ACM 模板

数据结构

并查集

```
struct dsu{
    int n;
    vector<int> fa;
    dsu(int _n) :n(_n){
        fa.resize(n + 1);
        iota(fa.begin(), fa.end(), 0);
    }
    int find(int x){
        return x == fa[x] ? x : fa[x] = find(fa[x]);
```

```
    }
    int merge(int x, int y){
        int fax = find(x), fay = find(y);
        if(fax == fay)return 0; // 一个集合
        return fa[find(x)] = find(y); // 合并到哪个集合了
    }
};
```

树状数组

```
#define lowbit(x) ((x)&(-(x)))
template<class T>
struct Fenwick_tree{
    Fenwick_tree(int size){
        n = size;
        tree.assign(n + 1, 0);
    }
    T query(int l, int r){
        auto query = [&](int pos){
            T res = 0;
            while(pos){ res += tree[pos]; pos -= lowbit(pos); }
            return res;
        };
        return query(r) - query(l - 1);
    }
    void update(int pos, T num){
        while(pos <= n){ tree[pos] += num; pos += lowbit(pos); }
    }
private:
    int n;
    vector<T> tree;
};
```

线段树

```
template <class Data, class Num>
struct Segment_Tree{
    inline void update(int l, int r, Num x){ update(1, l, r, x); }
    inline Data query(int l, int r){ return query(1, l, r); }
    Segment_Tree(vector<Data>& a){
        n = a.size();
        tree.assign(n * 4 + 1, {});
        build(a, 1, 1, n);
    }
private:
    int n;
    struct Tree{ int l, r; Data data; };
    vector<Tree> tree;
    inline void pushup(int pos){
```

```
        tree[pos].data = tree[pos << 1].data + tree[pos << 1 | 1].data;
    }
    inline void pushdown(int pos){
        tree[pos << 1].data = tree[pos << 1].data +
tree[pos].data.lazytag;
        tree[pos << 1 | 1].data = tree[pos << 1 | 1].data +
tree[pos].data.lazytag;
        tree[pos].data.lazytag = Num::zero();
    }
    void build(vector<Data>& a, int pos, int l, int r){
        tree[pos].l = l; tree[pos].r = r;
        if(l == r){ tree[pos].data = a[l - 1]; return; }
        int mid = (tree[pos].l + tree[pos].r) >> 1;
        build(a, pos << 1, l, mid);
        build(a, pos << 1 | 1, mid + 1, r);
        pushup(pos);
    }
    void update(int pos, int& l, int& r, Num& x){
        if(l > tree[pos].r || r < tree[pos].l)return;
        if(l <= tree[pos].l && tree[pos].r <= r){ tree[pos].data =
tree[pos].data + x; return; }
        pushdown(pos);
        update(pos << 1, l, r, x); update(pos << 1 | 1, l, r, x);
        pushup(pos);
    }
    Data query(int pos, int& l, int& r){
        if(l > tree[pos].r || r < tree[pos].l)return Data::zero();
        if(l <= tree[pos].l && tree[pos].r <= r)return tree[pos].data;
        pushdown(pos);
        return query(pos << 1, l, r) + query(pos << 1 | 1, l, r);
    }
};
struct Num{
    ll add;
    inline static Num zero(){ return { 0 }; }
    inline Num operator+(Num b){ return { add + b.add }; }
};
struct Data{
    ll sum, len;
    Num lazytag;
    inline static Data zero(){ return { 0,0,Num::zero() }; }
    inline Data operator+(Num b){ return { sum + len * b.add,len,lazytag +
b }; }
    inline Data operator+(Data b){ return { sum + b.sum,len +
b.len,Num::zero() }; }
};
```

图论

存图

```
struct Graph{
    int n;
    struct Edge{ int to, w; };
    vector<vector<Edge>> graph;
    Graph(int _n){ n = _n; graph.assign(n + 1, vector<Edge>()); };
    void add(int u, int v, int w){ graph[u].push_back({ v,w }); }
};
```

最短路

dijkstra

```
void dij(Graph& graph, vector<int>& dis, int t){
    vector<int> visit(graph.n + 1, 0);
    priority_queue<pair<int, int>> que;
    dis[t] = 0;
    que.emplace(0, t);
    while(!que.empty()){
        int u = que.top().second; que.pop();
        if(visit[u])continue;
        visit[u] = 1;
        for(auto& [to, w] : graph.graph[u]){
            if(dis[to] > dis[u] + w){
                dis[to] = dis[u] + w;
                que.emplace(-dis[to], to);
            }
        }
    }
}
```

