

Team Reference

## Pollard

```
1  const int max_step = 4e5;
2
3  unsigned long long gcd(unsigned long long a, unsigned long long b){
4      if (!a) return 1;
5      while (a) swap(a, b%=a);
6      return b;
7  }
8
9  unsigned long long get(unsigned long long a, unsigned long long b){
10     if (a > b)
11         return a-b;
12     else
13         return b-a;
14 }
15
16 unsigned long long pollard(unsigned long long n){
17     unsigned long long x = (rand() + 1) % n, y = 1, g;
18     int stage = 2, i = 0;
19     g = gcd(get(x, y), n);
20     while (g == 1){
21         if (i == max_step)
22             break;
23         if (i == stage){
24             y = x;
25             stage <= 1;
26         }
27         x = (x * (__int128)x + 1) % n;
28         i++;
29         g = gcd(get(x, y), n);
30     }
31     return g;
32 }
```

**pragma**

```
#pragma GCC optimize("O3,no-stack-protector")
#pragma GCC target("sse,sse2,sse4,ssse3,popcnt,abm,mmx,avx,tune=native")
```

**Алгебра Pick**

$$B + \Gamma / 2 - 1 = \text{AREA},$$

где  $B$  — количество целочисленных точек внутри многоугольника, а  $\Gamma$  — количество целочисленных точек на границе многоугольника.

**Newton**

$$x_{i+1} = x_i - \frac{f(x_i)}{f'(x_i)}$$

**Catalan**

$$C_n = \sum_{k=0}^{n-1} C_k C_{n-1-k}$$

$$C_i = \frac{1}{n+1} \binom{2n}{n}$$

**Кол-во графов**

$$G_N := 2^{n(n-1)/2}$$

Количество связных помеченных графов

$$\text{Conn}_N = G_N - \frac{1}{N} \sum_{K=1}^{N-1} K \binom{N}{K} \text{Conn}_K G_{N-K}$$

Количество помеченных графов с  $K$  компонентами связности

$$D[N][K] = \sum_{S=1}^N \binom{N-1}{S-1} \text{Conn}_S D[N-S][K-1]$$

**Miller-Rabbin**

```
a=a^t
FOR i = 1...s
    if a^2=1 && |a|!=1
        NOT PRIME
a=a^2
return a==1 ? PRIME : NOT PRIME
```

**Интегрирование по формуле Симпсона**

$$\int_a^b f(x) dx?$$

$$x_i := a + ih, i = 0 \dots 2n$$

$$h = \frac{b-a}{2n}$$

$$\int = (f(x_0) + 4f(x_1) + 2f(x_2) + 4f(x_3) + 2f(x_4) + \dots + 4f(x_{2n-1}) + f(x_{2n})) \frac{h}{3}$$

$$O(n^4).$$

**Простые числа**

```
1009,1013;10007,10009;100003,100019
1000003,1000033;10000019,10000079
100000007,100000037
10000000019,10000000033
1000000000039,1000000000061
```

1000000000000031,10000000000000067  
 10000000000000061,10000000000000069  
 100000000000000003,100000000000000009

