
ACM TEMPLATE

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Contents

1	string	2
1.1	kmp	2
1.2	ekmp	2
1.3	manacher	3
1.4	ac 自动机	5
1.5	后缀数组	6
1.6	后缀自动机	9
1.7	elfhash	10
1.8	散列 hash	10
1.9	可获取任意段字符串的 hash	11
2	数学	12
2.1	素数	12
2.1.1	筛素数	12
2.1.2	Miller-Rabbin	12
2.2	Gcd	13
2.3	extend-gcd	13
2.3.1	求模线性方程	13
2.3.2	求逆	13
2.4	快速加	14
2.5	快速幂	14
2.6	矩阵类	14
2.7	容斥	15
2.8	组合数	16
2.8.1	暴力求解	16
2.8.2	打表	16
2.8.3	质因数分解	16
2.8.4	Lucas	18
2.9	pollardRho	19
2.10	欧拉函数	20
2.10.1	一般的求法	20
2.10.2	递推	20
2.10.3	单独求	20
2.11	高斯消元	21
2.11.1	模二消元	21
2.11.2	浮点	22
2.12	格雷码	22
2.13	离散对数	23
2.14	字典序	25
2.14.1	排列	25
2.14.2	组合	25
2.15	置换 polya	26
3	数据结构	27
3.1	树状数组	27
3.2	坐标离散	27
3.3	lca-rmq	28
3.4	rmq2d	29
3.5	划分树	31
3.6	扫描线矩形面积并	32

4	图论	35
4.1	前向星	35
4.2	并差集	35
4.3	spfa	35
4.4	LCA	36
4.5	Dinic	37
4.6	sap	38
4.7	费用流	40
5	计算几何	43
5.1	动态凸包	43

1 string

1.1 kmp

$\text{next}[j]$ 的值表示 $P[0\dots j-1]$ 中最长后缀的长度等于相同字符序列的前缀。

j 为最远位置使得 $\text{mod}[0\dots j-1] == \text{mod}[i-j+1\dots i]$

next 的值就是每个 j next 往前

重要的是理解那个往前

例: ababa nxt 为: 0 0 1 2 3

那么 $\text{nxt}[\text{nxt}[5]] = \text{nxt}[3] = 2$; 即 $s[0\dots 1] = s[2\dots 3]$

性质: $\text{Len} - \text{nxt}[\text{len}-1]$ 就是从 0 开始最短的串能重复出整个串, 比如 abcbabcb 就只需要 abc 就能重复完

```

1 int len1, len2, nxt[10005];
2 char mod[10005], s[1000005];
3 void get_nxt(char mod[], int len) {
4     int i, j = 0;
5     nxt[0] = 0;
6     for (i = 1; i < len; i++) {
7         while (j > 0 && mod[j] != mod[i]) j = nxt[j - 1];
8         if (mod[j] == mod[i]) j++;
9         nxt[i] = j;
10    }
11 }
12 int KMP(int len1, int len2, char s[], char mod[], int pos = 0)
13 {
14     int i = pos, j = 0, ret = 0;
15     while (i < len1) {
16         while (j && mod[j] != s[i]) j = nxt[j - 1];
17         if (mod[j] == s[i++]) {
18             if ((++j) == len2) ret++;
19         }
20     }
21     return ret;
22 }
```

1.2 ekmp

q 是 B 串继续向后匹配的指针, p 是 A 串继续向后匹配的指针, 也是曾经到达过的最远位置 +1

q 在每次计算后会减小 1, 直观的讲就是 B 串向后错了一位

```

1 const int N = 100010;
2
3 int len_s, len_t;
4 int nxt[N], extend[N];
5 char S[N], T[N];
6 void build_nxt()
7 {
8     int k, q, p, a;
9     nxt[0] = len_t;
```

```

10  for (k = 1, q = -1; k < len_t; k ++, q —) {
11      if (q < 0 || k + nxt[k - a] >= p) {
12          if (q < 0) q = 0, p = k;
13          while (p < len_t && T[p] == T[q]) {
14              p ++, q ++;
15          }
16          nxt[k] = q, a = k;
17      }
18      else {
19          nxt[k] = nxt[k - a];
20      }
21  }
22 }
23 void extend_KMP()
24 {
25     int k, q, p, a;
26     for (k = 0, q = -1; k < len_s; k ++, q —) {
27         if (q < 0 || k + nxt[k - a] >= p) {
28             if (q < 0) q = 0, p = k;
29             while (p < len_s && q < len_t && S[p] == T[q]) {
30                 p ++, q ++;
31             }
32             extend[k] = q, a = k;
33         }
34         else {
35             extend[k] = nxt[k - a];
36         }
37     }
38 }
39 int main(){
40     fi;
41     scanf("%s",S);
42     scanf("%s",T);
43
44     len_t=strlen(T);
45     len_s=strlen(S);
46     build_nxt();
47     extend_KMP();
48
49     return 0;
50 }

```

1.3 manacher

最长回文子串模板

hdu3068, 最长回文子串模板, Manacher 算法, 时间复杂度 $O(n)$, 相当快

str 是这样一串字符串 (下标从 1 开始):

举例: 若原字符串为 "abcd", 则 str 为 "\$#a#b#c#d#", 最后还有一个终止符。

n 为 str 的长度, 若原字符串长度为 nn, 则 $n=2*nn+2$ 。

rad[i] 表示回文的半径, 即最大的 j 满足 $str[i-j+1...i] = str[i+1...i+j]$,

而 $rad[i]-1$ 即为以 $str[i]$ 为中心的回文子串在原串中的长度

```

1  #define M 20000050
2  char str1[M],str[2*M]; //start from index 1
3  int rad[M],nn,n;
4  void Manacher(int *rad,char *str,int n)
5  {
6      int i;
7      int mx = 0;
8      int id;
9      for(i=1; i<n; i++)
10     {
11         if( mx > i ) rad[i] = rad[2*id-i]<mx-i?rad[2*id-i]:mx-i;
12         else rad[i] = 1;
13         for(; str[i+rad[i]] == str[i-rad[i]]; rad[i]++);
14         if( rad[i] + i > mx )
15         {
16             mx = rad[i] + i;
17             id = i;
18         }
19     }
20 }
21 struct PLD{
22     int l,r;
23     PLD(int x=0,int y = -1):l(x),r(y){}
24 }p[N];
25
26 void getlr(int n){
27     fr(i,2,n){
28         p[i].l = i-rad[i]+1;
29         p[i].l = (p[i].l+1)/2-1;
30         p[i].r = p[i].l+rad[i]-2;
31     }
32 }
33
34
35 int main()
36 {
37     int i,ans,Case=1;
38     while(scanf("%s",str1)!=EOF)
39     {
40         nn=strlen(str1);
41         n=2*nn+2;
42         str[0]='$';
43         for(i=0;i<=nn;i++)
44         {
45             str[2*i+1]='#';
46             str[2*i+2]=str1[i];
47         }
48         Manacher(rad,str,n);
49         ans=1;
50         for(i=0;i<n;i++)

