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# **XCPC Template Manual**

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# 1 Math

## 1.1 BSGS

```
1 // Finds the primitive root modulo p
2 int generator(int p) {
3     vector<int> fact;
4     int phi = p - 1, n = phi;
5     for (int i = 2; i * i <= n; ++i) {
6         if (n % i == 0) {
7             fact.push_back(i);
8             while (n % i == 0) n /= i;
9         }
10    }
11    if (n > 1) fact.push_back(n);
12    for (int res = 2; res <= p; ++res) {
13        bool ok = true;
14        for (int factor : fact)
15            if (mod_pow(res, phi / factor, p) == 1) {
16                ok = false;
17                break;
18            }
19    }
20    if (ok) return res;
21 }
22 return -1;
23 }
24 // This program finds all numbers x such that  $x^k \equiv a \pmod n$ 
25 vector<int> BSGS(int n, int k, int a) {
26     if (a == 0) return vector<int>({0});
27
28     int g = generator(n);
29     // Baby-step giant-step discrete logarithm algorithm
30     int sq = (int)sqrt(n + .0) + 1;
31     vector<pair<int, int>> dec(sq);
32     for (int i = 1; i <= sq; ++i)
33         dec[i - 1] = {mod_pow(g, i * sq * k % (n - 1), n), i};
34
35     sort(dec.begin(), dec.end());
36     int any_ans = -1;
37     for (int i = 0; i < sq; ++i) {
38         int my = mod_pow(g, i * k % (n - 1), n) * a % n;
39         auto it = lower_bound(dec.begin(), dec.end(), make_pair(my, 0));
40         if (it != dec.end() && it->first == my) {
41             any_ans = it->second * sq - i;
42             break;
43         }
44     }
45     if (any_ans == -1) return vector<int>();
46     // Print all possible answers
47     int delta = (n - 1) / __gcd(k, n - 1);
48     vector<int> ans;
49     for (int cur = any_ans % delta; cur < n - 1; cur += delta)
50         ans.push_back(mod_pow(g, cur, n));
51     sort(ans.begin(), ans.end());
52     return ans;
53 }
```

## 1.2 FFT

```

1  const int MAXN = 4 * 1e5 + 3;
2  const double PI = acos(-1);
3  complex<double> a[MAXN], b[MAXN];
4
5  int n, bit;
6  int rev[MAXN];
7
8  void fft(complex<double> *a, int sign) {
9      for (int i = 0; i < n; ++i)
10         if (i < rev[i]) swap(a[i], a[rev[i]]);
11
12     for (int j = 1; j < n; j <= 1) {
13         complex<double> wn(cos(2 * PI / (j << 1)), sign * sin(2 * PI / (j << 1)));
14         for (int i = 0; i < n; i += (j << 1)) {
15             complex<double> w(1, 0), t0, t1;
16             FOR(k, 0, j) {
17                 t0 = a[i + k];
18                 t1 = w * a[i + j + k];
19                 a[i + k] = t0 + t1;
20                 a[i + j + k] = t0 - t1;
21                 w *= wn;
22             }
23         }
24     }
25     if (sign == -1)
26         for (int i = 0; i < n; ++i) a[i] /= n;
27 }
28
29 int main() {
30     ios::sync_with_stdio(false);
31     cin.tie(0);
32     cout.tie(0);
33
34     int n, m, x;
35     cin >> n >> m;
36     for (int i = 0; i <= n; ++i) {
37         cin >> x;
38         a[i].real(x);
39     }
40     for (int i = 0; i <= m; ++i) {
41         cin >> x;
42         b[i].real(x);
43     }
44
45     ::n = 1;
46     bit = 0;
47     while (::n <= n + m) {
48         ::n <<= 1;
49         ++bit;
50     }
51     rev[0] = 0;
52     FOR(i, 1, ::n) rev[i] = (rev[i >> 1] >> 1) | ((i & 1) << (bit - 1));
53     fft(a, 1);
54     fft(b, 1);
55     FOR(i, 0, ::n) a[i] *= b[i];
56     fft(a, -1);
57     FOR(i, 0, n + m + 1) cout << int(a[i].real() + .5) << " ";

```

```

58     cout << "\n";
59     return 0;
60 }

```

### 1.3 Linear Programming

```

1  // CCPC Final 2017 F
2  // sum(P(s)) = 1, P(s) >= 0
3  // max and equal (sum(P(s)) | i in s)
4  #include <bits/stdc++.h>
5  using namespace std;
6
7  const int MAXN = int(3e3);
8  const int MAXM = int(3e3);
9  const double INF = 1e20, EPS = 1e-9;
10
11 int n, m;
12 double a[MAXM][MAXN], v;
13
14 void pivot(int l, int e) {
15     int i, j;
16     a[l][e] = 1 / a[l][e];
17     for (j = 0; j <= n; ++j)
18         if (j != e) a[l][j] *= a[l][e];
19     for (i = 1; i <= m; ++i)
20         if (i != l && fabs(a[i][e]) > EPS) {
21             for (j = 0; j <= n; ++j)
22                 if (j != e) a[i][j] -= a[i][e] * a[l][j];
23             a[i][e] = -a[i][e] * a[l][e];
24         }
25     v += a[0][e] * a[l][0];
26     for (j = 1; j <= n; ++j)
27         if (j != e) a[0][j] -= a[0][e] * a[l][j];
28     a[0][e] = -a[0][e] * a[l][e];
29 }
30
31 double simplex() {
32     int e, l, i;
33     double mn;
34     v = 0;
35     while (true) {
36         for (e = 1; e <= n; ++e)
37             if (a[0][e] > EPS) break;
38         if (e > n) return v;
39         for (i = 1, mn = INF; i <= m; ++i)
40             if (a[i][e] > EPS && mn > a[i][0] / a[i][e])
41                 mn = a[i][0] / a[i][e], l = i;
42         if (mn == INF) return INF;
43         pivot(l, e);
44     }
45 }
46
47 void solve() {
48     static int n, m, g[10];
49     static vector<int> con[10], able;
50
51     scanf("%d %d", &n, &m);
52     for (int i = 0; i < n; ++i) {

```

```

53     scanf("%d", g + i);
54     con[i].clear();
55 }
56
57 if (n == 1) {
58     printf("%.10f\n", m >= g[0] ? 1. : 0.);
59     return;
60 }
61
62 able.clear();
63 for (int s = 0, S = 1 << n; s < S; ++s) {
64     int sum = 0;
65     for (int i = 0; i < n; ++i)
66         if (s >> i & 1) sum += g[i];
67     if (sum > m) continue;
68     able.push_back(s);
69     for (int i = 0; i < n; ++i)
70         if (s >> i & 1) con[i].push_back(able.size());
71 }
72 ::n = able.size();
73 ::m = 0;
74 static random_device rd;
75 mt19937 gen(rd());
76 shuffle(able.begin(), able.end(), gen);
77 for (int step = 0; step < n; ++step) {
78     int f = ++::m;
79     for (int i = 0; i <= ::n; ++i) a[f][i] = 0;
80     for (int x : con[step]) ++a[f][x];
81     if (step + 1 < n) {
82         for (int x : con[step + 1]) --a[f][x];
83     } else {
84         for (int x : con[0]) --a[f][x];
85     }
86 }
87
88 ++::m;
89 a[::m][0] = 1;
90 for (int i = 1; i <= ::n; ++i) a[::m][i] = 1;
91
92 ++::m;
93 a[::m][0] = -1;
94 for (int i = 1; i <= ::n; ++i) a[::m][i] = -1;
95
96 for (int i = 0; i <= ::n; ++i) a[0][i] = 0;
97 for (int x : con[0]) ++a[0][x];
98 printf("%.10f\n", simplex());
99 }
100
101 int main() {
102     int o_o, case_number = 1;
103     for (scanf("%d", &o_o); case_number <= o_o; ++case_number) {
104         printf("Case #d: ", case_number);
105         solve();
106     }
107     return 0;
108 }
109
110 // 备份
111 #include <bits/stdc++.h>

```

```

112 using namespace std;
113
114 typedef long double db;
115 const int MAXN = 3000;
116 const int MAXM = 3000;
117 const db EPS = 1e-9;
118 const db INF = 1e200;
119
120 namespace LP {
121     db a[MAXN][MAXN];
122     int idA[MAXN], idB[MAXN];
123     int m, n;
124
125     void put_out(int x) {
126         if (x == 0)
127             printf("Infeasible\n");
128         else
129             printf("Unbounded\n");
130         exit(0);
131     }
132
133     void pivot(int xA, int xB) {
134         swap(idA[xA], idB[xB]);
135         static int next[MAXN];
136         int i, j, last = MAXN - 1;
137         db tmp = -a[xB][xA];
138         a[xB][xA] = -1.0;
139         for (j = 0; j <= n; j++)
140             if (fabs(a[xB][j]) > EPS) a[xB][last = next[last] = j] /= tmp;
141         next[last] = -1;
142
143         for (i = 0; i <= m; i++)
144             if (i != xB && fabs(tmp = a[i][xA]) > EPS)
145                 for (a[i][xA] = 0.0, j = next[MAXN - 1]; ~j; j = next[j])
146                     a[i][j] += tmp * a[xB][j];
147     }
148
149     db calc() {
150         int xA, xB;
151         db Max, tmp;
152         while (1) {
153             xA = n + 1, idA[xA] = n + m + 1;
154             for (int i = 1; i <= n; i++)
155                 if (a[0][i] > EPS && idA[i] < idA[xA]) xA = i;
156
157             if (xA == n + 1) return a[0][0];
158             xB = m + 1, idB[xB] = n + m + 1, Max = -INF;
159             for (int i = 1; i <= m; i++)
160                 if (a[i][xA] < -EPS && ((tmp = a[i][0] / a[i][xA]) > Max + EPS ||
161                     (tmp > Max - EPS && idB[i] < idB[xB])))
162                     Max = tmp, xB = i;
163
164             if (xB == m + 1) put_out(1);
165
166             pivot(xA, xB);
167         }
168         return a[0][0];
169     }
170
171     void solve() {
172         for (int i = 1; i <= n; i++) idA[i] = i;
173         for (int i = 1; i <= m; i++) idB[i] = n + i;
174     }
175 }

```

```

171 static db tmp[MAXN];
172 db Min = 0.0;
173 int l;
174 for (int i = 1; i <= m; i++)
175     if (a[i][0] < Min) Min = a[i][0], l = i;
176 if (Min > -EPS) return calc();
177
178 idA[++n] = 0;
179 for (int i = 1; i <= m; i++) a[i][n] = 1.0;
180 for (int i = 0; i <= n; i++) tmp[i] = a[0][i], a[0][i] = 0.0;
181 a[0][n] = -1.0;
182
183 pivot(n, l);
184
185 if (calc() < -EPS) put_out(0);
186 for (int i = 1; i <= m; i++)
187     if (!idB[i]) {
188         for (int j = 1; j <= n; j++)
189             if (fabs(a[0][j]) > EPS) {
190                 pivot(j, i);
191                 break;
192             }
193         break;
194     }
195
196 int xA;
197 for (xA = 1; xA <= n; xA++)
198     if (!idA[xA]) break;
199 for (int i = 0; i <= m; i++) a[i][xA] = a[i][n];
200 idA[xA] = idA[n], n--;
201
202 for (int i = 0; i <= n; i++) a[0][i] = 0.0;
203 for (int i = 1; i <= m; i++)
204     if (idB[i] <= n) {
205         for (int j = 0; j <= n; j++) a[0][j] += a[i][j] * tmp[idB[i]];
206     }
207
208 for (int i = 1; i <= n; i++)
209     if (idA[i] <= n) a[0][i] += tmp[idA[i]];
210 return calc();
211 }
212 db ans[MAXN];
213 void findAns() {
214     for (int i = 1; i <= n; i++) ans[i] = 0.0;
215     for (int i = 1; i <= m; i++)
216         if (idB[i] <= n) ans[idB[i]] = a[i][0];
217 }
218 void work() {
219     for (int i = 1; i <= m; ++i)
220         for (int j = 1; j <= n; ++j) a[i][j] *= -1;
221     printf("%.10f\n", -double(solve()));
222 }
223 } // namespace LP
224
225 void solve() {
226     static int n, m, g[10];
227     static vector<int> con[10], able;
228
229     scanf("%d %d", &n, &m);

