

Contents

1 Contest Setup 2

1.1 vimrc 2

1.2 bashrc 2

1.3 C++ template 2

1.4 Java template 3

1.4.1 Java Issues 3

2 System Testing 3

3 Reminder 3

4 Useful code 3

4.1 Grep Error and Warnings 3

4.2 Leap year 3

4.3 Fast Exponentiation  $O(\log(exp))$  3

4.4 GCD  $O(\log(a + b))$  3

4.5 Extended Euclidean Algorithm 3

4.6 Mod Inverse 4

4.7 Prime Generator 4

4.8 Binomial Coefficient 4

4.9 STL quick reference 4

4.9.1 Map 4

4.9.2 Set 4

4.9.3 Algorithm 4

4.9.4 String 4

4.9.5 Priority Queue 4

5 Search 5

5.1 Ternary Search 5

5.2 折半完全列舉 5

5.3 Two-pointer 爬行法 5

6 Basic data structure 5

6.1 1D BIT 5

6.2 2D BIT 5

6.3 Union Find 5

6.4 Segment Tree 5

6.5 Sparse Table 5

7 Dynamic Programming 6

8 Tree 6

8.1 LCA 6

9 Graph 6

9.1 Articulation point / edge 6

9.2 CC 6

9.2.1 BCC vertex 6

9.2.2 BCC edge 6

9.2.3 SCC 6

9.3 Shortest Path 6

9.3.1 Dijkstra 6

9.3.2 Dijkstra (next-to-shortest path) 6

9.3.3 SPFA 6

9.3.4 Bellman-Ford 6

9.3.5 Floyd-Warshall 6

9.4 Kruskal MST 6

9.5 Flow 6

9.5.1 Max Flow (Dinic) 6

9.5.2 Min-Cut 6

9.5.3 Min Cost Max Flow 6

9.5.4 Maximum Bipartite Graph 6

10 String 6

10.1 Rolling Hash 6

10.2 KMP 6

10.3 Z Algorithm 7

10.4 Trie 7

10.5 Suffix Array 7

11 Geometry 7

11.1 EPS 7

11.2 Template 7

11.3 Half-plane intersection 8

# 1 Contest Setup

## 1.1 vimrc

```

1 | set number      " Show line numbers
2 | set mouse=a     " Enable inaction via mouse
3 | set showmatch   " Highlight matching brace
4 | set cursorline  " Show underline
5 | set cursorcolumn " highlight vertical column
6 |
7 | filetype on "enable file detection
8 | syntax on    "syntax highlight
9 |
10 | set autoindent " Auto-indent new lines
11 | set shiftwidth=4 " Number of auto-indent spaces
12 | set smartindent " Enable smart-indent
13 | set smarttab    " Enable smart-tabs
14 | set tabstop=4   " Number of spaces per Tab
15 |
16 | " -----Optional-----
17 |
18 | set undolevels=10000 " Number of undo levels
19 | set scrolloff=5     " Auto scroll
20 |
21 | set hlsearch " Highlight all search results
22 | set smartcase " Enable smart-case search
23 | set ignorecase " Always case-insensitive
24 | set incsearch " Searches for strings incrementally
25 |
26 | highlight Comment ctermfg=cyan
27 | set showmode
28 |
29 | set encoding=utf-8
30 | set fileencoding=utf-8
31 | set scriptencoding=utf-8

```

## 1.2 bashrc

```

1 | alias g++="g++ -Wall -Wextra -std=c++11 -O2"

```

## 1.3 C++ template

```

1 | #include <bits/stdc++.h>
2 |
3 | using namespace std;
4 |
5 | #define x first
6 | #define y second
7 |
8 | typedef long long int ll;
9 | typedef pair<int, int> ii;
10 |
11 | int main()
12 | {