```

```

51     ans=rad[i]>ans?rad[i]:ans;
52     printf("%d\n",ans-1);
53 }
54 return 0;
55 }

```

1.4 ac 自动机

```

1  char str[2000010];
2  char c[1010][55];
3
4  namespace AC {
5  const int dict = 26;
6  const int root = 0;
7  const int maxn = 3000000;
8  struct node {
9      int son[dict], fail, idx;
10 } tree[maxn];
11 int apr[10010];
12 bool vis[3000000];
13 int sz;
14 int initNode(int idx) {
15     memset(tree[idx].son, 0, sizeof(tree[idx]));
16     tree[idx].fail = tree[idx].idx = 0;
17     return idx;
18 }
19 void init() {
20     sz = initNode(0);
21     memset(apr, 0, sizeof(apr));
22 }
23 void ins(char *s, int idx) {
24     int cur = root, t;
25     while (*s) {
26         t = *s - 'A';
27         if (!tree[cur].son[t]) tree[cur].son[t] = initNode(++sz);
28         cur = tree[cur].son[t];
29         s++;
30     }
31     tree[cur].idx = idx;
32 }
33 queue<int> q;
34 void buildac() {
35     while(!q.empty()) q.pop();
36     int i, cur, nxt, f;
37     for ( i = 0 ; i < dict ; i++ )
38         if (tree[root].son[i]) q.push(tree[root].son[i]);
39
40     while (!q.empty()) {
41         cur = q.front();
42         q.pop();
43         f = tree[cur].fail;

```

```

44         for ( i = 0 ; i < dict ; i++ )
45             if (tree[cur].son[i]) {
46                 nxt = tree[cur].son[i];
47                 tree[nxt].fail = tree[f].son[i];
48                 q.push(nxt);
49             } else tree[cur].son[i] = tree[f].son[i];
50     }
51 }
52 void search(char *s) {
53     int i, cur = 0;
54     for ( ; *s ; s++ ) {
55         if( (*s) >= 'A' && (*s) <= 'Z' ) {
56             cur = tree[cur].son[*s - 'A'];
57             for ( i = cur ; i ; i = tree[i].fail ) { //用于优化vis
58                 apr[tree[i].idx]++;
59             }
60         } else {
61             cur = 0;
62         }
63     }
64     for(int i = 1; i <= 1010; ++i) {
65         if(apr[i]) {
66             printf("%s: %d\n", c[i], apr[i]);
67         }
68     }
69 }
70 };
71
72 int main() {
73     // freopen("input.txt", "r", stdin);
74     int n;
75
76     while(scanf("%d", &n) != EOF) {
77         AC::init();
78         for(int i = 1; i <= n ; ++i) {
79             scanf("%s", c[i]);
80             AC::ins(c[i], i);
81         }
82         AC::buildac();
83         getchar();
84         gets(str);
85         AC::search(str);
86     }
87
88     return 0;
89 }

```

1.5 后缀数组

da 函数的参数 m 代表字符串中字符的取值范围，是基数排序的一个参数，如果原序列都是字母可以直接取 128，如果原序列本身都是整数的话，则 m 可以取比最大的整数大 1 的值。
 $height[i] = LCP(i-1, i)$ $LCP(i, j) = lcp(\text{Suffix}(SA[i]), \text{Suffix}(SA[j]))$

就是从 $sa[i]$ 开始的后缀与从 $sa[j]$ 开始的后缀的最长公共前缀
 $LCP(i,j)=\min height[k] \mid i+1 \leq k \leq j$ 此时的 i, j 为 suffix 的对应值
 例: abaca
 rk 2 4 3 5 1 0
 sa 5 4 0 2 1 3
 height 0 0 1 1 0 0

```

1  const int maxn = 2010;
2  int wa[maxn],wb[maxn],wv[maxn],wss[maxn],sa[maxn];
3  bool cmp(int *r,int a,int b,int l)
4  {
5      return r[a]==r[b]&&r[a+l]==r[b+l];
6  }
7  void da(int *r,int *sa,int n,int m)
8  {
9      int i,j,p,*x=wa,*y=wb,*t;
10
11     for(i=0;i<m;i++) wss[i]=0;
12     for(i=0;i<n;i++) wss[x[i]=r[i]]++;
13     for(i=1;i<m;i++) wss[i]+=wss[i-1];
14     for(i=n-1;i>=0;i--) sa[--wss[x[i]]]=i;
15     for(j=1,p=1;p<n;j*=2,m=p)
16     {
17         for(p=0,i=n-j;i<n;i++) y[p++]=i;
18         for(i=0;i<n;i++) if(sa[i]>=j) y[p++]=sa[i]-j;
19         for(i=0;i<n;i++) wv[i]=x[y[i]];
20         for(i=0;i<m;i++) wss[i]=0;
21         for(i=0;i<n;i++) wss[wv[i]]++;
22         for(i=1;i<m;i++) wss[i]+=wss[i-1];
23         for(i=n-1;i>=0;i--) sa[--wss[wv[i]]]=y[i];
24         for(t=x,x=y,y=t,p=1,x[sa[0]]=0,i=1;i<n;i++)
25             x[sa[i]]=cmp(y,sa[i-1],sa[i],j)?p-1:p++;
26     }
27 }
28 int rk[maxn],height[maxn];
29 void calheight(int *r,int *sa,int n)
30 {
31     int i,j,k=0;
32     cl(rk);
33     for(i=1;i<=n;i++) rk[sa[i]]=i;
34     for(i=0;i<n;height[rk[i++]]=k)
35         for(k?k--:0,j=sa[rk[i]-1];r[i+k]==r[j+k];k++);
36 }
37 int dp[100010][18];
38 void rmqInit(int n){
39     fr(i, 0, n) dp[i][0] = height[i+2];
40     int k = (int)(log(n * 1.0) / log(2.0)); k++;
41     fr(j, 1, k){
42         for(int i = 0; i+(1 << j)-1 < n; ++i){
43             dp[i][j] = min(dp[i][j-1],dp[i+(1<<(j-1))][j-1]);
44         }
45     }
46 }