### Числа для Фурье

- prime:  $7340033 = 7 \cdot 2^{20} + 1; w : 5(w^{2^{20}} = 1)$
- prime:  $13631489 = 13 \cdot 2^{20} + 1; w : 3(w^{2^{20}} = 1)$
- prime:  $23068673 = 11 \cdot 2^{21} + 1; w : 38(w^{2^{21}} = 1)$
- prime:  $69206017 = 33 \cdot 2^{21} + 1; w : 45(w^{2^{21}} = 1)$
- prime:  $81788929 = 39 \cdot 2^{21} + 1; w : 94(w^{2^{21}} = 1)$
- prime:  $104857601 = 25 \cdot 2^{22} + 1; w : 21(w^{2^{22}} = 1)$
- prime:  $113246209 = 27 \cdot 2^{22} + 1; w : 66(w^{2^{22}} = 1)$
- prime:  $138412033 = 33 \cdot 2^{22} + 1; w : 30(w^{2^{22}} = 1)$
- prime:  $167772161 = 5 \cdot 2^{25} + 1; w : 17(w^{2^{25}} = 1)$
- prime:  $469762049 = 7 \cdot 2^{26} + 1; w : 30(w^{2^{26}} = 1)$
- prime:  $998244353 = 7 \cdot 17 \cdot 2^{23} + 1; w : 3^{7 \cdot 17}$ .

```

1  /** Begin fast allocation */
2  const int MAX_MEM = 5e8;
3  int mpos = 0;
4  char mem[MAX_MEM];
5  inline void * operator new ( size_t n ) {
6      assert((mpos += n) <= MAX_MEM);
7      return (void *) (mem + mpos - n);
8  }
9  inline void operator delete ( void * ) noexcept { } // must have!
10
11 /** End fast allocation */
12
13
14 #define pb push_back
15 #define mp make_pair
16 #define fst first
17 #define snd second
18 #define ll long long
19 #define forn(i, n) for (int i = 0; i < (int) (n); i++)
20 #define forlr(i, l, r) for (int i = (int) l; i <= (int) (r); i++)
21 #define forrl(i, r, l) for (int i = (int) r; i >= (int) (l); i--)
22
23 /** Interface */
24
25 inline int readChar();
26 template <class T = int> inline T readInt();
27 template <class T> inline void writeInt( T x, char end = 0 );
28 inline void writeChar( int x );
29 inline void writeWord( const char *s );
30
31 /** Read */
32
33 static const int buf_size = 2048;
34
35 inline int getChar() {
36     static char buf[buf_size];
37     static int len = 0, pos = 0;
38     if (pos == len)
39         pos = 0, len = fread(buf, 1, buf_size, stdin);
40     if (pos == len)
41         return -1;
42     return buf[pos++];
43 }
44
45 inline int readWord(char * buffer) {
46     int c = getChar();
47     while (c <= 32) {
48         c = getChar();
49     }
50
51     int len = 0;

```

```

52     while (c > 32) {
53         *buffer = (char) c;
54         c = getChar();
55         buffer++;
56         len++;
57     }
58     return len;
59 }
60
61 inline int readChar() {
62     int c = getChar();
63     while (c <= 32)
64         c = getChar();
65     return c;
66 }
67
68 template <class T>
69 inline T readInt() {
70     int s = 1, c = readChar();
71     T x = 0;
72     if (c == '-')
73         s = -1, c = getChar();
74     while ('0' <= c && c <= '9')
75         x = x * 10 + c - '0', c = getChar();
76     return s == 1 ? x : -x;
77 }
78
79 /** Write */
80
81 static int write_pos = 0;
82 static char write_buf[buf_size];
83
84 inline void writeChar( int x ) {
85     if (write_pos == buf_size)
86         fwrite(write_buf, 1, buf_size, stdout), write_pos = 0;
87     write_buf[write_pos++] = x;
88 }
89
90 template <class T>
91 inline void writeInt( T x, char end ) {
92     if (x < 0)
93         writeChar('-'), x = -x;
94
95     char s[24];
96     int n = 0;
97     while (x || !n)
98         s[n++] = '0' + x % 10, x /= 10;
99     while (n--)
100         writeChar(s[n]);
101     if (end)
102         writeChar(end);

