

# Nantong University ICPC Team Notebook (2018-19)

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May 9 2018

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# 第一章 输入输出

## 1.1 取消同步

```
1 std::ios::sync_with_stdio(false);
2 std::cin.tie(0);
```

## 1.2 浮点数输出格式

```
1 //include <iomanip>
2
3 std::cout << std::fixed << std::setprecision(12) << ans << std::endl;
```

## 1.3 整型快速输入

```
1 // 整型
2 //若读入不成功，返回false
3 //ios::sync_with_stdio(true)
4 //include <cctype>
5 bool quick_in(int &x) {
6     char c;
7     while((c = getchar()) != EOF && !isdigit(c));
8     if(c == EOF) {
9         return false;
10    }
11    x = 0;
12    do {
13        x *= 10;
14        x += c - '0';
15    } while((c = getchar()) != EOF && isdigit(c));
16    return true;
17 }
18
19 //带符号整型
20 //直接=返回值
21 //include <cctype>
22 int read() {
23     int x = 0, l = 1; char ch = getchar();
24     while (!isdigit(ch)) {if (ch=='-') l=-1; ch=getchar();}
```

```
25     while (isdigit(ch)) x=x*10+(ch^48),ch=getchar();
26     return x*1;
27 }
28
29 template <class T>
30 inline bool Read(T &ret) {
31     char c; int sgn;
32     if(c=getchar(),c==EOF) return 0; //EOF
33     while(c!='-'&&(c<'0' || c>'9')) c=getchar();
34     sgn=(c=='-') ?-1:1 ;
35     ret=(c=='-') ?0:(c-'0');
36     while(c=getchar(),c>='0'&&c<='9')
37         ret=ret*10+(c-'0');
38     ret*=sgn;
39     return 1;
40 }
```

## 1.4 字符串快速输入

```
1 bool quick_in(char *p) {
2     char c;
3     while((c = getchar()) != EOF && (c == '\u' || c == '\n'));
4     if(c == EOF) {
5         return false;
6     }
7     do {
8         *p++ = c;
9     } while((c=getchar()) != EOF && c != '\u' && c != '\n');
10    *p = 0;
11    return true;
12 }
```

## 1.5 整型快速输出

```
1 void quick_out(int x) {
2     char str[13];
3     if(x) {
4         int i;
5         for(i = 0; x; ++i) {
6             str[i] = x % 10 + '0';
7             x /= 10;
8         }
9         while(i--) {
10            putchar(str[i]);
11        }
12    } else {
13        putchar('0');
14    }
15 }
```

---

## 1.6 字符串快速输出

```
1 void quick_out(char *p) {  
2     while(*p) {  
3         putchar(*p++);  
4     }  
5 }
```

---

## 1.7 python 输入

```
1 a, b, c =map(int,input().split(' '))
```

---

## 第二章 动态规划

### 2.1 背包问题

```
1  const int maxn=100005;
2  int w[maxn],v[maxn],num[maxn];
3  int W,n;
4  int dp[maxn];
5
6  void ZOP(int weight, int value) {
7      for(int i = W; i >= weight; i--) {
8          dp[i]=std::max(dp[i],dp[i-weight]+value);
9      }
10 }
11
12 void CP(int weight, int value){
13     for(int i = weight; i <= W; i++) {
14         dp[i] = std::max(dp[i], dp[i-weight]+value);
15     }
16 }
17
18 void MP(int weight, int value, int cnt){
19     if(weight*cnt >= W) {
20         CP(weight, value);
21     } else {
22         for(int k = 1; k < cnt; k <= 1) {
23             ZOP(k*weight, k*value), cnt -= k;
24         }
25         ZOP(cnt*weight, cnt*value);
26     }
27 }
```

### 2.2 最长单调子序列 (nlogn)

```
1  int arr[maxn], n;
2
3  template<class Cmp>
4  int LIS (Cmp cmp) {
5      static int m, end[maxn];
6      m = 0;
7      for (int i=0; i<n; i++) {
8          int pos = lower_bound(end, end+m, arr[i], cmp)-end;
9          end[pos] = arr[i], m += pos==m;
```

```
10     }
11     return m;
12 }
13
14 bool greater1(int value) {
15     return value >=1;
16 }
17
18 /*****
19     std::cout << LIS(std::less<int>()) << std::endl;           //严格上升
20     std::cout << LIS(std::less_equal<int>()) << std::endl;     //非严格上升
21     std::cout << LIS(std::greater<int>()) << std::endl;        //严格下降
22     std::cout << LIS(std::greater_equal<int>()) << std::endl;  //非严格下降
23     std::cout << count_if(a,a+7,std::greater1) << std::endl;  //计数
24 *****/
```



## 第三章 数学

### 3.1 暴力判素数

```
1 bool is_prime(int u) {
2     if(u == 0 || u == 1) return false;
3     if(u == 2)         return true;
4     if(u%2 == 0)       return false;
5     for(int i=3; i <= sqrt(u) ; i+=2)
6         if(u%i==0)     return false;
7     return true;
8 }
```

### 3.2 埃氏筛

```
1 bool prime_or_not[maxn];
2 for (int i = 2; i <= int(sqrt(maxn)); i++) {
3     if (!prime_or_not[i]) {
4         for (int j = i * i; j <= maxn; j = j+i) {
5             prime_or_not[j] = 1;
6         }
7     }
8 }
```

### 3.3 欧拉筛

```
1 #include <iostream>
2
3 const int maxn = 1234;
4 int flag[maxn], primes[maxn], totPrimes;
5
6 void euler_sieve(int n) {
7     totPrimes = 0;
8     memset(flag, 0, sizeof(flag));
9     for (int i = 2; i <= n; i++) {
10         if (!flag[i]) {
11             primes[totPrimes++] = i;
12         }
13         for (int j = 0; i * primes[j] <= n; j++) {
14             flag[i * primes[j]] = true;
15             if (i % primes[j] == 0)
```

```
16         break;
17     }
18 }
19 }
```

