(g, &mateMap[0]);
    if(matched*2 == N) cout << "not␣optimal\n";
    else cout << "optimal\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Satellites

```cpp
#include <iostream>
#include <vector>
#include <stack>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/max_cardinality_matching.hpp>
using namespace std;
using namespace boost;

typedef adjacency_list<vecS, vecS, undirectedS, no_property, no_property> Graph;
typedef graph_traits<Graph>::vertex_descriptor Vertex;
typedef graph_traits<Graph>::out_edge_iterator OEI;

void testcase() {
    int G, S, L; cin >> G >> S >> L;

    Graph g(G+S);
    for(int l = 0; l < L; ++l) {
        int u, v; cin >> u >> v;
        add_edge(u, G+v, g);
    }

    vector<Vertex> mateMap(G+S, 0);
    checked_edmonds_maximum_cardinality_matching(g, &mateMap[0]);
    matching_size(g, &mateMap[0]);

    stack<int> fifo;
    vector<int> visited(G+S, 0);
    for(int v = 0; v < G; ++v) {
        if(mateMap[v] == graph_traits<Graph>::null_vertex()) {
            visited[v] = 1;
            fifo.push(v);
        }
    }

    while(!fifo.empty()) {
        int u = fifo.top(); fifo.pop();
        OEI ebegin, eend;
        for(tie(ebegin, eend) = out_edges(u, g); ebegin != eend; ++ebegin) {
            int v = boost::target(*ebegin, g);
            if(visited[v] == 1) continue;
            if(u < G) {
                if(mateMap[u] != v) {
                    visited[v] = 1;
                    fifo.push(v);
                }
            } else {
                if(mateMap[u] == v) {
                    visited[v] = 1;
                    fifo.push(v);
                }
            }
        }
    }

    vector<int> sat;
    vector<int> ground;
    for(int v = 0; v < G; ++v)
        if(visited[v] == 0) ground.push_back(v);
    for(int v = G; v < G+S; ++v)
        if(visited[v] == 1) sat.push_back(v);

    cout << ground.size() << "␣" << sat.size() << "\n";
    for(int i = 0; i < ground.size(); ++i) cout << ground[i] << "␣";
    for(int i = 0; i < sat.size(); ++i) cout << sat[i]-G << "␣";
    cout << "\n";
}

int main() {
    int TC; cin >> TC;
    while (TC--) testcase();
    return 0;
}
```

Kingdom Defence

```cpp
#include <iostream>
#include <vector>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/push_relabel_max_flow.hpp>
using namespace std;
using namespace boost;

typedef adjacency_list_traits<vecS, vecS, directedS> Traits;
typedef adjacency_list<vecS, vecS, directedS, no_property,
  property<edge_capacity_t, long,
  property<edge_residual_capacity_t, long,
  property<edge_reverse_t, Traits::edge_descriptor> > > > Graph;
typedef property_map<Graph, edge_capacity_t>::type EdgeCapacityMap;
typedef property_map<Graph, edge_reverse_t>::type ReverseEdgeMap;
typedef graph_traits<Graph>::edge_descriptor Edge;

void add_edge(int f, int t, int cap, Graph& g) {
    EdgeCapacityMap capacity = get(edge_capacity, g);
    ReverseEdgeMap rev_edge = get(edge_reverse, g);

    Edge edge;
    tie(edge, tuples::ignore) = add_edge(f, t, g);
    Edge reverse_edge;
    tie(reverse_edge, tuples::ignore) = add_edge(t, f, g);
    capacity[edge] = cap;
    rev_edge[edge] = reverse_edge;
    capacity[reverse_edge] = 0;
    rev_edge[reverse_edge] = edge;
}

void testcase() {
    int V, E; cin >> V >> E;
    Graph g(V+2);
    int source = V;
    int sink = V+1;

    vector<int> vertices;
    for(int v = 0; v < V; ++v) {
        int g, d; cin >> g >> d;
        vertices.push_back(d - g);
    }

    for(int e = 0; e < E; ++e) {
        int f, t, lb, ub; cin >> f >> t >> lb >> ub;
        add_edge(f, t, ub-lb, g);
        vertices[f] += lb;
        vertices[t] -= lb;
    }

    int flow_out = 0;
    bool all_pos = true;
    for(int v = 0; v < V; ++v) {
        if(vertices[v] < 0) {
            add_edge(source, v, abs(vertices[v]), g);
        } else if(vertices[v] > 0) {
            all_pos = false;
            add_edge(v, sink, vertices[v], g);
            flow_out += abs(vertices[v]);
        }
    }

    int max_flow = push_relabel_max_flow(g, source, sink);
    (max_flow == flow_out || all_pos) ? cout << "yes\n" : cout << "no\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
}
```

Coin Tossing

```cpp
#include <iostream>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/push_relabel_max_flow.hpp>
#include <boost/tuple/tuple.hpp>
using namespace std;
using namespace boost;

typedef adjacency_list_traits<vecS, vecS, directedS> Traits;
typedef adjacency_list<vecS, vecS, directedS, no_property,
  property<edge_capacity_t, long,
  property<edge_residual_capacity_t, long,
  property<edge_reverse_t, Traits::edge_descriptor> > > > Graph;
typedef property_map<Graph, edge_capacity_t>::type EdgeCapacityMap;
typedef property_map<Graph, edge_residual_capacity_t>::type ResidualCapacityMap;
typedef property_map<Graph, edge_reverse_t>::type ReverseEdgeMap;
typedef graph_traits<Graph>::edge_descriptor Edge;

void add_edge(int from, int to, int c, Graph& g) {
    EdgeCapacityMap capacity = get(edge_capacity, g);
    ReverseEdgeMap reverse = get(edge_reverse, g);
    ResidualCapacityMap res_capacity = get(edge_residual_capacity, g);

    Edge there, back;
    tie(there, tuples::ignore) = add_edge(from, to, g);
    tie(back, tuples::ignore) = add_edge(to, from, g);
    capacity[there] = c;
    capacity[back] = 0;
    reverse[there] = back;
    reverse[back] = there;
}

void testcase() {
    int N, M; cin >> N >> M;
    Graph g(N+M+2);
    int source = N+M+1;
    int sink = source + 1;

    for(int m = N; m < N+M; ++m) {
        int p1, p2, outcome;
        cin >> p1 >> p2 >> outcome;
        add_edge(source, m, 1, g);

        if(outcome == 1) {
            add_edge(m, p1, 1, g);
        }
        if(outcome == 2) {
            add_edge(m, p2, 1, g);
        }
        if(outcome == 0) {
            add_edge(m, p1, 1, g);
            add_edge(m, p2, 1, g);
        }
    }

    int sum = 0;
    for(int p = 0; p < N; ++p) {
        int score;  cin >> score;
        sum += score;
        add_edge(p, sink, score, g);
    }

    int f_max = push_relabel_max_flow(g, source, sink);
    if(M == sum && f_max == sum) cout << "yes\n";
    else cout << "no\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
}
```

Antenna

```cpp
#include <iostream>
#include <vector>
#include <cmath>
#include <CGAL/Exact_predicates_exact_constructions_kernel_with_sqrt.h>
#include <CGAL/Min_circle_2.h>
#include <CGAL/Min_circle_2_traits_2.h>
using namespace std;

typedef CGAL::Exact_predicates_exact_constructions_kernel_with_sqrt K;
typedef CGAL::Min_circle_2_traits_2<K> Traits;
typedef CGAL::Min_circle_2<Traits> Min_circle;

double ceil_to_double(const K::FT& x)
{
  double a = ceil(CGAL::to_double(x));
  while (a < x) a += 1;
  while (a-1 >= x) a -= 1;
  return a;
}

void testcase(int n) {
    vector<K::Point_2> citizens;
    for(int coord = 0; coord < n; ++coord) {
        double x, y; cin >> x >> y;
        K::Point_2 citizen(x, y);
        citizens.push_back(citizen);
    }

    Min_circle mc(citizens.begin(), citizens.end(), true);  // true important for speed.
    Traits::Circle c = mc.circle();
    K::FT radius = sqrt(c.squared_radius());

    cout << std::setiosflags(std::ios::fixed) << std::setprecision(0);  // scientific notation will be used otherwise!
    cout << ceil_to_double(radius) << "\n";
}

int main() {
    while(true) {
        int n; cin >> n;
        if(n == 0) return 0;
        testcase(n);
    }
    return 0;
}
```

Almost Antenna

```cpp
#include <iostream>
#include <vector>
#include <CGAL/Exact_predicates_exact_constructions_kernel_with_sqrt.h>
#include <CGAL/Min_circle_2.h>
#include <CGAL/Min_circle_2_traits_2.h>
using namespace std;

typedef CGAL::Exact_predicates_exact_constructions_kernel_with_sqrt K;
typedef CGAL::Min_circle_2_traits_2<K> Traits;
typedef CGAL::Min_circle_2<Traits> Min_circle;

double ceil_to_double(const K::FT& x) {
    double a = ceil(CGAL::to_double(x));
    while (a < x) a += 1;
    while (a-1 >= x) a -= 1;
    return a;
}

void testcase(int N) {
    vector<K::Point_2> points;
    for(int n = 0; n < N; ++n) {
        double x, y; cin >> x >> y;
        points.push_back(K::Point_2(x, y));
    }
    Min_circle mc(points.begin(), points.end(), true);

    K::FT min_rad; bool min_set = false;
    for(Min_circle::Support_point_iterator it = mc.support_points_begin(); it != mc.support_points_end(); ++it) {
        vector<K::Point_2>::iterator sp = find(points.begin(), points.end(), *it);
        iter_swap(sp, points.begin());
        Min_circle mc2(points.begin()+1, points.end(), true);
        Traits::Circle c = mc2.circle();
        K::FT radius= c.squared_radius();
        if(radius < min_rad || !min_set) {
            min_rad = radius;
            min_set = true;
        }
    }

    cout << ceil_to_double(CGAL::sqrt(min_rad))<< "\n";
}

int main() {
    cout << std::setiosflags(std::ios::fixed) << std::setprecision(0);
    while(true) {
        int N; cin >> N;
        if(N == 0) return 0;
        testcase(N);
    }
}
```

Hit

```cpp
#include <iostream>
#include <vector>
#include <CGAL/Exact_predicates_inexact_constructions_kernel.h>
using namespace std;

typedef CGAL::Exact_predicates_inexact_constructions_kernel K;

void testcase(int n) {
    double x1, y1, x2, y2;
    cin >> x1 >> y1 >> x2 >> y2;
    K::Point_2 p1(x1, y1);
    K::Point_2 p2(x2, y2);
    K::Ray_2 ray(p1, p2);

    vector<K::Segment_2> obstacles;
    for(int o = 0; o < n; ++o) {
        double r, s, t, u;
        cin >> r >> s >> t >> u;
        K::Point_2 p1(r, s);
        K::Point_2 p2(t, u);
        K::Segment_2 obstacle(p1, p2);
        obstacles.push_back(obstacle);
    }

    bool intersect = false;
    for(int obstacle = 0; obstacle < obstacles.size(); ++obstacle) {
        if(CGAL::do_intersect(obstacles[obstacle], ray)) {
            intersect = true;
            break;
        }
    }

    (intersect) ? cout << "yes\n" : cout << "no\n";
}

int main() {
    while(true) {
        int n; cin >> n;
        if(n == 0) return 0;
        testcase(n);
    }
}
```