```



```

230 for (int i = 0; i < n; ++i) {
231     scanf("%d", g + i);
232     con[i].clear();
233 }
234
235 if (n == 1) {
236     printf("%.10f\n", m >= g[0] ? 1.0 : 0.0);
237     return;
238 }
239
240 able.clear();
241 for (int s = 0; s < (1 << n); ++s) {
242     int sum = 0;
243     for (int i = 0; i < n; ++i)
244         if (s >> i & 1) sum += g[i];
245     if (sum > m) continue;
246
247     able.push_back(s);
248     for (int i = 0; i < n; ++i)
249         if (s >> i & 1) con[i].push_back(able.size());
250 }
251
252 LP::n = able.size();
253 LP::m = 0;
254
255 for (int step = 0; step < n; ++step) {
256     int &f = ++LP::m;
257     for (int i = 0; i <= LP::n; ++i) LP::a[f][i] = 0;
258     for (int x : con[step]) ++LP::a[f][x];
259     if (step + 1 < n) {
260         for (int x : con[step + 1]) --LP::a[f][x];
261     } else {
262         for (int x : con[0]) --LP::a[f][x];
263     }
264 }
265
266 ++LP::m;
267 LP::a[LP::m][0] = 1;
268 for (int i = 1; i <= LP::n; ++i) LP::a[LP::m][i] = 1;
269
270 ++LP::m;
271 LP::a[LP::m][0] = -1;
272 for (int i = 1; i <= LP::n; ++i) LP::a[LP::m][i] = -1;
273
274 for (int i = 0; i <= LP::n; ++i) LP::a[0][i] = 0;
275 for (int x : con[0]) ++LP::a[0][x];
276
277 static db a2[MAXM][MAXN];
278 for (int i = 1; i <= LP::m; ++i)
279     for (int j = 1; j <= LP::n; ++j) a2[i][j] = LP::a[i][j];
280 for (int i = 1; i <= LP::m; ++i)
281     for (int j = 1; j <= LP::n; ++j) LP::a[j][i] = a2[i][j];
282 swap(LP::n, LP::m);
283 for (int i = 1; i <= max(LP::n, LP::m); ++i) swap(LP::a[0][i], LP::a[i][0]);
284 LP::a[0][0] = 0;
285 for (int i = 1; i <= LP::m; ++i)
286     for (int j = 1; j <= LP::n; ++j) LP::a[i][j] *= -1;
287 for (int i = 1; i <= LP::m; ++i) LP::a[i][0] *= -1;
288 for (int i = 1; i <= LP::n; ++i) LP::a[0][i] *= -1;

```

```

289
290     LP::work();
291 }
292
293 int main() {
294     int o_o;
295     scanf("%d", &o_o);
296     for (int i = 1; i <= o_o; ++i) {
297         printf("Case #%d: ", i);
298         solve();
299     }
300     return 0;
301 }

```

## 1.4 Linear Recurrence

```

1 struct LinearRecurrence {
2     using int64 = long long;
3     using vec = std::vector<int64>;
4
5     static void extand(vec &a, size_t d, int64 value = 0) {
6         if (d <= a.size()) return;
7         a.resize(d, value);
8     }
9
10    static vec BerlekampMassey(const vec &s, int64 mod) {
11        std::function<int64(int64)> inverse = [&](int64 a) {
12            return a == 1 ? 1 : (int64)(mod - mod / a) * inverse(mod % a) % mod;
13        };
14        vec A = {1}, B = {1};
15        int64 b = s[0];
16        for (size_t i = 1, m = 1; i < s.size(); ++i, m++) {
17            int64 d = 0;
18            for (size_t j = 0; j < A.size(); ++j) { d += A[j] * s[i - j] % mod; }
19            if (!(d % mod)) continue;
20            if (2 * (A.size() - 1) <= i) {
21                auto temp = A;
22                extand(A, B.size() + m);
23                int64 coef = d * inverse(b) % mod;
24                for (size_t j = 0; j < B.size(); ++j) {
25                    A[j + m] -= coef * B[j] % mod;
26                    if (A[j + m] < 0) A[j + m] += mod;
27                }
28                B = temp, b = d, m = 0;
29            } else {
30                extand(A, B.size() + m);
31                int64 coef = d * inverse(b) % mod;
32                for (size_t j = 0; j < B.size(); ++j) {
33                    A[j + m] -= coef * B[j] % mod;
34                    if (A[j + m] < 0) A[j + m] += mod;
35                }
36            }
37        }
38        return A;
39    }
40
41    static void exgcd(int64 a, int64 b, int64 &g, int64 &x, int64 &y) {
42        if (!b)

```

```

43     x = 1, y = 0, g = a;
44     else {
45         exgcd(b, a % b, g, y, x);
46         y -= x * (a / b);
47     }
48 }
49
50 static int64 crt(const vec &c, const vec &m) {
51     int n = c.size();
52     int64 M = 1, ans = 0;
53     for (int i = 0; i < n; ++i) M *= m[i];
54     for (int i = 0; i < n; ++i) {
55         int64 x, y, g, tm = M / m[i];
56         exgcd(tm, m[i], g, x, y);
57         ans = (ans + tm * x * c[i] % M) % M;
58     }
59     return (ans + M) % M;
60 }
61
62 static vec ReedsSloane(const vec &s, int64 mod) {
63     auto inverse = [](int64 a, int64 m) {
64         int64 d, x, y;
65         exgcd(a, m, d, x, y);
66         return d == 1 ? (x % m + m) % m : -1;
67     };
68     auto L = [](const vec &a, const vec &b) {
69         int da = (a.size() > 1 || (a.size() == 1 && a[0])) ? a.size() - 1 : -1000;
70         int db = (b.size() > 1 || (b.size() == 1 && b[0])) ? b.size() - 1 : -1000;
71         return std::max(da, db + 1);
72     };
73     auto prime_power = [&](const vec &s, int64 mod, int64 p, int64 e) {
74         // linear feedback shift register mod p^e, p is prime
75         std::vector<vec> a(e), b(e), an(e), bn(e), ao(e), bo(e);
76         vec t(e), u(e), r(e), to(e, 1), uo(e), pw(e + 1);
77         ;
78         pw[0] = 1;
79         for (int i = pw[0] = 1; i <= e; ++i) pw[i] = pw[i - 1] * p;
80         for (int64 i = 0; i < e; ++i) {
81             a[i] = {pw[i]}, an[i] = {pw[i]};
82             b[i] = {0}, bn[i] = {s[0] * pw[i] % mod};
83             t[i] = s[0] * pw[i] % mod;
84             if (t[i] == 0) {
85                 t[i] = 1, u[i] = e;
86             } else {
87                 for (u[i] = 0; t[i] % p == 0; t[i] /= p, ++u[i])
88                     ;
89             }
90         }
91         for (size_t k = 1; k < s.size(); ++k) {
92             for (int g = 0; g < e; ++g) {
93                 if (L(an[g], bn[g]) > L(a[g], b[g])) {
94                     ao[g] = a[e - 1 - u[g]];
95                     bo[g] = b[e - 1 - u[g]];
96                     to[g] = t[e - 1 - u[g]];
97                     uo[g] = u[e - 1 - u[g]];
98                     r[g] = k - 1;
99                 }
100             }
101             a = an, b = bn;

```

```

102     for (int o = 0; o < e; ++o) {
103         int64 d = 0;
104         for (size_t i = 0; i < a[o].size() && i <= k; ++i) {
105             d = (d + a[o][i] * s[k - i]) % mod;
106         }
107         if (d == 0) {
108             t[o] = 1, u[o] = e;
109         } else {
110             for (u[o] = 0, t[o] = d; t[o] % p == 0; t[o] /= p, ++u[o])
111                 ;
112             int g = e - 1 - u[o];
113             if (L(a[g], b[g]) == 0) {
114                 extand(bn[o], k + 1);
115                 bn[o][k] = (bn[o][k] + d) % mod;
116             } else {
117                 int64 coef =
118                     t[o] * inverse(to[g], mod) % mod * pw[u[o] - uo[g]] % mod;
119                 int m = k - r[g];
120                 extand(an[o], ao[g].size() + m);
121                 extand(bn[o], bo[g].size() + m);
122                 for (size_t i = 0; i < ao[g].size(); ++i) {
123                     an[o][i + m] -= coef * ao[g][i] % mod;
124                     if (an[o][i + m] < 0) an[o][i + m] += mod;
125                 }
126                 while (an[o].size() && an[o].back() == 0) an[o].pop_back();
127                 for (size_t i = 0; i < bo[g].size(); ++i) {
128                     bn[o][i + m] -= coef * bo[g][i] % mod;
129                     if (bn[o][i + m] < 0) bn[o][i + m] += mod;
130                 }
131                 while (bn[o].size() && bn[o].back() == 0) bn[o].pop_back();
132             }
133         }
134     }
135 }
136 return std::make_pair(an[0], bn[0]);
137 };
138
139 std::vector<std::tuple<int64, int64, int>> fac;
140 for (int64 i = 2; i * i <= mod; ++i)
141     if (mod % i == 0) {
142         int64 cnt = 0, pw = 1;
143         while (mod % i == 0) mod /= i, ++cnt, pw *= i;
144         fac.emplace_back(pw, i, cnt);
145     }
146 if (mod > 1) fac.emplace_back(mod, mod, 1);
147 std::vector<vec> as;
148 size_t n = 0;
149 for (auto &&x : fac) {
150     int64 mod, p, e;
151     vec a, b;
152     std::tie(mod, p, e) = x;
153     auto ss = s;
154     for (auto &&x : ss) x %= mod;
155     std::tie(a, b) = prime_power(ss, mod, p, e);
156     as.emplace_back(a);
157     n = std::max(n, a.size());
158 }
159 vec a(n), c(as.size()), m(as.size());
160 for (size_t i = 0; i < n; ++i) {

```

```

161     for (size_t j = 0; j < as.size(); ++j) {
162         m[j] = std::get<0>(fac[j]);
163         c[j] = i < as[j].size() ? as[j][i] : 0;
164     }
165     a[i] = crt(c, m);
166 }
167 return a;
168 }
169
170 LinearRecurrence(const vec &s, const vec &c, int64 mod)
171     : init(s), trans(c), mod(mod), m(s.size()) {}
172
173 LinearRecurrence(const vec &s, int64 mod, bool is_prime = true) : mod(mod) {
174     vec A = is_prime ? BerlekampMassey(s, mod) : ReedsSloane(s, mod);
175     if (A.empty()) A = {0};
176     m = A.size() - 1;
177     trans.resize(m);
178     for (int i = 0; i < m; ++i) { trans[i] = (mod - A[i + 1]) % mod; }
179     std::reverse(trans.begin(), trans.end());
180     init = {s.begin(), s.begin() + m};
181 }
182
183 int64 calc(int64 n) {
184     if (mod == 1) return 0;
185     if (n < m) return init[n];
186     vec v(m), u(m << 1);
187     int msk = !!n;
188     for (int64 m = n; m > 1; m >>= 1) msk <<= 1;
189     v[0] = 1 % mod;
190     for (int x = 0; msk; msk >>= 1, x <<= 1) {
191         std::fill_n(u.begin(), m * 2, 0);
192         x |= !!n & msk;
193         if (x < m)
194             u[x] = 1 % mod;
195         else { // can be optimized by fft/ntt
196             for (int i = 0; i < m; ++i) {
197                 for (int j = 0, t = i + (x & 1); j < m; ++j, ++t) {
198                     u[t] = (u[t] + v[i] * v[j]) % mod;
199                 }
200             }
201             for (int i = m * 2 - 1; i >= m; --i) {
202                 for (int j = 0, t = i - m; j < m; ++j, ++t) {
203                     u[t] = (u[t] + trans[j] * u[i]) % mod;
204                 }
205             }
206         }
207         v = {u.begin(), u.begin() + m};
208     }
209     int64 ret = 0;
210     for (int i = 0; i < m; ++i) { ret = (ret + v[i] * init[i]) % mod; }
211     return ret;
212 }
213
214 vec init, trans;
215 int64 mod;
216 int m;
217 };