树上问题

最近公公祖先

倍增法

```
vector<int> dep;
vector<array<int, 21>> fa;
dep.assign(n + 1, 0);
fa.assign(n + 1, array<int, 21>{});
void binary_jump(int root){
    function<void(int)> dfs = [&](int t){
        dep[t] = dep[fa[t][0]] + 1;
        for(auto& [to] : graph[t]){
            if(to == fa[t][0])continue;
            fa[to][0] = t;
            dfs(to);
```

```
        }
    };
    dfs(root);
    for(int j = 1; j <= 20; j++)
        for(int i = 1; i <= n; i++)
            fa[i][j] = fa[fa[i][j - 1]][j - 1];
}
int lca(int x, int y){
    if(dep[x] < dep[y])swap(x, y);
    for(int i = 20; i >= 0; i--){
        if(dep[fa[x][i]] >= dep[y])x = fa[x][i];
    }
    if(x == y)return x;
    for(int i = 20; i >= 0; i--){
        if(fa[x][i] != fa[y][i]){
            x = fa[x][i];
            y = fa[y][i];
        }
    }
    return fa[x][0];
}
```

树剖

```
int lca(int x, int y){
    while(top[x] != top[y]){
        if(dep[top[x]] < dep[top[y]])swap(x, y);
        x = fa[top[x]];
    }
    if(dep[x] < dep[y])swap(x, y);
    return y;
}
```

树链剖分

```
vector<int> fa, siz, dep, son, dfn, rnk, top;
fa.assign(n + 1, 0);
siz.assign(n + 1, 0);
dep.assign(n + 1, 0);
son.assign(n + 1, 0);
dfn.assign(n + 1, 0);
rnk.assign(n + 1, 0);
top.assign(n + 1, 0);
void hld(int root){
    function<void(int)> dfs1 = [&](int t){
        dep[t] = dep[fa[t]] + 1;
        siz[t] = 1;
        for(auto& [to, w] : graph[t]){
```

```
            if(to == fa[t])continue;
            fa[to] = t;
            dfs1(to);
            if(siz[son[t]] < siz[to])son[t] = to;
            siz[t] += siz[to];
        }
    }; dfs1(root);
    int dfn_tail = 0;
    for(int i = 1; i <= n; i++)top[i] = i;
    function<void(int)> dfs2 = [&](int t){
        dfn[t] = ++dfn_tail;
        rnk[dfn_tail] = t;
        if(!son[t])return;
        top[son[t]] = top[t];
        dfs2(son[t]);
        for(auto& [to, w] : graph[t]){
            if(to == fa[t] || to == son[t])continue;
            dfs2(to);
        }
    }; dfs2(root);
}
```

强连通分量

```
void tarjan(Graph& g1, Graph& g2){
    int dfn_tail = 0, cnt = 0;
    vector<int> dfn(g1.n + 1, 0), low(g1.n + 1, 0), exist(g1.n + 1, 0),
belong(g1.n + 1, 0);
    stack<int> sta;
    function<void(int)> dfs = [&](int t){
        dfn[t] = low[t] = ++dfn_tail;
        sta.push(t); exist[t] = 1;
        for(auto& [to] : g1.graph[t]){
            if(!dfn[to]){
                dfs(to);
                low[t] = min(low[t], low[to]);
            }
            else if(exist[to])low[t] = min(low[t], dfn[to]);
        }
        if(dfn[t] == low[t]){
            cnt++;
            while(int temp = sta.top()){
                belong[temp] = cnt;
                exist[temp] = 0;
                sta.pop();
                if(temp == t)break;
            }
        }
    };
    for(int i = 1; i <= g1.n; i++)if(!dfn[i])dfs(i);
    g2 = Graph(cnt);
```

```
    for(int i = 1; i <= g1.n; i++)g2.w[belong[i]] += g1.w[i];
    for(int i = 1; i <= g1.n; i++)
        for(auto& [to] : g1.graph[i])
            if(belong[i] != belong[to])g2.add(belong[i], belong[to]);
}
```