```

```

13 |     return 0;
14 | }

```

## 1.4 Java template

```

1 | import java.io.*;
2 | import java.util.*;
3 |
4 | public class Main
5 | {
6 |     public static void main(String[] args)
7 |     {
8 |         MyScanner sc = new MyScanner();
9 |         out = new PrintWriter(new BufferedOutputStream(System.out));
10 |         // Start writing your solution here.
11 |
12 |         // Stop writing your solution here.
13 |         out.close();
14 |     }
15 |
16 |     public static PrintWriter out;
17 |
18 |     public static class MyScanner
19 |     {
20 |         BufferedReader br;
21 |         StringTokenizer st;
22 |
23 |         public MyScanner()
24 |         {
25 |             br = new BufferedReader(new InputStreamReader(System.in));
26 |         }
27 |
28 |         boolean hasNext()
29 |         {
30 |             while (st == null || !st.hasMoreElements()) {
31 |                 try {
32 |                     st = new StringTokenizer(br.readLine());
33 |                 } catch (Exception e) {
34 |                     return false;
35 |                 }
36 |             }
37 |             return true;
38 |         }
39 |
40 |         String next()
41 |         {
42 |             if (hasNext())
43 |                 return st.nextToken();
44 |             return null;
45 |         }
46 |
47 |         int nextInt()
48 |         {
49 |             return Integer.parseInt(next());
50 |         }

```

```

51     long nextLong()
52     {
53         return Long.parseLong(next());
54     }
55
56     double nextDouble()
57     {
58         return Double.parseDouble(next());
59     }
60
61     String nextLine()
62     {
63         String str = "";
64         try {
65             str = br.readLine();
66         } catch (IOException e) {
67             e.printStackTrace();
68         }
69         return str;
70     }
71 }
72
73 }

```

#### 1.4.1 Java Issues

1. Random Shuffle before sorting: `Random rnd = new Random(); rnd.nextInt();`
2. Use `StringBuilder` for large output

## 2 System Testing

1. Setup `bashrc` and `vimrc`
2. Look for compilation parameter and code it into `bashrc`
3. Test if `c++` and `java` templates work properly on local and judge machine
4. Test "divide by 0" → RE/TLE?
5. Test stack size

## 3 Reminder

1. 隊友的建議，要認真聽！通常隊友的建議都會突破你盲點
2. Read the problem statements carefully. Input and output specifications and constraints are crucial!
3. Estimate the **time complexity** and **memory complexity** carefully.
4. Time penalty is 20 minutes per WA, **don't rush!**
5. Sample test cases must all be tested and passed before every submission!
6. Test the corner cases, such as 0, 1, -1. Test all edge cases of the input specification.
7. Bus error: the code has `scanf, fgets` but have nothing to read! Check if you have early termination but didn't handle it properly.
8. Binary search? 數學算式移項合併後查詢?
9. Two Pointer ↔ Binary Search
10. Directed graph connectivity → DFS. Undirected graph → Union Find
11. Check connectivity of the graph if the problem statement doesn't say anything
12. `longlong = int * int` won't work!
13. Shifting for `longlongint` should be something like `1LL << 35`
14. For continuous input problems, be sure to read in all input BEFORE terminating and start processing next the input.
15. Don't use anonymous struct

## 4 Useful code

### 4.1 Grep Error and Warnings

```
1 || g++ main.cpp 2>&1 | grep -E 'warning|error'
```

### 4.2 Leap year

```
1 || year % 400 == 0 || (year % 4 == 0 && year % 100 != 0)
```

### 4.3 Fast Exponentiation $O(\log(\exp))$

```

1 ll fast_pow(ll base, ll exp, ll mod)
2 {
3     if (exp == 0)
4         return 1LL;
5     ll res = 1;
6     while (exp > 0) {
7         if (exp & 1) {
8             res = ((res % mod) * (base % mod)) % mod;
9         }
10        exp >>= 1;
11        base = (base * base) % mod;
12    }
13    return res;
14 }

```

### 4.4 GCD $O(\log(a + b))$

注意負數的 case!

```

1 ll gcd(ll a, ll b)
2 {
3     return b == 0 ? a : gcd(b, a % b);
4 }