```

## 1.5 Linear Sieve

```

1  const int MAXN = 1e7 + 5;
2
3  bool vis[MAXN];
4  int prime[MAXN / 10], prime_cnt;
5  int fac[MAXN], e[MAXN], d[MAXN], mu[MAXN], phi[MAXN];
6  // e 质因子最高次数, d 因数个数
7  void sieve() {
8      fac[1] = 1, e[1] = 0, d[1] = 1, mu[1] = 1, phi[1] = 1;
9      for (int i = 2; i < MAXN; ++i) {
10         if (!vis[i]) {
11             prime[prime_cnt++] = i;
12             fac[i] = i, e[i] = 1, d[i] = 2, mu[i] = -1, phi[i] = i - 1;
13         }
14         for (int j = 0; j < prime_cnt; ++j) {
15             int t = prime[j] * i;
16             if (t >= MAXN) { break; }
17             vis[t] = true;
18             fac[t] = prime[j];
19             if (i % prime[j] == 0) {
20                 e[t] = e[i] + 1;
21                 d[t] = d[i] / (e[i] + 1) * (e[t] + 1);
22                 mu[t] = 0;
23                 phi[t] = phi[i] * prime[j];
24                 break;
25             } else {
26                 e[t] = 1;
27                 d[t] = d[i] * 2;
28                 mu[t] = -mu[i];
29                 phi[t] = phi[i] * (prime[j] - 1);
30             }
31         }
32     }
33 }

```

## 1.6 Lucas

```

1  // C(n, m) = C(n / p, m / p) * C(n % p, m % p) (mod p)
2  ll lucas(ll n, ll k, int p) {
3      ll ret = 1;
4      while (n && k) {
5          ll nn = n % p, kk = k % p;
6          if (nn < kk) return 0;
7          ret = ret * f[nn] * mod_pow(f[kk] * f[nn - kk] % p, p - 2, p) % p;
8          n /= p, k /= p;
9      }
10     return res;
11 }

```

## 1.7 Miller Rabin

```

1  inline ll mod_mul(const ll &a, const ll &b, const ll &mod) {
2      ll k = (ll)((1.0L * a * b) / (1.0L * mod)), t = a * b - k * mod;
3      t -= mod;
4      while (t < 0) t += mod;
5      return t;

```

```

6  }
7  inline ll mod_pow(ll a, ll b, const ll &mod) {
8      ll res = 1;
9      for (; b; b >>= 1, a = mod_mul(a, a, mod))
10         (b & 1) && (res = mod_mul(res, a, mod));
11     return res;
12 }
13
14 inline bool check(const ll &x, const ll &p) {
15     if (!(x % p) || mod_pow(p % x, x - 1, x) ^ 1) return false;
16     ll k = x - 1, t;
17     while (~k & 1) {
18         if (((t = mod_pow(p % x, k >>= 1, x)) ^ 1) && (t ^ (x - 1))) return false;
19         if (!(t ^ (x - 1))) return true;
20     }
21     return true;
22 }
23
24 inline bool Miller_Rabin(const ll &x) {
25     if (x < 2) return false;
26     static const int p[12] = {2, 3, 5, 7, 11, 13, 17, 19, 61, 2333, 4567, 24251};
27     for (int i = 0; i < 12; ++i) {
28         if (!(x ^ p[i])) return true;
29         if (!check(x, p[i])) return false;
30     }
31     return true;
32 }

```

## 1.8 Pollard rho

```

1  inline ll rand64(ll x) {
2      return 1ll * ((rand() << 15 ^ rand()) << 30 ^ (rand() << 15 ^ rand())) % x;
3  }
4
5  inline ll Pollard_rho(const ll &x, const int &y) {
6      ll v0 = rand64(x - 1) + 1, v = v0, d, s = 1;
7      for (register int t = 0, k = 1;;) {
8          if (v = (mod_mul(v, v, x) + y) % x, s = mod_mul(s, abs(v - v0), x),
9              !(v ^ v0) || !s)
10             return x;
11         if (++t == k) {
12             if ((d = __gcd(s, x)) ^ 1) return d;
13             v0 = v, k <<= 1;
14         }
15     }
16 }
17
18 ll ans;
19 vector<ll> factor;
20 void findfac(ll n) {
21     if (Miller_Rabin(n)) {
22         factor.push_back(n);
23         return;
24     }
25     ll p = n;
26     while (p >= n) { p = Pollard_rho(p, rand64(n - 1) + 1); }
27     findfac(p);
28     findfac(n / p);

```

29 }

## 1.9 burnside

```

1 //  $|X/G| = \frac{1}{|G|} \sum_{g \in G} |X^g|$ 
2 // Gym - 101873B
3 // m边形，每边是n*n的矩形，用c种颜色染色，可进行水平旋转，问不同多边形个数。
4 #include <bits/stdc++.h>
5 using namespace std;
6
7 const int MOD = 1e9 + 7;
8
9 int mod_pow(int a, int b) {
10     int r = 1;
11     for (; b; b >>= 1, a = 1LL * a * a % MOD)
12         if (b & 1) r = 1LL * a * r % MOD;
13     return r;
14 }
15
16 int main() {
17     ios::sync_with_stdio(false);
18     cin.tie(nullptr);
19
20     int n, m, c;
21     cin >> n >> m >> c;
22
23     int ans = 0;
24     for (int i = 1; i <= m; ++i)
25         ans = (ans + mod_pow(c, n * n * __gcd(i, m))) % MOD;
26     ans = 1LL * ans * mod_pow(m, MOD - 2) % MOD;
27     cout << ans << '\n';
28     return 0;
29 }
```

## 1.10 china

```

1 int china(int n, int *a, int *m) {
2     int lcm = 1, res = 0;
3     for (int i = 0; i < n; ++i) lcm *= m[i];
4     for (int i = 0; i < n; ++i) {
5         int t = lcm / m[i], x, y;
6         exgcd(t, m[i], x, y);
7         x = (x % m[i] + m[i]) % m[i];
8         res = (res + 1LL * t * x) % lcm;
9     }
10    return res;
11 }
```

## 1.11 exctr

```

1 int exctr(int n, int *a, int *m) {
2     int M = m[0], res = a[0];
3     for (int i = 1; i < n; ++i) {
4         int a = M, b = m[i], c = (a[i] - res % b + b) % b, x, y;
5         int g = exgcd(a, b, x, y), bg = b / g;
6         if (c % g != 0) return -1;
```



```
7     x = 1LL * x * (c / g) % bg;
8     res += x * M;
9     M *= bg;
10    res = (res % M + M) % M;
11  }
12  return res;
13 }
```

## 1.12 exgcd

```
1 int exgcd(int a, int b, int &x, int &y) {
2     if (b == 0) return x = 1, y = 0, a;
3     int g = exgcd(b, a % b, y, x);
4     y -= a / b * x;
5     return g;
6 }
```

## 1.13 gauss

```
1
2 const double EPS = 1e-9;
3 const int MAXN = MAX_NODE;
4 double a[MAXN][MAXN], x[MAXN];
5 int equ, var;
6
7 int gauss() {
8     int i, j, k, col, max_r;
9     for (k = 0, col = 0; k < equ && col < var; k++, col++) {
10         max_r = k;
11         for (i = k + 1; i < equ; i++)
12             if (fabs(a[i][col]) > fabs(a[max_r][col])) max_r = i;
13         if (fabs(a[max_r][col]) < EPS) return 0;
14
15         if (k != max_r) {
16             for (j = col; j < var; j++) swap(a[k][j], a[max_r][j]);
17             swap(x[k], x[max_r]);
18         }
19
20         x[k] /= a[k][col];
21         for (j = col + 1; j < var; j++) a[k][j] /= a[k][col];
22         a[k][col] = 1;
23
24         for (i = k + 1; i < equ; i++)
25             if (i != k) {
26                 x[i] -= x[k] * a[i][col];
27                 for (j = col + 1; j < var; j++) a[i][j] -= a[k][j] * a[i][col];
28                 a[i][col] = 0;
29             }
30     }
31
32     for (col = equ - 1, k = var - 1; ~col; --col, --k) {
33         if (fabs(a[col][k]) > 0) {
34             for (i = 0; i < k; ++i) {
35                 x[i] -= x[k] * a[i][col];
36                 for (j = col + 1; j < var; j++) a[i][j] -= a[k][j] * a[i][col];
37                 a[i][col] = 0;
38             }
39         }
40     }
41 }
```

```

39     }
40 }
41
42 return 1;
43 }

```

## 1.14 杜教筛

```

1  // e = mu x 1
2  // d = 1 x 1
3  // sigma = d x 1
4  // phi = mu x id
5  // id = phi x 1
6  // id^2 = (id * phi) x id
7
8  // S = sum(f)
9  // sum(fxg) = sum(g(i)S(n/i))
10 map<int, int> mp_mu;
11
12 int S_mu(int n) {
13     if (n < MAXN) return sum_mu[n];
14     if (mp_mu[n]) return mp_mu[n];
15     int ret = 1;
16     for (int i = 2, j; i <= n; i = j + 1) {
17         j = n / (n / i);
18         ret -= S_mu(n / i) * (j - i + 1);
19     }
20     return mp_mu[n] = ret;
21 }
22
23 ll S_phi(int n) {
24     ll res = 0;
25     for (int i = 1, j; i <= n; i = j + 1) {
26         j = n / (n / i);
27         res += 1LL * (S_mu(j) - S_mu(i - 1)) * (n / i) * (n / i);
28     }
29     return (res - 1) / 2 + 1;
30 }

```

## 1.15 类欧几里德算法

```

1  //求 f=sum((a*i+b)/c),g=sum((a*i+b)/c*i),h=sum(((a*i+b)/c)^2), for i in [0..n],
2  //整除向下
3  #include <bits/stdc++.h>
4  #define int long long
5  using namespace std;
6  const int P = 998244353;
7  int i2 = 499122177, i6 = 166374059;
8  struct data {
9     data() { f = g = h = 0; }
10    int f, g, h;
11 }; // 三个函数打包
12 data calc(int n, int a, int b, int c) {
13     int ac = a / c, bc = b / c, m = (a * n + b) / c, n1 = n + 1, n21 = n * 2 + 1;
14     data d;
15     if (a == 0) { // 迭代到最底层
16         d.f = bc * n1 % P;