拓扑排序

```
void toposort(Graph& g, vector<int>& dis){
    vector<int> in(g.n + 1, 0);
    for(int i = 1; i <= g.n; i++)
        for(auto& [to] : g.graph[i])in[to]++;
    queue<int> que;
    for(int i = 1; i <= g.n; i++)
        if(!in[i]){
            que.push(i);
            dis[i] = g.w[i]; // dp
        }
    while(!que.empty()){
        int u = que.front(); que.pop();
        for(auto& [to] : g.graph[u]){
            in[to]--;
            dis[to] = max(dis[to], dis[u] + g.w[to]); // dp
            if(!in[to])que.push(to);
        }
    }
}
```

字符串

哈希

```
constexpr int N = 2e6;
constexpr ll mod[2] = { 2000000011, 2000000033 }, base[2] = { 20011,20033
};
vector<array<ll, 2>> pow_base(N);

pow_base[0][0] = pow_base[0][1] = 1;
for(int i = 1; i < N; i++){
    pow_base[i][0] = pow_base[i - 1][0] * base[0] % mod[0];
    pow_base[i][1] = pow_base[i - 1][1] * base[1] % mod[1];
}

struct Hash{
    int size;
    vector<array<ll, 2>> hash;
    Hash(){}
    Hash(const string& s){
        size = s.size();
```

```
        hash.resize(size);
        hash[0][0] = hash[0][1] = s[0];
        for(int i = 1; i < size; i++){
            hash[i][0] = (hash[i - 1][0] * base[0] + s[i]) % mod[0];
            hash[i][1] = (hash[i - 1][1] * base[1] + s[i]) % mod[1];
        }
    }
    array<ll, 2> operator[](const array<int, 2>& range)const{
        int l = range[0], r = range[1];
        if(l == 0)return hash[r];
        auto single_hash = [&](bool flag){
            return (hash[r][flag] - hash[l - 1][flag] * pow_base[r - l +
1][flag] % mod[flag] + mod[flag]) % mod[flag];
        };
        return { single_hash(0),single_hash(1) };
    }
};
```

manacher

```
void manacher(const string& _s, vector<int>& r){
    string s(_s.size() * 2 + 1, '$');
    for(int i = 0; i < _s.size(); i++)s[2 * i + 1] = _s[i];
    r.resize(_s.size() * 2 + 1);
    for(int i = 0, maxr = 0, mid = 0; i < s.size(); i++){
        if(i < maxr)r[i] = min(r[mid * 2 - i], maxr - i);
        while(i - r[i] - 1 >= 0 && i + r[i] + 1 <s.size() && s[i - r[i] -
1] == s[i + r[i] + 1]) ++r[i];
        if(i + r[i] > maxr) maxr = i + r[i], mid = i;
    }
}
```

数学

线性筛法

```
constexpr int N = 10000000;
vector<int> min_prime(N + 1, 0), primes;
for(int i = 2; i <= N; i++){
    if(min_prime[i] == 0){
        min_prime[i] = i;
        primes.push_back(i);
    }
    for(auto& prime : primes){
        if(prime > min_prime[i] || prime > N / i)break;
        min_prime[prime * i] = prime;
    }
}
```

分解质因数

```
void solve_num_primes(int num, vector<int>& ans){
    for(auto i = lower_bound(primes.begin(), primes.end(),
min_prime[num]); i != primes.end();i++){
        int prime = *i;
        if(prime > num / prime)break;
        if(num % prime == 0){
            while(num % prime == 0)num /= prime;
            ans.push_back(prime);
        }
    }
    if(num > 1)ans.push_back(num);
}
```

盒子与球

n个球, m个盒

球同	盒同	可空	公式
✓	✓	✓	$f_{n,m}=f_{n-1,m-1}+f_{n-m,m}$
✓	✓	×	$f_{n-m,m}$
×	✓	✓	$\Sigma_{i=1}^{m} g_{n,i}$
×	✓	×	$g_{n,m}=g_{n-1,m-1}+m*g_{n-1,m}$
✓	×	✓	C_{n+m-1}^{m-1}
✓	×	×	C_{n-1}^{m-1}
×	×	✓	m^n
×	×	×	$m!*g_{n,m}$