### 3.4 分解质因数

```
1  int cnt[maxn]; // 存储质因子是什么
2  int num[maxn]; // 该质因子的个数
3  int tot = 0; // 质因子的数量
4  void factorization(int x) // 输入x, 返回cnt数组和num数组
5  {
6      for(int i=2; i*i<=x; i++)
7      {
8          if(x%i==0)
9          {
10             cnt[tot]=i;
11             num[tot]=0;
12             while(x%i==0)
13             {
14                 x/=i;
15                 num[tot]++;
16             }
17             tot++;
18         }
19     }
20     if(x!=1)
21     {
22         cnt[tot]=x;
23         num[tot]=1;
24         tot++;
25     }
26 }
```

### 3.5 暴力判回文数

```
1  bool is_palindrome(int bob) {
2      int clare = bob, dave = 0;
3      while (clare){
4          dave = dave * 10 + clare % 10;
5          clare /= 10;
6      }
7      if(bob == dave) {
8          return true;
9      } else {
10         return false;
11     }
12 }
```

### 3.6 最大公约数

```
1 ll gcd(ll a, ll b) {
2     ll t;
3     while(b != 0) {
4         t=a%b;
5         a=b;
6         b=t;
7     }
8     return a;
9 }
```

### 3.7 最小公倍数

```
1 ll lcm(ll a, ll b) {
2     return a * b / gcd(a, b);
3 }
```

### 3.8 扩展欧几里得

```
1 //如果 $GCD(a,b) = d$ , 则存在 $x, y$ , 使 $d = ax + by$ 
2 //  $extended\_euclid(a, b) = ax + by$ 
3 int extended_euclid(int a, int b, int &x, int &y) {
4     int d;
5     if(b == 0) {
6         x = 1;
7         y = 0;
8         return a;
9     }
10    d = extended_euclid(b, a % b, y, x);
11    y -= a / b * x;
12    return d;
13 }
```

### 3.9 中国剩余定理

```
1 LL Crt(LL *div, LL *rmd, LL len) {
2     LL sum = 0;
3     LL lcm = 1;
4     //lcm为除数们的最小公倍数, 若div互素, 则如下一行计算lcm
5     for (int i = 0; i < len; ++i)
6         lcm *= div[i];
7     for (int i = 0; i < len; ++i) {
8         LL bsn = lcm / div[i];
9         LL inv = Inv(bsn, div[i]);
10        //  $dvd[i] = inv[i] * bsn[i] * rmd[i]$ 
```

```
11     LL dvd = MulMod(MulMod(inv, bsn, lcm), rmd[i], lcm);
12     sum = (sum + dvd) % lcm;
13 }
14 return sum;
15 }
```

### 3.10 欧拉函数

```
1 LL EulerPhi(LL n){
2     LL m = sqrt(n + 0.5);
3     LL ans = n;
4     for(LL i = 2; i <= m; ++i)
5         if(n % i == 0) {
6             ans = ans - ans / i;
7             while(n % i == 0)
8                 n/=i;
9         }
10    if(n > 1)
11        ans = ans - ans / n;
12    return ans;
13 }
```

### 3.11 求逆元

```
1 LL Inv(LL a, LL n){
2     return PowMod(a, EulerPhi(n) - 1, n);
3     //return PowMod(a,n-2,n); //n为素数
4 }
5
6 int Inv(int a, int n) {
7     int d, x, y;
8     d = extended_euclid(a, n, x, y);
9     if(d == 1) return (x%n + n) % n;
10    else return -1; // no solution
11 }
```

### 3.12 $C(n,m) \bmod p$ ( $n$ 很大 $p$ 可以很大)

```
1 LL C(const LL &n, const LL &m, const int &pr) {
2     LL ans = 1;
3     for (int i = 1; i <= m; i++) {
4         LL a = (n - m + i) % pr;
5         LL b = i % pr;
6         ans = (ans * (a * Inv(b, pr))) % pr;
7     }
8     return ans;
9 }
```

### 3.13 Lucas 定理

```
1 //C(n, m) mod p(n 很大 p 较小(不知道能不能为非素数))
2 LL Lucas(LL n, LL m, const int &pr) {
3     if (m == 0) return 1;
4     return C(n % pr, m % pr, pr) * Lucas(n / pr, m / pr, pr) % pr;
5 }
```

### 3.14 快速乘法取模

```
1 //by sevenkplus
2 #define ll long long
3 #define ld long double
4 ll mul(ll x, ll y, ll z){return (x*y-(ll)(x/(ld)z*y+1e-3)*z+z)%z;}
5
6 //by Lazer2001
7 inline long long mmul (long long a, long long b, const long long& Mod) {
8     long long lf = a * (b >> 25LL) % Mod * (1LL << 25) % Mod;
9     long long rg = a * (b & ( ( 1LL << 25 ) - 1 ) ) % Mod ;
10    return (lf + rg) % Mod ;
11 }
```

### 3.15 快速幂取模

```
1 using LL = long long;
2
3 LL PowMod(LL a, LL b, const LL &Mod) {
4     a %= Mod;
5     LL ans = 1;
6     while(b) {
7         if (b & 1){
8             ans = (ans * a) % Mod;
9         }
10        a = (a * a) % Mod;
11        b >>= 1;
12    }
13    return ans;
14 }
```

### 3.16 计算从 $C(n, 0)$ 到 $C(n, p)$ 的值

```
1 //by Yuhao Du
2 int p;
3 std::vector<int> gao(int n) {
```

```

4      std::vector<int> ret(p+1,0);
5      if (n==0) {
6          ret[0]=1;
7      } else if (n%2==0) {
8          std::vector<int> c = gao(n/2);
9          for(int i = 0; i <= p+1; i++) {
10             for(int j = 0; j <= p+1; j++) {
11                 if (i+j<=p) ret[i+j]+=c[i]*c[j];
12             }
13         }
14     } else {
15         std::vector<int> c = gao(n-1);
16         for(int i = 0; i <= p+1; i++) {
17             for(int j = 0; j <= 2; j++) {
18                 if (i+j<=p) ret[i+j]+=c[i];
19             }
20         }
21     }
22     return ret;
23 }

