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1 Basic

1.1 vimrc

```
set nu ai si cin ts=4 sw=4 sts=4 mouse=a expandtab
syn on
imap {<CR> {<CR><Esc>ko
map <F5> :w<LF>:!g++ -O2 -std=c++11 % && echo "----
Start-----" && ./a.out<LF>
map <F6> :w<LF>:!g++ -O2 -std=c++11 % && echo "----
Start-----" && time ./a.out < input.in<LF>
map <F9> :tabe %.in<LF>
```

1.2 int128

```
#define O ostream
O& operator << (O &out, __int128_t v) {
    O::sentry s(out);
    if (s) { __uint128_t uv = v < 0 ? -v : v;
        char buf[128], *d = end(buf);
        do { *(&d) = uv % 10 + '0'; uv /= 10;
        } while (uv != 0);
        if (uv < 0) *(&d) = '-'; int len = end(buf) - d;
        if (out.rdbuf()->sputn(d, len) != len)
            out.setstate(ios_base::badbit);
    }
    return out;
}

#define I istream
I& operator >> (I &in, __int128_t &v) {
    string s; in >> s; v = 0;
    for (int i = 0; i < (int)s.size(); i++)
        if ('0' <= s[i] && s[i] <= '9')
            v = 10 * v + s[i] - '0';
    return in;
}
```

2 Flow

2.1 Dinic

```
struct Graph { int n; struct Edge;
    struct Node : vector<Edge*> { int d;
    }_memN[MAXN], *node[MAXN], *s, *t;
    struct Edge { Node *v; Edge *r; LL c; Edge() {}
        Edge(Node *v, Edge *r, LL c) : v(v), r(r), c(c) {}
    }_memE[MAXM], *ptrE;
    inline void addEdge(int u, int v, LL c) {
        Edge *pos = ptrE;
        node[u]->emplace_back(new (ptrE++) Edge(node[v],
            pos + 1, c));
        node[v]->emplace_back(new (ptrE++) Edge(node[u],
            pos, c));
    }
    Graph(int n) : n(n) { ptrE = _memE;
        for (int i = 0; i < n; i++)
            node[i] = _memN + i;
    }
    inline LL maxFlow(int _s, int _t) {
        s = node[_s]; t = node[_t]; LL flow = 0;
        while (bfs()) flow += dfs(s, INF);
        return flow;
    }
    inline bool bfs() {
        for (int i = 0; i < n; i++)
            node[i]->d = -1;
        queue<Node*> q; q.push(s); s->d = 0;
        while (q.size()) {
            auto u = q.front(); q.pop();
            for (auto &e : *u) {
                if (!e->c || ~e->v->d) continue;
```

```

        e->v->d = u->d + 1; q.push(e->v);
    }
}
return ~t->d;
}
LL dfs(Node *u, LL a) {
    if (u == t || !a) return a; LL flow = 0;
    for (auto &e : *u) {
        if (u->d + 1 != e->v->d) continue;
        LL f = dfs(e->v, min(e->c, a));
        e->c -= f; e->r->c += f;
        flow += f; a -= f;
    }
    return flow;
}
};

```

2.2 MCMF

```

struct Graph {
    struct Node; struct Edge; int V;
    struct Node : vector<Edge*> {
        bool inq; Edge *pa; LL a, d;
        Node() { clear(); }
    }_memN[MAXN], *node[MAXN];
    struct Edge{
        Node *u, *v; Edge *rev;
        LL c, f, _c; Edge() {}
        Edge(Node *u, Node *v, LL c, LL _c, Edge *rev)
            : u(u), v(v), c(c), f(0), _c(_c), rev(rev) {}
    }_memE[MAXM], *ptrE;
    Graph(int V) : V(V) {
        for (int i = 0; i < V; i++)
            node[i] = _memN + i;
        ptrE = _memE;
    }
    void addEdge(int u, int v, LL c, LL _c) {
        *ptrE = Edge(node[u], node[v], c, _c, ptrE + 1);
        node[u]->push_back(ptrE++);
        *ptrE = Edge(node[v], node[u], 0, -_c, ptrE - 1);
        node[v]->push_back(ptrE++);
    }
    Node *s, *t;
    bool SPFA() {
        for (int i = 0; i < V; i++)
            node[i]->d = INF, node[i]->inq = false;
        queue<Node*> q; q.push(s); s->inq = true;
        s->d = 0, s->pa = NULL, s->a = INF;
        while (q.size()) {
            Node *u = q.front(); q.pop(); u->inq = false;
            for (auto &e : *u) {
                Node *v = e->v;
                if (e->c > e->f && v->d > u->d + e->_c) {
                    v->d = u->d + e->_c;
                    v->pa = e; v->a = min(u->a, e->c - e->f);
                    if (!v->inq) q.push(v), v->inq = true;
                }
            }
        }
        return t->d != INF;
    }
    pLL maxFlowMinCost(int _s, int _t) {
        s = node[_s], t = node[_t];
        pLL res = {0, 0};
        while (SPFA()) {
            res.F += t->a;
            res.S += t->d * t->a;
            for (Node *u = t; u != s; u = u->pa->u) {
                u->pa->f += t->a;
                u->pa->rev->f -= t->a;
            }
        }
        return res;
    }
};