```

```

45     }
46 }
47 inline int query(int l ,int r){
48     int k = (int)(log(r * 1.0 - l + 1) / log(2.0));
49     return min(dp[l][k], dp[r-(1<=k)+1][k]);
50 }
51 int lcp(int l,int r){
52     int t ;
53     l = rk[l],r = rk[r];
54     if(l>r) l^=r^=l^=r;
55     return query(l-1,r-2);
56 }
57
58 bool check(int x,int k){
59     fr(i , 0 ,k-1){
60         if(lcp(i*x,(i+1)*x) < x) return 0;
61     }
62     return 1;
63 }
64 int c[maxn];
65 char str[maxn];
66 int maxrep[maxn];
67 int main(){
68     fi;
69     while(sfstr(str)!=EOF){
70         int len = strlen(str);
71         int k;
72         sfint(k);
73         if( k == 1 ){
74             printf("%lld\n", (long long)len*(long long)(len+1)/2);
75             continue;
76         }
77         ll ans = 0;
78         fr(i , 0 ,len) c[i] = str[i]-'a'+1;
79         c[len] = 0;
80         da(c,sa,len+1,27);
81         calheight(c,sa,len);
82         rmqInit(len-1);
83
84         for(int i = 0; i < len; ++i ) maxrep[i] = 1;
85
86         for(int L = 1; L*k <= len; ++L ) //rep[L次的有多少个]
87         {
88             for(int i = L; i < len; i += L ) if( maxrep[i-L] == 1 )
89             {
90                 int t = lcp(i-L, i);
91                 if( t )
92                 {
93                     int j = 0;
94                     while( j < L && i-L >= j && str[i-L-j] == str[i-j] )
95                     {

```

```

96         if( t >= L && lcp(i-L-j, i-j) >= (k-1)*L )
97             maxrep[i-L-j] = max(maxrep[i-L-j], t/L+1);
98             ++t, ++j;
99         }
100     }
101 }
102 }
103 for(int i = 0; i < len; ++i )
104     if( maxrep[i] >= k )
105         ans += ll(maxrep[i] - k + 1);
106 printf("%lld\n", ans);
107 }
108 return 0;
109 }

```

1.6 后缀自动机

```

1  const int  maxn=2000010;
2  const int  kinds=26;
3
4  char ch[maxn];
5
6  struct Sam{
7      Sam *son[kinds],*fa;
8      int l ,cnt;
9      bool vst;
10 }a[maxn],*head,*last;
11
12 int top=-1;
13 void add(int x){
14     Sam *p=&a[++top],*bj=last;
15     p->l=last->l+1;last=p;
16     for(; bj && !bj->son[x] ; bj = bj->fa) bj->son[x] = p;
17     if (!bj) p->fa = head;
18     else if (bj->l+1 == bj->son[x]->l) p->fa = bj->son[x];
19     else{
20         Sam *r = &a[ ++ top],*q = bj->son[x];
21         *r = *q ,r->l= bj->l+1, p->fa = q->fa = r;
22         for( ; bj && bj->son[x] == q; bj = bj->fa) bj->son[x] = r;
23     }
24 }
25
26 Sam *b[maxn];
27 Sam *sta[maxn];
28 int dws[maxn];
29 void caltimes(int n){ // n = lenstr;
30     int i;
31     for (i = 0; i <= top; ++i) ++dws[a[i].l];
32     for (i = 1; i <= n; ++i) dws[i] += dws[i - 1];
33     for (i = 0; i <= top; ++i) b[--dws[a[i].l]] = &a[i];
34     for (last = head, i = 0; i < n; ++i)

```

```

35     (last = last->son[ch[i] - 'a'])->cnt++;
36
37     for (i = top; i > 0; --i){
38         b[i]->fa->cnt += b[i]->cnt;
39     }
40 }
41
42 int main(){
43     scanf("%s",ch);
44     head = last = &a[++top];
45     int n=strlen(ch);
46     fr(i,0,n) add( ch[i] - 'a');
47     int i;
48     caltimes(n);
49     return 0;
50 }

```

1.7 elfhash

如果最高的四位不为 0，则说明字符多余 7 个，现在正在存第 8 个字符，如果不处理，再加下一个字符时，第一个字符会被移出，因此要有如下处理。

该处理，如果对于字符串 (a-z 或者 A-Z) 就会仅仅影响 5-8 位，否则会影响 5-31 位，因为 C 语言使用的算数移位

因为 1-4 位刚刚存储了新加入到字符，所以不能右移 28

上面这行代码并不会对 X 有影响，本身 X 和 hash 的高 4 位相同，下面这行代码即对 28-31(高 4 位) 位清零。

返回一个符号位为 0 的数，即丢弃最高位，以免函数外产生影响。(我们可以考虑，如果只有字符，符号位不可能为负)

hash 左移 4 位，把当前字符 ASCII 存入 hash 低四位。

```

1 unsigned int ELFHash(char *str)
2 {
3     unsigned int hash = 0;
4     unsigned int x = 0;
5
6     while (*str)
7     {
8         hash = (hash << 4) + (*str++);
9         if ((x = hash & 0xF0000000L) != 0)
10        {
11            hash ^= (x >> 24);
12            hash &= ~x;
13        }
14    }
15    return (hash & 0x7FFFFFFF);
16 }

```

1.8 散列 hash

```

1 struct hash_map{
2     const static int P = 999887;

```

```

3  int head[P], next[N],key[N];
4  int sz;
5  inline void init(){
6      cl(head), sz = 0;
7  }
8  inline int find(uint val){
9      int x = val % P;
10     for (int i=head[x]; i; i=next[i])
11         if (key[i] == val) return i;
12     return 0;
13 }
14 inline int insert(uint val){
15     ++sz; key[sz] = val;
16     int x = val % P; next[sz] = head[x]; head[x] = sz;
17     return sz;
18 }
19 } hashed;

```

1.9 可获取任意段字符串的 hash

```

1  unsigned int S[N],P[N];
2  void init(char *str,int n){
3      S[0] = 1,P[0] = 1;
4      fr(i ,1, n+1) P[i] =P[i-1]*Z; //是zbase
5      fr(i , 0 ,n) S[i+1] = S[i]*Z+(str[i]-'a'+1);
6  }
7  int H(PLD x){ //这里获得一段的值hash  x.l r 收尾位置
8      int l=x.l; int r=x.r;
9      return S[r+1] - S[l] * P[r-l+1];
10 }

```

2 数学

2.1 素数

2.1.1 筛素数

```

1 bool flag[N+1];
2 int prime[N+1];
3 int totpri;
4 void getpri(){
5     int n=N;
6     int i,j;totpri=0;
7     for(i=2;i<=n;++i) { /*筛选素数快速的方法*/
8         if(!flag[i]) prime[totpri++]=i;
9         for(j=0;j<totpri&& i*prime[j]<=n;++j)
10            {
11                flag[i*prime[j]]=1;
12                if(i%prime[j]==0) break;
13            }
14     }
15 }
```