```

```

17     d.g = bc * n % P * n1 % P * i2 % P;
18     d.h = bc * bc % P * n1 % P;
19     return d;
20 }
21 if (a >= c || b >= c) { // 取模
22     d.f = n * n1 % P * i2 % P * ac % P + bc * n1 % P;
23     d.g = ac * n % P * n1 % P * n21 % P * i6 % P + bc * n % P * n1 % P * i2 % P;
24     d.h = ac * ac % P * n % P * n1 % P * n21 % P * i6 % P +
25         bc * bc % P * n1 % P + ac * bc % P * n % P * n1 % P;
26     d.f %= P, d.g %= P, d.h %= P;
27
28     data e = calc(n, a % c, b % c, c); // 迭代
29
30     d.h += e.h + 2 * bc % P * e.f % P + 2 * ac % P * e.g % P;
31     d.g += e.g, d.f += e.f;
32     d.f %= P, d.g %= P, d.h %= P;
33     return d;
34 }
35 data e = calc(m - 1, c, c - b - 1, a);
36 d.f = n * m % P - e.f, d.f = (d.f % P + P) % P;
37 d.g = m * n % P * n1 % P - e.h - e.f, d.g = (d.g * i2 % P + P) % P;
38 d.h = n * m % P * (m + 1) % P - 2 * e.g - 2 * e.f - d.f;
39 d.h = (d.h % P + P) % P;
40 return d;
41 }
42
43 int T, n, a, b, c;
44 signed main() {
45     scanf("%lld", &T);
46     while (T--) {
47         scanf("%lld%lld%lld%lld", &n, &a, &b, &c);
48         data ans = calc(n, a, b, c);
49         printf("%lld %lld %lld\n", ans.f, ans.h, ans.g);
50     }
51     return 0;
52 }

```

## 2 Dynamic Programming

### 2.1 斜率优化

```

1 // 树上斜率优化
2 // 定义dpi 表示i节点传递到根节点的最短耗时, 规定dproot=-P。
3 // 有如下转移方程dpu=dpv+dist(u,v)^2+P,v is an ancestor of u.
4
5 #include <bits/stdc++.h>
6 using namespace std;
7
8 typedef long long ll;
9 typedef pair<int, int> pii;
10 const int MAXN = 1e5 + 5;
11
12 vector<pii> adj[MAXN];
13 ll dp[MAXN], d[MAXN];
14 int n, p, q[MAXN], head, tail;
15
16 inline ll S(int a, int b) { return (d[b] - d[a]) << 1; }

```

```

17 inline ll G(int a, int b) { return dp[b] - dp[a] + d[b] * d[b] - d[a] * d[a]; }
18
19 void dfs(int u, int from) {
20     vector<int> dhead, dtail;
21     if (u ^ 1) {
22         while (head + 2 <= tail &&
23             S(q[head + 1], q[head]) * d[u] <= G(q[head + 1], q[head]))
24             dhead.push_back(q[head++]);
25         int v = q[head];
26         dp[u] = dp[v] + p + (d[u] - d[v]) * (d[u] - d[v]);
27     }
28     while (head + 2 <= tail &&
29         G(u, q[tail - 1]) * S(q[tail - 1], q[tail - 2]) <=
30         G(q[tail - 1], q[tail - 2]) * S(u, q[tail - 1]))
31         dtail.push_back(q[--tail]);
32     q[tail++] = u;
33     for (pii &e : adj[u]) {
34         if (e.first == from) continue;
35         d[e.first] = d[u] + e.second;
36         dfs(e.first, u);
37     }
38     --tail;
39     for (int i = dtail.size() - 1; ~i; --i) q[tail++] = dtail[i];
40     for (int i = dhead.size() - 1; ~i; --i) q[--head] = dhead[i];
41 }
42
43 void solve() {
44     cin >> n >> p;
45     for (int i = 1; i <= n; ++i) adj[i].clear();
46     for (int i = 1, u, v, w; i < n; ++i) {
47         cin >> u >> v >> w;
48         adj[u].emplace_back(v, w);
49         adj[v].emplace_back(u, w);
50     }
51     dp[1] = -p;
52     head = tail = 0;
53     dfs(1, 1);
54
55     ll ans = 0;
56     for (int i = 1; i <= n; ++i)
57         if (dp[i] > ans) ans = dp[i];
58     cout << ans << '\n';
59 }
60
61 int main() {
62     // freopen("in.txt", "r", stdin);
63     ios::sync_with_stdio(false);
64     cin.tie(0);
65
66     int o_o;
67     for (cin >> o_o; o_o; --o_o) solve();
68
69     return 0;
70 }

```

## 3 Data Structure

### 3.1 KD-tree

```

1  // 寻找近点
2  #include <bits/stdc++.h>
3  using namespace std;
4
5  const int MAXN = 2e5 + 5;
6  typedef long long ll;
7
8  namespace KD_Tree {
9
10 const int DIM = 2;
11
12 inline ll sqr(int x) { return 1LL * x * x; }
13
14 struct Point {
15     int x[DIM], id, c;
16
17     ll dist2(const Point &b) const {
18         return sqr(x[0] - b.x[0]) + sqr(x[1] - b.x[1]);
19     }
20 };
21 struct QNode {
22     Point p;
23     ll dis2;
24
25     QNode() {}
26     QNode(Point _p, ll _dis2) : p(_p), dis2(_dis2) {}
27
28     bool operator<(const QNode &b) const {
29         return dis2 < b.dis2 || (dis2 == b.dis2 && p.id < b.p.id);
30     }
31 } ans;
32 struct cmpx {
33     int div;
34     cmpx(int _div) : div(_div) {}
35     bool operator()(const Point &a, const Point &b) {
36         for (int i = 0; i < DIM; ++i)
37             if (a.x[(i + div) % DIM] != b.x[(i + div) % DIM])
38                 return a.x[(i + div) % DIM] < b.x[(i + div) % DIM];
39         return true;
40     }
41 };
42
43 bool cmp(const Point &a, const Point &b, int div) {
44     cmpx cp = cmpx(div);
45     return cp(a, b);
46 }
47
48 struct Node {
49     Point e;
50     Node *lc, *rc;
51     int div;
52 } node_pool[MAXN], *tail, *root;
53 void init() { tail = node_pool; }
54 Node *build(Point *a, int l, int r, int div) {
55     if (l >= r) return nullptr;

```

```

56     Node *p = tail++;
57     p->div = div;
58     int mid = (l + r) >> 1;
59     nth_element(a + l, a + mid, a + r, cmpx(div));
60     p->e = a[mid];
61     p->lc = build(a, l, mid, div ^ 1);
62     p->rc = build(a, mid + 1, r, div ^ 1);
63     return p;
64 }
65 void search(Point p, Node *x, int div) {
66     if (!x) return;
67     if (cmp(p, x->e, div)) {
68         search(p, x->lc, div ^ 1);
69         if (ans.dis2 == -1) {
70             if (x->e.c <= p.c) ans = QNode(x->e, p.dist2(x->e));
71             search(p, x->rc, div ^ 1);
72         } else {
73             QNode temp(x->e, p.dist2(x->e));
74             if (x->e.c <= p.c && temp < ans) ans = temp;
75             if (sqr(x->e.x[div] - p.x[div]) <= ans.dis2) search(p, x->rc, div ^ 1);
76         }
77     } else {
78         search(p, x->rc, div ^ 1);
79         if (ans.dis2 == -1) {
80             if (x->e.c <= p.c) ans = QNode(x->e, p.dist2(x->e));
81             search(p, x->lc, div ^ 1);
82         } else {
83             QNode temp(x->e, p.dist2(x->e));
84             if (x->e.c <= p.c && temp < ans) ans = temp;
85             if (sqr(x->e.x[div] - p.x[div]) <= ans.dis2) search(p, x->lc, div ^ 1);
86         }
87     }
88 }
89 void search(Point p) {
90     ans.dis2 = -1;
91     search(p, root, 0);
92 }
93 } // namespace KD_Tree
94
95 void solve() {
96     static KD_Tree::Point p[MAXN];
97     int n, m;
98     cin >> n >> m;
99     for (int i = 0; i < n; ++i) {
100         p[i].id = i;
101         cin >> p[i].x[0] >> p[i].x[1] >> p[i].c;
102     }
103     KD_Tree::init();
104     KD_Tree::root = KD_Tree::build(p, 0, n, 0);
105
106     for (KD_Tree::Point q; m; --m) {
107         cin >> q.x[0] >> q.x[1] >> q.c;
108         KD_Tree::search(q);
109         cout << KD_Tree::ans.p.x[0] << ' ' << KD_Tree::ans.p.x[1] << ' '
110             << KD_Tree::ans.p.c << '\n';
111     }
112 }
113 int main() {
114     ios::sync_with_stdio(false);

```

```

115     cin.tie(nullptr);
116
117     int o_o;
118     for (cin >> o_o; o_o; --o_o) solve();
119
120     return 0;
121 }
122
123 // 寻找远点
124 inline void cmin(int &a, int b) { b < a ? a = b : 1; }
125 inline void cmax(int &a, int b) { a < b ? a = b : 1; }
126 inline int ibs(int a) { return a < 0 ? -a : a; }
127 struct D {
128     int d[2], mx0, mx1, mi0, mi1;
129     D *l, *r;
130 } t[N], *rt;
131 int cpd, ans;
132 inline bool cmp(const D &a, const D &b) {
133     return (a.d[cpd] ^ b.d[cpd]) ? a.d[cpd] < b.d[cpd]
134         : a.d[cpd ^ 1] < b.d[cpd ^ 1];
135 }
136 inline void kd_upd(D *u) {
137     if (u->l) {
138         cmax(u->mx0, u->l->mx0);
139         cmax(u->mx1, u->l->mx1);
140         cmin(u->mi0, u->l->mi0);
141         cmin(u->mi1, u->l->mi1);
142     }
143     if (u->r) {
144         cmax(u->mx0, u->r->mx0);
145         cmax(u->mx1, u->r->mx1);
146         cmin(u->mi0, u->r->mi0);
147         cmin(u->mi1, u->r->mi1);
148     }
149 }
150 D *kd_bld(int l, int r, int d) {
151     int m = l + r >> 1;
152     cpd = d;
153     std::nth_element(t + l + 1, t + m + 1, t + r + 1, cmp);
154     t[m].mx0 = t[m].mi0 = t[m].d[0];
155     t[m].mx1 = t[m].mi1 = t[m].d[1];
156     if (l ^ m) t[m].l = kd_bld(l, m - 1, d ^ 1);
157     if (r ^ m) t[m].r = kd_bld(m + 1, r, d ^ 1);
158     kd_upd(t + m);
159     return t + m;
160 }
161 inline void kd_ins(D *ne) {
162     int cd = 0;
163     D *u = rt;
164     while (true) {
165         cmax(u->mx0, ne->mx0), cmin(u->mi0, ne->mi0);
166         cmax(u->mx1, ne->mx1), cmin(u->mi1, ne->mi1);
167         if (ne->d[cd] < u->d[cd]) {
168             if (u->l)
169                 u = u->l;
170             else {
171                 u->l = ne;
172                 return;
173             }

```

```

174     } else {
175         if (u->r)
176             u = u->r;
177         else {
178             u->r = ne;
179             return;
180         }
181     }
182     cd ^= 1;
183 }
184 }
185 inline int dist(int x, int y, D *u) {
186     int r = 0;
187     if (x < u->mi0)
188         r = u->mi0 - x;
189     else if (x > u->mx0)
190         r = x - u->mx0;
191     if (y < u->mi1)
192         r += u->mi1 - y;
193     else if (y > u->mx1)
194         r += y - u->mx1;
195     return r;
196 }
197 inline void kd_quy(D *u, const int &x, const int &y) {
198     int dl, dr, d0;
199     d0 = ibs(u->d[0] - x) + ibs(u->d[1] - y);
200     if (d0 < ans) ans = d0;
201     dl = u->l ? dist(x, y, u->l) : inf;
202     dr = u->r ? dist(x, y, u->r) : inf;
203     if (dl < dr) {
204         if (dl < ans) kd_quy(u->l, x, y);
205         if (dr < ans) kd_quy(u->r, x, y);
206     } else {
207         if (dr < ans) kd_quy(u->r, x, y);
208         if (dl < ans) kd_quy(u->l, x, y);
209     }
210 }