```

### 4.5 Extended Euclidean Algorithm

Bezout identity  $ax + by = \gcd(a, b)$ , where  $\gcd(a, b)$  is the smallest positive integer that can be written as  $ax + by$ , and every integer of the form  $ax + by$  is a multiple of  $\gcd(a, b)$ .

```

1 ll ext_gcd(ll a, ll b, ll &x, ll &y)
2 {
3     if (a == 0) {
4         x = 0;
5         y = 1;
6         return b;
7     }
8
9     ll x1, y1;
10    ll gcd = ext_gcd(b % a, a, x1, y1);
11
12    x = y1 - (b / a) * x1;
13    y = x1;

```

```

14 |     return gcd;
15 | }
16 |

```

## 4.6 Mod Inverse

Case 1  $\gcd(a, m) = 1$ :  $ax + my = \gcd(a, m) = 1$  (use `ext_gcd`)

Case 2  $m$  is prime:  $a^{m-2} \equiv a^{-1} \pmod{m}$  (use Fermat's little theorem)

## 4.7 Prime Generator

```

1 | bool is_prime[N];
2 | vector<ll> primes;
3 | void init()
4 | {
5 |     fill(is_prime, is_prime + N, true);
6 |     for (int i = 2; i < N; i++) {
7 |         if (is_prime[i] == true) {
8 |             primes.push_back(i);
9 |             for (int j = i * i; j < N; j += i)
10 |                 is_prime[j] = false;
11 |         }
12 |     }
13 | }

```

## 4.8 Binomial Coefficient

```

1 | int binomialCoeff(int n, int k)
2 | {
3 |     int res = 1;
4 |
5 |     if ( k > n - k ) // Since C(n, k) = C(n, n-k)
6 |         k = n - k;
7 |
8 |     for (int i = 0; i < k; ++i) // n...n-k / 1...k
9 |     {
10 |         res *= (n - i);
11 |         res /= (i + 1);
12 |     }
13 |
14 |     return res;
15 | }

```

## 4.9 STL quick reference

### 4.9.1 Map

```

1 | map<T1, T2> m; // iterable
2 | void clear();
3 | void erase(T1 key);
4 | it find(T1 key); // <key, val>
5 | void insert(pair<T1, T2> P);

```

```

6 | T2 &[](T1 key); // if key not in map, new key will be inserted with
   |     default val
7 | it lower_bound(T1 key); // = m.end() if not found, *it = <key, val>
8 | it upper_bound(T1 key); // = m.end() if not found, *it = <key, val>

```

### 4.9.2 Set

```

1 | set<T> s; // iterable
2 | void clear();
3 | size_t count(T val); // number of val in set
4 | void erase(T val);
5 | it find(T val); // = s.end() if not found
6 | void insert(T val);
7 | it lower_bound(T val); // = s.end() if not found, *it = <key, val>
8 | it upper_bound(T val); // = s.end() if not found, *it = <key, val>

```

### 4.9.3 Algorithm

```

1 | // return if i is smaller than j
2 | comp = [&](const T &i, const T &j) -> bool;
3 | vector<T> v;
4 | bool any_of(v.begin(), v.end(), [&](const T &i) -> bool);
5 | bool all_of(v.begin(), v.end(), [&](const T &i) -> bool);
6 | void copy(inp.begin(), inp.end(), out.begin());
7 | int count(v.begin(), v.end(), int val); // number of val in v
8 | it unique(v.begin(), v.end()); // it - v.begin() = size
9 | // after calling, v[nth] will be n-th smallest elem in v
10 | void nth_element(v.begin(), nth_it, bin_comp);
11 | void merge(in1.begin(), in1.end(), in2.begin(), in2.end(), out.begin(),
   |     comp);
12 | // include union, intersection, difference, symmetric_difference(xor)
13 | void set_union(in1.begin(), in1.end(), in2.begin(), in2.end(), out.
   |     begin(), comp);
14 | bool next_permutation(v.begin(), v.end());
15 | // v1, v2 need sorted already, whether v1 includes v2
16 | bool includes(v1.begin(), v1.end(), v2.begin(), v2.end());
17 | it find(v.begin(), v.end(), T val); // = v.end() if not found
18 | it search(v1.begin(), v1.end(), v2.begin(), v2.end());
19 | it lower_bound(v.begin(), v.end(), T val);
20 | it upper_bound(v.begin(), v.end(), T val);
21 | bool binary_search(v.begin(), v.end(), T val); // exist in v ?
22 | void sort(v.begin(), v.end(), comp);
23 | void stable_sort(v.begin(), v.end(), comp);