2.1.2 Miller-Rabbin

```

1 bool primeTest(ll n, ll b) {
2     ll m = n - 1;
3     ll counter = 0;
4     while ((m & 1) == 0) {
5         m >>= 1;
6         counter ++;
7     }
8     ll ret = pow_mod(b, m, n);
9     if (ret == 1 || ret == n - 1) {
10         return true;
11     }
12     counter --;
13     while (counter >= 0) {
14         ret = add_mod(ret, ret, n);
15         if (ret == n - 1) {
16             return true;
17         }
18         counter --;
19     }
20     return false;
21 }
22
23 const int BASIC[12] = {2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37};
24
25 bool isPrime(ll n) {
26     if (n < 2) {
27         return false;
28     }
```

```

29     if (n < 4) {
30         return true;
31     }
32     if (n == 3215031751LL) {
33         return false;
34     }
35     for (int i = 0; i < 12 && BASIC[i] < n; ++ i) {
36         if (!primeTest(n, BASIC[i])) {
37             return false;
38         }
39     }
40     return true;
41 }

```

2.2 Gcd

```

1 int gcd(int a,int b)
2 {
3     if(b==0) return a;
4     return gcd(b,a%b);
5 }

```

2.3 extend-gcd

2.3.1 求模线性方程

```

1 int e_gcd(int a,int b,int &x,int &y)
2 {
3     if(b==0)
4     {x=1;y=0;return a;}
5     int ans=e_gcd(b,a%b,x,y);
6     int temp=x;
7     x=y;
8     y=temp-(a/b)*y;
9     return ans;
10 }

```

2.3.2 求逆

```

1 // a * x + b * y = gcd(a, b)
2 long long extGcd(long long a, long long b, long long& x, long long&
   y) {
3     if (b == 0) {
4         x = 1;
5         y = 0;
6         return a;
7     } else {
8         int g = extGcd(b, a % b, y, x);
9         y -= a / b * x;
10        return g;
11    }
12 }
13

```

```

14 // ASSUME: gcd(a, m) == 1
15 long long modInv(long long a, long long m) {
16     long long x, y;
17     extGcd(a, m, x, y);
18     return (x % m + m) % m;
19 }

```

2.4 快速加

```

1 ll add_mod(ll a,ll b,ll m){
2     ll ans=0;
3     a%=m;
4     while(b){
5         if(b&1) ans=(ans+a)%m;
6         a=(a+a)%m;
7         b>>=1;
8     }
9     return ans%m;
10 }

```

2.5 快速幂

```

1 ll pow_mod(ll a,ll b,ll m) {
2     ll ans=1;
3     a%=m;
4     while(b)
5     {
6         if(b&1) ans=(ans*a)%m;
7         a=(a*a)%m;
8         b>>=1;
9     }
10    return ans;
11 }

```

2.6 矩阵类

```

1 ll MOD=10000;
2 template<int MAXN=1010,int MAXM=1010, typename T = int>
3 struct Mat{
4     int n,m;
5     T a[MAXN][MAXM];
6     Mat(int _n=0,int _m=0):n(_n),m(_m){}
7     void clear(){
8         memset(a,0,sizeof(a));
9     }
10    void identity(){
11        memset(a,0,sizeof(a));
12        for(i , 0 ,n){
13            a[i][i] = 1;
14        }
15    }
16    Mat operator + (const Mat &b) const{
17        Mat tmp(n,m);

```



```

18         for(int i = 0;i<n;++i){
19             for(int j = 0;j<m;++j){
20                 tmp.a[i][j] = a[i][j] + b.a[i][j];
21             }
22         }
23         return tmp;
24     }
25     Mat operator - (const Mat &b) const{
26         Mat tmp(n,m);
27         for(int i = 0;i<n;++i){
28             for(int j = 0;j<m;++j){
29                 tmp.a[i][j] = a[i][j] - b.a[i][j];
30             }
31         }
32         return tmp;
33     }
34     Mat operator * (const Mat &b) const{
35         Mat tmp(n,m);
36         tmp.clear();
37         for(int i = 0;i<n;++i){
38             for(int j = 0;j<n;++j)
39                 for(int k = 0;k < n;++k){
40                     tmp.a[i][j] = (tmp.a[i][j] + a[i][k] * b.a[k][j]) %
                        MOD;
41                 }
42             }
43         return tmp;
44     }
45     Mat operator ^ (int b) {
46         Mat ret(n,m);
47         ret.identity();
48         while(b){
49             if(b&1)
50                 ret = (*this)*ret;
51             (*this) = (*this)*(*this);
52             b>>=1;
53         }
54         return ret;
55     }
56     void disp(){
57         fr(i , 0 ,n){
58             fr(j , 0 ,m){
59                 printf("%d_",a[i][j]);
60             }
61             puts("");
62         }
63     }
64 };

```

2.7 容斥

```
1 ll lim;
```

```

2 ll dfs(int pos,ll d){
3     ll ret = 0;
4     while(pos<totpri&&prime[pos] <= k&& prime[pos] * d<=lim){
5         ret += lim/(prime[pos]*d) - dfs(pos+1,d*prime[pos]);
6         pos++;
7     }
8     return ret;
9 }

```

2.8 组合数

2.8.1 暴力求解

```

1 C(n,m)=n*(n-1)*...*(n-m+1)/m, !n<=15
2 int Combination(int n, int m)
3 {
4     const int M = 10007;
5     int ans = 1;
6     for(int i=n; i>=(n-m+1); --i)
7         ans *= i;
8     while(m)
9         ans /= m--;
10    return ans % M;
11 }

```

2.8.2 打表

```

1 C(n,m)=C(n-1,m-1)+C(n-1,m), n<=10,000
2 const int M = 10007;
3 const int N = 1000;
4 ll C[N][N];
5 void initc(){
6     int i,j;
7     for(i=0; i<N; ++i){
8         C[0][i] = 0;
9         C[i][0] = 1;
10    }
11    for(i=1; i<N; ++i){
12        for(j=1; j<N; ++j)
13            C[i][j] = (C[i-1][j] + C[i-1][j-1]) % MOD;
14    }
15 }

```

2.8.3 质因数分解

$C(n,m)=n!/(m!(n-m)!)$, $C(n,m)=p_1a_1-b_1-c_1p_2a_2-b_2-c_2p_kak-b_k-ck,n\leq 10,000,000$

```

1 //用筛法生成素数
2 const int MAXN = 10000000;
3 bool arr[MAXN+1] = {false};
4 vector<int> produce_prim_number(){
5     vector<int> prim;
6     prim.push_back(2);
7     int i,j;