```

3 DataStructure

3.1 unorderedMap

```

struct Key { int F, S; Key() {}
    Key(int _x, int _y) : F(_x), S(_y) {}
    bool operator == (const Key &b) const {
        return tie(F, S) == tie(b.F, b.S);
    }
};
struct KeyHasher {
    size_t operator() (const Key &b) const {
        return k.F + k.S * 100000;
    }
};
typedef unordered_map<Key, int, KeyHasher> map_t;

```

3.2 pbdsTree

```

#include <bits/extc++.h>
using namespace __gnu_pbds;
using namespace std;
typedef tree<int, null_type, less<int>, rb_tree_tag,
    tree_order_statistics_node_update> set_t;
typedef cc_hash_table<int, int> umap_t;
int main() {
    set_t s; s.insert(12); s.insert(505);
    assert(*s.find_by_order(0) == 12);
    assert(s.find_by_order(2) == end(s));
    assert(s.order_of_key(12) == 0);
    assert(s.order_of_key(505) == 1);
    s.erase(12);
    assert(*s.find_by_order(0) == 505);
    assert(s.order_of_key(505) == 0);
}

```

3.3 pbdsHeap

```

#include <bits/extc++.h>
typedef __gnu_pbds::priority_queue<int> heap_t;
int main() { heap_t a, b;
    a.clear(); a.push(1); a.push(3);
    b.clear(); b.push(2); b.push(4);
    assert(a.top() == 3); assert(b.top() == 4);
    a.join(b);
    assert(a.top() == 4); assert(b.empty());
}

```

3.4 Sptr

```

template <typename T> struct Sptr{
    pair<T, int> *p;
    T *operator->(){return &p->F;}
    T &operator*(){return p->F;}
    operator pair<T, int>*(){return p;}
    Sptr &operator = (const Sptr& t){
        if (p && !--p->S) delete p;
        (p = t.p) && ++p->S;
        return *this;
    }
    Sptr(pair<T, int> *t = 0) : p(t){ p && ++p->S;}
    Sptr(const Sptr &t) : p(t.p) { p && ++p->S; }
    ~Sptr(){ if (p && !--p->S) delete p; }
};

```



```

    if (!u) u = rt.back();
    if (u->R <= mL || mR <= u->L) return u;
//<<<<<<<<<<PRESISTENT
    PTR ret = _new(*u);
    if (mL <= u->L && u->R <= mR) {
        // tag;
        return ret;
    }
    push(u);
    ret->l = modify(mL, mR, v, u->l);
    ret->r = modify(mL, mR, v, u->r);
    return pull(ret);
//=====
    if (mL <= u->L && u->R <= mR) {
        // modify function
        return u;
    }
    push(u);
    modify(mL, mR, v, u->l); modify(mL, mR, v, u->r);
    return pull(u);
//>>>>>>>>>ORIGIN
}
};