```

### 4.9.4 String

### 4.9.5 Priority Queue

```

1 | bool cmp(ii a, ii b)
2 | {
3 |     if(a.first == b.first)
4 |         return a.second > b.second;
5 |     return b.first > a.first;
6 | }

```

```

7 | priority_queue< ii, vector<ii>, function<bool(ii, ii)> > pq(cmp);
8 |

```

## 5 Search

### 5.1 Ternary Search

### 5.2 折半完全列舉

### 5.3 Two-pointer 爬行法

## 6 Basic data structure

### 6.1 1D BIT

```

1 | // BIT is 1-based
2 | const int MAX_N = 20000; //這個記得改!
3 | ll bit[MAX_N + 1];
4 |
5 | int sum(int i) {
6 |     int s = 0;
7 |     while (i > 0) {
8 |         s += bit[i];
9 |         i -= (i & -i);
10 |    }
11 |    return s;
12 | }
13 |
14 | void add(int i, int x) {
15 |     while (i <= MAX_N) {
16 |         bit[i] += x;
17 |         i += (i & -i);
18 |     }
19 | }

```

### 6.2 2D BIT

```

1 | // BIT is 1-based
2 | const int MAX_N = 20000, MAX_M = 20000; //這個記得改!
3 | ll bit[MAX_N + 1][MAX_M + 1];
4 |
5 | ll sum(int a, int b) {
6 |     ll s = 0;
7 |     for (int i = a; i > 0; i -= (i & -i))
8 |         for (int j = b; j > 0; j -= (j & -j))
9 |             s += bit[i][j];
10 |    return s;
11 | }
12 |
13 | void add(int a, int b, ll x) {
14 |     // MAX_N, MAX_M 須適時調整!
15 |     for (int i = a; i <= MAX_N; i += (i & -i))
16 |         for (int j = b; j <= MAX_M; j += (j & -j))

```

```

17 |         bit[i][j] += x;
18 |    }

```

### 6.3 Union Find

```

1 | #define N 20000 // 記得改
2 | struct UFDS {
3 |     int par[N];
4 |
5 |     void init() {
6 |         memset(par, -1, sizeof(par));
7 |     }
8 |
9 |     int root(int x) {
10 |         return par[x] < 0 ? x : par[x] = root(par[x]);
11 |     }
12 |
13 |     void merge(int x, int y) {
14 |         x = root(x);
15 |         y = root(y);
16 |
17 |         if (x != y) {
18 |             if (par[x] > par[y])
19 |                 swap(x, y);
20 |             par[x] += par[y];
21 |             par[y] = x;
22 |         }
23 |     }
24 | }

```

### 6.4 Segment Tree

### 6.5 Sparse Table

```

1 | struct {
2 |     int sp[MAX_LOG_N][MAX_N]; // MAX_LOG_N = ceil(lg(MAX_N))
3 |
4 |     void build(int inp[], int n) {
5 |         for (int j = 0; j < n; j++) {
6 |             sp[0][j] = inp[j];
7 |         }
8 |
9 |         for (int i = 1; (1 << i) <= n; i++)
10 |            for (int j = 0; j + (1 << i) <= n; j++)
11 |                sp[i][j] =
12 |                    min(sp[i - 1][j], sp[i - 1][j + (1 << (i - 1))]);
13 |     }
14 |
15 |     int query(int l, int r) { // [l, r)
16 |         int k = floor(log2(r - l));
17 |
18 |         return min(sp[k][l], sp[k][r - (1 << k)]);
19 |     }
20 | } sptb;