```

### 3.17 二分分数树 (Stern-Brocot Tree)

```

1  //Author:CookieC
2  //未做模板调整，请自行调整
3  #include <cmath>
4  #define LL long long
5  #define LD long double
6
7  void SternBrocot(LD X, LL &A, LL &B) {
8      A=X+0.5;
9      B=1;
10     if(A==X)
11         return;
12     LL la=X, lb=1, ra=X+1, rb=1;
13     long double C=A, a, b, c;
14     do {
15         a = la+ra;
16         b = lb+rb;
17         c = a/b;
18         if(std::abs(C-X) > std::abs(c-X)) {
19             A=a;
20             B=b;
21             C=c;
22             if(std::abs(X-C) < 1e-10) {
23                 break;
24             }
25         }
26         if(X<c) {
27             ra=a;
28             rb=b;
29         } else {

```

```
30         la=a;
31         lb=b;
32     }
33 } while(lb+rb<=1e5);
34 }
```

---

### 3.18 计算莫比乌斯函数

```
1  const int n=1<<20;
2  int mu[n];
3  int getMu() {
4      for(int i=1;i<=n;i++) {
5          int target=i==1?1:0;
6          int delta=target-mu[i];
7          mu[i]=delta;
8          for(int j=i+i;j<=n;j+=i) {
9              mu[j]+=delta;
10         }
11     }
12 }
```

---

## 第四章 图论

### 4.1 并查集

```
1 int fa[N];
2
3 void init(int n) {
4     for (int i = 1; i <= n; i++) fa[i] = i;
5 }
6
7 int find(int u) {
8     return fa[u] == u ? fa[u] : fa[u] = find(fa[u]);
9 }
10
11 void unin(int u, int v) {
12     fa[find(v)] = find(u);
13 }
```

### 4.2 可撤销并查集（按秩合并）

```
1 #include <iostream>
2 #include <stack>
3 #include <utility>
4
5 class UFS {
6     private:
7         int *fa, *rank;
8         std::stack <std::pair <int*, int> > stk ;
9     public:
10         UFS() {}
11         UFS(int n) {
12             fa = new int[(const int)n + 1];
13             rank = new int[(const int)n + 1];
14             memset (rank, 0, n+1);
15             for (int i = 1; i <= n; ++i) {
16                 fa [i] = i;
17             }
18         }
19         inline int find(int x) {
20             while (x ^ fa[x]) {
21                 x = fa[x];
22             }
23             return x;
24         }
25 }
```



```

22     }
23     return x ;
24 }
25 inline int Join (int x, int y) {
26     x = find(x), y = find(y);
27     if (x == y) {
28         return 0;
29     }
30     if (rank[x] <= rank[y]) {
31         stk.push(std::make_pair (fa + x, fa[x]));
32         fa[x] = y;
33         if (rank[x] == rank[y]) {
34             stk.push(std::make_pair (rank + y, rank[y]));
35             ++rank[y];
36             return 2;
37         }
38         return 1 ;
39     }
40     stk.push(std::make_pair(fa + y, fa [y]));
41     return fa[y] = x, 1;
42 }
43 inline void Undo ( ) {
44     *stk.top( ).first = stk.top( ).second ;
45     stk.pop( ) ;
46 }
47 }T;

```

### 4.3 Kruskal 最小生成树

```

1  #include <vector>
2  #include <algorithm>
3
4  #define maxm 1000
5  #define maxn 1000
6
7  class Kruskal {
8      struct UdEdge {
9          int u, v, w;
10         UdEdge(){}
11         UdEdge(int u,int v,int w):u(u), v(v), w(w){}
12     };
13     int N, M;
14     UdEdge pool[maxm];
15     UdEdge *E[maxm];
16     int P[maxn];
17     int Find(int x){
18         if(P[x] == x)
19             return x;
20         return P[x] = Find(P[x]);
21     }
22     public:
23     static bool cmp(const UdEdge *a, const UdEdge *b) {

```

```
24     return a->w < b->w;
25 }
26 void Clear(int n) {
27     N = n;
28     M = 0;
29 }
30 void AddEdge(int u, int v, int w) {
31     pool[M] = UEdge(u, v, w);
32     E[M] = &pool[M];
33     ++M;
34 }
35 int Run() {
36     int i, ans=0;
37     for(i = 1; i <= N; ++i)
38         P[i] = i;
39     std::sort(E, E+M, cmp);
40     for(i = 0; i < M; ++i) {
41         UEdge *e = E[i];
42         int x = Find(e->u);
43         int y = Find(e->v);
44         if(x != y) {
45             P[y] = x;
46             ans += e->w;
47         }
48     }
49     return ans;
50 }
51 };
```

## 4.4 Prim 最小生成树

```
1 int d[maxn][maxn];
2 int lowc[maxn];
3 int vis[maxn];
4
5 int prim(int n) {
6     int ans = 0;
7     memset(vis, 0, sizeof(vis));
8     for (int i = 2; i <= n; i++)
9         lowc[i] = d[1][i];
10    vis[1] = 1;
11    for (int i = 1; i < n; i++) {
12        int minc = INF;
13        int p = -1;
14        for (int j = 1; j <= n; j++) {
15            if (!vis[j] && minc > lowc[j]) {
16                minc = lowc[j];
17                p = j;
18            }
19        }
20        vis[p] = 1;
21        ans += minc;
```

```
22     for (int j = 1; j <= n; j++) {
23         if (!vis[j] && lowc[j] > d[p][j])
24             lowc[j] = d[p][j];
25     }
26 }
27 return ans;
28 }
```