```

```

8   for(i=3; i*i<=MAXN; i+=2){
9       if(!arr[i]){
10          prim.push_back(i);
11          for(j=i*i; j<=MAXN; j+=i)
12             arr[j] = true;
13      }
14  }
15  while(i<=MAXN){
16      if(!arr[i])
17          prim.push_back(i);
18      i+=2;
19  }
20  return prim;
21 }
22
23 //计算n中素因子!的指数p
24 int Cal(int x, int p){
25     int ans = 0;
26     long long rec = p;
27     while(x>=rec){
28         ans += x/rec;
29         rec *= p;
30     }
31     return ans;
32 }
33
34 //计算的次方对取模, 二分法nkM
35 int Pow(long long n, int k, int M){
36     long long ans = 1;
37     while(k){
38         if(k&1){
39             ans = (ans * n) % M;
40         }
41         n = (n * n) % M;
42         k >>= 1;
43     }
44     return ans;
45 }
46
47 //计算C(n,m)
48 int Combination(int n, int m){
49     const int M = 10007;
50     vector<int> prim = produce_prim_number();
51     long long ans = 1;
52     int num;
53     for(int i=0; i<prim.size() && prim[i]<=n; ++i){
54         num = Cal(n, prim[i]) - Cal(m, prim[i]) - Cal(n-m, prim[i]);
55         ans = (ans * Pow(prim[i], num, M)) % M;
56     }
57     return ans;
58 }

```

2.8.4 Lucas

/* 定理, 将 m, n 化为 p 进制, 有: $C(n, m) = C(n_0, m_0) * C(n_1, m_1) \dots \pmod p$, 算一个不是很大的 $C(n, m) \% p$, p 为素数, 化为线性同余方程, 用扩展的欧几里德定理求解, n 在 `int` 范围内, 修改一下可以满足 `long long` 范围内。*/

```

1
2
3 const int M = 10007;
4 int ff[M+5]; //打表, 记录n, 避免重复计算!
5
6 //求最大公因数
7 int gcd(int a, int b){
8     if(b==0)
9         return a;
10    else
11        return gcd(b, a%b);
12 }
13
14 //解线性同余方程, 扩展欧几里德定理
15 int x, y;
16 void Extended_gcd(int a, int b){
17     if(b==0) {
18         x=1;
19         y=0;
20     }
21     else{
22         Extended_gcd(b, a%b);
23         long t=x;
24         x=y;
25         y=t-(a/b)*y;
26     }
27 }
28
29 //计算不大的C(n, m)
30 int C(int a, int b){
31     if(b>a)
32         return 0;
33     b=(ff[a-b]*ff[b])%M;
34     a=ff[a];
35     int c=gcd(a, b);
36     a/=c;
37     b/=c;
38     Extended_gcd(b, M);
39     x=(x+M)%M;
40     x=(x*a)%M;
41     return x;
42 }
43
44 //定理Lucas
45 int Combination(int n, int m){

```

```

46     int ans=1;
47     int a,b;
48     while(m||n){
49         a=n%M;
50         b=m%M;
51         n/=M;
52         m/=M;
53         ans=(ans*C(a,b))%M;
54     }
55     return ans;
56 }
57
58 int main(void){
59     int i,m,n;
60     ff[0]=1;
61     for(i=1;i<=M;i++) //预计算n!
62         ff[i]=(ff[i-1]*i)%M;
63
64     scanf("%d%d",&n, &m);
65     printf("%d\n",func(n,m));
66
67     return 0;
68 }

```

2.9 pollardRho

```

1 vector <ll> divisors;
2 ll pollardRho(ll n, ll seed) {
3     ll x, y;
4     x = y = rand() % (n - 1) + 1;
5     ll head = 1;
6     ll tail = 2;
7     while (true) {
8         x = pow_mod(x,2, n);
9         x = add_mod(x, seed, n);
10        if (x == y) {
11            return n;
12        }
13        ll d = gcd(abs(x - y), n);
14        if (1 < d && d < n) {
15            return d;
16        }
17        head ++;
18        if (head == tail) {
19            y = x;
20            tail <= 1;
21        }
22    }
23 }
24 void factorize(ll n) {
25     if (n > 1) {

```

```

26         if (isPrime(n)) {
27             divisors.push_back(n);
28         } else {
29             ll d = n;
30             while (d >= n) {
31                 d = pollardRho(n, rand() % (n - 1) + 1);
32             }
33             factorize(n / d);
34             factorize(d);
35         }
36     }
37 }

```

2.10 欧拉函数

2.10.1 一般的求法

```

1  const int N = 100010;
2  bool is_prime[N];
3  ll phi[N];
4  ll prime[N];
5  void init(){
6      ll i, j, k = 0;
7      phi[1] = 1;
8      for(i = 2; i < N; i++){
9          if(is_prime[i] == false){
10             prime[k++] = i;
11             phi[i] = i-1;
12         }
13         for(j = 0; j < k && i*prime[j] < N; j++){
14             is_prime[ i*prime[j] ] = true;
15             if(i%prime[j] == 0){
16                 phi[ i*prime[j] ] = phi[i] * prime[j];
17                 break;
18             }
19             else phi[ i*prime[j] ] = phi[i] * (prime[j]-1);
20         }
21     }
22 }

```

2.10.2 递推

```

1  for (i = 1; i <= maxn; i++) phi[i] = i;
2  for (i = 2; i <= maxn; i += 2) phi[i] /= 2;
3  for (i = 3; i <= maxn; i += 2) if(phi[i] == i) {
4      for (j = i; j <= maxn; j += i)
5          phi[j] = phi[j] / i * (i - 1);
6  }

```

2.10.3 单独求

```

1  ll Euler_Phi(ll n)
2  {
3      ll t = n, p = n;

```

```

4   ll sq = sqrt (n);
5
6   for (int i=0;prime[i]<=sq && i<totpri;i++)
7   {
8       if (t%prime[i]==0)
9       {
10          p = p/prime[i]*(prime[i]-1);
11
12          while (t%prime[i]==0)
13              t/=prime[i];
14
15          //sq = sqrt(t);
16      }
17
18      if (t == 1)
19          break;
20  }
21
22  if (t > 1)
23      p = p/t*(t-1);
24
25  return p;
26 }