```

### 3.2 LCT

```

1 struct LCT {
2     struct node {
3         int val, add;
4         node *fa, *ch[2];
5         void modify(const int &x) {
6             val += x;
7             add += x;
8         }
9     } node_mset[MaxS], *cnode, *null;
10    LCT() {
11        cnode = node_mset;
12        null = cnode++;
13        *null = (node){0, 0, null, {null, null}};
14    }
15    inline node *newnode() {
16        *cnode = (node){0, 0, null, {null, null}};
17        return cnode++;
18    }

```



```

19 inline bool isrt(node *u) const {
20     return (u->fa->ch[0] != u) && (u->fa->ch[1] != u);
21 }
22 inline bool which(node *u) const { return u->fa->ch[1] == u; }
23 void push_down(node *u) {
24     if (!isrt(u)) push_down(u->fa);
25     if (u->add) {
26         u->ch[0]->modify(u->add);
27         u->ch[1]->modify(u->add);
28         u->add = 0;
29     }
30 }
31 inline void rotate(node *u) {
32     node *f = u->fa;
33     int d = which(u);
34     f->ch[d] = u->ch[d ^ 1];
35     f->ch[d]->fa = f;
36     u->ch[d ^ 1] = f;
37     u->fa = f->fa;
38     if (!isrt(f)) f->fa->ch[which(f)] = u;
39     f->fa = u;
40 }
41 inline void splay(node *u) {
42     push_down(u);
43     for (node *f; !isrt(u); rotate(u))
44         if (!isrt(f = u->fa)) rotate(which(u) == which(f) ? f : u);
45 }
46 inline void access(node *x) {
47     for (node *y = null; x != null; x = x->fa) {
48         splay(x);
49         x->ch[1] = y;
50         y = x;
51     }
52 }
53 inline void cut(node *u) {
54     access(u);
55     splay(u);
56     u->ch[0]->fa = null;
57     u->ch[0] = null;
58 }
59 inline void link(node *u, node *v) {
60     cut(u);
61     u->fa = v;
62 }
63 } tree;

```

### 3.3 Splay

```

1 #include <algorithm>
2 #include <cstdio>
3 #include <cstring>
4 #include <iostream>
5 using namespace std;
6
7 const int MAXN = 2e5 + 10;
8
9 struct Node {
10     long long sum;

```

```

11  int id, val, lazy, size;
12  Node *fa, *ch[2];
13  } node_pool[MAXN], *pool_it, *root, *nil;
14
15  Node *newnode(int id, int val) {
16      pool_it->id = id;
17      pool_it->lazy = 0;
18      pool_it->size = 1;
19      pool_it->sum = pool_it->val = val;
20      pool_it->fa = pool_it->ch[0] = pool_it->ch[1] = nil;
21      return pool_it++;
22  }
23
24  void maintain(Node *u) {
25      if (u == nil) { return; }
26      u->size = u->ch[0]->size + u->ch[1]->size + 1;
27      u->sum = u->ch[0]->sum + u->ch[1]->sum + u->val;
28  }
29
30  void push_down(Node *u) {
31      if (u->lazy) {
32          if (u->ch[0] != nil) {
33              u->ch[0]->val += u->lazy;
34              u->ch[0]->sum += 1LL * u->ch[0]->size * u->lazy;
35              u->ch[0]->lazy += u->lazy;
36          }
37          if (u->ch[1] != nil) {
38              u->ch[1]->val += u->lazy;
39              u->ch[1]->sum += 1LL * u->ch[1]->size * u->lazy;
40              u->ch[1]->lazy += u->lazy;
41          }
42          u->lazy = 0;
43      }
44  }
45
46  inline void rot(Node *u) {
47      Node *f = u->fa, *ff = f->fa;
48      int d = u == f->ch[1];
49      push_down(f);
50      push_down(u);
51      if ((f->ch[d] = u->ch[d ^ 1]) != nil) f->ch[d]->fa = f;
52      if ((u->fa = ff) != nil) ff->ch[f == ff->ch[1]] = u;
53      f->fa = u;
54      u->ch[d ^ 1] = f;
55      maintain(f);
56      maintain(u);
57  }
58
59  void splay(Node *u, Node *target) {
60      for (Node *f; u->fa != target; rot(u))
61          if ((f = u->fa)->fa != target) {
62              ((u == f->ch[1]) ^ (f == f->fa->ch[1])) ? rot(u) : rot(f);
63          }
64      if (target == nil) root = u;
65  }
66
67  inline void insert(int id, int val) {
68      if (root == nil) {
69          root = newnode(id, val);

```

```

70     return;
71 }
72 Node *u = root;
73 while (u != nil) {
74     int d = id >= u->id;
75     ++u->size;
76     push_down(u);
77     u->sum += val;
78     if (u->ch[d] != nil) {
79         u = u->ch[d];
80     } else {
81         u->ch[d] = newnode(id, val);
82         u->ch[d]->fa = u;
83         u = u->ch[d];
84         break;
85     }
86 }
87 splay(u, nil);
88 }
89
90 inline Node *find_pred(int id) {
91     Node *u = root, *ret = nil;
92     while (u != nil) {
93         push_down(u);
94         if (u->id < id) {
95             ret = u;
96             u = u->ch[1];
97         } else {
98             u = u->ch[0];
99         }
100     }
101     return ret;
102 }
103
104 inline Node *find_succ(int id) {
105     Node *u = root, *ret = nil;
106     while (u != nil) {
107         push_down(u);
108         if (u->id > id) {
109             ret = u;
110             u = u->ch[0];
111         } else {
112             u = u->ch[1];
113         }
114     }
115     return ret;
116 }
117
118 Node *find_kth(int k) {
119     Node *u = root;
120     while (u != nil) {
121         push_down(u);
122         if (u->ch[0]->size + 1 == k) {
123             splay(u, nil);
124             return u;
125         }
126         if (u->ch[0]->size >= k) {
127             u = u->ch[0];
128         } else {

```

```

129     k -= u->ch[0]->size + 1;
130     u = u->ch[1];
131 }
132 }
133 return nil;
134 }
135
136 Node *range(int l, int r) {
137     Node *pred = find_pred(l);
138     Node *succ = find_succ(r);
139
140     splay(pred, nil);
141     splay(succ, root);
142     push_down(pred);
143     push_down(succ);
144     return root->ch[1]->ch[0];
145 }
146
147 int main() {
148
149     // freopen("input.txt", "r", stdin);
150
151     ios::sync_with_stdio(false);
152     cin.tie(0);
153     cout.tie(0);
154
155     int n;
156     cin >> n;
157
158     pool_it = node_pool;
159     nil = pool_it++;
160     nil->ch[0] = nil->ch[1] = nil->fa = nil;
161     nil->id = -1;
162     nil->val = 0;
163     root = nil;
164
165     insert(-0x3fffffff, 0);
166     insert(0x3fffffff, 0);
167
168     return 0;
169 }

```

### 3.4 zkw

```

1  int tree[MAXN * 2], pre;
2
3  void init(int n, int *a) {
4      memset(tree, 0, sizeof(tree));
5      for (pre = 1; pre <= n; pre <= 1) {}
6      for (int i = 1; i <= n; ++i) tree[i + pre] = a[i];
7      for (int i = pre; i; --i) tree[i] = max(tree[i << 1], tree[i << 1 | 1]);
8  }
9
10 void update(int pos, const int &val) {
11     tree[pos + pre] = val;
12     for (pos >>= 1; pos; pos >>= 1)
13         tree[pos] = max(tree[pos << 1], tree[pos << 1 | 1]);
14 }

```

```

15
16 int query(int s, int t) {
17     int res = 0;
18     for (s += pre - 1, t += pre + 1; s ^ t ^ 1; s >>= 1, t >>= 1) {
19         if (~s & 1) res = max(res, tree[s ^ 1]);
20         if (t & 1) res = max(res, tree[t ^ 1]);
21     }
22     return res;
23 }

```

## 4 String

### 4.1 AC 自动机

```

1 int ch[MAX_NODE][26], fail[MAX_NODE], dep[MAX_NODE], node_c;
2
3 int add_char(int u, int id) {
4     if (ch[u][id] < 0) ch[u][id] = node_c++;
5     return ch[u][id];
6 }
7 void build_acam() {
8     queue<int> que;
9     for (int i = 0; i < 26; ++i)
10         if (~ch[0][i]) {
11             que.push(ch[0][i]);
12             fail[ch[0][i]] = 0;
13             dep[ch[0][i]] = 1;
14         }
15     while (!que.empty()) {
16         int u = que.front(), f = fail[u];
17         que.pop();
18         for (int i = 0; i < 26; ++i)
19             if (~ch[u][i]) {
20                 que.push(ch[u][i]);
21                 for (f = fail[u]; ch[f][i] == 1; f = fail[f]) {}
22                 fail[ch[u][i]][i] = ch[f][i];
23                 dep[ch[u][i]] = dep[u] + 1;
24             }
25     }
26     for (int i = 1; i < node_c; ++i) adj[fail[i]].push_back(i);
27 }

```

### 4.2 Hash

```

1
2 const unsigned int KEY = 6151;
3 const unsigned int MOD = 1610612741;
4
5 unsigned int hash[MAXN], p[MAXN];
6
7 inline unsigned int get_hash(int l, int r) {
8     return (hash[r] + MOD - 1ULL * hash[l - 1] * p[r - l + 1] % MOD) % MOD;
9 }
10
11 void init(char *s, int n) {
12     p[0] = 1;

```

```

13  for (int i = 1; i <= n; ++i) {
14      p[i] = p[i - 1] * KEY % MOD;
15      hash[i] = (1LL * hash[i - 1] * KEY + s[i]) % MOD;
16  }
17  }

```

### 4.3 KMP

```

1  void get_next(char *S, int *nxt, int n) {
2      nxt[0] = -1;
3      int j = -1;
4      for (int i = 1; i < n; ++i) {
5          while ((~j) && S[j + 1] != S[i]) j = nxt[j];
6          nxt[i] = (S[j + 1] == S[i]) ? (++j) : j;
7      }
8  }
9
10 int pattern(char *S, char *T, int *nxt, int n, int m) {
11     int j = -1;
12     for (int i = 0; i < m; ++i) {
13         while ((~j) && S[j + 1] != T[i]) j = nxt[j];
14         j += S[j + 1] == T[i];
15         if (j == n - 1) return i - n + 1;
16     }
17     return -1;
18 }

```

### 4.4 SAM

```

1  struct Node {
2      int len;
3      Node *link, *ch[ALPHABET_SIZE];
4  } node_pool[MAXS], *node_it, *root, *last;
5
6  Node *new_node(int len) {
7      node_it->len = len;
8      return node_it++;
9  }
10 void sam_init() {
11     node_it = node_pool;
12     last = root = new_node(0);
13 }
14 void sam_extend(int c, int val) {
15     Node *p = last, *np = new_node(p->len + 1);
16     for (last = np; p && !p->ch[c]; p = p->link) p->ch[c] = np;
17     if (!p) {
18         np->link = root;
19     } else {
20         Node *q = p->ch[c];
21         if (q->len == p->len + 1) {
22             np->link = q;
23         } else {
24             Node *nq = new_node(p->len + 1);
25             memcpy(nq->ch, q->ch, sizeof(q->ch));
26             nq->link = q->link;
27             q->link = np->link = nq;
28             for (; p && p->ch[c] == q; p = p->link) p->ch[c] = nq;