```

3.7 SparseTable

```

struct SparseTable{
    vector<vector<int>> > data;
    int (*op)(int a, int b);
    SparseTable(vector<int> &arr, int (*_op)(int a, int b
        )) {
        op = _op;
        int n = (int)arr.size(), lgN = __lg(n) + 1;
        data.resize(lgN);
        for (int i = 0 ; i < n ; i++)
            data[0].push_back(arr[i]);
        for (int h = 1 ; h < lgN ; h++){
            int len = 1 << (h - 1), i = 0;
            for (; i + len < n ; i++)
                data[h].push_back(op(data[h-1][i], data[h-1][i+
                    len]));
            if (!i) break;
            for (; i < n ; i++)
                data[h].push_back(data[h-1][i]);
        }
        int query(int l, int r){
            int h = __lg(r - l), len = 1 << h;
            return op(data[h][l], data[h][r-len]);
        }
    }
};

```

3.8 BIT

```

struct BIT {
    vector<int> data; int n;
    BIT(int n) : n(n) {
        data.clear(); data.resize(n + 1, 0);
    }
    int lowbit(int x) { return x & -x; }
    int query(int x) { x++;
        int ret = 0;
        while (x > 0) ret += data[x], x -= lowbit(x);
        return ret;
    }
    void modify(int x, int d) { x++;
        while (x <= n) data[x] += d, x += lowbit(x);
    }
};

```

4 Graph

4.1 MMC

```

double MMC(vector<vector<Edge>> &G) {
    int n = G.size(); G.resize(n + 1);
    for (int i = 0 ; i < n ; i++)
        G[n].push_back({i, 0});
    n++;
    vector<vector<LL>> > d(n, vector<LL>(n + 1, INF));
    d[n - 1][0] = 0;
    for (int k = 1 ; k <= n ; k++)
        for (int i = 0 ; i < n ; i++)
            for (auto &e : G[i])
                d[e.v][k] = min(d[e.v][k], d[i][k - 1] + e.w);
    double minW = INF;
    for (int i = 0 ; i < n ; i++) {
        double maxW = -INF;
        for (int k = 0 ; k < n ; k++)
            maxW = max(maxW, (d[i][n] - d[i][k]) / double(n -
                k));
        minW = min(minW, maxW);
    }
    return minW;
}

```

4.2 CutBridge

```

struct Graph { int V, stamp;
    struct Node : vector<Node*> {
        int low, dfn; bool is_cut; Node *pa;
        Node() { low = dfn = -1;
            is_cut = false; pa = NULL;
        }
    } _memN[MAXN], *node[MAXN];
    Graph(int V) : V(V) { stamp = 0;
        for (int i = 0 ; i < V ; i++)
            node[i] = _memN + i;
    }
    void addEdge(int u, int v) {
        node[u]->push_back(node[v]);
        node[v]->push_back(node[u]);
    }
    void Tarjan(Node *u, Node *pa) {
        u->pa = pa; u->dfn = u->low = ++stamp;
        for (auto &v : *u) if (!v->dfn)
            Tarjan(v, u), u->low = min(u->low, v->low);
        else if (pa != v)
            u->low = min(u->low, v->dfn);
    }
    void CutBridge() { int rt_son = 0;
        Tarjan(node[0], NULL);
        for (int i = 1 ; i < V ; i++) {
            Node *pa = node[i]->pa;
            if (pa == node[0]) rt_son++;
            else if (node[i]->low >= pa->dfn)
                pa->is_cut = true;
        }
        if (rt_son > 1) node[0]->is_cut = true;
        for (int i = 0 ; i < V ; i++)
            if (node[i]->is_cut)
                /* node[i] is a cut */;
        for (int i = 0 ; i < V ; i++) {
            Node *pa = node[i]->pa;
            if (pa && node[i]->low > pa->dfn)
                /* pa and node[i] is a bridge */;
        }
    }
};

```

4.3 Dijkstra

```

typedef struct Edge { int v; LL w;
    bool operator > (const Edge &b) const {
        return w > b.w;
    }
} S;
vector<LL> Dijkstra(vector<vector<Edge> > &G, int s) {
    priority_queue<S, vector<S>, greater<S> > pq;
    vector<LL> d(G.size(), INF);
    d[s] = 0; pq.push({s, d[s]});
    while (pq.size()) {
        auto p = pq.top(); pq.pop();
        if (d[p.v] < p.w) continue;
        for (auto &e : G[p.v]) {
            if (d[e.v] > d[p.v] + e.w) {
                d[e.v] = d[p.v] + e.w;
                pq.push({e.v, d[e.v]});
            }
        }
    }
    return d;
}