```

## 7 Dynamic Programming

## 8 Tree

### 8.1 LCA

## 9 Graph

### 9.1 Articulation point / edge

### 9.2 CC

#### 9.2.1 BCC vertex

#### 9.2.2 BCC edge

#### 9.2.3 SCC

### 9.3 Shortest Path

#### 9.3.1 Dijkstra

#### 9.3.2 Dijkstra (next-to-shortest path)

#### 9.3.3 SPFA

#### 9.3.4 Bellman-Ford

#### 9.3.5 Floyd-Warshall

### 9.4 Kruskal MST

### 9.5 Flow

#### 9.5.1 Max Flow (Dinic)

#### 9.5.2 Min-Cut

#### 9.5.3 Min Cost Max Flow

#### 9.5.4 Maximum Bipartite Graph

## 10 String

### 10.1 Rolling Hash

1. Use two rolling hashes if needed.
2. The prime for pre-calculation can be 137 and 257, for modulo can be  $1e9 + 7$  and *0xdefaced*

```

1 #define N 1000100
2 #define B 137
3 #define M 1000000007
4
5 typedef long long ll;
6
7 char inp[N];
8 int len;
9 ll p[N], h[N];
10
```

```

11 void init()
12 { // build polynomial table and hash value
13     p[0] = 1; // b to the ith power
14     for (int i = 1; i <= len; i++) {
15         h[i] = (h[i - 1] * B % M + inp[i - 1]) % M; // hash value
16         p[i] = p[i - 1] * B % M;
17     }
18 }
19
20 ll get_hash(int l, int r) // [l, r] of the inp string array
21 {
22     return ((h[r + 1] - (h[l] * p[r - l + 1])) % M + M) % M;
23 }
```

### 10.2 KMP

```

1 void fail()
2 {
3     int len = strlen(pat);
4
5     f[0] = 0;
6     int j = 0;
7     for (int i = 1; i < len; i++) {
8         while (j != 0 && pat[i] != pat[j])
9             j = f[j - 1];
10
11         if (pat[i] == pat[j])
12             j++;
13
14         f[i] = j;
15     }
16 }
17
18 int match()
19 {
20     int res = 0;
21     int j = 0, plen = strlen(pat), tlen = strlen(text);
22
23     for (int i = 0; i < tlen; i++) {
24         while (j != 0 && text[i] != pat[j])
25             j = f[j - 1];
26
27         if (text[i] == pat[j]) {
28             if (j == plen - 1) { // find match
29                 res++;
30                 j = f[j];
31             } else {
32                 j++;
33             }
34         }
35     }
36
37     return res;
38 }
```

## 10.3 Z Algorithm

## 10.4 Trie

```

1 #define N 600010
2 struct node {
3     int child[26];
4     bool ending;
5 } trie[N];
6
7 /*
8  root is 0
9  memset(trie, 0, sizeof(trie));
10 freeNode = 1;
11 */
12 int freeNode;
13 void insert(string &str, int pos, int node)
14 {
15     if (pos == (int)str.length()) {
16         trie[node].ending = true;
17     } else { // find which way to go
18         int c = str[pos] - 'a';
19         if (trie[node].child[c] == 0) // give a new node
20             trie[node].child[c] = freeNode++;
21         insert(str, pos + 1, trie[node].child[c]);
22     }
23 }

```

## 10.5 Suffix Array

## 11 Geometry

1. Keep things in integers as much as possible!
2. Try not to divide
3. If you have decimals, if they are fixed precision, you can usually just multiply all the input and use integers instead

### 11.1 EPS

$a > b \rightarrow a - b > 0 \rightarrow a - b > EPS$  (stands for positive)  
 $a \geq b \rightarrow a - b \geq 0 \rightarrow a - b > -EPS$  (stands for positive or zero)

### 11.2 Template

```

1 typedef long long ll;
2
3 typedef pair<ll, ll> pt; // points are stored using long long
4 typedef pair<pt, pt> seg; // segments are a pair of points
5
6 #define x first
7 #define y second
8
9 #define EPS 1e-9
10
11 pt operator+(pt a, pt b)