线性基

```
// 线性基
struct basis{
    array<unsigned ll, 64> p{};

    // 将x插入此线性基中
    void insert(unsigned ll x){
        for(int i = 63; i >= 0; i--){
            if((x >> i) & 1){
                if(p[i])x ^= p[i];
                else{
                    p[i] = x; break;
```

```
                }
            }
        }
    }

    // 将另一个线性基插入此线性基中
    void insert(basis other){
        for(int i = 0; i <= 63; i++){
            if(!other.p[i])continue;
            insert(other.p[i]);
        }
    }

    // 最大异或值
    unsigned ll max_basis(){
        unsigned ll res = 0;
        for(int i = 63; i >= 0; i--){
            if((res ^ p[i]) > res)res ^= p[i];
        }
        return res;
    }
};
```

计算几何

```
constexpr double PI = 3.141592653589793116;
constexpr double eps = 1e-8;
using T = double;

// 两浮点数是否相等
bool equal(const T& a, const T& b){
    return abs(a - b) < eps;
}

// 向量
struct vec{
    T x, y;
    vec() :x(0), y(0){}
    vec(const T& _x, const T& _y) :x(_x), y(_y){}

    // 模
    double length()const{
        return sqrt(x * x + y * y);
    }

    // 与x轴正方向的夹角
    double angle()const{
        double angle = atan2(y, x);
        if(angle < 0)angle += 2 * PI;
        return angle;
    }
```

```
    // 逆时针旋转
    void rotate(const double& theta){
        double temp = x;
        x = x * cos(theta) - y * sin(theta);
        y = y * cos(theta) + temp * sin(theta);
    }

    bool operator==(const vec& other)const{ return equal(x, other.x) &&
equal(y, other.y); }
    bool operator<(const vec& other)const{ return angle() == other.angle()
? x < other.x : angle() < other.angle(); }

    vec operator+(const vec& other)const{ return { x + other.x,y + other.y
}; }
    vec operator-()const{ return { -x,-y }; }
    vec operator-(const vec& other)const{ return -other + (*this); }
    vec operator*(const T& other)const{ return { other * x,other * y }; }
    T operator*(const vec& other)const{ return x * other.x + y * other.y;
}

    // 叉积 结果大于0，a在b的顺时针，小于0，a在b的逆时针，等于0共线，可能同向或反向，结
果绝对值表示 a b形成的平行四边行的面积
    T operator^(const vec& other)const{ return x * other.y - y * other.x;
}

    friend istream& operator>>(istream& input, vec& data){
        input >> data.x >> data.y;
        return input;
    }
    friend ostream& operator<<(ostream& output, const vec& data){
        output << fixed << setprecision(6);
        output << data.x << " " << data.y;
        return output;
    }
};

// 求两点间的距离
double distance(const vec& a, const vec& b){
    return (a.x - b.x) * (a.x - b.x) + (a.y - b.y) * (a.y - b.y);
}

// 求两向量夹角
double angle(const vec& a, const vec& b){
    double theta = abs(a.angle() - b.angle());
    if(theta > PI)theta = 2 * PI - theta;
    return theta;
}

// 计算多边形的面积，polygon里必须是存的相邻的点
T polygon_area(const vector<vec>& polygon){
    T ans = 0;
    for(int i = 1; i < polygon.size(); i++)ans += polygon[i - 1] ^
polygon[i];
```

```
    ans += polygon[polygon.size() - 1] ^ polygon[0];
    return abs(ans / 2);
}

// 直线
struct Line{
    vec point, direction;

    Line(){}
    Line(const vec& _point, const vec& _direction) :point(_point),
direction(_direction){}
};

// 两直线是否垂直
bool perpendicular(const Line& a, const Line& b){
    return a.direction * b.direction == 0;
}

// 两直线是否平行
bool parallel(const Line& a, const Line& b){
    return (a.direction ^ b.direction) == 0;
}

// 两直线交点
vec intersection(const T& A, const  T& B, const T& C, const T& D, const T&
E, const T& F){
    return { (B * F - C * E) / (A * E - B * D),(C * D - A * F) / (A * E -
B * D) };
}

// 两直线交点
vec intersection(const Line& a, const Line& b){
    return intersection(a.direction.y, -a.direction.x, a.direction.x *
a.point.y - a.direction.y * a.point.x,
        b.direction.y, -b.direction.x, b.direction.x * b.point.y -
b.direction.y * b.point.x);
}
```