```

2.11 高斯消元

2.11.1 模二消元

```

1  int gauss(int n){
2      int r,c;
3      for(r = 0, c=0;r<n,c<n;++r,++c){
4          int p = r;
5          fr(i , r+1,n){
6              if(a[i][c] > a[p][c]) p = i;
7          }
8          if (p != r){
9              fr(i , c,n+1){
10                 swap(a[p][i],a[r][i]);
11             }
12         }
13         if(a[r][c] == 0){
14             r--;continue;
15         }
16         fr(i , 0,n){
17             if (a[i][c] == 0||i == r) continue;
18             fr(j,c,n+1) a[i][j] = a[i][j]^a[r][j];
19         }
20     }
21     fr(i , r,n) if (a[i][n]) return -1;
22     return n-r;
23 }

```

2.11.2 浮点

```

1  const double eps = 1e-12;
2  const int MAXN = 30;
3  inline int gauss(double a[][4],bool l[],double ans[],const int &n){
4      int res = 0,r = 0;
5      for(int i = 0;i < n;++i) l[i] = false;
6      for(int i = 0;i < n;++i) {
7          for(int j = r;j < n;++j){
8              if( fabs(a[j][i]) > eps) {
9                  for(int k = i; k<= n;++k) swap(a[j][k], a[r][k]);
10                 break;
11             }
12         }
13         if( fabs(a[r][i]) < eps){
14             ++res;
15             continue;
16         }
17         for(int j = 0; j< n;++j){
18             if( j !=r&& fabs(a[j][i])>eps){
19                 double tmp = a[j][i] / a[r][i];
20                 for(int k = i ; k<=n ; ++k){
21                     a[j][k] -= tmp * a[r][k];
22                 }
23             }
24         }
25         l[i] = true;++r;
26     }
27
28     fr(i ,0 ,n){
29         fr(j , 0,n+1){
30             printf("%lf_",a[i][j]);
31         }
32         puts("");
33     }
34     for(int i = 0; i< n ;++i){ //有问题
35         if (l[i])
36             for(int j = 0; j< n; ++j){
37                 if (fabs(a[j][i]) > 0){
38                     ans[i] = a[j][n] / a[j][i];
39                 }
40             }
41     }
42     return res;
43 }

```

2.12 格雷码

生成 reflected gray code

每次调用 gray 取得下一个码

000...000 是第一个码,100...000 是最后一个码


```

1 void gray(int n,int *code){
2     int t=0,i;
3     for (i=0;i<n;t+=code[i++]);
4     if (t&1)
5         for (n--;!code[n];n--);
6         code[n-1]=1-code[n-1];
7 }

```

2.13 离散对数

```

1 #define MAXN 131071
2 struct HashNode {
3     ll data, id, next;
4 };
5 HashNode hash[MAXN<<1];
6 bool flag[MAXN<<1];
7 ll top;
8
9 void Insert ( ll a, ll b )
10 {
11     ll k = b & MAXN;
12     if ( flag[k] == false )
13     {
14         flag[k] = true;
15         hash[k].next = -1;
16         hash[k].id = a;
17         hash[k].data = b;
18         return;
19     }
20     while( hash[k].next != -1 )
21     {
22         if( hash[k].data == b ) return;
23         k = hash[k].next;
24     }
25     if ( hash[k].data == b ) return;
26     hash[k].next = ++top;
27     hash[top].next = -1;
28     hash[top].id = a;
29     hash[top].data = b;
30 }
31
32 ll Find ( ll b )
33 {
34     ll k = b & MAXN;
35     if( flag[k] == false ) return -1;
36     while ( k != -1 )
37     {
38         if( hash[k].data == b ) return hash[k].id;
39         k = hash[k].next;
40     }
41     return -1;

```

```

42 }
43
44 ll gcd ( ll a, ll b )
45 {
46     return b ? gcd ( b, a % b ) : a;
47 }
48
49 ll ext_gcd (ll a, ll b, ll& x, ll& y )
50 {
51     ll t, ret;
52     if ( b == 0 )
53     {
54         x = 1, y = 0;
55         return a;
56     }
57     ret = ext_gcd ( b, a % b, x, y );
58     t = x, x = y, y = t - a / b * y;
59     return ret;
60 }
61 ll mod_exp ( ll a, ll b, ll n )
62 {
63     ll ret = 1;
64     a = a % n;
65     while ( b >= 1 )
66     {
67         if( b & 1 )
68             ret = ret * a % n;
69         a = a * a % n;
70         b >>= 1;
71     }
72     return ret;
73 }
74
75 ll BabyStep_GiantStep ( ll A, ll B, ll C ) //A^X %C == B
76 {
77     memset(flag,0,sizeof(flag));
78     top = MAXN; B %= C;
79     ll tmp = 1, i;
80     for ( i = 0; i <= 100; tmp = tmp * A % C, i++ )
81         if ( tmp == B % C ) return i;
82
83     ll D = 1, cnt = 0;
84     while( (tmp = gcd(A,C)) !=1 )
85     {
86         if( B % tmp ) return -1;
87         C /= tmp;
88         B /= tmp;
89         D = D * A / tmp % C;
90         cnt++;
91     }
92

```

```

93     ll M = (ll)ceil(sqrt(C+0.0));
94     for ( tmp = 1, i = 0; i <= M; tmp = tmp * A % C, i++ )
95         Insert ( i, tmp );
96
97     ll x, y, K = mod_exp( A, M, C );
98     for ( i = 0; i <= M; i++ )
99     {
100         ext_gcd ( D, C, x, y ); // D * X = 1 ( mod C )
101         tmp = ((B * x) % C + C) % C;
102         if( (y = Find(tmp)) != -1 )
103             return i * M + y + cnt;
104         D = D * K % C;
105     }
106     return -1;
107 }

```

2.14 字典序

2.14.1 排列

```

1  int perm2num(int n, int *p) {
2      int i, j, ret = 0, k = 1;
3      for (i = n - 2; i >= 0; k *= n - (i—))
4          for (j = i + 1; j < n; j++)
5              if (p[j] < p[i])
6                  ret += k;
7      return ret;
8  }
9  void num2perm(int n, int *p, int t) {
10     int i, j;
11     for (i = n - 1; i >= 0; i—)
12         p[i] = t % (n - i), t /= n - i;
13     for (i = n - 1; i; i—)
14         for (j = i - 1; j >= 0; j—)
15             if (p[j] <= p[i])
16                 p[i]++;
17 }

```

2.14.2 组合

```

1  int comb(int n, int m) {
2      int ret = 1, i;
3      m = m < (n - m) ? m : (n - m);
4      for (i = n - m + 1; i <= n; ret *= (i++));
5      for (i = 1; i <= m; ret /= (i++));
6      return m < 0 ? 0 : ret;
7  }
8  int comb2num(int n, int m, int *c) {
9      int ret = comb(n, m), i;
10     for (i = 0; i < m; i++)
11         ret —= comb(n - c[i], m - i);
12     return ret;
13 }