## 4.5 SPFA 最短路

```
1  #include <queue>
2  #include <cstring>
3  #include <vector>
4  #define maxn 10007
5  #define INF 0x7FFFFFFF
6  using namespace std;
7  struct Edge{
8      int v,w;
9      Edge(int v,int w):v(v),w(w){}
10 };
11 int d[maxn];
12 bool inq[maxn];
13 vector<Edge> G[maxn];
14 void SPFA(int s){
15     queue<int> q;
16     memset(inq,0,sizeof(inq));
17     for(int i=0;i<maxn;++i)
18         d[i]=INF;
19     d[s]=0;
20     inq[s]=1;
21     q.push(s);
22     int u;
23     while(!q.empty()){
24         u=q.front();
25         q.pop();
26         inq[u]=0;
27         for(vector<Edge>::iterator e=G[u].begin();e!=G[u].end();++e) {
28             if(d[e->v]>d[u]+e->w){
29                 d[e->v]=d[u]+e->w;
30                 if(!inq[e->v]){
31                     q.push(e->v);
32                     inq[e->v]=1;
33                 }
34             }
35         }
36     }
37 }
```

## 4.6 dijkstra 最短路

```
1  #include <vector>
2  #include <queue>
3  #define INF 0x7FFFFFFF
4  #define maxn 1000
5  using namespace std;
6  class Dijkstra{
7  private:
8      struct HeapNode{
9          int u;
10         int d;
11         HeapNode(int u, int d) :u(u), d(d){}
12         bool operator < (const HeapNode &b) const{
13             return d > b.d;
14         }
15     };
16     struct Edge{
17         int v;
18         int w;
19         Edge(int v, int w) :v(v), w(w){}
20     };
21     vector<Edge>G[maxn];
22     bool vis[maxn];
23 public:
24     int d[maxn];
25     void clear(int n){
26         int i;
27         for(i=0;i<n;++i)
28             G[i].clear();
29         for(i=0;i<n;++i)
30             d[i] = INF;
31         memset(vis, 0, sizeof(vis));
32     }
33     void AddEdge(int u, int v, int w){
34         G[u].push_back(Edge(v, w));
35     }
36     void Run(int s){
37         int u;
38         priority_queue<HeapNode> q;
39         d[s] = 0;
40         q.push(HeapNode(s, 0));
41         while (!q.empty()){
42             u = q.top().u;
43             q.pop();
44             if (!vis[u]){
45                 vis[u] = 1;
46                 for (vector<Edge>::iterator e = G[u].begin(); e != G[u].end(); ++e)
47                     if (d[e->v] > d[u] + e->w){
48                         d[e->v] = d[u] + e->w;
49                         q.push(HeapNode(e->v, d[e->v]));
50                     }
51             }
52         }
53     }
54 };
```

## 4.7 Floyd 任意两点间最短路

```
1 // #define inf maxn*maxw+10
2 for(int i = 0; i < n; i++) {
3     for(int j = 0; j < n; j++) {
4         d[i][j] = inf;
5     }
6 }
7 d[0][0] = 0;
8 for(int k = 0; k < n; k++) {
9     for(int i = 0; i < n; i++) {
10        for(int j = 0; j < n; j++) {
11            d[i][j] = std::min(d[i][j], d[i][k] + d[k][j]);
12        }
13    }
14 }
```

## 4.8 Dinic 最大流

```
1 #include <queue>
2 #include <vector>
3 #include <cstring>
4
5 #define INF 0x7FFFFFFF
6 #define maxn 1010
7
8 using namespace std;
9 struct Edge{
10     int c,f;
11     unsigned v,flip;
12     Edge(unsigned v,int c,int f,unsigned flip):v(v),c(c),f(f),flip(flip){}
13 };
14
15 /*
16  *b: BFS使用 ,
17  *a: 可改进量 , 不会出现负数可改进量。
18  *p[v]: u到v的反向边, 即v到u的边。 *cur[u]: i开始搜索的位置 , 此位置前所有路已满载。 *s: 源点。
19  *t: 汇点 。
20  */
21
22 class Dinic{
23 private:
24     bool b[maxn];
25     int a[maxn];
26     unsigned p[maxn],cur[maxn],d[maxn];
27     vector<Edge> G[maxn];
28 public:
29     unsigned s,t;
30     void Init(unsigned n){
```

```

31     for(int i=0;i<=n;++i)
32         G[i].clear();
33 }
34 void AddEdge(unsigned u,unsigned v,int c){
35     G[u].push_back(Edge(v,c,0,G[v].size()));
36     G[v].push_back(Edge(u,0,0,G[u].size()-1)); //使用无向图时将0改为c即可
37 }
38 bool BFS(){
39     unsigned u,v;
40     queue<unsigned> q;
41     memset(b,0,sizeof(b));
42     q.push(s);
43     d[s]=0;
44     b[s]=1;
45     while(!q.empty()){
46         u=q.front();
47         q.pop();
48         for(auto it=G[u].begin();it!=G[u].end();++it) {
49             Edge &e=*it;
50             if(!b[e.v]&&e.c>e.f){
51                 b[e.v]=1;
52                 d[e.v]=d[u]+1;
53                 q.push(e.v);
54             }
55         }
56     }
57     return b[t];
58 }
59 int DFS(unsigned u,int a){
60     if(u==t || a==0)
61         return a;
62     int flow=0,f;
63     for(unsigned &i=cur[u];i<G[u].size();++i){
64         Edge &e=G[u][i];
65         if(d[u]+1==d[e.v]&&(f=DFS(e.v,min(a,e.c-e.f)))>0){
66             a-=f;
67             e.f+=f;
68             G[e.v][e.flip].f-=f;
69             flow+=f;
70             if(!a) break;
71         }
72     }
73     return flow;
74 }
75 int MaxFlow(unsigned s,unsigned t){
76     int flow=0;
77     this->s=s;
78     this->t=t;
79     while(BFS()){
80         memset(cur,0,sizeof(cur));
81         flow+=DFS(s,INF);
82     }
83     return flow;
84 }