杂项

高精度

```
struct bignum{
    int num[4001];
    int len;
    bignum(){ len = 0; }
    bignum operator +(const bignum& b){
        bignum c;
        for(int i = 1, j = 0, x; i <= len || i <= b.len || j; i++){
            x = j; j = 0;
            if(i <= len)x += num[i];
```

```
            if(i <= b.len)x += b.num[i];
            if(x >= 10)j = 1, x -= 10;
            c.num[++c.len] = x;
        }
        return c;
    }
    bignum operator *(const bignum& b){
        bignum c;
        memset(c.num, 0, sizeof(c.num));
        for(int i = 1; i <= len; i++){
            int g = 0;
            for(int j = 1, pos; j <= b.len; j++){
                pos = i + j - 1;
                c.num[pos] += num[i] * b.num[j] + g;
                g = c.num[pos] / 10; c.num[pos] %= 10;
            }
            if(g)c.num[i + b.len] = g;
        }
        c.len = len + b.len;
        while(!c.num[c.len] && c.len != 1)c.len--;
        return c;
    }
};
bignum read(){
    bignum x;
    char c = getchar();
    while(c < '0' || c>'9')c = getchar();
    while(c >= '0' && c <= '9'){
        x.num[++x.len] = c - '0';
        c = getchar();
    }
    reverse(x.num + 1, x.num + 1 + x.len);
    return x;
}
void print(bignum x){
    for(int i = x.len; i; i--)putchar(x.num[i] + '0');
}
```

表达式求值

```
// 格式化表达式
string format(const string& s1){
    stringstream ss(s1);
    string s2;
    char ch;
    while((ch = ss.get()) != EOF){
        if(ch == ' ')continue;
        if(isdigit(ch))s2 += ch;
        else{
            if(s2.back() != ' ')s2 += ' ';
            s2 += ch; s2 += ' ';
```

```
        }
    }
    return s2;
}

// 中缀表达式转后缀表达式
string convert(const string& s1){

    unordered_map<char, int> rank{ {'+',2},{'-',2},{'*',1},{'/',1},{'^',0}
};
    stringstream ss(s1);
    string s2, temp;
    stack<char> op;
    while(ss >> temp){
        if(isdigit(temp[0]))s2 += temp + ' ';
        else if(temp[0] == '(')op.push('(');
        else if(temp[0] == ')'){
            while(op.top() != '('){
                s2 += op.top(); s2 += ' '; op.pop();
            }
            op.pop();
        }
        else{
            while(!op.empty() && op.top() != '(' && (temp[0] != '^' &&
rank[op.top()] <= rank[temp[0]] || rank[op.top()] < rank[temp[0]])){
                s2 += op.top(); s2 += ' '; op.pop();
            }
            op.push(temp[0]);
        }
    }
    while(!op.empty()){
        s2 += op.top(); s2 += ' '; op.pop();
    }
    return s2;
}

// 计算后缀表达式
int calc(const string& s){
    stack<int> num;
    stringstream ss(s);
    string temp;
    while(ss >> temp){
        if(isdigit(temp[0]))num.push(stoi(temp));
        else{
            int b = num.top(); num.pop();
            int a = num.top(); num.pop();
            if(temp[0] == '+')a += b;
            else if(temp[0] == '-')a -= b;
            else if(temp[0] == '*')a *= b;
            else if(temp[0] == '/')a /= b;
            else if(temp[0] == '^')a = ksm(a, b);
            num.push(a);
        }
    }
```

```
    return num.top();
}
```

对拍

linux/Mac

```
g++ a.cpp -o program/a -O2 -std=c++17
g++ b.cpp -o program/b -O2 -std=c++17
g++ suiji.cpp -o program/suiji -O2 -std=c++17

cnt=0

while true; do
    let cnt++
    echo TEST:$cnt

    ./program/suiji > in
    ./program/a < in > out.a
    ./program/b < in > out.b

    diff out.a out.b
    if [ $? -ne 0 ];then break;fi
done
```

windows

```
@echo off

g++ a.cpp -o program/a -O2 -std=c++17
g++ b.cpp -o program/b -O2 -std=c++17
g++ suiji.cpp -o program/suiji -O2 -std=c++17

set cnt=0

:again
    set /a cnt=cnt+1
    echo TEST:%cnt%
    .\program\suiji > in
    .\program\a < in > out.a
    .\program\b < in > out.b

    fc output.a output.b
if not errorlevel 1 goto again
```