First Hit

```cpp
#include <iostream>
#include <CGAL/Exact_predicates_exact_constructions_kernel.h>
#include <CGAL/enum.h>
#include <climits>
using namespace std;

typedef CGAL::Exact_predicates_exact_constructions_kernel K;

double floor_to_double(const K::FT& x) {
  double a = std::floor(CGAL::to_double(x));
  while (a > x) a -= 1;
  while (a+1 <= x) a += 1;
  return a;
}

void testcase(int n) {
    K::Ray_2 ray;
    double x1, y1, x2, y2; cin >> ray;

    bool min_exists = false;
    K::FT current_dist;
    K::Point_2 current_point;

    for(size_t o = 0; o < n; ++o) {
        double r, s, t, u; cin >> r >> s >> t >> u;
        K::Point_2 p1(r, s);
        K::Point_2 p2(t, u);
        K::Segment_2 obstacle (p1, p2);

        if(CGAL::do_intersect(ray, obstacle)) {
            K::Point_2 intersection_point;
            CGAL::Object o = CGAL::intersection(ray, obstacle);
            if(const K::Point_2* p = CGAL::object_cast<K::Point_2>(&o))
                intersection_point = *p;
            else if (const K::Segment_2* s = CGAL::object_cast<K::Segment_2>(&o))
                intersection_point =
                        CGAL::has_smaller_distance_to_point(ray.source(), s->source(), s->target()) ?
                        s->source() : s->target();
            else throw runtime_error("strange␣segment␣intersection");
            K::FT intersection_dist = CGAL::squared_distance(intersection_point, ray.source());
            if(!min_exists || current_dist > intersection_dist) {
                current_dist = intersection_dist;
                current_point = intersection_point;
                min_exists = true;
            }
        }
    }

    if(min_exists) cout << floor_to_double(current_point.x()) << "␣" << floor_to_double(current_point.y()) << "\n";
    else cout << "no\n";
}

int main() {
    cin.sync_with_stdio(false);
    cout << std::setiosflags(std::ios::fixed) << std::setprecision(0);
    while(true) {
        int n; cin >> n;
        if(n == 0) return 0;
        testcase(n);
    }
}
```

Search Snippets

```cpp
#include <iostream>
#include <vector>
#include <queue>
#include <climits>
using namespace std;

typedef vector<int> vi;
typedef vector<vi> vii;

void testcase() {
    int N; cin >> N;
    vi count;
    for(int n = 0; n < N; ++n) {
        int m; cin >> m;
        count.push_back(m);
    }

    vii lists(N);
    for(int n = 0; n < N; ++n) {
        for(int m = 0; m < count[n]; ++m) {
            int p; cin >> p;
            lists[n].push_back(p);
        }
    }

    priority_queue<pair<int, pair<int, int> > > max_heap;
    priority_queue<pair<int, pair<int, int> >, vector<pair<int, pair<int, int> > >, greater<pair<int, pair<int, int> > > > min_heap;
    for(int n = 0; n < N; ++n) {
        max_heap.push(make_pair(lists[n][0], make_pair(n, 0)));
        min_heap.push(make_pair(lists[n][0], make_pair(n, 0)));
    }

    int min_interval = INT_MAX;
    while(true) {
        pair<int, pair<int, int> > a = min_heap.top();
        pair<int, pair<int, int> > b = max_heap.top();
        int interval = b.first - a.first + 1;

        min_interval = min(interval, min_interval);
        int min_list = a.second.first;
        int element = a.second.second;

        if(element+1 < lists[min_list].size()) {
            max_heap.push(make_pair(lists[min_list][element+1], make_pair(min_list, element+1)));
            min_heap.pop();
            min_heap.push(make_pair(lists[min_list][element+1], make_pair(min_list, element+1)));
        } else {
            break;
        }
    }

    cout << min_interval << "\n";
}

int main() {
    int TC; cin >> TC;
    while (TC--) testcase();
    return 0;
}
```

Bistro

```cpp
#include <vector>
#include <iostream>
#include <cmath>
#include <CGAL/Exact_predicates_inexact_constructions_kernel.h>
#include <CGAL/Delaunay_triangulation_2.h>
using namespace std;

typedef CGAL::Exact_predicates_inexact_constructions_kernel K;
typedef CGAL::Delaunay_triangulation_2<K> Triangulation;
typedef Triangulation::Finite_faces_iterator faces_iterator;

double floor_to_double(const K::FT& x)
{
  double a = std::floor(CGAL::to_double(x));
  while (a > x) a -= 1;
  while (a+1 <= x) a += 1;
  return a;
}

void testcase(int n) {
    vector<K::Point_2> delaunay_vertices;
    for(int i = 0; i < n; ++i) {
        K::Point_2 p; cin >> p;
        delaunay_vertices.push_back(p);
    }

    Triangulation t;
    t.insert(delaunay_vertices.begin(), delaunay_vertices.end());

    int points; cin >> points;
    for(int i = 0; i < points; ++i) {
        K::Point_2 p; cin >> p;
        Triangulation::Vertex_handle v = t.nearest_vertex(p);
        K::Point_2 vp = v->point();
        K::FT distance = CGAL::squared_distance(p, vp);
        cout << floor_to_double(distance) << "\n";
    }
}

int main() {
    cin.sync_with_stdio(false);
    cout << std::setiosflags(std::ios::fixed) << std::setprecision(0);
    while(true) {
        int n; cin >> n;
        if(n == 0) return 0;
        testcase(n);
    }
    return 0;
}
```

Germs

```cpp
#include <iostream>
#include <vector>
#include <cmath>
#include <CGAL/Exact_predicates_inexact_constructions_kernel.h>
#include <CGAL/Delaunay_triangulation_2.h>
#include <CGAL/Triangulation_vertex_base_with_info_2.h>
using namespace std;

typedef CGAL::Exact_predicates_inexact_constructions_kernel     K;
typedef CGAL::Triangulation_vertex_base_with_info_2<int, K>     Vb;
typedef CGAL::Triangulation_data_structure_2<Vb>                Tds;
typedef CGAL::Delaunay_triangulation_2<K, Tds>                  Delaunay;
typedef Delaunay::Finite_edges_iterator                         FEI;
typedef Delaunay::Finite_vertices_iterator                      FVI;

void testcase(int N) {
    double left, bottom, right, top; cin >> left >> bottom >> right >> top;
    vector<K::Segment_2> rectangle;
    rectangle.push_back(K::Segment_2(K::Point_2(left, bottom), K::Point_2(left, top)));
    rectangle.push_back(K::Segment_2(K::Point_2(left, top), K::Point_2(right, top)));
    rectangle.push_back(K::Segment_2(K::Point_2(right, top), K::Point_2(right, bottom)));
    rectangle.push_back(K::Segment_2(K::Point_2(right, bottom), K::Point_2(left, bottom)));

    vector<pair<K::Point_2, int> > points;
    for(int b = 0; b < N; ++b) {
        double x, y; cin >> x >> y;
        points.push_back(make_pair(K::Point_2(x, y), b));
    }

    Delaunay t;
    t.insert(points.begin(), points.end());

    vector<pair<double, pair<int, int> > > edges;
    for(FEI e = t.finite_edges_begin(); e != t.finite_edges_end(); ++e) {
        Delaunay::Vertex_handle v1 = e->first->vertex((e->second + 1) % 3);
        Delaunay::Vertex_handle v2 = e->first->vertex((e->second + 2) % 3);
        K::FT edge_length = CGAL::sqrt(CGAL::squared_distance(v1->point(), v2->point()));
        edges.push_back(make_pair(edge_length, make_pair(v1->info(), v2->info())));
    }

    for(FVI p = t.finite_vertices_begin(); p != t.finite_vertices_end(); ++p) {
        Delaunay::Vertex_handle vertex = p;
        K::FT min; bool min_set = false;
        for(int seg = 0; seg < 4; ++seg) {
            K::FT seg_min = CGAL::squared_distance(rectangle[seg], vertex->point());
            if(min_set == false || min > seg_min) { min_set = true; min = seg_min; }
        }
        edges.push_back(make_pair(2*CGAL::sqrt(min), make_pair(p->info(), p->info())));
    }

    sort(edges.begin(), edges.end());

    int dead = 0;
    int pointer = 0;
    int h = 0;
    bool first_time = true;
    vector<int> deadlist(N, 0);

    while(dead != N) {
        double min_length = 2 * (pow(h, 2.0) + 0.5);
        int temp_dead = 0;
        while(edges[pointer].first <= min_length && pointer < edges.size()) {
            int v1 = edges[pointer].second.first;
            int v2 = edges[pointer].second.second;
            if(deadlist[v1] == 0) { ++temp_dead; deadlist[v1] = 1; }
            if(deadlist[v2] == 0) { ++temp_dead; deadlist[v2] = 1; }
            ++pointer;
        }
        if(dead == 0 && temp_dead > 0) cout << h << "␣";
        dead += temp_dead;
        if((N-dead)/(double)N < 0.5 && first_time) {
            cout << h << "␣";
            first_time = false;
```

```
74          }
75          if(N == dead) cout << h << "\n";
76          ++h;
77      }
78  }
79
80  int main() {
81       while(true) {
82          int N; cin >> N;
83          if(N == 0) return 0;
84          testcase(N);
85      }
86  }
```

Graypes

```cpp
#include <vector>
#include <iostream>
#include <CGAL/Exact_predicates_inexact_constructions_kernel.h> // use inexact because Input points == output points.
#include <CGAL/Delaunay_triangulation_2.h>
using namespace std;

typedef CGAL::Exact_predicates_inexact_constructions_kernel K;
typedef CGAL::Delaunay_triangulation_2<K> Triangulation;
typedef Triangulation::Finite_edges_iterator FEI;

double ceil_to_double(const K::FT& x)
{
    double a = ceil(CGAL::to_double(x));
    while (a < x) a += 1;
    while (a-1 >= x) a -= 1;
    return a;
}

void testcase(int n) {
    vector<K::Point_2> points;
    for(int i = 0; i < n; ++i) {
        K::Point_2 p; cin >> p;
        points.push_back(p);
    }

    Triangulation t;
    t.insert(points.begin(), points.end());
    K::FT min_length;
    bool min_set = false;
    for (FEI e = t.finite_edges_begin(); e != t.finite_edges_end(); e++) {
        // REMEMBER bad idea: K::Segment_2 seg = t.segment(edge); seg.squared_length().
        Triangulation::Vertex_handle v1 = e->first->vertex((e->second + 1) % 3);
        Triangulation::Vertex_handle v2 = e->first->vertex((e->second + 2) % 3);

        K::FT length = CGAL::squared_distance(v1->point(), v2->point());
        if(!min_set || min_length > length) {
            min_length = length;
            min_set = true;
        }
    }

    double seconds = ceil_to_double(CGAL::sqrt(min_length)*50);
    cout << seconds << "\n";
}

int main() {
    cin.sync_with_stdio(false);
    cout << std::setiosflags(std::ios::fixed) << std::setprecision(0);
    while(true) {
        int n; cin >> n;
        if(n == 0) return 0;
        testcase(n);
    }
}
```