```

```

29     }
30 }
31 }

```

## 4.5 mancher

```

1 void mancher(char *s, int n) {
2     str[0] = '~';
3     str[1] = '!';
4     for (int i = 1; i <= n; ++i) {
5         str[i * 2] = s[i];
6         str[i * 2 + 1] = '!';
7     }
8     for (int i = 1, j = 0; i <= n; ++i) {
9         if (p[j] + j > i) {
10            p[i] = min(p[2 * j - i], p[j] + j - i);
11        } else {
12            p[i] = 1;
13        }
14        while (str[i + p[i]] == str[i - p[i]]) { ++p[i]; }
15        if (i + p[i] > j + p[j]) { j = i; }
16    }
17 }

```

## 4.6 后缀数组 (SAIS)

```

1 // UOJ 模板题, 最快算法
2 // 字符串必须为正数, BUFFER_SIZE 要随 MAX_LENGTH 同步变化, 1e6为25
3 #include <bits/stdc++.h>
4
5 const int BUFFER_SIZE = 1u << 23 | 1;
6 char buffer[BUFFER_SIZE], *buffer_ptr = buffer;
7 #define alloc(x, type, len) \
8     type *x = (type *)buffer_ptr; \
9     buffer_ptr += (len) * sizeof(type); \
10 #define clear_buffer() \
11     memset(buffer, 0, buffer_ptr - buffer), buffer_ptr = buffer;
12
13 template <int MAX_LENGTH> class SuffixArray {
14 #define L_TYPE true
15 #define S_TYPE false
16 public:
17     int sa[MAX_LENGTH], rank[MAX_LENGTH], height[MAX_LENGTH];
18     void compute(int n, int m, int *s) {
19         sais(n, m, s, sa);
20         for (int i = 0; i < n; ++i) rank[sa[i]] = i;
21         for (int i = 0, h = 0; i < n; ++i) {
22             if (rank[i]) {
23                 int j = sa[rank[i] - 1];
24                 while (s[i + h] == s[j + h]) ++h;
25                 height[rank[i]] = h;
26             } else {
27                 h = 0;
28             }
29             if (h) --h;
30         }
31     }

```

```

32
33 private:
34     int l_bucket[MAX_LENGTH], s_bucket[MAX_LENGTH];
35
36     void induce(int n, int m, int *s, bool *type, int *sa, int *bucket,
37                 int *l_bucket, int *s_bucket) {
38         memcpy(l_bucket + 1, bucket, m * sizeof(int));
39         memcpy(s_bucket + 1, bucket + 1, m * sizeof(int));
40         sa[l_bucket[s[n - 1]]++] = n - 1;
41         for (int i = 0; i < n; ++i) {
42             int t = sa[i] - 1;
43             if (t >= 0 && type[t] == L_TYPE) sa[l_bucket[s[t]]++] = t;
44         }
45         for (int i = n - 1; i >= 0; --i) {
46             int t = sa[i] - 1;
47             if (t >= 0 && type[t] == S_TYPE) sa[--s_bucket[s[t]]] = t;
48         }
49     }
50     void sais(int n, int m, int *s, int *sa) {
51         alloc(type, bool, n + 1);
52         alloc(bucket, int, m + 1);
53         type[n] = false;
54         for (int i = n - 1; i >= 0; --i) {
55             ++bucket[s[i]];
56             type[i] = s[i] > s[i + 1] || (s[i] == s[i + 1] && type[i + 1] == L_TYPE);
57         }
58         for (int i = 1; i <= m; ++i) {
59             bucket[i] += bucket[i - 1];
60             s_bucket[i] = bucket[i];
61         }
62         memset(rank, -1, n * sizeof(int));
63
64         alloc(lms, int, n + 1);
65         int n1 = 0;
66         for (int i = 0; i < n; ++i) {
67             if (!type[i] && (i == 0 || type[i - 1])) lms[rank[i] = n1++] = i;
68         }
69         lms[n1] = n;
70         memset(sa, -1, n * sizeof(int));
71         for (int i = 0; i < n1; ++i) sa[--s_bucket[s[lms[i]]]] = lms[i];
72         induce(n, m, s, type, sa, bucket, l_bucket, s_bucket);
73         int m1 = 0;
74         alloc(s1, int, n + 1);
75         for (int i = 0, t = -1; i < n; ++i) {
76             int r = rank[sa[i]];
77             if (r != -1) {
78                 int len = lms[r + 1] - sa[i] + 1;
79                 m1 += t == -1 || len != lms[rank[t] + 1] - t + 1 ||
80                     memcmp(s + t, s + sa[i], len * sizeof(int)) != 0;
81                 s1[r] = m1;
82                 t = sa[i];
83             }
84         }
85         alloc(sa1, int, n + 1);
86         if (n1 == m1) {
87             for (int i = 0; i < n1; ++i) sa1[s1[i] - 1] = i;
88         } else {
89             sais(n1, m1, s1, sa1);
90         }

```



```

91     memset(sa, -1, n * sizeof(int));
92     memcpy(s_bucket + 1, bucket + 1, m * sizeof(int));
93     for (int i = n1 - 1; i >= 0; --i) {
94         int t = lms[sa1[i]];
95         sa[--s_bucket[s[t]]] = t;
96     }
97     induce(n, m, s, type, sa, bucket, l_bucket, s_bucket);
98 }
99 #undef S_TYPE
100 #undef L_TYPE
101 };
102
103 const int MAXN = 1e5 + 5;
104 SuffixArray<MAXN> sa;
105 char str[MAXN];
106 int s[MAXN];
107
108 int main() {
109     int n = fread(str, 1, MAXN, stdin);
110     while (str[n - 1] - 97u > 25) --n;
111     for (int i = 0; i < n; ++i) s[i] = str[i] - 'a' + 1;
112     sa.compute(n, 26, s);
113     for (int i = 0; i < n; ++i) printf("%d%c", sa.sa[i] + 1, " \n"[i == n - 1]);
114     for (int i = 1; i < n; ++i) printf("%d%c", sa.height[i], " \n"[i == n - 1]);
115     return 0;
116 }

```

## 4.7 后缀数组（倍增）

```

1  // UOJ 模板题
2  #include <bits/stdc++.h>
3  using namespace std;
4
5  const int MAXN = 1e5 + 3;
6
7  template <int MAX_LENGTH> class SuffixArray {
8  public:
9      int n, sa[MAX_LENGTH], rank[MAX_LENGTH], height[MAX_LENGTH];
10
11      void compute(char *s, int n, int m) {
12          int i, p, w, j, k;
13          this->n = n;
14          if (n == 1) {
15              sa[0] = rank[0] = height[0] = 0;
16              return;
17          }
18          memset(cnt, 0, m * sizeof(int));
19          for (i = 0; i < n; ++i) ++cnt[rank[i] = s[i]];
20          for (i = 1; i < m; ++i) cnt[i] += cnt[i - 1];
21          for (i = n - 1; ~i; --i) sa[--cnt[rank[i]]] = i;
22          for (w = 1; w < n; w <= 1, m = p) {
23              for (p = 0, i = n - 1; i >= n - w; --i) id[p++] = i;
24              for (i = 0; i < n; ++i)
25                  if (sa[i] >= w) id[p++] = sa[i] - w;
26              memset(cnt, 0, m * sizeof(int));
27              for (i = 0; i < n; ++i) ++cnt[px[i] = rank[id[i]]];
28              for (i = 1; i < m; ++i) cnt[i] += cnt[i - 1];
29              for (i = n - 1; ~i; --i) sa[--cnt[px[i]]] = id[i];

```

```

30     memcpy(old_rank, rank, n * sizeof(int));
31     for (i = p = 1, rank[sa[0]] = 0; i < n; ++i)
32         rank[sa[i]] = cmp(sa[i], sa[i - 1], w) ? p - 1 : p++;
33 }
34 for (i = 0; i < n; ++i) rank[sa[i]] = i;
35 for (i = k = height[rank[0]] = 0; i < n; height[rank[i++]] = k)
36     if (rank[i])
37         for (k > 0 ? --k : 0, j = sa[rank[i] - 1]; s[i + k] == s[j + k]; ++k) {}
38 }
39
40 void init_st_table(int n) {
41     int lgn = lg[n];
42     for (int i = 0; i < n; ++i) table[0][i] = height[i];
43     for (int i = 1; i <= lgn; ++i)
44         for (int j = 0, l = 1 << (i - 1); j + l < n; ++j)
45             table[i][j] = min(table[i - 1][j], table[i - 1][j + l]);
46 }
47
48 int lcp(int i, int j) {
49     if (i > j) swap(i, j);
50     ++i;
51     int lgl = lg[j - i + 1];
52     return min(table[lgl][i], table[lgl][j - (1 << lgl) + 1]);
53 }
54
55 private:
56     int table[17][MAX_LENGTH], lg[MAX_LENGTH];
57     int old_rank[MAX_LENGTH], id[MAX_LENGTH], px[MAX_LENGTH], cnt[MAX_LENGTH];
58
59     bool cmp(int x, int y, int w) {
60         return old_rank[x] == old_rank[y] && old_rank[x + w] == old_rank[y + w];
61     }
62 };
63
64 char s[MAXN];
65 SuffixArray<MAXN> sa;
66
67 int main(int argc, char *argv[]) {
68     int n = fread(s, 1, MAXN, stdin);
69     while (s[n - 1] - 97u > 25) --n;
70     for (int i = 0; i < n; ++i) s[i] -= 'a';
71     s[n] = '$';
72     sa.compute(s, n, 26);
73     for (int i = 0; i < n; ++i) printf("%d%c", sa.sa[i] + 1, " \n"[i == n - 1]);
74     for (int i = 1; i < n; ++i) printf("%d%c", sa.height[i], " \n"[i == n - 1]);
75     return 0;
76 }

```

## 4.8 回文树

```

1 //最长双回文串
2 struct PT {
3     char s[MAXL];
4     int fail[MAXL], ch[26][MAXL], l[MAXL], dep[MAXL], lst, nc, n;
5     void init() {
6         l[0] = 0;
7         l[1] = -1;
8         fail[0] = fail[1] = 1;

```

```

9     for (int i = 0; i < 26; ++i) {
10         for (int j = 0; j < nc; ++j) { ch[i][j] = 0; }
11     }
12     for (int i = 2; i < nc; ++i) {
13         l[i] = 0;
14         fail[i] = 0;
15     }
16
17     lst = 0;
18     nc = 2;
19     n = 0;
20     s[0] = '#';
21 }
22
23 int insert(char c) {
24     int id = c - 'a';
25     s[++n] = c;
26     while (s[n - 1[lst] - 1] != s[n]) { lst = fail[lst]; }
27     if (ch[id][lst] == 0) {
28         l[nc] = l[lst] + 2;
29         int f = fail[lst];
30         while (s[n - 1[f] - 1] != s[n]) { f = fail[f]; }
31         fail[nc] = ch[id][f];
32         dep[nc] = dep[fail[nc]] + 1;
33         ch[id][lst] = nc;
34         ++nc;
35     }
36     lst = ch[id][lst];
37     return lst;
38 }
39 } pt;
40
41 char S[MAXL];
42 int len[MAXL];
43 int main() {
44     ios::sync_with_stdio(false);
45     cin.tie(0);
46     cout.tie(0);
47
48     cin >> S;
49     int n = strlen(S);
50     pt.init();
51     for (int i = 0; i < n; ++i) { len[i] = pt.l[pt.insert(S[i])]; }
52     pt.init();
53     int ans = 0;
54     for (int i = n - 1; i; --i) {
55         ans = max(ans, len[i - 1] + pt.l[pt.insert(S[i])]);
56     }
57     cout << ans << "\n";
58
59     return 0;
60 }

