

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 Γ — 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

$$Conn_N = G_N - \frac{1}{N} \sum_{K=1}^{N-1} K \binom{N}{K} Conn_K G_{N-K}$$

Количество помеченных графов с K компонентами связности

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

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  struct state {
2      state() {
3          std::fill(next, next + 26, -1);
4      }
5
6      int len = 0, link = -1;
7      bool term = false;
8
9      int next[26];
10 };
11
12 vector<state> st;
13 int last;
14
15 void sa_init() {
16     last = 0;
17     st.clear();
18     st.resize(1);
19 }
20
21 void sa_extend (char c) {
22     int cur = st.size();
23     st.resize(st.size() + 1);
24
25     st[cur].len = st[last].len + 1;
26     int p;
27     for (p=last; p!=-1 && st[p].next[c - 'a'] == -1; p=st[p].link)
28         st[p].next[c - 'a'] = cur;
29     if (p == -1)
30         st[cur].link = 0;
31     else {
32         int q = st[p].next[c - 'a'];
33         if (st[p].len + 1 == st[q].len)
34             st[cur].link = q;
35         else {
36             int clone = st.size();
37             st.resize(st.size() + 1);
38             st[clone].len = st[p].len + 1;
39             std::copy(st[q].next, st[q].next + 26, st[clone].next);
40             st[clone].link = st[q].link;
41             for (; p!=-1 && st[p].next[c - 'a']==q; p=st[p].link)
42                 st[p].next[c - 'a'] = clone;
43             st[q].link = st[cur].link = clone;
44         }
45     }
46     last = cur;
47 }
48
49 for(int v=last; v!=-1; v=st[v].link) // set termination flag.
50     st[v].term = 1;

```

```

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  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 }

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  //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  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);
52             }
53         }
54 }

```

```
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