```

4.4 Blossom

```

struct Graph { struct Edge; int V;
    struct Node : vector<Edge*> {
        Node *p, *s, *m; int S, v;
        Node() : S(-1), v(-1) { p = s = m = NULL; }
    } _memN[MAXN], *node[MAXN];
    struct Edge { Node *v;
        Edge(Node *v = NULL) : v(v) {}
    } _memE[MAXM], *ptrE;
    Graph(int V) : V(V) { ptrE = _memE;
        for (int i = 0; i < V; i++) node[i] = _memN + i;
    }
    void addEdge(int u, int v) {
        node[u]->push_back(new (ptrE++) Edge(node[v]));
        node[v]->push_back(new (ptrE++) Edge(node[u]));
    }
    inline int maxMatch() { int ans = 0;
        for (int i = 0; i < V; i++)
            if (!node[i]->m && bfs(node[i])) ans++;
        return ans;
    }
    inline bool bfs(Node *u) {
        for (int i = 0; i < V; i++)
            node[i]->s = node[i], node[i]->S = -1;
        queue<Node*> q; q.push(u), u->S = 0;
        while (q.size()) { u = q.front(); q.pop();
            for (auto &e : *u) { Node *v = e->v;
                if (!v->S) { v->p = u; v->S = 1;
                    if (!v->m) return augment(u, v);
                    q.push(v->m); v->m->S = 0;
                } else if (!v->S && v->s != u->s) {
                    Node *l = LCA(v->s, u->s);
                    flower(v, u, l, q); flower(u, v, l, q);
                }
            }
        }
        return false;
    }
    inline bool augment(Node *u, Node *v) {
        for (Node *l; u; v = l, u = v ? v->p : NULL)
            l = u->m, u->m = v, v->m = u;
        return true;
    }
    inline Node* LCA(Node *u, Node *v) {
        static int t = 0;
        for (++t; ; swap(u, v)) {
            if (!u) continue; if (u->v == t) return u;
            u->v = t; u = u->m; if (!u) continue;
            u = u->p; if (!u) continue; u = u->s;
        }
    }
    inline void flower(Node *u, Node *v, Node *l, queue<
        Node*> &q) {

```

```

        while (u->s != 1) { u->p = v; v = u->m;
            if (v->S == 1) q.push(v), v->S = 0;
            u->s = v->s = 1; u = v->p;
        }
    }
};

```

5 Geometry

5.1 Point

```

using T = double;
const T EPS = 1e-8;
#define O operator
#define CP (const P &p) const
typedef struct P { T x, y;
    P(T x = 0, T y = 0) : x(x), y(y) {}
    P O+CP { return P(x + p.x, y + p.y); }
    P O-CP { return P(x - p.x, y - p.y); }
    T O*CP { return x * p.x + y * p.y; }
    T O%CP { return x * p.y - y * p.x; }
    T O<CP { return (x < p.x) || ((x == p.x) && (y < p.y)); }
    P O*(const T c) const { return P(x * c, y * c); }
    P O/(const T c) const { return P(x / c, y / c); }
} V;
T leng2(V a) { return a * a; }
T leng(V a) { return sqrt(leng2(a)); }
T dist2(P a, P b) { return leng2(a - b); }
T dist(P a, P b) { return sqrt(dist2(a, b)); }

```

5.2 Line

```

struct L { P p1, p2; L() {}
    L(P p1, P p2) : p1(p1), p2(p2) {}
};
T dist(P p, L l) {
    V v1 = p - l.p1, v2 = l.p2 - l.p1;
    return abs(v1 % v2) / leng(v2);
}
T dist(L l1, L l2) {
    V v1 = l1.p2 - l1.p1; V v2 = l2.p2 - l2.p1;
    if (v1 % v2 != 0) return 0;
    return dist(l1.p1, l2);
}
T dir(P p, L l) {
    return (l.p2 - l.p1) % (p - l.p1);
}
bool parallel(L l1, L l2) {
    return abs((l1.p1 - l1.p2) % (l2.p1 - l2.p2)) <= EPS;
}
int intersect(L l1, L l2) {
    // -1: infinity, 1: one, 0: none
    return parallel(l1, l2) ?
        (abs(dir(l1.p2, l2)) <= EPS ? -1 : 0) : 1;
}
P ProjectPointLine(P p, L l) {
    // assume l.p1 != l.p2
    return l.p1 + (l.p2 - l.p1) * ((p - l.p1) % (l.p2 - l.p1)) / ((l.p2 - l.p1) % (l.p2 - l.p1));
}