H1N1

```cpp
#include <iostream>
#include <vector>
#include <queue>
#include <CGAL/Exact_predicates_inexact_constructions_kernel.h>
#include <CGAL/Delaunay_triangulation_2.h>
using namespace std;

typedef CGAL::Exact_predicates_inexact_constructions_kernel     K;
typedef CGAL::Delaunay_triangulation_2<K>                       Delaunay;
typedef Delaunay::All_faces_iterator                            AFI;
typedef map<Delaunay::Face_handle, int>                         StateMap;

int testcase(int N) {
    vector<K::Point_2> points;
    for(int n = 0; n < N; ++n) {
        double x, y; cin >> x >> y;
        points.push_back(K::Point_2(x, y));
    }

    int M; cin >> M;
    vector<pair<K::Point_2, double> > people;
    for(int m = 0; m < M; ++m) {
        double x, y, d; cin >> x >> y >> d;
        people.push_back(make_pair(K::Point_2(x, y), d));
    }

    StateMap state;
    Delaunay t;
    t.insert(points.begin(), points.end());

    for(int p = 0; p < M; ++p) {
        K::Point_2 coord = people[p].first;
        K::FT d = people[p].second;

        if(CGAL::squared_distance(coord, t.nearest_vertex(coord)->point()) < d) {
            cout << "n";
            continue;
        }

        Delaunay::Face_handle start_face = t.locate(coord);
        if(t.is_infinite(start_face)) {
            cout << "y";
            continue;
        }

        bool stop = false;
        queue<Delaunay::Face_handle> fifo;
        fifo.push(start_face);
        int bfs_id = p+1;
        state[start_face] = bfs_id;
        while(!fifo.empty()) {
            Delaunay::Face_handle f = fifo.front(); fifo.pop();
            for(int e = 0; e < 3; ++e) {
                K::Segment_2 seg = t.segment(f, e);
                Delaunay::Face_handle neighbour = f->neighbor(e);

                if((seg.squared_length() >= 4*d) && state[neighbour] != bfs_id){
                    if(t.is_infinite(neighbour)) {
                        cout << "y";
                        stop = true;
                        break;
                    }
                    fifo.push(neighbour);
                    state[neighbour] = bfs_id;
                }
            }
            if(stop) break;

        }
        if(!stop) cout << "n";
    }
    cout << "\n";
}
```

```
74
75  int main() {
76      while(true) {
77          int N; cin >> N;
78          if(N == 0) return 0;
79          testcase(N);
80      }
81  }
```

HikingMaps

```cpp
#include <iostream>
#include <vector>
#include <queue>
#include <climits>
#include <CGAL/Exact_predicates_inexact_constructions_kernel.h>
#include <CGAL/ch_jarvis.h>
using namespace std;

typedef CGAL::Exact_predicates_inexact_constructions_kernel K;      // does not pass last TC with exact constructions.
typedef vector<int> vi;
typedef vector<vi> vii;

void testcase() {
    int M, N; cin >> M >> N; // M-1 legs, N maps.

    vector<pair<K::Point_2, K::Point_2> > legs;     // using a vector a segment, prevents from passing the 4th TC.
    K::Point_2 prev;
    cin >> prev;
    for(int m = 1; m < M; ++m) {
        int x, y; cin >> x >> y;
        K::Point_2 now(x, y);
        legs.push_back(make_pair(prev, now));
        prev = now;
    }

    vii lists(M-1); // storing "leg contained by map" data.
    for(int n = 0; n < N; ++n) {
        vector<K::Point_2> points(6);
        for(int i = 0; i < 6; ++i)
            cin >> points[i];

        vector<K::Point_2> ccw; // store the given vertices in counter-clockwise fashion.
        CGAL::ch_jarvis_march(points.begin(), points.end(), points[0], points[0], back_inserter(ccw));
        if(points[1] != ccw[1]) {   // ugly... making sure two consecutive vertices span a triangle edge.
            ccw.clear();
            CGAL::ch_jarvis_march(points.begin(), points.end(), points[1], points[1], back_inserter(ccw));
        }

        for(int l = 0; l < legs.size(); ++l) {  // iterate over each leg.
            bool isOutside;     // is set if to true, if origin or source is to the right to the edges.
            for(int p = 0; p < ccw.size()-1; p = p+2) {
                isOutside = (CGAL::right_turn(ccw[p], ccw[p+1], legs[l].first) ||
                CGAL::right_turn(ccw[p], ccw[p+1], legs[l].second)) ? true : false;   // if one of the leg points ↙
                    ↳ outside, then set to yes.
                if(isOutside) break;
            }
            if(!isOutside) lists[l].push_back(n);   // both end points of leg are inside.
        }
    }

    vi pointers(M-1, 0);
    priority_queue<int> max_heap;
    priority_queue<pair<int, int>, std::vector<pair<int, int> >, greater<pair<int, int> > > min_heap;
    for(int l = 0; l < lists.size(); ++l) {
        max_heap.push(lists[l][0]);
        min_heap.push(make_pair(lists[l][0], l));
    }

    int min_interval = INT_MAX;
    while(true) {
        pair<int, int> min_pair = min_heap.top(); min_heap.pop();
        int min_value = min_pair.first;
        int min_list = min_pair.second;

        int max_value = max_heap.top();
        int min_new = abs(max_value - min_value);
        min_interval = min(min_new, min_interval);
        if(pointers[min_list] == lists[min_list].size()-1) break;

        pointers[min_list]++;
        int new_value = lists[min_list][pointers[min_list]];
        max_heap.push(new_value);
        min_heap.push(make_pair(new_value, min_list));
```

```
73      }
74
75      cout << min_interval+1 << "\n";
76  }
77
78  int main() {
79      ios_base::sync_with_stdio(false);
80      int TC; cin >> TC;
81      while(TC--) testcase();
82      return 0;
83  }
```

Maximize It!

```
#include <iostream>
#include <cassert>
#include <CGAL/basic.h>
#include <CGAL/QP_models.h>
#include <CGAL/QP_functions.h>
#include <CGAL/Gmpz.h>
using namespace std;

#ifdef CGAL_USE_GMP
#include <CGAL/Gmpz.h>
typedef CGAL::Gmpz ET;
#else
#include <CGAL/MP_Float.h>
typedef CGAL::MP_Float ET;
#endif

// program and solution types
typedef CGAL::Quadratic_program<int> Program;
typedef CGAL::Quadratic_program_solution<ET> Solution;

void program_1(int a, int b) {
    Program qp (CGAL::SMALLER, true, 0, false, 0);      // use bounds instead of extra constraints.
    const int X = 0;
    const int Y = 1;

    // minimize -b*y + a*x^2
    qp.set_c(Y, -b);
    qp.set_d(X, X, a*2);

    // x + y <= 4
    qp.set_a(X, 0, 1);
    qp.set_a(Y, 0, 1);
    qp.set_b(0, 4);

    // 4x + 2y <= a*b
    qp.set_a(X, 1, 4);
    qp.set_a(Y, 1, 2);
    qp.set_b(1, a*b);

    // -x + y <= 1
    qp.set_a(X, 2, -1);
    qp.set_a(Y, 2, 1);
    qp.set_b(2, 1);

    Solution s = CGAL::solve_quadratic_program(qp, ET());
    assert(s.solves_quadratic_program(qp));

    if(s.is_optimal()) {
        int sign;
        (s.objective_value() <= 0) ? sign = -1 : sign = 1;
        cout << floor(to_double(sign*s.objective_value())) << "\n";     // std::ceil?, ceil_to_double fct?
    } else if(s.is_unbounded())
        cout << "unbounded\n";
    else if(s.is_infeasible())
        cout << "no\n";

}

void program_2(int a, int b) {
    Program qp (CGAL::SMALLER, false, 0, true, 0);
    const int X = 0;
    const int Y = 1;
    const int Z = 2;

    qp.set_l(Z, 0);
    qp.set_u(Z, false);

    // minimize a*x^2 + b*y + z^4
    qp.set_d(X, X, 2*a);
    qp.set_d(Z, Z, 2*1);        // by convention: we multiply value by 2.

    qp.set_c(Y, b);

```

```
74      qp.set_a(X, 0, 1);
75      qp.set_a(Y, 0, 1);
76      qp.set_b(0, -4);
77      qp.set_r(0, CGAL::LARGER);
78
79      qp.set_a(X, 1, 4);
80      qp.set_a(Y, 1, 2);
81      qp.set_a(Z, 1, 1);
82      qp.set_b(1, -1*a*b);
83      qp.set_r(1, CGAL::LARGER);
84
85      qp.set_a(X, 2, -1);
86      qp.set_a(Y, 2, 1);
87      qp.set_b(2, -1);
88      qp.set_r(2, CGAL::LARGER);
89
90      qp.set_a(Z, 3, 1);
91      qp.set_b(3, 0);
92      qp.set_r(3, CGAL::LARGER);
93
94      Solution s = CGAL::solve_quadratic_program(qp, ET());
95      assert(s.solves_quadratic_program(qp));
96
97      if(s.is_optimal()) {
98          double result = ceil(CGAL::to_double(s.objective_value()));
99          cout << result << "\n";
100     }
101     else if(s.is_unbounded())
102         cout << "unbounded\n";
103     else if(s.is_infeasible())
104         cout << "no\n";
105 }
106
107 int main() {
108     ios_base::sync_with_stdio(false);
109     cout << std::setiosflags(std::ios::fixed) << std::setprecision(0);
110     int p, a, b;
111     while(true) {
112         cin >> p;
113         if(p == 0) return 0;
114         cin >> a >> b;
115         if(p == 1) program_1(a, b);
116         if(p == 2) program_2(a, b);
117     }
118 }
```

Collisions

```cpp
#include <iostream>
#include <vector>
#include <set>
#include <CGAL/Exact_predicates_inexact_constructions_kernel.h>
#include <CGAL/Delaunay_triangulation_2.h>
#include <CGAL/Triangulation_vertex_base_with_info_2.h>
using namespace std;

typedef CGAL::Exact_predicates_inexact_constructions_kernel     K;
typedef CGAL::Delaunay_triangulation_2<K>                       D_Triangulation;
typedef D_Triangulation::Finite_edges_iterator                  FEI;
typedef set<D_Triangulation::Vertex_handle>                      vertex_set;

void testcase() {
    int n, d; cin >> n >> d;

    vector<K::Point_2> points;
    for(int i = 0; i < n; ++i) {
        int x, y; cin >> x >> y;
        points.push_back(K::Point_2(x, y));
    }

    D_Triangulation t;
    t.insert(points.begin(), points.end());
    vertex_set in_danger;
    for(FEI e = t.finite_edges_begin(); e != t.finite_edges_end(); ++e) {
        D_Triangulation::Vertex_handle v1 = e->first->vertex((e->second + 1) % 3);
        D_Triangulation::Vertex_handle v2 = e->first->vertex((e->second + 2) % 3);
        K::FT squared_d = CGAL::squared_distance(v1->point(), v2->point());
        double distance = CGAL::sqrt(squared_d);

        if(distance < d) {
           in_danger.insert(v1); in_danger.insert(v2);
        }
    }
    cout << in_danger.size() << "\n";

}

int main() {
    int TC; std::cin >> TC;
    while(TC--) testcase();
}
```