```

```
85  };
```

## 4.9 2-SAT 问题

```
1  class TwoSAT{
2      private:
3          const static int maxm=maxn*2;
4
5          int S[maxm],c;
6          vector<int> G[maxm];
7
8          bool DFS(int u){
9              if(vis[u^1])
10                 return false;
11              if(vis[u])
12                 return true;
13              vis[u]=1;
14              S[c++]=u;
15              for(auto &v:G[u])
16                 if(!DFS(v))
17                     return false;
18              return true;
19          }
20
21      public:
22          int N;
23          bool vis[maxm];
24
25          void Clear(){
26              for(int i=2;i<(N+1)*2;++i)
27                  G[i].clear();
28              memset(vis,0,sizeof(bool)*(N+1)*2);
29          }
30
31          void AddClause(int x,int xv,int y,int yv){
32              x=x*2+xv;
33              y=y*2+yv;
34              G[x].push_back(y);
35              G[y].push_back(x);
36          }
37
38          bool Solve(){
39              for(int i=2;i<(N+1)*2;i+=2)
40                  if(!vis[i]&&!vis[i+1]){
41                      c=0;
42                      if(!DFS(i)){
43                          while(c>0)
44                              vis[S[--c]]=0;
45                          if(!DFS(i+1))
46                              return false;
47                      }
48                  }
```

```
49         return true;
50     }
51 };
```

---



## 第五章 数据结构

### 5.1 树状数组

```
1 void add(int i, int x) {
2     for(; i <= n; i += i & -i)
3         tree[i] += x;
4 }
5
6 int sum(int i) {
7     int ret = 0;
8     for(; i; i -= i & -i) ret += tree[i];
9     return ret;
10 }
```

### 5.2 二维树状数组

```
1 int N;
2 int c[maxn][maxn];
3
4 inline int lowbit(int t) {
5     return t & (-t);
6 }
7
8 void update(int x, int y, int v) {
9     for (int i=x; i<=N; i+=lowbit(i)) {
10         for (int j=y; j<=N; j+=lowbit(j)) {
11             c[i][j] += v;
12         }
13     }
14 }
15
16 int query(int x, int y) {
17     int s = 0;
18     for (int i=x; i>0; i-=lowbit(i)) {
19         for (int j=y; j>0; j-=lowbit(j)) {
20             s += c[i][j];
21         }
22     }
23     return s;
24 }
25
26 int sum(int x, int y, int xx, int yy) {
```

```
27     x--, y--;
28     return query(xx, yy) - query(xx, y) - query(x, yy) + query(x, y);
29 }
```

## 5.3 堆

```
1  const int N = 1000;
2
3  template <class T>
4  class Heap {
5      private:
6          T h[N];
7          int len;
8      public:
9          Heap() {
10             len = 0;
11         }
12         inline void push(const T& x) {
13             h[++len] = x;
14             std::push_heap(h+1, h+1+len, std::greater<T>());
15         }
16         inline T pop() {
17             std::pop_heap(h+1, h+1+len, std::greater<T>());
18             return h[len--];
19         }
20         inline T& top() {
21             return h[1];
22         }
23         inline bool empty() {
24             return len == 0;
25         }
26     };
```

## 5.4 RMQ

```
1  //A为原始数组, d[i][j]表示从i开始, 长度为(1<<j)的区间最小值
2
3  int A[maxn];
4  int d[maxn][30];
5
6  void init(int A[], int len) {
7      for (int i = 0; i < len; i++) d[i][0] = A[i];
8      for (int j = 1; (1 << j) <= len; j++) {
9          for (int i = 0; i + (1 << j) - 1 < len; i++) {
10             d[i][j] = min(d[i][j - 1], d[i + (1 << (j - 1))][j - 1]);
11         }
12     }
13 }
14
```

```

15 int query(int l, int r) {
16     int p = 0;
17     while ((1 << (p + 1)) <= r - l + 1)p++;
18     return min(d[l][p], d[r - (1 << p) + 1][p]);
19 }

```

## 5.5 线段树

```

1  //A为原始数组，sum记录区间和，Add为懒惰标记
2
3  int A[maxn], sum[maxn << 2], Add[maxn << 2];
4
5  void pushup(int rt) {
6      sum[rt] = sum[rt << 1] + sum[rt << 1 | 1];
7  }
8
9  void pushdown(int rt, int l, int r) {
10     if (Add[rt]) {
11         int mid = (l + r) >> 1;
12         Add[rt << 1] += Add[rt];
13         Add[rt << 1 | 1] += Add[rt];
14         sum[rt << 1] += (mid - l + 1)*Add[rt];
15         sum[rt << 1 | 1] += (r - mid)*Add[rt];
16         Add[rt] = 0;
17     }
18 }
19
20 void build(int l, int r, int rt) {
21     if (l == r) {
22         sum[rt] = A[l];
23         return;
24     }
25     int mid = (l + r) >> 1;
26     build(l, mid, rt << 1);
27     build(mid + 1, r, rt << 1 | 1);
28     pushup(rt);
29 }
30
31 // 区间加值
32 void update(int L, int R, int val, int l, int r, int rt) {
33     if (L <= l && R >= r) {
34         Add[rt] += val;
35         sum[rt] += (r - l + 1)*val;
36         return;
37     }
38     pushdown(rt, l, r);
39     int mid = (l + r) >> 1;
40     if (L <= mid)update(L, R, val, l, mid, rt << 1);
41     if (R > mid)update(L, R, val, mid + 1, r, rt << 1 | 1);
42     pushup(rt);
43 }
44

```

```
45 //点修改
46 void update(int index, int val, int l, int r, int rt) {
47     if (l == r) {
48         sum[rt] = val;
49         return;
50     }
51     int mid = (l + r) >> 1;
52     if (index <= mid)update(index, val, l, mid, rt << 1);
53     else update(index, val, mid + 1, r, rt << 1 | 1);
54     pushup(rt);
55 }
56
57 //区间查询
58 int query(int L, int R, int l, int r, int rt) {
59     if (L <= l && R >= r) {
60         return sum[rt];
61     }
62     pushdown(rt, l, r);
63     int mid = (l + r) >> 1;
64     int ret = 0;
65     if (L <= mid)ret += query(L, R, l, mid, rt << 1);
66     if (R > mid)ret += query(L, R, mid + 1, r, rt << 1 | 1);
67     return ret;
68 }
```