```

```

14 void num2comb(int n, int m, int* c, int t) {
15     int i, j = 1, k;
16     for (i = 0; i < m; c[i++] = j++)
17         for (; t > (k = comb(n - j, m - i - 1)); t -= k, j++);
18 }

```

2.15 置换 polya

求置换的循环节, polya 原理

perm[0..n-1] 为 0..n-1 的一个置换 (排列)

返回置换最小周期, num 返回循环节个数

```

1 #define MAXN 1000
2 int polya(int* perm, int n, int& num) {
3     int i, j, p, v[MAXN] = {0}, ret = 1;
4     for (num = i = 0; i < n; i++)
5         if (!v[i]) {
6             for (num++, j = 0, p = i; !v[p = perm[p]]; j++)
7                 v[p] = 1;
8             ret *= j / gcd(ret, j);
9         }
10    return ret;
11 }

```

3 数据结构

3.1 树状数组

注意 init 的时候要小一个 1

```

1  template<int MAXN=300000, typename T = int>
2  struct BIT {
3      int n;
4      T a[MAXN];
5
6      void init(int n) {
7          this->n = n;
8          fill(a, a + n + 1, T());
9      }
10     void add(int i, T v) {
11         for (int j = i; j <= n; j = (j | (j - 1)) + 1) {
12             a[j] += v;
13         }
14     }
15     //(0..i];
16     T sum(int i) const {
17         T ret = T();
18         for (int j = i; j > 0; j = j & (j - 1)) {
19             ret += a[j];
20         }
21         return ret;
22     }
23     T get(int i) const {
24         return sum(i) - sum(i-1);
25     }
26     void set(int i, T v) {
27         add(i, v - get(i));
28     }
29
30     void add(int l, int r, T v) //need sum is ith val; get && set
        can't use;
31     {
32         add(l, v); add(r+1, -v);
33     }
34 };

```

3.2 坐标离散

注意下标~

```

1  const int MaxN=100;
2  int axis[MaxN];
3  int r[MaxN]; //排序用到的数组;
4  int mp[MaxN]; //离散值到原始值的映射;
5  int M; //离散值的最大值, [1, M];

```

```

6 bool cmp(int a, int b) {return axis[a] < axis[b];}
7 void Lisan(int N)
8 {
9     for(int i=0; i<N; i++) r[i] = i;
10    sort(r, r+N, cmp);
11    mp[1] = axis[r[0]];
12    axis[r[0]] = M = 1;
13    for(int i=1; i<N; i++)
14    {
15        if(axis[r[i]] == mp[M]) axis[r[i]] = M;
16        else mp[++M] = axis[r[i]], axis[r[i]] = M;
17    }
18 }
19 int main(){
20     for (int i=0;i<5;i++) scanf("%d",&axis[i]);
21     Lisan(5);
22     return 0;
23 }

```

3.3 lca-rmq

```

1 using namespace std;
2 typedef long long ll;
3 const int N=10010;
4 int n;
5 struct E{
6     int u,v,nxt,w;
7 }edg[2000010];
8
9 int tote,head[N];
10 void init(){
11     tote=0;
12     memset(head,-1,sizeof(head));
13 }
14 inline void addedg(int u,int v){
15     edg[tote].u=u;edg[tote].v=v;edg[tote].nxt=head[u];head[u]=tote++;
16 };
17
18 int vst[N],e[N<<1],r[N],d[N<<1];
19 int cnt;
20 int fa[N];
21 void dfs(int u, int depth) {
22     vst[u] = true;
23     e[cnt] = u;
24     d[cnt] = depth;
25     r[u] = cnt++;
26     for(int i=head[u];i!=-1;i=edg[i].nxt){
27         int v=edg[i].v;
28         if (!vst[v]){
29             dfs(v,depth+1);
30             e[cnt]=u;

```

```

31     d[cnt++]=depth;
32 }
33 }
34 }
35 inline int _min(int i, int j) {
36     if (d[i] < d[j]) return i;
37     return j;
38 }
39 int dp[2*N][16];
40 void rmpinit(){
41     int nn = 2 * n - 1;
42     for (int i = 0; i < nn; ++i) //下标是从开始的0
43         dp[i][0] = i;
44     int k = (int)(log(nn * 1.0) / log(2.0));
45     for (int j = 1; j <= k; ++j) {
46         for (int i = 0; i + (1 << j) - 1 < nn; ++i)
47             dp[i][j] = _min(dp[i][j-1], dp[i+(1<<(j-1))][j-1]);
48     }
49 }
50 inline int query(int l, int r) {
51     int k = (int)(log(r * 1.0 - l + 1) / log(2.0));
52     return _min(dp[l][k], dp[r-(1<<k)+1][k]);
53 }
54 int main(){
55     //fi;
56     int t;
57     scanf("%d",&t);
58     int u,v;
59     while(t--){
60         scanf("%d",&n);
61         init();
62         fr(i,0,n+1) fa[i]=i;
63         fr(i,0,n-1){
64             scanf("%d%d",&u,&v);
65             addedg(u,v);//addedg(v,u);
66             fa[v]=u;
67         }
68         int root;
69         fr(i,1,n+1) if (fa[i]==i) {root=i;break;}
70         cnt=0;cl(vst);
71         dfs(root,0);
72         rmpinit();
73
74         scanf("%d%d",&u,&v);
75         if (r[u]<=r[v]) printf("%d\n", e[query(r[u], r[v])]);
76         else printf("%d\n", e[query(r[v], r[u])]);
77     }
78     return 0;
79 }

```

3.4 rmq2d

```

1  const dl _eps=1e-6;
2  const int N = 301;
3  int t,n;
4  int dp[N][N][9][9];
5  void in(int &a)
6  {
7      char c,f;
8      while(((f=getchar())<'0' || f>'9')&&f!='-');
9      c=(f=='-')?getchar():f;
10     for(a=0;c>='0'&&c<='9';c=getchar())a=a*10+c-'0';
11     if(f=='-')a=-a;
12 }
13 void initrmq(){
14     int i,j;
15     int m = log(double(n)) / log(2.0);
16     fr(i,0,m+1){
17         fr(j,0,m+1){
18             if (i==0 && j==0) continue;
19             for(int r = 0; r+(1<<i)-1 < n; ++r){
20                 for(int c = 0; c+(1<<j)-1 < n; ++c){
21                     if(i == 0) dp[r][c][i][j] = min(dp[r][c][i][j-1] , dp[r][
22                         c+(1<<(j-1))][i][j-1]);
23                     else dp[r][c][i][j] = min(dp[r][c][i-1][j] , dp[r+(1<<(i
24                         -1))][c][i-1][j]);
25                 }
26             }
27         }
28     }
29     int rmq_2d_query(int X1,int Y1,int X2,int Y2){
30         int x = log(double(X2 - X1 +1)) / log(2.0);
31         int y = log(double(Y2 - Y1 +1)) / log(2.0);
32         int m1 = dp[X1][Y1][x][y];
33         int m2 = dp[X2-(1<<x)+1][Y1][x][y];
34         int m3 = dp[X1][Y2-(1<<y)+1][x][y];
35         int m4 = dp[X2-(1<<x)+1][Y2-(1<<y)+1][x][y];
36         return min(min(m1,m2),min(m3,m4));
37     }
38     void inp(){
39         int i,j,m,X1,Y1,X2,Y2;
40         in(n);
41         fr(i , 0,n){
42             fr(j,0,n){
43                 in(dp[i][j][0][0]);
44             }
45         }
46         initrmq();
47         sfint(m);
48         while(m--){
49             in(X1);in(Y1);in(X2);in(Y2);