Diet

```
#include <iostream>
#include <cassert>
#include <CGAL/basic.h>
#include <CGAL/QP_models.h>
#include <CGAL/QP_functions.h>
using namespace std;

#ifdef CGAL_USE_GMP
#include <CGAL/Gmpz.h>
typedef CGAL::Gmpz ET;
#else
#include <CGAL/MP_Float.h>
typedef CGAL::MP_Float ET;
#endif

typedef CGAL::Quadratic_program<int> Program;
typedef CGAL::Quadratic_program_solution<ET> Solution;

// N: nutrients, M: foods
void testcase(int N, int M) {
    Program lp(CGAL::SMALLER, true, 0, false, 0);

    for(int n = 0; n < N; ++n) {
        int min, max; cin >> min >> max;
        lp.set_b(n, min);
        lp.set_r(n, CGAL::LARGER);
        lp.set_b(N+n, max);
    }

    for(int m = 0; m < M; ++m) {
        int p; cin >> p;
        lp.set_c(m, p);

        for(int n = 0; n < N; ++n) {
            int amount; cin >> amount;
            lp.set_a(m, n, amount);
            lp.set_a(m, N+n, amount);
        }
    }

    Solution s = CGAL::solve_linear_program(lp, ET());
    assert (s.solves_linear_program(lp));

    if(s.is_infeasible())
        cout << "No such diet.\n";
    else
        cout << floor(to_double(s.objective_value())) << "\n";
}

int main() {
    while(true) {
        int N, M; cin >> N >> M;
        if(N == 0 && M == 0) return 0;
        testcase(N, M);
    }
}
```

Porfolios

```cpp
#include <iostream>
#include <cassert>
#include <CGAL/basic.h>
#include <CGAL/QP_models.h>
#include <CGAL/QP_functions.h>
using namespace std;

#ifdef CGAL_USE_GMP
#include <CGAL/Gmpz.h>
typedef CGAL::Gmpz ET;
#else
#include <CGAL/MP_Float.h>
typedef CGAL::MP_Float ET;
#endif

typedef CGAL::Quadratic_program<int> Program;
typedef CGAL::Quadratic_program_solution<ET> Solution;

// N: assets, M: portfolios
void testcase(int N, int M) {
    Program qp(CGAL::SMALLER, true, 0, false, 0);

    for(int n = 0; n < N; ++n) {
        int c, r; cin >> c >> r;
        qp.set_a(n, 0, c);
        qp.set_a(n, 1, r);
    }

    for(int i = 0; i < N; ++i) {
        for(int j = 0; j < N; ++j) {
            int cij; cin >> cij;
            qp.set_d(i, j, 2*cij);
        }
    }

    for(int m = 0; m < M; ++m) {
        int C, R, V; cin >> C >> R >> V;
        qp.set_b(0, C);
        qp.set_b(1, R);
        qp.set_r(1, CGAL::LARGER);

        Solution s = CGAL::solve_quadratic_program(qp, ET());
        assert(s.solves_quadratic_program(qp));

        //cout << s;

        if(s.is_optimal() && (to_double(s.objective_value()) <= V)) {
            cout << "Yes.\n";
        } else {
            cout << "No.\n";
        }
    }
}

int main() {
    while(true) {
        int N, M; cin >> N >> M;
        if(N == 0 && M == 0) return 0;
        testcase(N, M);
    }
}
```

Inball

```cpp
#include <iostream>
#include <cassert>
#include <CGAL/basic.h>
#include <CGAL/QP_models.h>
#include <CGAL/QP_functions.h>
using namespace std;

#ifdef CGAL_USE_GMP
#include <CGAL/Gmpz.h>
typedef CGAL::Gmpz ET;
#else
#include <CGAL/MP_Float.h>
typedef CGAL::MP_Float ET;
#endif

typedef CGAL::Quadratic_program<int> Program;
typedef CGAL::Quadratic_program_solution<ET> Solution;

int main() {
    ios_base::sync_with_stdio(false);
    int n; cin >> n;

    while(n > 0) {
        int d; cin >> d;
        Program lp(CGAL::SMALLER, false, 0, false, 0);
        lp.set_c(d, -1);
        lp.set_l(d, true, 0);

        for(int i = 0; i < n; ++i) {
            int l2 = 0;
            for(int j = 0; j < d; ++j) {
                int a; cin >> a;
                lp.set_a(j, i, a);
                l2 += a*a;
            }
            l2 = sqrt(l2);
            lp.set_a(d, i, l2);

            int b; cin >> b;
            lp.set_b(i, b);
        }

        Solution s = CGAL::solve_linear_program(lp, ET());
        if(s.is_infeasible()) {
            cout << "none\n";
        } else if(s.is_unbounded()) {
            cout << "inf\n";
        } else {
            cout << floor(-CGAL::to_double(s.objective_value())) << "\n";
        }

        cin >> n;
    }
}
```

Monkey Island

```cpp
#include <vector>
#include <iostream>
#include <climits>
#include <boost/graph/strong_components.hpp>
#include <boost/graph/adjacency_list.hpp>
#include <boost/tuple/tuple.hpp>
using namespace std;
using namespace boost;

typedef vector<int> vi;
typedef adjacency_list<vecS, vecS, directedS, no_property, no_property> Graph;
typedef graph_traits<Graph>::edge_descriptor Edge;
typedef graph_traits<Graph>::edge_iterator EdgeIterator;

void testcase() {
    int N, M; cin >> N >> M;

    Graph g(N);
    for(int e = 0; e < M; ++e) {
        int v1, v2;
        cin >> v1 >> v2;
        add_edge(v1-1, v2-1, g);
    }

    vi costs(N);
    for(int n = 0; n < N; ++n) {
        int cost; cin >> cost;
        costs[n] = cost;
    }

    vector<int> scc(N);
    int nscc = strong_components(g, &scc[0]);

    vi incoming_comp(nscc, 0);
    EdgeIterator ebeg, eend;
    for(tie(ebeg, eend) = edges(g); ebeg != eend; ++ebeg) {
        int u = source(*ebeg, g);
        int v = target(*ebeg, g);
        if(scc[u] != scc[v]) incoming_comp[scc[v]] = 1;
    }

    int total = 0;
    for(int comp = 0; comp < nscc; ++comp) {
        if(incoming_comp[comp] == 1) continue;
        int min_cost = INT_MAX;
        for(int v = 0; v < N; ++v) {
            if(scc[v] == comp) min_cost = min(min_cost, costs[v]);
        }
        total += min_cost;
    }

    cout << total << "\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Placing Knights

```cpp
#include <iostream>
#include <vector>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/max_cardinality_matching.hpp>
using namespace std;
using namespace boost;

typedef vector<int> vi;
typedef vector<vi> vii;
typedef adjacency_list<vecS, vecS, undirectedS, no_property, no_property> Graph;
typedef graph_traits<Graph>::vertex_descriptor Vertex;

int N;

int co_to_index(int i, int j) {
    return i*N + j;
}

void add_valid_edges(int i, int j, vii& holes, Graph& g) {
    int y = 1;
    for(int x = -2; x <= 2; x = x + 4) {
        if(i+y >= 0 && i+y < N && j+x >= 0 && j+x <= N && holes[i+y][j+x] == 1) {
            add_edge(co_to_index(i, j), co_to_index(i+y, j+x), g);
        }
    }
    y = 2;
    for(int x = -1; x <= 1; x = x + 2) {
        if(i+y >= 0 && i+y < N && j+x >= 0 && j+x <= N && holes[i+y][j+x] == 1) {
            add_edge(co_to_index(i, j), co_to_index(i+y, j+x), g);
        }
    }
}

void testcase() {
    cin >> N;
    Graph g(N*N);
    vii holes(N, vi(N));
    int sum_holes = 0;

    for(int i = 0; i < N; ++i) {
        for(int j = 0; j < N; ++j) {
            int hole; cin >> hole;
            holes[i][j] = hole;
            if(holes[i][j] == 0) ++sum_holes;
        }
    }

    for(int i = 0; i < N-1; ++i) {
        for(int j = 0; j < N; ++j) {
            if(holes[i][j] == 1) add_valid_edges(i, j, holes, g);
        }
    }

    vector<Vertex> mateMap(num_vertices(g), 0);
    checked_edmonds_maximum_cardinality_matching(g, &mateMap[0]);
    // mistake: forgot to substract the holes.
    cout << num_vertices(g)- sum_holes - matching_size(g, &mateMap[0]) << "\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Shopping Trip

```cpp
#include <iostream>
#include <vector>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/push_relabel_max_flow.hpp>
using namespace std;
using namespace boost;

typedef adjacency_list_traits<vecS, vecS, directedS> Traits;
typedef adjacency_list<vecS, vecS, directedS, no_property,
  property<edge_capacity_t, long,
  property<edge_residual_capacity_t, long,
  property<edge_reverse_t, Traits::edge_descriptor> > > > Graph;
typedef property_map<Graph, edge_capacity_t>::type EdgeCapacityMap;
typedef property_map<Graph, edge_residual_capacity_t>::type ResidualCapacityMap;
typedef property_map<Graph, edge_reverse_t>::type ReverseEdgeMap;
typedef graph_traits<Graph>::edge_descriptor Edge;

void testcase() {
    int n, m, s; cin >> n >> m >> s;
    Graph g(n);
    EdgeCapacityMap capacity = get(edge_capacity, g);
    ReverseEdgeMap rev_edge = get(edge_reverse, g);
    ResidualCapacityMap res_capacity = get(edge_residual_capacity, g);

    for(int store = 0; store < s; ++store){
        int store_vertex; cin >> store_vertex;
        Edge edge;
        tie(edge, tuples::ignore) = add_edge(store_vertex, n, g);
        Edge reverse_edge;
        tie(reverse_edge, tuples::ignore) = add_edge(n, store_vertex, g);
        capacity[edge] = 1;
        rev_edge[edge] = reverse_edge;
        capacity[reverse_edge] = 0;
        rev_edge[reverse_edge] = edge;
    }

    for(int e = 0; e < m; ++e) {
        int v1, v2; cin >> v1 >> v2;
        Edge edge;
        tie(edge, tuples::ignore) = add_edge(v1, v2, g);
        Edge reverse_edge;
        tie(reverse_edge, tuples::ignore) = add_edge(v2, v1, g);
        capacity[edge] = 1;
        rev_edge[edge] = reverse_edge;
        capacity[reverse_edge] = 0;
        rev_edge[reverse_edge] = edge;
        Edge edge2;
        tie(edge2, tuples::ignore) = add_edge(v2, v1, g);
        Edge reverse_edge2;
        tie(reverse_edge2, tuples::ignore) = add_edge(v1, v2, g);
        capacity[edge2] = 1;
        rev_edge[edge2] = reverse_edge2;
        capacity[reverse_edge2] = 0;
        rev_edge[reverse_edge2] = edge2;
    }

    long max_flow = push_relabel_max_flow(g, 0, n);
    if(max_flow == s) cout << "yes\n"; else cout << "no\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

TheeV