```

## 4.9 扩展 KMP

```

1 // next[i]:x[i...m-1] 与 x[0...m-1] 的最长公共前缀
2 // extend[i]:y[i...n-1] 与 x[0...m-1] 的最长公共前缀
3 void prework(char x[], int m, int next[]) {

```

```

4  next[0] = m;
5  int j = 0;
6  while (j + 1 < m && x[j] == x[j + 1]) ++j;
7  next[1] = j;
8  int k = 1;
9  for (int i = 2; i < m; ++i) {
10     int p = next[k] + k - 1;
11     int L = next[i - k];
12     if (i + L < p + 1)
13         next[i] = L;
14     else {
15         j = max(0, p - i + 1);
16         while (i + j < m && x[i + j] == x[j]) j++;
17         next[i] = j;
18         k = i;
19     }
20 }
21 }
22 void exkmp(char x[], int m, char y[], int n, int next[], int extend[]) {
23     prework(x, m, next);
24     int j = 0;
25     while (j < n && j < m && x[j] == y[j]) ++j;
26     extend[0] = j;
27     int k = 0;
28     for (int i = 1; i < n; ++i) {
29         int p = extend[k] + k - 1;
30         int L = next[i - k];
31         if (i + L < p + 1)
32             extend[i] = L;
33         else {
34             j = max(0, p - i + 1);
35             while (i + j < n && j < m && y[i + j] == x[j]) j++;
36             extend[i] = j;
37             k = i;
38         }
39     }
40 }

```

## 5 Graph Theory

### 5.1 SAP

```

1  struct MF {
2      struct Edge {
3          int to, cap, flow;
4      } edges[MAXM * 4];
5
6      vector<int> adj[MAXN];
7      int n, edges_c, dep[MAXN], depc[MAXN], s, t, last[MAXN];
8
9      void init(int _n) {
10         n = _n;
11         for (int i = 1; i <= n; ++i) adj[i].clear();
12         edges_c = 0;
13     }
14
15     void add_edge(int v, int u, int cap) {

```

```

16     edges[edges_c] = {v, cap, 0};
17     adj[u].push_back(edges_c++);
18     edges[edges_c] = {u, 0, 0};
19     adj[v].push_back(edges_c++);
20 }
21
22 int dfs(int u, int flow) {
23     if (u == t || !flow) return flow;
24     int v, e, temp, res = 0;
25     for (int &i = last[u]; i < (int)adj[u].size(); ++i) {
26         e = adj[u][i];
27         v = edges[e].to;
28         if (edges[e].cap == edges[e].flow) continue;
29         if (dep[v] != dep[u] - 1) continue;
30         temp = dfs(v, min(flow, edges[e].cap - edges[e].flow));
31         edges[e].flow += temp, edges[e ^ 1].flow -= temp;
32         res += temp, flow -= temp;
33         if (!flow) return res;
34         if (!dep[s]) return res;
35     }
36     last[u] = 0;
37     if (!(--depc[dep[u]])) dep[s] = n + 1;
38     ++depc[++dep[u]];
39     return res;
40 }
41 int max_flow(int s, int t) {
42     this->s = s, this->t = t;
43
44     static queue<int> que;
45     memset(dep + 1, 0, sizeof(int) * n);
46     memset(depc + 1, 0, sizeof(int) * n);
47     memset(last + 1, 0, sizeof(int) * n);
48     while (!que.empty()) que.pop();
49     dep[t] = 1, que.push(t);
50
51     while (!que.empty()) {
52         int u = que.front();
53         que.pop();
54         ++depc[dep[u]];
55         for (int i = 0, v; i < (int)adj[u].size(); ++i) {
56             v = edges[adj[u][i]].to;
57             if (dep[v]) continue;
58             dep[v] = dep[u] + 1;
59             que.push(v);
60         }
61     }
62
63     int res = 0;
64     while (dep[s] <= n) res += dfs(s, INT_MAX);
65     return res;
66 }
67 };

```

## 5.2 tarjan

```

1 vector<int> adj[MAXN];
2 int dfn[MAXN], low[MAXN], dfs_c;
3 int bel[MAXN], size[MAXN], scc, stk[MAXN], top, in_stack[MAXN];

```

```

4
5 void tarjan(int u) {
6     dfn[u] = low[u] = ++dfs_c;
7     stk[top++] = u;
8     in_stack[u] = 1;
9     for (size_t i = 0; i < adj[u].size(); ++i) {
10         int v = adj[u][i];
11         if (!dfn[v]) {
12             tarjan(v);
13             (low[v] < low[u]) && (low[u] = low[v]);
14         } else if (in_stack[v] && dfn[v] < low[u]) {
15             low[u] = dfn[v];
16         }
17     }
18     if (low[u] == dfn[u]) {
19         int v;
20         size[++scc] = 0;
21         do {
22             v = stk[--top];
23             in_stack[v] = 0;
24             bel[v] = scc;
25             ++size[scc];
26         } while (u != v);
27     }
28 }

```

### 5.3 一般图最大匹配

```

1 class GeneralMatch {
2 public:
3     int n;
4     vector<vector<int>> g;
5     vector<int> match, aux, label, orig, parent;
6     queue<int> q;
7     int aux_time;
8
9     GeneralMatch(int n)
10         : match(n, -1), aux(n, -1), label(n), orig(n), parent(n, -1),
11           aux_time(-1) {
12         this->n = n;
13         g.resize(n);
14     }
15
16     void add_edge(int u, int v) {
17         g[u].push_back(v);
18         g[v].push_back(u);
19     }
20
21     int find(int x) { return x == orig[x] ? x : orig[x] = find(orig[x]); }
22
23     int lca(int u, int v) {
24         ++aux_time;
25         u = find(u), v = find(v);
26         for (;;) swap(u, v) {
27             if (~u) {
28                 if (aux[u] == aux_time) return u;
29                 aux[u] = aux_time;
30                 if (match[u] == -1) {

```

```

31         u = -1;
32     } else {
33         u = find(parent[match[u]]);
34     }
35 }
36 }
37 }
38
39 void blossom(int u, int v, int o) {
40     while (find(u) != o) {
41         parent[u] = v;
42         v = match[u];
43         q.push(v);
44         label[v] = 0;
45         orig[u] = orig[v] = o;
46         u = parent[v];
47     }
48 }
49
50 int bfs(int x) {
51     iota(orig.begin(), orig.end(), 0);
52     fill(label.begin(), label.end(), -1);
53     while (!q.empty()) q.pop();
54     q.push(x);
55     label[x] = 0;
56     while (!q.empty()) {
57         int u = q.front();
58         q.pop();
59         for (int v : g[u]) {
60             if (label[v] == -1) {
61                 parent[v] = u;
62                 label[v] = 1;
63                 if (match[v] == -1) {
64                     while (v != -1) {
65                         int pv = parent[v];
66                         int next_v = match[pv];
67                         match[v] = pv;
68                         match[pv] = v;
69                         v = next_v;
70                     }
71                     return 1;
72                 }
73                 q.push(match[v]);
74                 label[match[v]] = 0;
75             } else if (label[v] == 0 && find(u) != find(v)) {
76                 int o = lca(u, v);
77                 blossom(u, v, o);
78                 blossom(v, u, o);
79             }
80         }
81     }
82     return 0;
83 }
84
85 int find_max_match() {
86     int res = 0;
87     for (int i = 0; i < n; ++i) {
88         if (~match[i]) continue;
89         res += bfs(i);

```

```

90     }
91     return res;
92 }
93 };

```

## 5.4 上下界费用流

```

1  #include <bits/stdc++.h>
2  using namespace std;
3
4  const int MAXN = 53;
5  const int MAX_NODE = 113;
6  const int MAX_EDGE = 1e5 + 5;
7  const int INF = 0x3f3f3f3f;
8
9  int n, s, t, ss, tt, tote;
10 int R[MAXN], C[MAXN], board[MAXN][MAXN];
11
12 struct Edge {
13     int to, cap, flow, cost;
14 } edges[MAX_EDGE];
15 vector<int> adj[MAX_NODE];
16
17 int from[MAX_NODE], in[MAX_NODE];
18 void add_edge(int from, int to, int l, int r, int cost) {
19     in[to] += l, in[from] -= l;
20     edges[tote] = (Edge){to, r - l, 0, cost};
21     adj[from].push_back(tote++);
22     edges[tote] = (Edge){from, 0, 0, -cost};
23     adj[to].push_back(tote++);
24 }
25
26 bool spfa(int s, int t) {
27     static queue<int> q;
28     static bool inq[MAX_NODE];
29     static int dist[MAX_NODE];
30     memset(inq + 1, 0, sizeof(bool) * tt);
31     memset(dist + 1, 0x3f, sizeof(int) * tt);
32     memset(from + 1, -1, sizeof(int) * tt);
33     dist[0] = 0, from[0] = -1;
34     q.push(0);
35     while (!q.empty()) {
36         int u = q.front();
37         q.pop();
38         inq[u] = false;
39         for (int e : adj[u]) {
40             if (edges[e].cap == edges[e].flow) continue;
41             int v = edges[e].to, d = dist[u] + edges[e].cost;
42             if (d >= dist[v]) continue;
43             dist[v] = d;
44             from[v] = e;
45             if (!inq[v]) {
46                 q.push(v);
47                 inq[v] = true;
48             }
49         }
50     }
51     return dist[t] < INF;

```



```

52 }
53
54 pair<int, int> min_cost_max_flow(int s, int t) {
55     int flow = 0, cost = 0;
56     while (spfa(s, t)) {
57         int mi = INF;
58         for (int it = from[t]; ~it; it = from[edges[it ^ 1].to])
59             mi = min(mi, edges[it].cap - edges[it].flow);
60         flow += mi;
61         for (int it = from[t]; ~it; it = from[edges[it ^ 1].to]) {
62             edges[it].flow += mi, edges[it ^ 1].flow -= mi;
63             cost += mi * edges[it].cost;
64         }
65     }
66     return make_pair(flow, cost);
67 }
68
69 void solve() {
70     tote = 0;
71     s = 2 * n + 1, t = 2 * n + 2, ss = 0, tt = 2 * n + 3;
72     for (int i = 0; i <= tt; ++i) adj[i].clear(), in[i] = 0;
73
74     memset(R + 1, 0, sizeof(int) * n);
75     memset(C + 1, 0, sizeof(int) * n);
76
77     for (int i = 1; i <= n; ++i)
78         for (int j = 1; j <= n; ++j) {
79             cin >> board[i][j];
80             R[i] += board[i][j];
81             C[j] += board[i][j];
82         }
83
84     for (int i = 1; i <= n; ++i) {
85         add_edge(s, i, R[i], R[i], 0);
86         add_edge(s, i + n, C[i], C[i], 0);
87     }
88
89     for (int i = 1, l, r; i <= n; ++i) {
90         cin >> l >> r;
91         add_edge(i, t, l, r, 0);
92     }
93
94     for (int i = 1, l, r; i <= n; ++i) {
95         cin >> l >> r;
96         add_edge(i + n, t, l, r, 0);
97     }
98
99     for (int step = n * n / 2, x1, y1, x2, y2; step; --step) {
100         cin >> x1 >> y1 >> x2 >> y2;
101         if (board[x1][y1] == board[x2][y2]) continue;
102         if (board[x2][y2]) swap(x1, x2), swap(y1, y2);
103         if (x1 == x2)
104             add_edge(y1 + n, y2 + n, 0, 1, 1);
105         else
106             add_edge(x1, x2, 0, 1, 1);
107     }
108     add_edge(t, s, 0, INF, 0);
109     int sum = 0;
110     for (int i = 1; i < tt; ++i) {
111         if (in[i] > 0) {