## 第六章 字符串

### 6.1 TRIE

```
1 #include <cstring>
2
3 const int maxn = 10000*50+10;
4 const int max_stringlen = 26+2;
5 int trie[maxn][max_stringlen];
6 int val[maxn];
7 int trie_index;
8
9 int index_of(const char &c) {
10     return c - 'a';
11 }
12 void trie_init() {
13     trie_index = 0;
14     memset(val, 0, sizeof(val));
15     memset(trie, 0, sizeof(trie));
16 }
17 void trie_insert(char *s, int v) { //要求v!=0
18     int len = strlen(s);
19     int now = 0;
20     for (int i = 0; i < len; ++i) {
21         int idx = index_of(s[i]);
22         int &tr = trie[now][idx];
23         if (!tr) {
24             tr = ++trie_index;
25         }
26         now = tr;
27     }
28     val[now] += v;
29 }
```

### 6.2 后缀数组

```
1 //Author:CookieC
2 #include <cstring>
3 const int maxn = 10010;
4
5 char str[maxn];
6 int s[maxn], si[maxn], n;
7
```

```

8 void BuildSi(int m) {
9     //si为第一关键字排在第i位的后缀在s中的下标
10    //y为第二关键字排在第i位的后缀在s中的下标
11    //m为字母的种类
12    static int t1[maxn], t2[maxn], c[maxn];
13    int *x=t1, *y=t2;
14    int i;
15    //基数排序
16    memset(c, 0, sizeof(int)*m);
17    for(i=0; i<n; ++i) ++c[x[i]=s[i]];
18    for(i=1; i<m; ++i) c[i]+=c[i-1];
19    for(i=n-1; i>=0; --i) si[--c[x[i]]]=i;
20    for(int k=1; k<=n; k<=1) {
21        int p=0;
22
23        //第二关键字排序
24        for(i=n-k; i<n; ++i) y[p++]=i;
25        for(i=0; i<n; ++i) if(si[i]>=k) y[p++]=si[i]-k;
26
27        //第一关键字与第二关键字合并排序
28        memset(c, 0, sizeof(int)*m);
29        for(i=0; i<n; ++i)
30            ++c[x[y[i]]];
31        for(i=0; i<m; ++i)
32            c[i]+=c[i-1];
33        for(i=n-1; i>=0; --i)
34            si[--c[x[y[i]]]]=y[i];
35
36        //判断相邻元素是否等价，等价则标上同等大小的数字。
37        swap(x, y);
38        p=1;
39        x[si[0]]=0;
40        for(i=1; i<n; ++i)
41            x[si[i]]=y[si[i-1]]==y[si[i]]&&y[si[i-1]+k]==y[si[i]+k]?p-1:p++;
42        if(p>=n)
43            break;
44        m=p;
45    }
46 }

```

## 6.3 后缀自动机

```

1 //Author: CookiC
2 #include <cstring>
3 #define MAXN 10000
4
5 struct State{
6     State *f, *c[26];
7     int len;
8 };
9
10 State *root, *last, *cur;

```

```
11 State StatePool[MAXN];
12
13 State* NewState(int len){
14     cur->len=len;
15     cur->f=0;
16     memset(cur->c,0,sizeof(cur->c));
17     return cur++;
18 }
19
20 void Init(){
21     cur=StatePool;
22     last=StatePool;
23     root=NewState(0);
24 }
25
26 void Extend(int w){
27     State *p = last;
28     State *np = NewState(p->len+1);
29     while(p&&!p->c[w]) {
30         p->c[w] = np;
31         p = p->f;
32     }
33     if(!p) {
34         np->f=root;
35     } else {
36         State *q=p->c[w];
37         if(p->len+1==q->len) {
38             np->f=q;
39         } else {
40             State *nq = NewState(p->len+1);
41             memcpy(nq->c, q->c, sizeof(q->c));
42             nq->f = q->f;
43             q->f = nq;
44             np->f = nq;
45             while(p&&p->c[w]==q) {
46                 p->c[w]=nq;
47                 p=p->f;
48             }
49         }
50     }
51     last=np;
52 }
53
54 bool Find(char *s,int len) {
55     int i;
56     State *p=root;
57     for(i=0;i<len;++i) {
58         if(p->c[s[i]-'a']) {
59             p=p->c[s[i]-'a'];
60         } else {
61             return false;
62         }
63     }
64     return true;
```

---

```
65 }
```

---

## 6.4 最长回文子串

```
1  const int maxn=2000005;
2  int f[maxn];
3  std::string a, s;
4  int manacher() {
5      int n=0, res=0, maxr=0, pos=0;
6      for (int i=0; a[i]; i++) {
7          s[++n] = '#', s[++n] = a[i];
8          s[++n] = '#';
9      }
10     for (int i=1; i<=n; i++) {
11         f[i] = (i<maxr? std::min(f[pos*2-i], maxr-i+1): 1);
12         while (i-f[i]>0 && i+f[i]<=n && s[i-f[i]]==s[i+f[i]]) {
13             f[i]++;
14         }
15         if (i+f[i]-1 > maxr) {
16             maxr=i+f[i]-1;
17             pos=i;
18         }
19         res = std::max(res, f[i]-1);
20     }
21     return res;
22 }
```