```cpp
#include <iostream>
#include <vector>
#include <CGAL/Exact_predicates_exact_constructions_kernel.h>
#include <CGAL/Min_circle_2.h>
#include <CGAL/Min_circle_2_traits_2.h>
using namespace std;

typedef CGAL::Exact_predicates_exact_constructions_kernel K;
typedef CGAL::Min_circle_2_traits_2<K> MinCircleTraits;
typedef CGAL::Min_circle_2<MinCircleTraits> Min_circle;
typedef vector<pair<K::FT, K::Point_2> > dp;

bool pairCompare(const pair<K::FT, K::Point_2>& lhs, const pair<K::FT, K::Point_2>& rhs) {
    return lhs.first > rhs.first;
}

double ceil_to_double(const K::FT& x) {
    double a = std::ceil(CGAL::to_double(x));
    while (a < x) a += 1;
    while (a >= x+1) a -= 1;
    return a;
}

void testcase() {
    int N; cin >> N;
    dp cities;

    int x, y; cin >> x >> y;
    K::Point_2 capitol(x, y);
    cities.push_back(make_pair(0, capitol));

    for(int n = 1; n < N; ++n) {
        int x, y; cin >> x >> y;
        K::Point_2 p(x, y);
        K::FT dist = CGAL::squared_distance(capitol, p);
        cities.push_back(make_pair(dist, p));
    }
    sort(cities.begin(), cities.end(), pairCompare);

    int i = 0;
    K::FT r1 = cities[0].first, r2 = 0;
    K::FT t = r1;
    Min_circle mc;
    while(r1 > r2 && i < N-1) {
        r1 = cities[i+1].first;

        //cout << "insert in mincircle: " << cities[i].second << "\n";
        mc.insert(cities[i].second);
        MinCircleTraits::Circle c = mc.circle();
        r2 = c.squared_radius();
        //cout << "r1: " << r1 << "\n" << "r2: " << r2 << "\n";
        //cout << "diff: " << abs(r1 - r2) << " r1: " << r1 << " r2:" << r2 << "\n";
        ++i;
    }

    if(r1 == r2)
        t = r1;
    if(r2 > r1)
        t = min(r2, cities[i-1].first);

    cout << ceil_to_double(t) << "\n";
}

int main() {
    cin.sync_with_stdio(false);
    cout << std::setiosflags(std::ios::fixed) << std::setprecision(0);
    int TC; cin >> TC;
    while(TC--) testcase();
}
```

Poker Chips

```cpp
#include <iostream>
#include <vector>
#include <map>
#include <cmath>
using namespace std;

typedef vector<int> vi;
typedef vector<vi> vii;
typedef map<vector<int>, int> vector_int;

vi M;
int N;
vector_int dp_table;
vii chips;

int find_max(vi& state) {
    if(dp_table.count(state) == 1)
        return dp_table[state];

    for(int n = 1; n < pow(2.0, N); ++n) {
        vi new_state = state;
        int T = 0;
        int prev = -1;

        for(int k = 0; k < N; ++k) {
            if((n & (1 << k)) && (state[k] != 0)) {
                int color = chips[k][state[k]-1];
                if(prev == color || prev == -1) {
                    --new_state[k];
                    prev = color;
                    ++T;
                } else {
                    T = 0;  // !important to avoids wasted loops and computing invalid states.
                    break;
                }
            }
        }

        if(T != 0) { // if T=0, then invalid subset.
            int K = (T <= 1) ? 0 : pow(2.0, T-2);
            dp_table[state] = max(find_max(new_state) + K, dp_table[state]);
        }
    }

    return dp_table[state];
}

void testcase() {
    cin >> N;
    M = vi(N);
    for(int n = 0; n < N; ++n)
        cin >> M[n];

    chips = vii(N);
    for(int n = 0; n < N; ++n) {
        for(int m = 0; m < M[n]; ++m) {
            int col; cin >> col;
            chips[n].push_back(col);
        }
    }

    dp_table = vector_int();
    cout << find_max(M) << "\n";
}

int main() {
    ios_base::sync_with_stdio(false);
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Portfolio Revisited

```cpp
#include <iostream>
#include <cassert>
#include <CGAL/basic.h>
#include <CGAL/QP_models.h>
#include <CGAL/QP_functions.h>
using namespace std;

#ifdef CGAL_USE_GMP
#include <CGAL/Gmpz.h>
typedef CGAL::Gmpz ET;
#else
#include <CGAL/MP_Float.h>
typedef CGAL::MP_Float ET;
#endif

typedef CGAL::Quadratic_program<int> Program;
typedef CGAL::Quadratic_program_solution<ET> Solution;

void testcase(int N, int M) {
    Program qp (CGAL::SMALLER, true, 0, false, 0);

    for(int n = 0; n < N; ++n) {
        int c, r; cin >> c >> r;
        qp.set_a(n, 0, c);
        qp.set_a(n, 1, r);
    }
    qp.set_r(1, CGAL::LARGER);

    for(int i = 0; i < N; ++i) {
        for(int j = 0; j < N; ++j) {
            int vij; cin >> vij;
            qp.set_d(i, j, 2*vij);
        }
    }

    for(int m = 0; m < M; ++m) {
        int C, V; cin >> C >> V;
        int R = 0;
        qp.set_b(0, C);
        qp.set_b(1, R);

        int lo = 0;
        int hi = 100;
        bool fixed = false;
        while(lo <= hi) {
            int mid = (fixed) ? (lo + (hi-lo+1)/2) : hi;

            qp.set_b(1, mid);
            Solution s = CGAL::solve_quadratic_program(qp, ET());
            assert(s.solves_quadratic_program(qp));

            if(s.is_optimal() && s.objective_value() <= V) {
                R = mid;
                if(!fixed) {
                    lo = hi+1;
                    hi = 2*hi;
                } else {
                    lo = mid+1;
                }
            } else {
                fixed = true;
                hi = mid-1;
            }
        }
        cout << R << "\n";
    }
}

int main() {
    while(true) {
        int N, M; cin >> N >> M;
        if(N == 0 && M == 0) return 0;
        testcase(N, M);
```

```
74          }
75      }
```

Stamp Exhibition

```cpp
#include <iostream>
#include <cassert>
#include <cmath>
#include <CGAL/basic.h>
#include <CGAL/QP_models.h>
#include <CGAL/QP_functions.h>
#include <CGAL/Exact_predicates_inexact_constructions_kernel.h>
using namespace std;

#ifdef CGAL_USE_GMP
#include <CGAL/Gmpq.h>
typedef CGAL::Gmpq ET;
#else
#include <CGAL/MP_Float.h>
typedef CGAL::MP_Float ET;
#endif

typedef CGAL::Exact_predicates_inexact_constructions_kernel K;
typedef CGAL::Quadratic_program<double> Program;
typedef CGAL::Quadratic_program_solution<ET> Solution;

void testcase() {
    int L, S, W; cin >> L >> S >> W;

    vector<K::Point_2> lamps;
    for(int l = 0; l < L; ++l) {
        int x, y; cin >> x >> y;
        lamps.push_back(K::Point_2(x, y));
    }

    vector<pair<K::Point_2, double> > stamps;
    for(int s = 0; s < S; ++s) {
        int x, y; double m; cin >> x >> y >> m;
        stamps.push_back(make_pair(K::Point_2(x, y), m));
    }

    vector<K::Segment_2> walls;
    for(int w = 0; w < W; ++w) {
        int x1, y1, x2, y2; cin >> x1 >> y1 >> x2 >> y2;
        walls.push_back(K::Segment_2(K::Point_2(x1, y1), K::Point_2(x2, y2)));
    }

    if(S == 0) { cout << "yes\n"; return; }
    if(L == 0) { cout << "no\n"; return; }

    Program lp (CGAL::SMALLER, true, 1, true, pow(2.0, 12));
    for(int l = 0; l < L; ++l) {
        for(int s = 0; s < S; ++s) {
            bool intersect = false;
            for(int w = 0; w < W; ++w) {
                K::Segment_2 stamp_lamp(stamps[s].first, lamps[l]);
                if(CGAL::do_intersect(stamp_lamp, walls[w])) {
                    intersect = true;
                    break;
                }
            }

            double param = 0;
            if(!intersect)
                param = 1.0/CGAL::squared_distance(stamps[s].first, lamps[l]);
            lp.set_a(l, s, param);
            lp.set_a(l, S+s, param);
            lp.set_b(s, stamps[s].second);
            lp.set_b(S+s, 1.0);
            lp.set_r(S+s, CGAL::LARGER);
        }
    }

    Solution s = CGAL::solve_linear_program(lp, ET());
    assert (s.solves_linear_program(lp));
    (!s.is_infeasible()) ? cout << "yes\n" : cout << "no\n";
}

```

```cpp
int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Tetris

```cpp
#include <iostream>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/push_relabel_max_flow.hpp>
#include <boost/tuple/tuple.hpp>
using namespace std;
using namespace boost;

typedef adjacency_list_traits<vecS, vecS, directedS> Traits;
typedef adjacency_list<vecS, vecS, directedS, no_property,
  property<edge_capacity_t, long,
  property<edge_residual_capacity_t, long,
  property<edge_reverse_t, Traits::edge_descriptor> > > > Graph;
typedef property_map<Graph, edge_capacity_t>::type EdgeCapacityMap;
typedef property_map<Graph, edge_reverse_t>::type ReverseEdgeMap;
typedef graph_traits<Graph>::edge_descriptor Edge;

void add_edge(int from, int to, int cap, Graph& g) {
    //cout << "adding edge: " << from << " " << to << " " << cap << "\n";
    EdgeCapacityMap capacity = get(edge_capacity, g);
    ReverseEdgeMap reverse = get(edge_reverse, g);

    Edge there, back;
    tie(there, tuples::ignore) = add_edge(from, to, g);
    tie(back, tuples::ignore) = add_edge(to, from, g);
    capacity[there] = cap;
    capacity[back] = 0;
    reverse[there] = back;
    reverse[back] = there;
}

void testcase() {
    int W, N; cin >> W >> N;

    int source = 0;
    int sink = W;
    Graph g(2*W);

    for(int v = 1; v < W; ++v) {
        add_edge(v, W+v, 1, g);
    }

    for(int n = 0; n < N; ++n) {
        int v1, v2; cin >> v1 >> v2;
        int from = (min(v1, v2) == 0) ? 0 : min(v1, v2) + W;
        int to = max(v1, v2);
        add_edge(from, to, 1, g);
    }

    int maxflow = push_relabel_max_flow(g, source, sink);
    cout << maxflow << "\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
}
```

Beach Bar