```

5.3 Segment

```

struct S { P p1, p2; S() {}
    S(P p1, P p2) : p1(p1), p2(p2) {}
};
T dist(P p, S s) {

```

```

V v = s.p2 - s.p1, v1 = p - s.p1, v2 = p - s.p2;
if (v * v1 < -EPS) return leng(v1);
if (v * v2 > EPS) return leng(v2);
return abs(v1 % v2) / leng(v);
}
T btw(P p, S s) { return (s.p1 - p) * (s.p2 - p); }
T dir(P p, S s) { return dir(p, L{s.p1, s.p2}); }
bool intersect(P p, S s) {
    return abs(dir(p, s)) < EPS && btw(p, s) <= EPS;
}
bool intersection(S s1, S s2) {
    T c1 = dir(s2.p1, s1), c2 = dir(s2.p2, s1);
    T c3 = dir(s1.p1, s2), c4 = dir(s1.p2, s2);
    if (c1 * c2 < -EPS && c3 * c4 < -EPS) return true;
    if (abs(c1) < EPS && intersect(s2.p1, s1)) return true;
    if (abs(c2) < EPS && intersect(s2.p2, s1)) return true;
    if (abs(c3) < EPS && intersect(s1.p1, s2)) return true;
    if (abs(c4) < EPS && intersect(s1.p2, s2)) return true;
    return false;
}
T dist(S s1, S s2) {
    if (intersection(s1, s2)) return 0;
    return min({
        dist(s1.p1, s2), dist(s1.p2, s2),
        dist(s2.p1, s1), dist(s2.p2, s1)
    });
}
}

```

5.4 Circle

```

P CircleCenter(P a, P b, P c) {
    P ret;
    T A1 = b.x - a.x, A2 = c.x - a.x;
    T B1 = b.y - a.y, B2 = c.y - a.y;
    T C1 = (A1 * A1 + B1 * B1) / 2;
    T C2 = (A2 * A2 + B2 * B2) / 2;
    T D = A1 * B2 - A2 * B1;
    ret.x = a.x + (C1 * B2 - C2 * B1) / D;
    ret.y = a.y + (A1 * C2 - A2 * C1) / D;
    return ret;
}

pair<P, T> SmallestEnclosingCircle(vector<P> & points)
{
    T r = 0; int pn = points.size();
    if (pn == 0) {
        return pair<P, T>(P(0, 0), 0);
    }
    P ret = points[0];
    for (int i = 1; i < pn; i++) {
        if (dist(points[i], ret) > r + EPS) {
            ret = points[i]; r = 0;
            for (int j = 0; j < i; j++) {
                if (dist(points[j], ret) > r + EPS) {
                    ret.x = (points[i].x + points[j].x) / 2;
                    ret.y = (points[i].y + points[j].y) / 2;
                    r = dist(points[j], ret);
                    for (int k = 0; k < j; k++) {
                        if (dist(points[k], ret) > r + EPS) {
                            ret = CircleCenter(points[i], points[j],
                                points[k]);
                            r = dist(points[i], ret);
                        }
                    }
                }
            }
        }
    }
    return pair<P, T>(ret, r); // center, radius
}

vector<P> CircleLineIntersection(P c, T r, L l) {

```

```

vector<P> ret;
P b = l.p2 - l.p1;
P a = l.p1 - c;

P c1 = ProjectPointLine(c, l);
T dis = dist2(c, c1);
if (dis > r * r) return ret;
if (fabs(dis - r * r) < EPS) {
    ret.push_back(c1);
    return ret;
}
T x = (r * r - dis);
ret.push_back(c1 + b * sqrt(x / (b * b)));
ret.push_back(c1 - b * sqrt(x / (b * b)));
return ret;
}