```

```

111     sum += in[i];
112     add_edge(ss, i, 0, in[i], 0);
113 } else if (in[i] < 0) {
114     add_edge(i, tt, 0, -in[i], 0);
115 }
116 }
117
118 pair<int, int> ans = min_cost_max_flow(ss, tt);
119 if (sum != ans.first) {
120     cout << "-1\n";
121 } else {
122     cout << ans.second << '\n';
123 }
124 }
125
126 int main() {
127     ios::sync_with_stdio(false);
128     cin.tie(nullptr);
129
130     while (cin >> n) solve();
131     return 0;
132 }

```

## 5.5 最小费用流

```

1  class MinCostFlow {
2  public:
3      struct Result {
4          int flow, cost;
5      };
6      struct Edge {
7          int to, next, rest, cost;
8      };
9
10     vector<bool> inq;
11     vector<int> head, dist, from, flow;
12     vector<Edge> edges;
13
14     MinCostFlow(int n, int m) : inq(n), head(n, -1), dist(n), from(n), flow(n) {
15         edges.reserve(2 * m);
16     }
17
18     void add_edge(int u, int v, int capacity, int cost) {
19         internal_add_edge(u, v, capacity, cost);
20         internal_add_edge(v, u, 0, -cost);
21     }
22
23     void internal_add_edge(int u, int v, int capacity, int cost) {
24         edges.push_back((Edge){v, head[u], capacity, cost});
25         head[u] = edges.size() - 1;
26     }
27
28     Result augment(int source, int sink) {
29         fill(dist.begin(), dist.end(), INT_MAX);
30         dist[source] = 0;
31         flow[source] = INT_MAX;
32         queue<int> q;
33         q.push(source);

```

```

34     while (!q.empty()) {
35         int u = q.front();
36         q.pop();
37         inq[u] = false;
38         for (int it = head[u]; ~it; it = edges[it].next) {
39             auto &e = edges[it];
40             int v = e.to;
41             if (e.rest > 0 && dist[u] + e.cost < dist[v]) {
42                 from[v] = it;
43                 dist[v] = dist[u] + e.cost;
44                 flow[v] = min(e.rest, flow[u]);
45                 if (!inq[v]) {
46                     q.push(v);
47                     inq[v] = true;
48                 }
49             }
50         }
51     }
52
53     if (dist[sink] == INT_MAX) return {0, 0};
54     int min_flow = flow[sink];
55     for (int u = sink; u != source; u = edges[from[u] ^ 1].to) {
56         edges[from[u]].rest -= min_flow;
57         edges[from[u] ^ 1].rest += min_flow;
58     }
59     return {min_flow, dist[sink]};
60 }
61
62 Result min_cost_flow(int source, int sink) {
63     int flow = 0, cost = 0;
64     for (;;) {
65         auto result = augment(source, sink);
66         if (!result.flow) break;
67         flow += result.flow, cost += result.cost;
68     }
69     return {flow, cost};
70 }
71 };

```

## 6 Java

### 6.1 进制转换

```

1  import java.io.*;
2  import java.util.*;
3  import java.math.*;
4
5  /**
6   * Built using CHelper plug-in
7   * Actual solution is at the top
8   */
9  public class Main {
10     public static void main(String[] args) {
11         InputStream inputStream = System.in;
12         OutputStream outputStream = System.out;
13         Scanner in = new Scanner(inputStream);
14         PrintWriter out = new PrintWriter(outputStream);

```

```

15     Solver solver = new Solver();
16     int testCount = Integer.parseInt(in.next());
17     for (int i = 1; i <= testCount; i++)
18         solver.solve(i, in, out);
19     out.close();
20 }
21
22 static class Solver {
23     public void solve(int testNumber, Scanner in, PrintWriter out) {
24         int a = in.nextInt();
25         int b = in.nextInt();
26         String num = in.next();
27
28         BigInteger value = BigInteger.ZERO;
29         for (int i = 0; i < num.length(); ++i) {
30             value = value.multiply(BigInteger.valueOf(a));
31             value = BigInteger.valueOf(getValue(num.charAt(i))).add(value);
32         }
33         out.println(a + " " + num);
34
35         if (value.equals(BigInteger.ZERO)) {
36             out.println(b + " 0");
37             out.println();
38             return;
39         }
40
41         out.print(b + " ");
42
43         char[] ans = new char[1000];
44         int length = 0;
45         while (!value.equals(BigInteger.ZERO)) {
46             int digit = value.mod(BigInteger.valueOf(b)).intValue();
47             value = value.divide(BigInteger.valueOf(b));
48             ans[length] = getChar(digit);
49             ++length;
50         }
51
52         for (int i = length - 1; i >= 0; --i) {
53             out.print(ans[i]);
54         }
55         out.println("\n");
56     }
57
58     private int getValue(char ch) {
59         if (ch >= 'A' && ch <= 'Z') {
60             return ch - 'A' + 10;
61         }
62         if (ch >= 'a' && ch <= 'z') {
63             return ch - 'a' + 36;
64         }
65         return ch - '0';
66     }
67
68     private char getChar(int x) {
69         if (x < 10) {
70             return (char) ('0' + x);
71         } else if (x < 36) {
72             return (char) ('A' + x - 10);
73         } else {

```

```

74         return (char) ('a' + x - 36);
75     }
76 }
77
78 }
79 }

```

## 7 Others

### 7.1 FastIO

```

1  namespace FastIO {
2  struct Control {
3      int ct, val;
4      Control(int Ct, int Val = -1) : ct(Ct), val(Val) {}
5      inline Control operator()(int Val) { return Control(ct, Val); }
6  } _endl(0), _prs(1), _setprecision(2);
7
8  const int IO_SIZE = 1 << 16 | 127;
9
10 struct FastIO {
11     char in[IO_SIZE], *p, *pp, out[IO_SIZE], *q, *qq, ch[20], *t, b, K, prs;
12     FastIO() : p(in), pp(in), q(out), qq(out + IO_SIZE), t(ch), b(1), K(6) {}
13     ~FastIO() { fwrite(out, 1, q - out, stdout); }
14     inline char getc() {
15         return p == pp && (pp = (p = in) + fread(in, 1, IO_SIZE, stdin), p == pp)
16             ? (b = 0, EOF)
17             : *p++;
18     }
19     inline void putc(char x) {
20         q == qq && (fwrite(out, 1, q - out, stdout), q = out), *q++ = x;
21     }
22     inline void puts(const char str[]) {
23         fwrite(out, 1, q - out, stdout), fwrite(str, 1, strlen(str), stdout),
24             q = out;
25     }
26     inline void getline(string &s) {
27         s = "";
28         for (char ch; (ch = getc()) != '\n' && b;) s += ch;
29     }
30 #define indef(T) \
31     inline FastIO &operator>>(T &x) { \
32         x = 0; \
33         char f = 0, ch; \
34         while (!isdigit(ch = getc()) && b) f |= ch == '-'; \
35         while (isdigit(ch)) x = (x << 1) + (x << 3) + (ch ^ 48), ch = getc(); \
36         return x = f ? -x : x, *this; \
37     }
38 indef(int);
39 indef(long long);
40
41 inline FastIO &operator>>(string &s) {
42     s = "";
43     char ch;
44     while (isspace(ch = getc()) && b) {}
45     while (!isspace(ch) && b) s += ch, ch = getc();
46     return *this;

```

```

47 }
48 inline FastIO &operator>>(double &x) {
49     x = 0;
50     char f = 0, ch;
51     double d = 0.1;
52     while (!isdigit(ch = getc()) && b) f |= (ch == '-');
53     while (isdigit(ch)) x = x * 10 + (ch ^ 48), ch = getc();
54     if (ch == '.')
55         while (isdigit(ch = getc())) x += d * (ch ^ 48), d *= 0.1;
56     return x = f ? -x : x, *this;
57 }
58 #define outdef(_T) \
59 inline FastIO &operator<<(_T x) { \
60     !x && (putc('0'), 0), x < 0 && (putc('-'), x = -x); \
61     while (x) *t++ = x % 10 + 48, x /= 10; \
62     while (t != ch) *q++ = *--t; \
63     return *this; \
64 }
65 outdef(int);
66 outdef(long long);
67 inline FastIO &operator<<(char ch) { return putc(ch), *this; }
68 inline FastIO &operator<<(const char str[]) { return puts(str), *this; }
69 inline FastIO &operator<<(const string &s) { return puts(s.c_str()), *this; }
70 inline FastIO &operator<<(double x) {
71     int k = 0;
72     this->operator<<(int(x));
73     putc('.');
74     x -= int(x);
75     prs && (x += 5 * pow(10, -K - 1));
76     while (k < K) putc(int(x *= 10) ^ 48), x -= int(x), ++k;
77     return *this;
78 }
79 inline FastIO &operator<<(const Control &cl) {
80     switch (cl.ct) {
81     case 0: putc('\n'); break;
82     case 1: prs = cl.val; break;
83     case 2: K = cl.val; break;
84     }
85     return *this;
86 }
87 inline operator bool() { return b; }
88 };
89 } // namespace FastIO

```

## 7.2 duipai

```

1 #/usr/bin/bash
2
3 while true; do
4     python gen.py > in.txt
5     time ./my < in.txt > out.txt
6     time ./std < in.txt > ans.txt
7     if diff out.txt ans.txt; then
8         echo AC
9     else
10        echo WA
11        exit 0
12    fi

```

13 done

### 7.3 emacs

```
1 (defun comp ()
2   (interactive)
3   (save-some-buffers t)
4   (setq filename (file-name-nondirectory buffer-file-name))
5   (setq progname (file-name-sans-extension filename))
6   (setq suffix (file-name-extension filename))
7   (compile (concat "g++ " filename " -o " progname " -std=gnu++14 -O2 -Wall -Werror")))
8 (add-hook 'c++-mode
9   '(lambda ()
10     (c-set-style "K&R")
11     (setq tab-width 2)
12     (setq indent-tabs-mode nil)
13     (setq c-basic-offset 2)))
14 (global-set-key [f5] 'comp)
15
16 (ido-mode t)
17 (delete-selection-mode t)
18 (global-auto-revert-mode t)
```

### 7.4 myalloc

```
1 // useage: vector<int, myalloc<int>> L;
2 static char space[10000000], *sp = space;
3 template <typename T> struct myalloc : allocator<T> {
4   myalloc() {}
5   template <typename T2> myalloc(const myalloc<T2> &a) {}
6   template <typename T2> myalloc<T> &operator=(const myalloc<T2> &a) {
7     return *this;
8   }
9   template <typename T2> struct rebind { typedef myalloc<T2> other; };
10  inline T *allocate(size_t n) {
11    T *result = (T *)sp;
12    sp += n * sizeof(T);
13    return result;
14  }
15  inline void deallocate(T *p, size_t n) {}
16 };
```

### 7.5 vimrc

```
1 syntax enable
2 set syntax=on
3 set nobackup
4 set noswapfile
5 set noundofile
6 set nu
7 set smartindent
8 set cindent
9 set noeb
10 set tabstop=2
11 set softtabstop=2
12 set shiftwidth=2
```

```
13 set expandtab
14
15 :imap jk <Esc>
16
17 map <F5> : call Complie() <CR>
18 func Complie()
19     exec "w"
20     exec "!g++ % -o %< -g -Wall -std=gnu++14 -static"
21 endfunc
22
23 map <F6> : call Run() <CR>
24 func Run()
25     exec "!./%<"
26 endfunc
27
28 map <F9> : call DeBug() <CR>
29 func DeBug()
30     exec "!gdb %<"
31 endfunc
```