```

```
103 }
104
105 inline void writeWord( const char *s ) {
106     while (*s)
107         writeChar(*s++);
108 }
109
110 struct Flusher {
111     ~Flusher() {
112         if (write_pos)
113             fwrite(write_buf, 1, write_pos, stdout), write_pos = 0;
114     }
115 } flusher;
```

```

1  struct line {
2      ll k, b;
3      ll at(ll x) const {
4          return k * x + b;
5      }
6  };
7  double intersec(line a, line b) {
8      return 1.0 * (b.b - a.b) / (a.k - b.k);
9  }
10 struct convex_hull_trick {
11     vector<double> x = {-1e18};
12     vector<line> lines;
13     void add(line l) {
14         // l.k increasing
15         if (lines.empty()) {
16             lines.pb(l);
17         } else {
18             while (lines.size() > 1 && intersec(l, lines[lines.size() - 2]) <
↪ x.back()) {
19                 lines.pop_back();
20                 x.pop_back();
21             }
22             x.push_back(intersec(l, lines.back()));
23             lines.push_back(l);
24         }
25     }
26 };
27 struct cht_forward_iterator {
28     int ci = 0;
29     ll promote(const convex_hull_trick& cht, ll value) {
30         while (ci < (int)cht.x.size() - 1 && cht.x[ci + 1] < value)
31             ci++;
32         return cht.lines[ci].at(value);
33     }
34 };
35 const int g = 275;
36 struct sqrt_dec {
37     struct block {
38         vector<int> bs;
39         convex_hull_trick cht;
40         cht_forward_iterator it;
41         block(vector<int> b) {
42             bs = b;
43             int k = b.size();
44             forn(i, k) {
45                 cht.add({ b[i], 1ll * b[i] * (k - i) });
46             }
47         }
48         ll value(ll x) {
49             if (cht.lines.empty())
50                 return 0;

```



```
51         return it.promote(cht, x);
52     }
53 };
54 void insert(block& bl, int b) {
55     auto v = std::move(bl.bs);
56     v.insert(lower_bound(all(v), b), b);
57     bl = block(std::move(v));
58 }
59 vector<block> blocks;
60 sqrt_dec(int n) {
61     blocks.resize((n + g - 1) / g, block({}));
62 }
63 void add(int i, int b) {
64     insert(blocks[i / g], b);
65 }
66 ll get_max() {
67     int sm = 0;
68     ll ans = 0;
69     for (int i = blocks.size() - 1; i >= 0; i--) {
70         ans = max(ans, blocks[i].value(sm));
71         sm += blocks[i].bs.size();
72     }
73     return ans;
74 }
75 };
```

```
1  struct treap{
2      map<char, int> go;
3      int len, suff;
4      long long sum_in;
5      treap(){}
6  };
7
8  treap v[max_n * 4];
9  int last = 0;
10
11 int add_treap(int max_len){
12     v[number].sum_in = 0;
13     v[number].len = max_len;
14     v[number].suff = -1;
15     number++;
16     return number - 1;
17 }
18
19 void add_char(char c){
20     int cur = last;
21     int new_treap = add_treap(v[cur].len + 1);
22     last = new_treap;
23     while (cur != -1){
24         if (v[cur].go.count(c) == 0){
25             v[cur].go[c] = new_treap;
26             v[new_treap].sum_in += v[cur].sum_in;
27             cur = v[cur].suff;
28             if (cur == -1)
29                 v[new_treap].suff = 0;
30         }else{
31             int a = v[cur].go[c];
32             if (v[a].len == v[cur].len + 1){
33                 v[new_treap].suff = a;
34             }else{
35                 int b = add_treap(v[cur].len + 1);
36                 v[b].go = v[a].go;
37                 v[b].suff = v[a].suff;
38                 v[new_treap].suff = b;
39                 while (cur != -1 && v[cur].go.count(c) != 0 && v[cur].go[c] == a){
40                     v[cur].go[c] = b;
41                     v[a].sum_in -= v[cur].sum_in;
42                     v[b].sum_in += v[cur].sum_in;
43                     cur = v[cur].suff;
44                 }
45                 v[a].suff = b;
46             }
47             return;
48         }
49     }
50 }
```

```
1  int k = sqrt((double)p) + 2;
2
3  for (int i = k; i >= 1; i--)
4      mp[bin(b, (i * 111 * k) % (p-1), p)] = i;
5
6  bool answered = false;
7  int ans = INT32_MAX;
8  for (int i = 0; i <= k; i++){
9      int sum = (n * 111 * bin(b, i, p)) % p;
10     if (mp.count(sum) != 0){
11         int an = mp[sum] * 111 * k - i;
12         if (an < p)
13             ans = min(an, ans);
14     }
15 }
```

```

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