```cpp
#include <vector>
#include <iostream>
#include <climits>
#include <algorithm>
using namespace std;

typedef vector<int> vi;
const int normalize = 1000000;

void testcase() {
    int N; cin >> N;
    vi points;
    for(int n = 0; n < N; ++n) {
        int x; cin >> x;
        points.push_back(x + normalize);
    }
    sort(points.begin(), points.end());

    int g_counter = INT_MIN;
    int g_length = INT_MIN;
    vi solution;
    for(int n = 0; n < N; ++n) {
        int start_interval = points[n];
        int end_interval = start_interval + 200;
        int k = n;
        int counter = 0;
        while(points[k] <= end_interval && k < N) {
            ++counter;
            ++k;
        }
        int length = (points[k-1] - start_interval);

        if(counter > g_counter || (counter == g_counter && length < g_length)) {
            g_counter = counter;
            g_length = length;
            solution.clear();
        }

        if(g_counter == counter && g_length == length) {
            int output =  start_interval + length/2 - normalize;
            solution.push_back(output);
            if(length % 2 != 0) {
                solution.push_back(output+1);
            }
        }
    }

    g_length = (g_length % 2 == 0) ? g_length/2 : g_length/2+1;
    cout << g_counter << "␣" << g_length <<"\n";
    for(int s = 0; s < solution.size(); ++s) {
        cout << solution[s];
        if(s != solution.size() - 1) cout << "␣";
    }
    cout << "\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Cover

```cpp
#include <iostream>
#include <vector>
#include <algorithm>
#include <CGAL/Exact_predicates_exact_constructions_kernel.h>
#include <CGAL/Delaunay_triangulation_2.h>
using namespace std;

typedef CGAL::Exact_predicates_exact_constructions_kernel           K;
typedef CGAL::Delaunay_triangulation_2<K>                           Delaunay;
typedef Delaunay::Finite_faces_iterator                             FFI;
typedef Delaunay::Finite_edges_iterator                             FEI;

double ceil_to_double(const K::FT& x) {
    double a = ceil(CGAL::to_double(x));
    while (a < x) a += 1;
    while (a-1 >= x) a -= 1;
    return a;
}

template<typename T>
K::FT check_intersection(const T* obj, const K::Point_2 p1, const vector<K::Segment_2>& rectangle) {
    for (int i = 0; i < 4; ++i) {
        if(!do_intersect(rectangle[i], *obj)) continue;
        CGAL::Object o = intersection(rectangle[i], *obj);
        const K::Point_2* p2 = CGAL::object_cast<K::Point_2>(&o);
        K::FT sqrd = CGAL::squared_distance(p1, *p2);
        return sqrd;
    }
    return 0;
}

void testcase(int N) {
    vector<K::Point_2> points;
    vector<K::Segment_2> rectangle;

    double x1, y1, x2, y2;
    cin >> x1 >> y1 >> x2 >> y2;
    K::Point_2 sw (x1, y1);
    K::Point_2 nw(x1, y2);
    K::Point_2 se(x2, y1);
    K::Point_2 ne(x2, y2);
    rectangle.push_back(K::Segment_2(sw, nw));
    rectangle.push_back(K::Segment_2(se, ne));
    rectangle.push_back(K::Segment_2(sw, se));
    rectangle.push_back(K::Segment_2(nw, ne));

    for(int n = 0; n < N; ++n) {
        double x, y; cin >> x >> y;
        points.push_back(K::Point_2(x, y));
    }

    // O(n log n)
    Delaunay t;
    t.insert(points.begin(), points.end());
    K::FT min_rad;

    // check corners
    min_rad = CGAL::squared_distance(sw, t.nearest_vertex(sw)->point());
    min_rad = max(min_rad, CGAL::squared_distance(se, t.nearest_vertex(se)->point()));
    min_rad = max(min_rad, CGAL::squared_distance(nw, t.nearest_vertex(nw)->point()));
    min_rad = max(min_rad, CGAL::squared_distance(ne, t.nearest_vertex(ne)->point()));

    // iterate over all faces to find largest circle - O(N)
    for(FFI f = t.finite_faces_begin(); f != t.finite_faces_end(); ++f) {
        K::Point_2 cc = t.circumcenter(f);
        if(cc.x() >= x1 && cc.x() <= x2 && cc.y() >= y1 && cc.y() <= y2) {
            K::Point_2 point = f->vertex(1)->point();
            K::FT dist = CGAL::squared_distance(point, cc);
            min_rad = max(min_rad, dist);
        }
    }

    // check for intersection with rectangle boundary - O(n*4)
```

```
74      for(FEI e = t.finite_edges_begin(); e != t.finite_edges_end(); ++e) {
75          CGAL::Object o = t.dual(e);
76          if(const K::Ray_2* r = CGAL::object_cast<K::Ray_2>(&o))
77              min_rad = max(min_rad, check_intersection(r, t.segment(e).source(), rectangle));
78          else if(const K::Segment_2* s = CGAL::object_cast<K::Segment_2>(&o))
79              min_rad = max(min_rad, check_intersection(s, t.segment(e).source(), rectangle));
80      }
81
82      cout << ceil(CGAL::sqrt(to_double(min_rad))) << "\n";
83  }
84
85  int main() {
86      cin.sync_with_stdio(false);
87      cout << std::setiosflags(std::ios::fixed) << std::setprecision(0);
88      while(true) {
89          int N; cin >> N;
90          if(N == 0) return 0;
91          testcase(N);
92      }
93  }
```

Divisor Distance

```cpp
#include <iostream>
#include <cmath>
using namespace std;

int ancestor(int v) {
    for(int k = 2; k <= ceil(sqrt(v)); ++k) {
        if(v % k == 0) return (v/k);
    }
    return 1;
}

void testcase() {
    int N, C; cin >> N >> C;
    for(int c = 0; c < C; ++c) {
        int v1, v2; cin >> v1 >> v2;
        int counter = 0;
        while(v1 != v2) {
            ++counter;
            if(v1 < v2) {
                v2 = ancestor(v2);
            } else {
                v1 = ancestor(v1);
            }
        }
        cout << counter << "\n";
    }
}

int main() {
    ios_base::sync_with_stdio(false);
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Tiles

```cpp
#include <iostream>
#include <vector>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/max_cardinality_matching.hpp>
using namespace std;
using namespace boost;

typedef vector<int> vi;
typedef vector<vi> vii;
typedef adjacency_list<vecS, vecS, undirectedS, no_property, no_property> Graph;
typedef graph_traits<Graph>::vertex_descriptor Vertex;

void testcase() {
    int W, H; cin >> W >> H;

    vii matrix(H);
    int blocked = 0;
    int vcounter = 0;
    for(int h = 0; h < H; ++h) {
        for(int w = 0; w < W; ++w) {
            char input; cin >> input;
            blocked += (input == 'x');
            matrix[h].push_back((input == '.') ? vcounter++ : -1);
        }
    }

    int V = (W*H - blocked);
    if(V % 2 == 1) {
        cout << "no\n";
        return;
    }

    Graph g(V);
    for(int h = 0; h < H; ++h) {
        for(int w = 0; w < W; ++w) {
            if(matrix[h][w] == -1) continue;
            if(w+1 < W && matrix[h][w+1] != -1) add_edge(matrix[h][w], matrix[h][w+1], g);
            if(h+1 < H && matrix[h+1][w] != -1) add_edge(matrix[h][w], matrix[h+1][w], g);
        }
    }

    vector<Vertex> mateMap(num_vertices(g), 0);
    checked_edmonds_maximum_cardinality_matching(g, &mateMap[0]);
    int matching = matching_size(g, &mateMap[0]);

    if(matching * 2 == V) cout << "yes\n";
    else cout << "no\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Connecting Capitals

All the following algorithms run in linear time.

1 Maximum Matching in Tree

```cpp
#include <iostream>
#include <vector>
using namespace std;

typedef vector<int> vi;
typedef vector<vi> vii;

int matching(int vertex, int parent, vii& adj, vi& M) {
    if(M[vertex] != -1) return M[vertex];

    int total = 0;
    for(int c = 0; c < adj[vertex].size(); ++c) {
        if(adj[vertex][c] == parent) continue;
        int child = adj[vertex][c];
        total += matching(child, vertex, adj, M);
    }
    int Mprime = total; // crucial, otherwise I increment M[vertex] everytime I iterate over a.
    M[vertex] = total;

    for(int c = 0; c < adj[vertex].size(); ++c) {
        if(adj[vertex][c] == parent) continue;
        int a = adj[vertex][c];
        total = 1 + Mprime - M[a];
        for(int w = 0; w < adj[a].size(); ++w){
            if(adj[a][w] == vertex) continue;
            total += matching(adj[a][w], a, adj, M);
        }
        M[vertex] = max(total, M[vertex]);
    }

    return M[vertex];
}

void testcase() {
    int N; cin >> N;
    vii adj(N);
    vi M(N, -1);

    for(int n = 0; n < N-1; ++n) {
        int v1, v2; cin >> v1 >> v2;
        adj[v1].push_back(v2);
        adj[v2].push_back(v1);
    }

    int match = matching(0, 0, adj, M);
    cout << match << "\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

2 Outputting Maximum Matching

```cpp
#include <iostream>
#include <vector>
using namespace std;

typedef vector<int> vi;
typedef vector<vi> vii;

int matching(int vertex, int parent, vii& adj, vi& M, vi& matchings) {
    if(M[vertex] != -1) return M[vertex];

    int total = 0;
    for(int c = 0; c < adj[vertex].size(); ++c) {
```

```
        if(adj[vertex][c] == parent) continue;
        int child = adj[vertex][c];
        total += matching(child, vertex, adj, M, matchings);
    }
    int Mprime = total;
    M[vertex] = total;

    for(int c = 0; c < adj[vertex].size(); ++c) {
        if(adj[vertex][c] == parent) continue;
        int a = adj[vertex][c];
        total = 1 + Mprime - M[a];
        for(int w = 0; w < adj[a].size(); ++w){
            if(adj[a][w] == vertex) continue;
            total += matching(adj[a][w], a, adj, M, matchings);
        }
        if(total > M[vertex]) {
            matchings[vertex] = a;
            M[vertex] = max(total, M[vertex]);
        }
    }

    return M[vertex];
}

void testcase() {
    int N; cin >> N;
    vii adj(N);
    vi M(N, -1);
    vi matchings(N, -1);

    for(int n = 0; n < N-1; ++n) {
        int v1, v2; cin >> v1 >> v2;
        adj[v1].push_back(v2);
        adj[v2].push_back(v1);
    }

    int match = matching(0, 0, adj, M, matchings);
    cout << match << "\n";

    for(int m = 0; m < N; ++m) {
        if(matchings[m] != -1) cout << m << "␣" << matchings[m] << "\n";
    }
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

3 MVC in Tree

Selection of the minimum set of vertices such that all edges are incident to one vertex.

```
#include <iostream>
#include <vector>
using namespace std;

typedef vector<int> vi;
typedef vector<vi> vii;

int N;
vii adj;
vii dp_table;

int MVC(int vertex, int parent, bool taken) {
    if(dp_table[vertex][taken] != -1) return dp_table[vertex][taken];

    int ans = 0;
    if(adj[vertex].size() == 1 && vertex != 0) {
        ans = taken;
    }
    else if(taken == 1) {
        ans = 1;
        for(int i = 0; i < (int)adj[vertex].size(); ++i) {
            int child = adj[vertex][i];
            if(child == parent) continue;
```

```
            ans += min(MVC(child, vertex, false), MVC(child, vertex, true));
        }
    }
    else if(taken == 0) {
        ans = 0;
        for(int i = 0; i < (int) adj[vertex].size(); ++i) {
            int child = adj[vertex][i];
            if(child == parent) continue;
            ans += MVC(child, vertex, true);
        }
    }

    dp_table[vertex][taken] = ans;
    return ans;
}

void testcase() {
    cin >> N;
    adj.clear(); adj.assign(N, vi(0));
    dp_table.clear(); dp_table.assign(N, vi(2 , -1));

    for(int n = 0; n < N-1; ++n) {
        int v1, v2; cin >> v1 >> v2;
        adj[v1].push_back(v2);
        adj[v2].push_back(v1);
    }

    cout << min(MVC(0, 0, true), MVC(0, 0, false)) << "\n";

    // print vertex cover. V - MVC = MIS, because tree = bipartite graph (KÃűnigstheorem).
    for(int i = 0; i < N; ++i) {
        if(dp_table[i][1] <= dp_table[i][0]) cout << i << "␣";
    }
    cout << "\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

4 MIS in Tree

Selects a set of vertices, such that none of them are adjacent.