```

5.5 Convex

```

T cross(const P &o, const P &a, const P &b) {
    return (a - o) % (b - o);
}

vector<P> convexHull(vector<P> &ps) {
    sort(ps.begin(), ps.end());
    vector<P> stk, ret;
    for (auto &p : ps) {
        while (stk.size() >= 2 && cross(stk[stk.size() - 2],
            stk.back(), p) <= 0)
            stk.pop_back();
        stk.push_back(p);
    }
    stk.pop_back();
    for (auto &p : stk) ret.push_back(p);
    reverse(ps.begin(), ps.end()); stk.clear();
    for (auto &p : ps) {
        while (stk.size() >= 2 && cross(stk[stk.size() - 2],
            stk.back(), p) <= 0)
            stk.pop_back();
        stk.push_back(p);
    }
    for (auto &p : stk) ret.push_back(p);
    return ret;
}

```

5.6 Polygon

```

bool PointInPolygon(const vector<P> & points, P p) {
    bool ret = 0;
    for (int i = 0; i < points.size(); i++) {
        int j = (i + 1) % points.size();
        T x = points[i].x + (points[j].x - points[i].x) * (
            p.y - points[i].y) / (points[j].y - points[i].y);
        if ((points[i].y <= p.y && p.y < points[j].y ||
            points[j].y <= p.y && p.y < points[i].y) && p.x < x)
            ret = !ret;
    }
    // strictly interior: ret = 1
    // strictly exterior: ret = 0
    // on boundary: ret = 0 or 1
    return ret;
}

bool PointOnPolygon(const vector<P> & points, P p) {
    for (int i = 0; i < points.size(); i++) {
        P a = points[i], b = points[(i + 1) % points.size()];
        if (dist2(ProjectPointLine(p, L{a, b}), p) < EPS)
            return true;
    }
    return false;
}

```

5.7 ClosetPair

```

pair<P, P> solve(vector<P> &ps, int L, int R) {
    pair<P, P> ret = {P{-INF, -INF}, P{INF, INF}};
    if (R - L <= 1) return ret;
    int M = (R + L) >> 1;
    pair<P, P> pL = solve(ps, L, M);
    pair<P, P> pR = solve(ps, M, R);
    T d = min(dist(pL.F, pL.S), dist(pR.F, pR.S));
    ret = (dist(pL.F, pL.S) + EPS < dist(pR.F, pR.S) ? pL
          : pR);
    vector<P> C;
    for (int i = L ; i < R ; i++)
        if (abs(ps[M].x - ps[i].x) < d)
            C.push_back({ps[i].y, ps[i].x});
    sort(C.begin(), C.end());
    for (int i = 0 ; i < (int)C.size() ; i++) {
        for (int j = i + 1 ; j < (int)C.size() && C[j].x -
              C[i].x < d ; j++)
            ret = (d + EPS < dist(C[i], C[j]) ? ret :
                  make_pair(C[i], C[j])),
            d = min(d, dist(C[i], C[j]));
    }
    return ret;
}

pair<P, P> closetPair(vector<P> &ps) {
    sort(ps.begin(), ps.end());
    return solve(ps, 0, ps.size());
}

```

6 String

6.1 ACAutomaton

```

const int SIGMA = 26;
const int MAXLEN = 1e5;
struct ACAutomaton{
    struct Node : vector<Node*> { Node *f;
        Node() : f(NULL) { clear(); resize(SIGMA); }
    }*r, *o;
    ACAutomaton() { o = new Node(), r = new Node(); }
    ~ACAutomaton() { remove(r); delete o; }
    void remove(Node *u) { if (!u) return ;
        for (auto &v : *u) remove(v); delete u;
    }
    int idx(char c) { return c - 'a'; }
    void buildTrie(string &s) { Node *u = r;
        for (auto &c : s) { int i = idx(c);
            if (!(*u)[i]) (*u)[i] = new Node(); u = (*u)[i];
        }
    }
    // LatexBegin
    u->dp++;
    for (int i = 0 ; i < s.size() ; i++)
        u = trans(u, idx(s[i]));
    }
    return ans;
}
};

```

6.2 KMP