```

linear sieve

```

1  const int N = 100000000;
2  int lp[N+1];
3  vector<int> pr;
4
5  for (int i=2; i<=N; ++i) {
6      if (lp[i] == 0) {
7          lp[i] = i;
8          pr.push_back (i);
9      }
10     for (int j=0; j<(int)pr.size() && pr[j]<=lp[i] && i*pr[j]<=N; ++j)
11         lp[i * pr[j]] = pr[j];
12 }

```

kasai

```

1  //p[i] -- prefix (id of first symbol) on i-th position of suff array (from 0)
2  for (int i = 0; i < n; i++)
3      r[p[i]] = i;
4  int k = 0;
5  for (int j = 0; j < n; j++){
6      int i = r[j];
7      k--;
8      if (k < 0 || i == n - 1)
9          k = 0;
10     if (i != n - 1)
11         while (s[p[i] + k] == s[p[i + 1] + k])
12             k++;
13     lcp[i] = k;
14 }
15 for (int i = 0; i + 1 < n; i++)
16     cout << lcp[i] << " ";

```

```

1  fill(par, par + 301, -1);
2  fill(par2, par2 + 301, -1);
3
4  int ans = 0;
5  for (int v = 0; v < n; v++){
6      memset(useda, false, sizeof(useda));
7      memset(usedb, false, sizeof(usedb));
8      useda[v] = true;
9      for (int i = 0; i < n; i++)
10         w[i] = make_pair(a[v][i] + row[v] + col[i], v);
11     memset(prev, 0, sizeof(prev));
12     int pos;
13     while (true){
14         pair<pair<int, int>, int> p = make_pair(make_pair(1e9, 1e9), 1e9);
15         for (int i = 0; i < n; i++)
16             if (!usedb[i])
17                 p = min(p, make_pair(w[i], i));
18         for (int i = 0; i < n; i++)
19             if (!useda[i])
20                 row[i] += p.first.first;
21         for (int i = 0; i < n; i++)
22             if (!usedb[i]){
23                 col[i] -= p.first.first;
24                 w[i].first -= p.first.first;
25             }
26         ans += p.first.first;
27         usedb[p.second] = true;
28         prev[p.second] = p.first.second; //из второй в первую
29         int x = par[p.second];
30         if (x == -1){
31             pos = p.second;
32             break;
33         }
34         useda[x] = true;
35         for (int j = 0; j < n; j++)
36             w[j] = min(w[j], {a[x][j] + row[x] + col[j], x});
37     }
38     while (pos != -1){
39         int nxt = par2[prev[pos]];
40         par[pos] = prev[pos];
41         par2[prev[pos]] = pos;
42         pos = nxt;
43     }
44 }
45
46 cout << ans << "\n";
47 for (int i = 0; i < n; i++)
48     cout << par[i] + 1 << " " << i + 1 << "\n";

```

```

1  struct edge{
2      int from, to;
3      int c, f, num;
4      edge(int from, int to, int c, int num):from(from), to(to), c(c), f(0),
    ↪ num(num){}
5      edge(){}
6  };
7
8  const int max_n = 600;
9
10 edge eds[150000];
11 int num = 0;
12 int it[max_n];
13 vector<int> gr[max_n];
14 int s, t;
15 vector<int> d(max_n);
16
17 bool bfs(int k){
18     queue<int> q;
19     q.push(s);
20     fill(d.begin(), d.end(), -1);
21     d[s] = 0;
22     while (!q.empty()){
23         int v = q.front();
24         q.pop();
25         for (int x : gr[v])
26             if (d[eds[x].to] == -1 && eds[x].c - eds[x].f >= (1 << k)){
27                 d[eds[x].to] = d[v] + 1;
28                 q.push(eds[x].to);
29             }
30     }
31
32     return (d[t] != -1);
33 }
34
35 int dfs(int v, int flow, int k){
36     if (flow < (1 << k))
37         return 0;
38     if (v == t)
39         return flow;
40     for (; it[v] < gr[v].size(); it[v]++){
41         if (d[v] + 1 != d[eds[gr[v][it[v]]].to])
42             continue;
43         int num = gr[v][it[v]];
44         int res = dfs(eds[gr[v][it[v]]].to, min(flow, eds[gr[v][it[v]]].c -
    ↪ eds[gr[v][it[v]]].f), k);
45         if (res){
46             eds[num].f += res;
47             eds[num ^ 1].f -= res;
48             return res;
49     }