```

```

12 {
13     return pt(a.x + b.x, a.y + b.y);
14 }
15
16 pt operator-(pt a, pt b)
17 {
18     return pt(a.x - b.x, a.y - b.y);
19 }
20
21 pt operator*(pt a, int d)
22 {
23     return pt(a.x * d, a.y * d);
24 }
25
26 ll cross(pt a, pt b)
27 {
28     return a.x * b.y - a.y * b.x;
29 }
30
31 int ccw(pt a, pt b, pt c)
32 {
33     ll res = cross(b - a, c - a);
34     // printf("%lld\n", res);
35     if (res > 0)
36         return 1;
37     else if (res == 0)
38         return 0;
39     else
40         return -1;
41 }
42
43 double dist(pt a, pt b)
44 {
45     double dx = a.x - b.x;
46     double dy = a.y - b.y;
47     return (dx * dx + dy * dy);
48 }
49
50 bool overlap(seg a, seg b)
51 {
52     // a.x -> a, a.y -> b, b.x -> c, b.y -> d
53     return ccw(a.x, a.y, b.x) == 0 && ccw(a.x, a.y, b.y) == 0;
54 }
55
56 bool intersect(seg a, seg b)
57 {
58     // printf("%d\n", overlap(a, b));
59     if (overlap(a, b) == true) {
60         double d = 0;
61         d = max(d, dist(a.x, a.y));
62         d = max(d, dist(a.x, b.x));
63         d = max(d, dist(a.x, b.y));
64         d = max(d, dist(a.y, b.x));
65         d = max(d, dist(a.y, b.y));
66         d = max(d, dist(b.x, b.y));
67     }

```

```

68     // d > dist(a.x, a.y) + dist(b.x, b.y)
69     if (d - (dist(a.x, a.y) + dist(b.x, b.y)) > EPS)
70         return false;
71     return true;
72 }
73
74 // bitch man.... Equal sign..
75 if (ccw(a.x, a.y, b.x) * ccw(a.x, a.y, b.y) <= 0 &&
76     ccw(b.x, b.y, a.x) * ccw(b.x, b.y, a.y) <= 0)
77     return true;
78 return false;
79 }
80
81 vector<pt> halfHull(vector<pt> &points)
82 {
83     vector<pt> res;
84
85     for (int i = 0; i < (int)points.size(); i++) {
86         while ((int)res.size() >= 2 &&
87             ccw(res[res.size() - 2], res[res.size() - 1], points[i])
88             < 0)
89             res.pop_back(); // res.size() - 2 can't be assign before
90                             // size() >= 2
91                             // check, bitch
92         res.push_back(points[i]);
93     }
94     return res;
95 }
96
97 vector<pt> convexHull(vector<pt> &points)
98 {
99     vector<pt> upper, lower;
100
101     // make upper hull
102     sort(points.begin(), points.end());
103
104     upper = halfHull(points);
105     // make lower hull
106     reverse(points.begin(), points.end());
107     lower = halfHull(points);
108
109     // merge hulls
110     if ((int)upper.size() > 0) // yes sir~
111         upper.pop_back();
112     if ((int)lower.size() > 0)
113         lower.pop_back();

```

```

114     vector<pt> res(upper.begin(), upper.end());
115     res.insert(res.end(), lower.begin(), lower.end());
116
117     return res;
118 }
119
120
121 bool completelyInside(vector<pt> &outer, vector<pt> &inner)
122 {
123     int even = 0, odd = 0;
124     for (int i = 0; i < (int)inner.size(); i++) {
125         // y = slope * x + offset
126         int cntIntersection = 0;
127         ll slope = rand() % INT_MAX + 1;
128         ll offset = inner[i].y - slope * inner[i].x;
129
130         ll farx = 111111 * (slope >= 0 ? 1 : -1);
131         ll fary = farx * slope + offset;
132         seg a = seg(pt(inner[i].x, inner[i].y), pt(farx, fary));
133         for (int j = 0; j < (int)outer.size(); j++) {
134             seg b = seg(outer[j], outer[(j + 1) % (int)outer.size()]);
135
136             if ((b.x.x * slope + offset == b.x.y) ||
137                 (b.y.x * slope + offset == b.y.y)) { // on-line
138                 i--;
139                 break;
140             }
141
142             if (intersect(a, b) == true)
143                 cntIntersection++;
144         }
145
146         if (cntIntersection % 2 == 0) // outside
147             even++;
148         else
149             odd++;
150     }
151
152     return odd == (int)inner.size();
153 }
154
155 // srand(time(NULL))
156 // rand()

```

### 11.3 Half-plane intersection