```
#include <iostream>
#include <vector>
using namespace std;

typedef vector<int> vi;
typedef vector<vi> vii;

vii adj;
vii dp_table;
vi values;

int MWIS(int v, bool taken) {
    int ans;
    if(adj[v].size() == 1 && v != 0) {
        if(taken) return values[v];
        else return 0;
    }
    else if(taken) {
        ans = values[v];
        for(int i = 0; i < (int) adj[v].size(); ++i) {
            if(adj[v][i] == vertex) continue;
            ans += values[adj[v][i]][false];
        }
    }
    else if(!taken) {
        for(int i = 0; i < (int) adj[v].size(); ++i) {
            if(adj[v][i] == vertex) continue;
            ans += max(values[adj[v][i]][true], values[adj[v][i]][false]);
        }
    }
```

```
31
32      dp_table[v][taken] = ans;
33      return ans;
34  }
35
36  void testcase() {
37      int N; cin >> N;
38      adj.clear(); adj.assign(N, vi(0);
39      dp_table.clear(); dp_table.assign(N, vi(2, -1));
40      values.clear(); values.assign(N, 0);
41
42      for(int n = 0; n < N-1; ++n) {
43          int v1, v2; cin >> v1 >> v2;
44          adj[v1].push_back(v2);
45          adj[v2].push_back(v1);ssssss
46      }
47
48      for(int n = 0; n < N; ++n) {
49          int val; cin >> val;
50          values[n] = val;
51      }
52
53      cout << max(MWIS(0, true), MWIS(0, false)) << "\n";
54  }
55
56  int main() {
57      int TC; cin >> TC;
58      while(TC--) testcase();
59      return 0;
60  }
```

Deleted Entries Stike Back

Missing.

Light The Stage

```cpp
#include <vector>
#include <map>
#include <iostream>
#include <cmath>
#include <CGAL/Delaunay_triangulation_2.h>
#include <CGAL/Exact_predicates_inexact_constructions_kernel.h>
using namespace std;

typedef CGAL::Exact_predicates_inexact_constructions_kernel K;
typedef CGAL::Delaunay_triangulation_2<K> Delaunay;
typedef vector<pair<K::Point_2, int> > vp;

int P, L, H;

vector<int> get_winners(int maxLamp, vp& participants, vector<K::Point_2>& lamps) {
    Delaunay t;
    t.insert(lamps.begin(), lamps.begin()+maxLamp);

    vector<int> winners;
    for(int p = 0; p < P; ++p) {
        int radius = participants[p].second;
        K::Point_2 loc = participants[p].first;
        Delaunay::Vertex_handle lamp = t.nearest_vertex(loc);
        K::FT dist = CGAL::squared_distance(loc, lamp->point());
        K::FT dist_p = H+radius;
        if(dist >= dist_p*dist_p) {
            winners.push_back(p);
        }
    }
    return winners;
}

void testcase() {
    cin >> P >> L;
    vp participants;
    for(size_t p = 0; p < P; ++p) {
        int x, y, r;
        cin >> x >> y >> r;
        participants.push_back(make_pair(K::Point_2(x, y), r));
    }

    cin >> H;

    vector<K::Point_2> lamps;
    for(size_t l = 0; l < L; ++l) {
        int x, y;
        cin >> x >> y;
        lamps.push_back(K::Point_2(x, y));
    }

    vector<int> winners;
    winners = get_winners(L, participants, lamps);
    if(winners.size() != 0) {
        for(int i = 0; i < winners.size(); ++i) cout << winners[i] << "␣";
        cout << "\n";
        return;
    }

    int lo = 0;
    int hi = L;
    int D = -1;
    map<int, int> results;
    while(lo < hi) {
        int mid = lo + (hi-lo+1)/2;
        vector<int> survivers = get_winners(mid, participants, lamps);
        int count = survivers.size();
        results[mid] = (count == 0) ? -1 : count;

        if(lo+1 == hi && results[lo] != 0 && results[hi] == -1) {
            D = lo;
            break;
        }

```

```
74          if(count == 0) {
75              hi = mid;
76          } else {
77              lo = mid;
78          }
79      }
80      winners = get_winners(D, participants, lamps);
81      for(int i = 0; i < winners.size(); ++i) cout << winners[i] << "␣";
82      cout << "\n";
83  }
84
85  int main() {
86      std::ios_base::sync_with_stdio(false);
87      int TC; cin >> TC;
88      while (TC--) testcase();
89      return 0;
90  }
```

Radiation

```
#include <iostream>
#include <vector>
#include <CGAL/basic.h>
#include <CGAL/QP_models.h>
#include <CGAL/QP_functions.h>
using namespace std;

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

#ifdef CGAL_USE_GMP
#include <CGAL/Gmpz.h>
typedef CGAL::Gmpz ET, IT;
#else
#include <CGAL/MP_Float.h>
typedef CGAL::MP_Float ET;
#endif

typedef CGAL::Quadratic_program<IT> Program;
typedef CGAL::Quadratic_program_solution<ET> Solution;
map<pair<int, int>, IT> Powers;

IT pw(int b, int e) {
    if(Powers[make_pair(b, e)] != 0)
        return Powers[make_pair(b, e)];

    IT sol = 1;
    for(int i = 1; i <= e; ++i) {
        sol *= b;
    }
    Powers[make_pair(b, e)] = sol;
    return sol;
}

void testcase() {
    int H, T; cin >> H >> T;

    vector<Point> cells;
    for(int c = 0; c < (H+T); ++c) {
        Point p;
        cin >> p.x >> p.y >> p.z;
        cells.push_back(p);
    }

    int lo = 0;
    int hi = 29;
    int d = -1;
    vector<int> results(30, -1);

    while(lo <= hi) {
        Program lp(CGAL::SMALLER, false, 0, false, 0);
        lp.set_c(0, -1);
        lp.set_u(0, true, 1); // MISTAKE!!! before set_u(0, 1);

        int deg = lo + (hi-lo+1)/2;
        for(int row = 0; row < cells.size(); ++row) {
            lp.set_b(row, 0);
            if(row >= H) { // tumor cell
                lp.set_a(0, row, -1);
                lp.set_r(row, CGAL::LARGER);
            }

            int col = 1;
            for(int i = 0; i <= deg; ++i) {
                for(int j = 0; j <= deg-i; ++j) {
                    for(int k = 0; k <= deg-i-j; ++k) {
                        IT coeff = pw(cells[row].x, i) * pw(cells[row].y, j) * pw(cells[row].z, k);
                        lp.set_a(col++, row, coeff);
                    }
                }
            }
        }

        CGAL::Quadratic_program_options options;
```

```
        options.set_pricing_strategy(CGAL::QP_BLAND);
        Solution s = CGAL::solve_linear_program(lp, ET(), options);
        results[deg] = (CGAL::to_double(s.objective_value()) < 0 && s.is_optimal()) ? true : false;

        if((lo < 29) && (results[lo] == 0) && (results[lo+1] == 1)) {
            d = lo+1;
            break;
        } else if((hi > 0) && (results[hi] == 1 && results[hi-1] == 0)) {
            d = hi;
            break;
        } else if(results[0] == 1) {
            d = 0;
            break;
        } else {
            if(results[deg]) hi = deg-1;
            else lo = deg + 1;
        }
    }
    (d == -1) ? cout << "Impossible!\n" : cout << d << "\n";
}

int main() {
    ios_base::sync_with_stdio(false);
    int TC; cin >> TC;
    while(TC--) testcase();
}
```

Sweepers

```
#include <iostream>
#include <vector>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/push_relabel_max_flow.hpp>
#include <boost/graph/strong_components.hpp>
using namespace std;
using namespace boost;

typedef vector<int> vi;
typedef adjacency_list_traits<vecS, vecS, directedS> Traits;
typedef adjacency_list<vecS, vecS, directedS, no_property,
  property<edge_capacity_t, long,
  property<edge_residual_capacity_t, long,
  property<edge_reverse_t, Traits::edge_descriptor> > > > Graph;
typedef property_map<Graph, edge_capacity_t>::type EdgeCapacityMap;
typedef property_map<Graph, edge_reverse_t>::type ReverseEdgeMap;
typedef graph_traits<Graph>::edge_descriptor Edge;
typedef graph_traits<Graph>::vertex_descriptor Vertex;

int N, M, S;

void add_edge(int from, int to, int cap, Graph& g) {
    EdgeCapacityMap capacity = get(edge_capacity, g);
    ReverseEdgeMap reverse = get(edge_reverse, g);

    Edge there, back;
    tie(there, tuples::ignore) = add_edge(from, to, g);
    tie(back, tuples::ignore) = add_edge(to, from, g);
    capacity[there] = cap;
    capacity[back] = 0;
    reverse[there] = back;
    reverse[back] = there;
}

void testcase() {
    cin >> N >> M >> S;
    int source = N;
    int sink = N+1;
    Graph g(N+2);
    vi starts(N, 0), exits(N, 0);

    for(int s = 0; s < S; ++s) {
        int room; cin >> room;
        ++starts[room];
    }

    for(int s = 0; s < S; ++s) {
        int room; cin >> room;
        ++exits[room];
    }

    for(int m = 0; m < M; ++m) {
        int v1, v2; cin >> v1 >> v2;
        add_edge(v1, v2, 1, g);
        add_edge(v2, v1, 1, g);
    }

    for(int n = 0; n < N; ++n) {
        if(starts[n] > 0) add_edge(source, n, starts[n], g);
        if(exits[n] > 0) add_edge(n, sink, exits[n], g);
    }

    bool isEulerian = true;
    bool isConnected = false;
    graph_traits<Graph>::vertex_iterator viter, vend;
    for (tie(viter, vend) = vertices(g); viter != vend; ++viter) {
        if(*viter == source || *viter == sink) continue;
        int count = out_degree(*viter, g);
        if(starts[*viter] > 0) ++count;
        if(exits[*viter] > 0) ++count;
        count = count/2;
        if(count % 2 == 1) {
```