```

```

50     }
51     return 0;
52 }
53
54 void add(int fr, int to, int c, int nm){
55     gr[fr].push_back(num);
56     eds[num++] = edge(fr, to, c, nm);
57     gr[to].push_back(num);
58     eds[num++] = edge(to, fr, 0, nm); //corrected c
59 }
60
61 int ans = 0;
62 for (int k = 30; k >= 0; k--)
63     while (bfs(k)){
64         memset(it, 0, sizeof(it));
65         while (int res = dfs(s, 1e9 + 500, k))
66             ans += res;
67     }
68
69 // decomposition
70
71 int path_num = 0;
72 vector<int> paths[550];
73 int flows[550];
74
75 int decomp(int v, int flow){
76     if (flow < 1)
77         return 0;
78     if (v == t){
79         path_num++;
80         flows[path_num - 1] = flow;
81         return flow;
82     }
83     for (int i = 0; i < gr[v].size(); i++){
84         int num = gr[v][i];
85         int res = decomp(eds[num].to, min(flow, eds[num].f));
86         if (res){
87             eds[num].f -= res;
88             paths[path_num - 1].push_back(eds[num].num);
89             return res;
90         }
91     }
92     return 0;
93 }
94
95 while (decomp(s, 1e9 + 5));
96

```

```

1  long long ans = 0;
2  int mx = 2 * n + 2;
3
4  memset(upd, 0, sizeof(upd));
5  for (int i = 0; i < mx; i++)
6      dist[i] = inf;
7  dist[st] = 0;
8  queue<int> q;
9  q.push(st);
10 upd[st] = 1;
11 while (!q.empty()){
12     int v = q.front();
13     q.pop();
14     if (upd[v]){
15         for (int x : gr[v]) {
16             edge &e = edges[x];
17             if (e.c - e.f > 0 && dist[v] != inf && dist[e.to] > dist[v] + e.w) {
18                 dist[e.to] = dist[v] + e.w;
19                 if (!upd[e.to])
20                     q.push(e.to);
21                 upd[e.to] = true;
22                 p[e.to] = x;
23             }
24         }
25         upd[v] = false;
26     }
27 }
28
29 for (int i = 0; i < k; i++){
30     for (int i = 0; i < mx; i++)
31         d[i] = inf;
32     d[st] = 0;
33     memset(used, false, sizeof(used));
34     set<pair<int, int> > s;
35     s.insert(make_pair(0, st));
36     for (int i = 0; i < mx; i++){
37         int x;
38         while (!s.empty() && used[(s.begin() -> second)]){
39             s.erase(s.begin());
40         }
41         if (s.empty())
42             break;
43         x = s.begin() -> second;
44         used[x] = true;
45         s.erase(s.begin());
46         for (int i = 0; i < gr[x].size(); i++){
47             edge &e = edges[gr[x][i]];
48             if (!used[e.to] && e.c - e.f > 0){
49                 if (d[e.to] > d[x] + (e.c - e.f) * e.w + dist[x] - dist[e.to]){
50                     d[e.to] = d[x] + (e.c - e.f) * e.w + dist[x] - dist[e.to];
51                     p[e.to] = gr[x][i];

```



```
52             s.insert(make_pair(d[e.to], e.to));
53         }
54     }
55 }
56 dist[x] += d[x];
57 }
58 int pos = t;
59 while (pos != st){
60     int id = p[pos];
61     edges[id].f += 1;
62     edges[id ^ 1].f -= 1;
63     pos = edges[id].from;
64 }
65 }
```

```

1  string min_cyclic_shift (string s) {
2      s += s;
3      int n = (int) s.length();
4      int i=0, ans=0;
5      while (i < n/2) {
6          ans = i;
7          int j=i+1, k=i;
8          while (j < n && s[k] <= s[j]) {
9              if (s[k] < s[j])
10                 k = j;
11             else
12                 ++k;
13             ++j;
14         }
15         while (i <= k) i += j - k;
16     }
17     return s.substr (ans, n/2);
18 }