---



## 第七章 几何

### 7.1 平面几何公式

- 1 三角形：
- 2 1. 半周长  $P=(a+b+c)/2$
- 3 2. 面积  $S=aHa/2=absin(C)/2=sqrt(P(P-a)(P-b)(P-c))$
- 4 3. 中线  $Ma=sqrt(2(b^2+c^2)-a^2)/2=sqrt(b^2+c^2+2bccos(A))/2$
- 5 4. 角平分线  $Ta=sqrt(bc((b+c)^2-a^2))/(b+c)=2bccos(A/2)/(b+c)$
- 6 5. 高线  $Ha=bsin(C)=csin(B)=sqrt(b^2-((a^2+b^2-c^2)/(2a))^2)$
- 7 6. 内切圆半径  $r=S/P=asin(B/2)sin(C/2)/sin((B+C)/2)$
- 8  $=4Rsin(A/2)sin(B/2)sin(C/2)=sqrt((P-a)(P-b)(P-c)/P)$
- 9  $=Ptan(A/2)tan(B/2)tan(C/2)$
- 10 7. 外接圆半径  $R=abc/(4S)=a/(2sin(A))=b/(2sin(B))=c/(2sin(C))$
- 11
- 12
- 13 四边形：
- 14  $D1, D2$ 为对角线,  $M$ 为对角线中点连线,  $A$ 为对角线夹角
- 15 1.  $a^2+b^2+c^2+d^2=D1^2+D2^2+4M^2$
- 16 2.  $S=D1D2sin(A)/2$
- 17 (以下对圆的内接四边形)
- 18 3.  $ac+bd=D1D2$
- 19 4.  $S=sqrt((P-a)(P-b)(P-c)(P-d))$ ,  $P$ 为半周长
- 20
- 21
- 22 正  $n$  边形：
- 23  $R$ 为外接圆半径,  $r$ 为内切圆半径
- 24 1. 中心角  $A=2PI/n$
- 25 2. 内角  $C=(n-2)PI/n$
- 26 3. 边长  $a=2sqrt(R^2-r^2)=2Rsin(A/2)=2rtan(A/2)$
- 27 4. 面积  $S=na^2/2=nr^2tan(A/2)=nR^2sin(A)/2=na^2/(4tan(A/2))$
- 28
- 29
- 30 圆：
- 31 1. 弧长  $l=rA$
- 32 2. 弦长  $a=2sqrt(2hr-h^2)=2rsin(A/2)$
- 33 3. 弓形高  $h=r-sqrt(r^2-a^2/4)=r(1-cos(A/2))=atan(A/4)/2$
- 34 4. 扇形面积  $S1=r^2A/2$
- 35 5. 弓形面积  $S2=(r^2A-(r^2-a(r-h)))/2=r^2(A-sin(A))/2$
- 36
- 37
- 38 棱柱：
- 39 1. 体积  $V=Ah$ ,  $A$ 为底面积,  $h$ 为高
- 40 2. 侧面积  $S=lp$ ,  $l$ 为棱长,  $p$ 为直截面周长
- 41 3. 全面积  $T=S+2A$
- 42

棱锥：

1. 体积  $V=Ah/3$ ,  $A$ 为底面积,  $h$ 为高  
(以下对正棱锥)
2. 侧面积  $S=lp/2$ ,  $l$ 为斜高,  $p$ 为底面周长
3. 全面积  $T=S+A$

棱台：

1. 体积  $V=(A_1+A_2+\sqrt{A_1A_2})h/3$ ,  $A_1, A_2$ 为上下底面积,  $h$ 为高  
(以下为正棱台)
2. 侧面积  $S=(p_1+p_2)l/2$ ,  $p_1, p_2$ 为上下底面周长,  $l$ 为斜高
3. 全面积  $T=S+A_1+A_2$

圆柱：

1. 侧面积  $S=2\pi rh$
2. 全面积  $T=2\pi r(h+r)$
3. 体积  $V=\pi r^2h$

圆锥：

1. 母线  $l=\sqrt{h^2+r^2}$
2. 侧面积  $S=\pi rl$
3. 全面积  $T=\pi r(l+r)$
4. 体积  $V=\pi r^2h/3$

圆台：

1. 母线  $l=\sqrt{h^2+(r_1-r_2)^2}$
2. 侧面积  $S=\pi(r_1+r_2)l$
3. 全面积  $T=\pi r_1(l+r_1)+\pi r_2(l+r_2)$
4. 体积  $V=\pi(r_1^2+r_2^2+r_1r_2)h/3$

球：

1. 全面积  $T=4\pi r^2$
2. 体积  $V=4\pi r^3/3$

球台：

1. 侧面积  $S=2\pi rh$
2. 全面积  $T=\pi(2rh+r_1^2+r_2^2)$
3. 体积  $V=\pi h(3(r_1^2+r_2^2)+h^2)/6$

球扇形：

1. 全面积  $T=\pi r(2h+r_0)$ ,  $h$ 为球冠高,  $r_0$ 为球冠底面半径
2. 体积  $V=2\pi r^2h/3$

## 第八章 类

### 8.1 点类

```
1 struct point {
2     double x, y;
3     point() { };
4     point(double x, double y) :x(x), y(y) { }
5     point operator - (const point &b) const {
6         return point(x - b.x, y - b.y);
7     }
8     point operator + (const point &b) const {
9         return point(x + b.x, y + b.y);
10    }
11    point operator * (const double k) const {
12        return point(k * x, k * y);
13    }
14    point operator / (const double k) const {
15        return point(x / k, y / k);
16    }
17    double slope() {
18        return y / x;
19    }
20 };
```

### 8.2 分数类

```
1 struct Fraction {
2     long long num;
3     long long den;
4     Fraction(long long num=0, long long den=1) {
5         if(den<0) {
6             num=-num;
7             den=-den;
8         }
9         assert(den!=0);
10        long long g=gcd(abs(num),den);
11        this->num=num/g;
12        this->den=den/g;
13    }
14    Fraction operator +(const Fraction &o) const {
15        return Fraction(num*o.den+o.num,den*o.den);
16    }
```

```

17 Fraction operator -(const Fraction &o) const {
18     return Fraction(num*o.den-den*o.num,den*o.den);
19 }
20 Fraction operator *(const Fraction &o) const {
21     return Fraction(num*o.num,den*o.den);
22 }
23 Fraction operator /(const Fraction &o) const {
24     return Fraction(num*o.den,den*o.num);
25 }
26 bool operator <(const Fraction &o) const {
27     return num*o.den< den*o.num;
28 }
29 bool operator ==(const Fraction &o) const {
30     return num*o.den==den*o.num;
31 }
32 };