```
74              isEulerian = false;
75              break;
76          }
77      }
78
79      if(!isEulerian) {
80          cout << "no\n";
81          return;
82      }
83
84      int maxflow = push_relabel_max_flow(g, source, sink);
85      if(maxflow != S)
86          cout << "no\n";
87      else
88          cout << "yes\n";
89  }
90
91  int main() {
92      int TC; cin >> TC;
93      while(TC--) testcase();
94  }
```

The Bracelet

```cpp
#include <iostream>
#include <stack>
#include <set>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/connected_components.hpp>
using namespace std;
using namespace boost;

typedef vector<pair<int, int> > vpi;
typedef adjacency_list<vecS, vecS, undirectedS, no_property, property<edge_weight_t, int> > Graph;
typedef graph_traits<Graph>::vertex_iterator VI;
typedef graph_traits<Graph>::out_edge_iterator EI;
typedef graph_traits<Graph>::edge_descriptor Edge;
typedef property_map<Graph, edge_weight_t>::type WeightMap;

void printEulerGraph(int v, Graph& g) {
    WeightMap weight = get(edge_weight, g);
    stack<int> fifo;
    fifo.push(v);
    vector<int> sol;
    while(!fifo.empty()) {
        int v = fifo.top();
        EI ebegin, eend;
        bool hasFreeEdge = false;
        for(tie(ebegin, eend) = out_edges(v, g); ebegin != eend; ++ebegin) {
            if(weight[*ebegin] == 0) {
                hasFreeEdge = true;
                weight[*ebegin] = 1;
                fifo.push(boost::target(*ebegin, g));
                break;
            }
        }
        if(!hasFreeEdge) {
            sol.push_back(v);
            fifo.pop();
        }
    }
    for(int s = 0; s < sol.size()-1; ++s) {
        cout << sol[s] << "␣" << sol[s+1] << "\n";
    }
    cout << "\n";
}

void testcase(int TC) {
    cout << "Case␣#" << ++TC << "\n";
    int N; cin >> N;

    Graph g(50);
    WeightMap weight = get(edge_weight, g);
    set<int> colors;

    for(int n = 0; n < N; ++n) {
        int v1, v2; cin >> v1 >> v2;
        colors.insert(v1); colors.insert(v2);
        Edge e;
        tie(e, tuples::ignore) = add_edge(v1, v2, g);
        weight[e] = 0;
    }

    vector<int> component(num_vertices(g));
    int num = connected_components(g, &component[0]) - (51 - colors.size());
    int start = -1;
    VI vbegin, vend;
    for(tie(vbegin, vend) = vertices(g); vbegin != vend; ++vbegin) {
        int deg = out_degree(*vbegin, g);
        if(deg % 2 == 1 || num > 1) {
            cout << "some␣beads␣may␣be␣lost\n\n";
            return;
        }
        if(deg > 0) start = *vbegin;
    }

```

```
74      printEulerGraph(start, g);
75  }
76
77  int main() {
78      int TC; cin >> TC;
79      for(int t = 0; t < TC; ++t) testcase(t);
80  }
```

Knights

```cpp
#include <iostream>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/push_relabel_max_flow.hpp>
using namespace std;
using namespace boost;

typedef adjacency_list_traits<vecS, vecS, directedS> Traits;
typedef adjacency_list<vecS, vecS, directedS, no_property,
  property<edge_capacity_t, long,
  property<edge_residual_capacity_t, long,
  property<edge_reverse_t, Traits::edge_descriptor> > > > Graph;
typedef property_map<Graph, edge_capacity_t>::type EdgeCapacityMap;
typedef property_map<Graph, edge_reverse_t>::type ReverseEdgeMap;
typedef graph_traits<Graph>::edge_descriptor Edge;

int M;
int N;
int K;

int index(int x, int y) {
    return y*M + x;
}

void add_edges(int from, int to, Graph& g) {
    EdgeCapacityMap capacity = get(edge_capacity, g);
    ReverseEdgeMap reverse = get(edge_reverse, g);

    Edge there, back;
    tie(there, tuples::ignore) = add_edge(from, to, g);
    tie(back, tuples::ignore) = add_edge(to, from, g);
    capacity[there] = 1;
    capacity[back] = 0;
    reverse[there] = back;
    reverse[back] = there;
}

void testcase() {
    cin >> M >> N >> K;    // M: cols, N: rows, K: #knights

    int graph_size = 2*(M*N)+2;     // M*N for each coordinate, 2*(M*N) because we need vertex-disjoint paths only.
    Graph g(graph_size);
    int source = graph_size-2;
    int sink = graph_size-1;
    for(int y = 0; y < N; ++y) {
        for(int x = 0; x < M; ++x) {
            int v_in = index(x, y);
            int v_out = index(x, y) + M*N;

            add_edges(v_in, v_out, g);

            if(x+1 < M) {
                add_edges(v_out, index(x+1, y), g);
                add_edges(index(x+1, y)+(M*N), v_in, g);
            }
            if(y+1 < N) {
                add_edges(v_out, index(x, y+1), g);
                add_edges(index(x, y+1)+(M*N), v_in, g);
            }
            if(x-1 < 0 || x+1 >= M || y-1 < 0 || y+1 >= N) {
                add_edges(v_out, sink, g);
            }
        }
    }

    for(int k = 0; k < K; ++k) {
        int x, y; cin >> x >> y;
        add_edges(source, index(x, y), g);
    }

    int maxflow = push_relabel_max_flow(g, source, sink);
    cout << maxflow << "\n";
}
```

```
74
75  int main() {
76      int TC; cin >> TC;
77      while(TC--) testcase();
78  }
```

Next Path

```cpp
#include <iostream>
#include <vector>
#include <queue>
#include <boost/graph/adjacency_list.hpp>
#include <boost/tuple/tuple.hpp>
#include <boost/graph/dijkstra_shortest_paths.hpp>
using namespace std;
using namespace boost;

const int MAX_LENGTH = 100000000;   // do not pick INT_MAX otherwise overflow resulting in -INT_MAX confusing min.

typedef vector<int> vi;
typedef adjacency_list<vecS, vecS, directedS, no_property, property<edge_weight_t, int> > Graph;
typedef graph_traits<Graph>::edge_descriptor Edge;
typedef graph_traits<Graph>::vertex_descriptor Vertex;
typedef property_map<Graph, edge_weight_t>::type WeightMap;
typedef graph_traits<Graph>::out_edge_iterator OutEdgeIterator;

int BFS(int start, int end, Graph& g) {
    if(start == end) return 0;
    vi distances(num_vertices(g), -1);
    std::queue<int> fifo;
    fifo.push(start);
    distances[start] = 0;
    while(!fifo.empty()) {
        int v = fifo.front(); fifo.pop();
        OutEdgeIterator ebegin, eend;
        for(tie(ebegin, eend) = out_edges(v, g); ebegin != eend; ++ebegin) {
            int u = target(*ebegin, g);
            if(distances[u] == -1) {
                distances[u] = distances[v] + 1;
                fifo.push(u);
                if(u == end) return distances[u];
            }
        }
    }
    return MAX_LENGTH;
}

void testcase() {
    int N, M, s, t; cin >> N >> M >> s >> t;
    --t; --s;

    Graph g(N);
    WeightMap weights = get(edge_weight, g);

    for(int m = 0; m < M; ++m) {
        int v1, v2; cin >> v1 >> v2;
        Edge edge;
        tie(edge, tuples::ignore) = add_edge(v1-1, v2-1, g);
        weights[edge] = 1;
    }

    vi d(N);
    vector<Vertex> p(N);
    dijkstra_shortest_paths(g, s, predecessor_map(&p[0]).distance_map(&d[0]));

    if(d[t] == INT_MAX) { cout << "no\n"; return; }     // there is no path from s to t.

    int sp = MAX_LENGTH;
    int b = t;
    int prev = t;
    while(true) {
        OutEdgeIterator ebegin, eend;
        for(tie(ebegin, eend) = out_edges(b, g); ebegin != eend; ++ebegin) {
            if(target(*ebegin, g) == prev && prev != s && b != t) continue; // do not pick the edge in P, start end ↙
                ↳ end path are special states.
            sp = min(sp, d[source(*ebegin, g)] + 1 + BFS(target(*ebegin, g), t, g));
        }
        if(b == s || sp == d[t]) break;
        prev = b;
        b = p[b];
    }
```

```
73      (sp == MAX_LENGTH) ? cout << "no\n" : cout << sp << "\n";
74  }
75
76  int main() {
77      ios_base::sync_with_stdio(false);
78      int TC; cin >> TC;
79      while(TC--) testcase();
80  }
```

Odd Route

```cpp
#include <iostream>
#include <vector>
#include <boost/graph/adjacency_list.hpp>
#include <boost/graph/dijkstra_shortest_paths.hpp>
#include <boost/tuple/tuple.hpp>
#include <climits>
using namespace std;
using namespace boost;

typedef adjacency_list<vecS, vecS, directedS, no_property, property<edge_weight_t, int> > Graph;
typedef property_map<Graph, edge_weight_t>::type EdgeWeightMap;
typedef graph_traits<Graph>::edge_descriptor Edge;
typedef graph_traits<Graph>::vertex_descriptor Vertex;

void add_edges(Graph& g, int u, int v, int w) {
    int uee = u*4;      int vee = v*4;
    int ueo = uee+1;     int veo = vee+1;
    int uoe = uee+2;     int voe = vee+2;
    int uoo = uee+3;     int voo = vee+3;

    EdgeWeightMap weights = get(edge_weight, g);

    Edge edge;
    if(w % 2 == 0) {
        tie(edge, tuples::ignore) = add_edge(uee, voe, g); weights[edge] = w;
        tie(edge, tuples::ignore) = add_edge(ueo, voo, g); weights[edge] = w;
        tie(edge, tuples::ignore) = add_edge(uoe, vee, g); weights[edge] = w;
        tie(edge, tuples::ignore) = add_edge(uoo, veo, g); weights[edge] = w;
    } else {
        tie(edge, tuples::ignore) = add_edge(uee, voo, g); weights[edge] = w;
        tie(edge, tuples::ignore) = add_edge(ueo, voe, g); weights[edge] = w;
        tie(edge, tuples::ignore) = add_edge(uoe, veo, g); weights[edge] = w;
        tie(edge, tuples::ignore) = add_edge(uoo, vee, g); weights[edge] = w;
    }
}

void testcase() {
    int N, M, s, t; cin >> N >> M >> s >> t;
    Graph g(N*4);

    for(int m = 0; m < M; ++m) {
        int u, v, w; cin >> u >> v >> w;
        add_edges(g, u, v, w);
    }

    vector<int> d(num_vertices(g), -1);
    dijkstra_shortest_paths(g, s*4, distance_map(&d[0]));
    (d[4*t+3] < INT_MAX) ? cout << d[4*t+3] : cout << "no";
    cout << "\n";
}

int main() {
    int TC; cin >> TC;
    while(TC--) testcase();
    return 0;
}
```

Radiation 2

Missing.