```

Sum over subsets

```

1  for(int i = 0; i<(1<<N); ++i)
2      F[i] = A[i];
3  for(int i = 0; i < N; ++i) for(int mask = 0; mask < (1<<N); ++mask){
4      if(mask & (1<<i))
5          F[mask] += F[mask^(1<<i)];
6  }

```

```
1  vector<int> getZ(string s){
2      vector<int> z;
3      z.resize(s.size(), 0);
4      int l = 0, r = 0;
5      for (int i = 1; i < s.size(); i++){
6          if (i <= r)
7              z[i] = min(r - i + 1, z[i - 1]);
8          while (i + z[i] < s.size() && s[z[i]] == s[i + z[i]])
9              z[i]++;
10         if (i + z[i] - 1 > r){
11             r = i + z[i] - 1;
12             l = i;
13         }
14     }
15     return z;
16 }
17
18 vector<int> getP(string s){
19     vector<int> p;
20     p.resize(s.size(), 0);
21     int k = 0;
22     for (int i = 1; i < s.size(); i++){
23         while (k > 0 && s[i] == s[k])
24             k = p[k - 1];
25         if (s[i] == s[k])
26             k++;
27         p[i] = k;
28     }
29     return p;
30 }
31
32 vector<int> getH(string s){
33     vector<int> h;
34     h.resize(s.size() + 1, 0);
35     for (int i = 0; i < s.size(); i++)
36         h[i + 1] = ((h[i] * 111 * pow) + s[i] - 'a' + 1) % mod;
37     return h;
38 }
39
40 int getHash(vector<int> &h, int l, int r){
41     int res = (h[r + 1] - h[l] * p[r - l + 1]) % mod;
42     if (res < 0)
43         res += mod;
44     return res;
45 }
```

## suf array + lcp

```

1  char *s; // входная строка
2  int n; // длина строки
3  const int maxlen = ...; // максимальная длина строки
4  const int alphabet = 256; // размер алфавита, <= maxlen
5  //
6  int p[maxlen], cnt[maxlen], c[maxlen];
7  memset (cnt, 0, alphabet * sizeof(int));
8  for (int i=0; i<n; ++i)
9      ++cnt[s[i]];
10 for (int i=1; i<alphabet; ++i)
11     cnt[i] += cnt[i-1];
12 for (int i=0; i<n; ++i)
13     p[--cnt[s[i]]] = i;
14 c[p[0]] = 0;
15 int classes = 1;
16 for (int i=1; i<n; ++i) {
17     if (s[p[i]] != s[p[i-1]]) ++classes;
18     c[p[i]] = classes-1;
19 }
20 //
21 int pn[maxlen], cn[maxlen];
22 for (int h=0; (1<<h)<n; ++h) {
23     for (int i=0; i<n; ++i) {
24         pn[i] = p[i] - (1<<h);
25         if (pn[i] < 0) pn[i] += n;
26     }
27     memset (cnt, 0, classes * sizeof(int));
28     for (int i=0; i<n; ++i)
29         ++cnt[c[pn[i]]];
30     for (int i=1; i<classes; ++i)
31         cnt[i] += cnt[i-1];
32     for (int i=n-1; i>=0; --i)
33         p[--cnt[c[pn[i]]]] = pn[i];
34     cn[p[0]] = 0;
35     classes = 1;
36     for (int i=1; i<n; ++i) {
37         int mid1 = (p[i] + (1<<h)) % n, mid2 = (p[i-1] + (1<<h)) % n;
38         if (c[p[i]] != c[p[i-1]] || c[mid1] != c[mid2])
39             ++classes;
40         cn[p[i]] = classes-1;
41     }
42     memcpy (c, cn, n * sizeof(int));
43 }