```

### 8.3 矩阵

```

1  #define maxm 10
2  typedef long long LL;
3
4  const LL Mod=1e9+7;
5  struct Matrix {
6      int n, m;
7      LL mat[maxm][maxm];
8      void clear() {
9          memset(mat, 0, sizeof(mat));
10     }
11
12     Matrix(int n, int m) :n(n), m(m) {
13         //不要设置默认构造函数，让编译器检查初始化遗漏
14         clear();
15     }
16
17     Matrix operator +(const Matrix &M) const {
18         Matrix res(n, m);
19         for (LL i = 0; i < n; ++i) for (LL j = 0; j < m; ++j) {
20             res.mat[i][j] = (mat[i][j] + M.mat[i][j]) % Mod;
21         }
22         return res;
23     }
24
25     Matrix operator *(const Matrix &M) const {
26         if (m != M.n){
27             std::cout << "Wrong!" << std::endl;
28             return Matrix(-1, -1);
29         }
30         Matrix res(n, M.m);
31         res.clear();
32         int i,j,k;
33         for (i = 0; i < n; ++i)

```

```

34         for (j = 0; j < M.m; ++j)
35             for (k = 0; k < m; ++k) {
36                 res.mat[i][j] += mat[i][k] * M.mat[k][j]%Mod;
37                 res.mat[i][j] %= Mod;
38             }
39         return res;
40     }
41     Matrix operator *(const LL &x) const {
42         Matrix res(n,m);
43         int i,j;
44         std::cout << n << ' ' << m << std::endl;
45         for (i = 0; i < n; ++i)
46             for (j = 0; j < m; ++j)
47                 res[i][j] = mat[i][j] * x % Mod;
48         return res;
49     }
50
51     Matrix operator ^(LL b) const { // 矩阵快速幂 , 取余Mod
52         if (n != m)
53             return Matrix(-1, -1);
54         Matrix a(*this);
55         Matrix res(n, n);
56         res.clear();
57         for (LL i = 0; i < n; ++i)
58             res.mat[i][i] = 1;
59         for (; b; b >>= 1) {
60             if (b & 1) {
61                 res = a * res;
62             }
63             a = a * a;
64         }
65         return res;
66     }
67
68     LL* operator [](int i) {
69         return mat[i];
70     }
71
72     void Print() const {
73         for (int i = 0; i < n; ++i) {
74             for (int j = 0; j < m; ++j)
75                 std::cout << mat[i][j] << ' ';
76             std::cout << '\n';
77         }
78     }
79 };

```

## 8.4 01 矩阵

```

1 #include <bitset>
2 #define maxn 1000
3 struct Matrix01{

```

```
4     int n,m;
5     std::bitset<maxn> a[maxn];
6     void Resize(int x,int y){
7         n=x;
8         m=y;
9     }
10    std::bitset<maxn>& operator [] (int n) {
11        return a[n];
12    }
13    void print(){
14        for(int i = 0; i < n; ++i)
15            std::cout << a[i] << std::endl;
16    }
17 };
18
19 Matrix01 operator & (Matrix01 &a,Matrix01 &b){ int i,j,k;
20     Matrix01 c;
21     c.Resize(a.n,b.m);
22     for(i = 0; i < a.n; ++i) {
23         c[i].reset();
24         for(j = 0; j < b.m; ++j)
25             if(a[i][j])
26                 c[i]|=b[j];
27     }
28     return c;
29 }
```

## 第九章 黑科技

### 9.1 位运算

```
1 //去掉最后一位
2 x >> 1
3 //在最后加一个0
4 x << 1
5 //在最后加一个1
6 x << 1 + 1
7 //把最后一位变成1
8 x | 1
9 //把最后一位变成0
10 x | 1 - 1
11 //最后一位取反
12 x ^ 1
13 //把右数第k位变成1
14 x | (1 << (k-1))
15 //把右数第k位变成0
16 x & ~ (1 << (k-1))
17 //右数第k位取反
18 x ^ (1 << (k-1))
19 //取末三位
20 x & 7
21 //取末k位
22 x & (1 << k-1)
23 //取右数第k位
24 x >> (k-1) & 1
25 //把末k位变成1
26 x | (1 << k-1)
27 //末k位取反
28 x ^ (1 << k-1)
29 //把右边连续的1变成0
30 x & (x+1)
31 //x个1
32 ((1<<x)-1)
33 //二进制里1的数量
34 (x>>16)+(x&((1<<16)-1))
```

### 9.2 珂朵莉树 (Old Driver Tree)

```
1 #include <set>
2 #include <algorithm>
```

```
3
4 using LL = long long;
5
6 struct node {
7     int l, r;
8     mutable LL v;
9     node(int L, int R = -1, LL V = 0) : l(L), r(R), v(V) {}
10    bool operator < (const node& o) const {
11        return l < o.l;
12    }
13 };
14
15 std::set<node> s;
16
17 //分割SET 返回一个pos位置的迭代器
18 std::set<node>::iterator split(int pos) {
19     auto it = s.lower_bound(node(pos));
20     if (it != s.end() && it->l == pos) return it;
21     --it;
22     if (pos > it->r) return s.end();
23     int L = it->l, R = it->r;
24     LL V = it->v;
25     s.erase(it);
26     s.insert(node(L, pos - 1, V));
27     return s.insert(node(pos, R, V)).first;
28 }
29
30 //区间加值
31 void add(int l, int r, LL val=1) {
32     split(l);
33     auto itr = split(r+1), itl = split(l);
34     for (; itl != itr; ++itl) itl->v += val;
35 }
36
37 //区间赋值
38 void assign(int l, int r, LL val = 0) {
39     split(l);
40     auto itr = split(r+1), itl = split(l);
41     s.erase(itl, itr);
42     s.insert(node(l, r, val));
43 }
```