```

```

1  int num = 0;
2  long long phi = n, nn = n;
3  for (long long x:primes){
4      if (x*x>nn)
5          break;
6      if (nn % x == 0){
7          while (nn % x == 0)
8              nn /= x;
9          phi -= phi/x;
10         num++;
11     }
12 }
13 if (nn != 1){
14     phi -= phi/nn;
15     num++;
16 }
17 if (!(num == 1 && n % 2 != 0) || n == 4 || n == 2 || (num == 2 && n % 2 == 0 && n
    ↪ % 4 != 0)){
18     cout << "-1\n";
19     continue;
20 }
21 vector<long long> v;
22 long long pp = phi;
23 for (long long x:primes){
24     if (x*x>pp)
25         break;
26     if (pp % x == 0){
27         while (pp % x == 0)
28             pp /= x;
29         v.push_back(x);
30     }
31 }
32 if (pp != 1){
33     v.push_back(pp);
34 }
35 while (true){
36     long long a = primes[rand()%5000]%n;
37     if (gcd(a, n) != 1)
38         continue;
39     bool bb = false;
40     for (long long x:v)
41         if (pow(a, phi/x) == 1){
42             bb = true;
43             break;
44         }
45     if (!bb){
46         cout << a << "\n";
47         break;
48     }
49 }

```

```

1  int log = 20;
2  int N = 1 << log;
3
4  typedef complex<double> cd;
5
6  int rev[N];
7  cd root[N];
8
9  void init() {
10     for (int i = 0; i != N; ++i)
11         rev[i] = (rev[i >> 1] >> 1) + ((i & 1) << (maxlog - 1));
12
13     const double pi = acos(-1);
14     for (int k = 1; k < maxn; k *= 2) {
15         cd tmp(pi / k);
16         root[k] = {1, 0};
17         for (int i = 1; i < k; i++)
18             root[k + i] = (i & 1) ? root[(k + i) >> 1] * tmp : root[(k + i) >> 1];
19     }
20 }
21
22 void fft(vector<cd>& a) {
23     for (int i = 0; i != N; ++i)
24         if (rev[i] < i)
25             swap(res[rev[i]], res[i]);
26     for (int k = 1; k < maxn; k *= 2)
27         for (int i = 0; i < maxn; i += 2 * k)
28             for (int j = 0; j != k; ++j) {
29                 cd tmp = root[k + j] * res[i + j + k];
30                 res[i + j + k] = res[i + j] - tmp;
31                 res[i + j] = res[i + j] + tmp;
32             }
33 }
34
35 void inv_fft(vector<cd>& a) {
36     fft(a);
37     reverse(a.begin() + 1, a.end());
38
39     for (cd& elem: a)
40         elem /= N;
41 }
42
43 void fast_fourier(vector<int>& a) { // AND-FFT.
44     for (int k = 1; k < SZ(a); k *= 2)
45         for (int start = 0; start < (1 << K); start += 2 * k) {
46             for (int off = 0; off < k; ++off) {
47                 int a_val = a[start + off];
48                 int b_val = a[start + k + off];
49
50                 a[start + off] = b_val;
51                 a[start + k + off] = add(a_val, b_val);

```

```
10         }
11     }
12 }
13
14 void inverse_fast_fourier(vector<int>& a) {
15     for (int k = 1; k < SZ(a); k *= 2)
16         for (int start = 0; start < (1 << K); start += 2 * k) {
17             for (int off = 0; off < k; ++off) {
18                 int a_val = a[start + off];
19                 int b_val = a[start + k + off];
20
21                 a[start + off] = sub(b_val, a_val);
22                 a[start + k + off] = a_val;
23             }
24         }
25 }
```

DM

**Кол-во корневых деревьев:**

$$t(G) = \frac{1}{n} \lambda_2 \dots \lambda_n \quad (\lambda_1 = 0)$$

**Кол-во эйлеровых циклов:**

$$e(D) = t^-(D, x) \cdot \prod_{y \in D} (\text{outdeg}(y) - 1)!$$

**Наличие совершенного паросочетания:**

$T$  – матрица с нулями на диагонали. Если есть ребро  $(i, j)$ , то  $a_{i,j} := x_{i,j}$ ,  $a_{j,i} = -x_{i,j}$   
 $\det(T) = 0 \Leftrightarrow$  нет совершенного паросочетания.



## **Whitespace code FFT**