```



```

50     printf("%d\n",rmq_2d_query(X1-1,Y1-1,X2-1,Y2-1));
51 }
52 }
53 int main(){
54     fi;
55     sfint(t);
56     while(t--){
57         inp();
58     }
59     return 0;
60 }

```

3.5 划分树

```

1  int a[100001];
2  int b[21][100001];
3  int sum[21][100001];    //sum[i表示]l—这些点中有多少个进入了左子树。i
4  int n,m;
5
6  void build(int l,int r,int d){    //代表在树上第几层d
7      if (l==r) return;
8      int i,mid=(l+r)>>1,id1=l,id2=mid+1,midsum=0;
9      for (i=mid;i>=l&&a[i]==a[mid];i--)midsum+=1;
10     for (i=l;i<=r;i++){
11         sum[d][i]=i==l?0:sum[d][i-1];
12         if (b[d][i]<a[mid]){
13             b[d+1][id1++]=b[d][i];
14             sum[d][i]+=1;
15         }
16         else if(b[d][i]==a[mid]&&midsum){
17             midsum-=1;
18             b[d+1][id1++]=b[d][i];
19             sum[d][i]+=1;
20         }
21         else b[d+1][id2++]=b[d][i];
22     }
23     build(l,mid,d+1);
24     build(mid+1,r,d+1);
25 }
26
27 int search(int x,int y,int k){
28     int l=1,r=n,d=0;
29     int ls,rs,mid;
30     while (x!=y){
31         ls=x==l?0:sum[d][x-1];    //因为要包含x
32         rs=sum[d][y];
33         mid=(l+r)>>1;
34         if (k<=rs-ls) {            //在左子树上
35             x=l+ls;
36             y=l+rs-1;
37             r=mid;
38         }

```

```

39     else                //在右子树上
40     {
41         x=mid+1+x-l-ls;  // (x-l-ls)是指处在前面且进入右子树的个数，因为在
                           子树中保持位置顺序不变，所以在右子树中前面有xx(x-l-ls)个数。
42         y=mid+1+y-l-rs;
43         k-=rs-ls;
44         l=mid+1;
45     }
46     d+=1;
47 }
48 return b[d][x];
49 }
50
51 int main(){
52     freopen("in.txt","r",stdin);
53     int cnt=1;
54     while(scanf("%d",&n)!=EOF){
55         int i,x,y,t;
56         for (i=1;i<=n;i++){
57             scanf("%d",&t);
58             a[i]=b[0][i]=t;
59         }
60         sort(a+1,a+n+1);
61         build(1,n,0);
62         scanf("%d",&m);
63         printf("Case_ %d:\n",cnt++);
64         while(m--){
65             scanf("%d%d",&x,&y);
66             int k=(y-x+1)/2+1;
67             printf("%d\n",search(x,y,k));
68         }
69     }
70     return 0;
71 }

```

3.6 扫描线矩形面积并

```

1  const int N = 400000;
2  int n;
3  struct ARR {
4      int a[N];
5      int tot;
6      void init(){tot = 0;}
7      void add(int x){
8          a[tot++] = x;
9      }
10     void uni() {
11         sort(a,a+tot);
12         tot = unique(a,a+tot)-a;
13     }
14     int fd(int x){
15         return lower_bound(a,a+tot,x)-a;

```

```

16     }
17 }A;
18 struct Line{
19     int s,e,y,f;
20     bool operator < (const Line & l) const {
21         if( y == l.y) return s < l.s;
22         return y < l.y;
23     }
24 }l[N];
25 int tot;
26 void add_line(int s,int e,int y,int f){
27     if (s == e) return ;
28     A.add(s);A.add(e);
29     l[tot].s = s;l[tot].e = e;l[tot].y = y;l[tot++].f = f;
30 }
31 void init(){
32     tot = 0;A.init();
33     sfint(n);
34     int x,y,h;
35     fr(i , 0 ,n){
36         sfint3(x,y,h);
37         add_line(x,y,0,1);
38         add_line(x,y,h,-1);
39     }
40     /*int x1, y1, x2, y2, x3, y3, x4, y4;
41     fr(i , 0 ,n){
42         scanf("%d%d%d%d%d%d%d", &x1,&y1,&x2,&y2,&x3,&y3,&x4,&y4);
43         add_line(x1,x3,y1,1); add_line(x1,x3,y2,-1);
44         add_line(x3,x4,y1,1); add_line(x3,x4,y3,-1);
45         add_line(x3,x4,y4,1); add_line(x3,x4,y2,-1);
46         add_line(x4,x2,y1,1); add_line(x4,x2,y2,-1);
47     }*/
48     A.uni();
49 }
50
51 struct SEGT{
52     struct SEGtr
53     {
54         int l,r,cov;
55         ll len;
56     }tr[N*4];
57     void build(int rt,int l,int r){
58         tr[rt].l = l;tr[rt].r = r;tr[rt].cov = 0;tr[rt].len = 0;
59         if(l == r){
60             return;
61         }
62         int mid = (l+r)>>1;
63         build(rt<<1,l,mid);
64         build(rt<<1|1,mid+1,r);
65     }
66     void up(int rt){

```

```

67     if(tr[rt].cov != 0) tr[rt].len = A.a[tr[rt].r+1]-A.a[tr[rt].l];
68     else if( tr[rt].l == tr[rt].r) tr[rt].len = 0;
69     else {
70         tr[rt].len=tr[rt<<1].len+tr[rt<<1|1].len;
71     }
72 }
73 void update(int rt,int l,int r,int add){
74     if(tr[rt].l >= l && tr[rt].r <= r) {
75         tr[rt].cov += add;
76         up(rt);
77         return ;
78     }
79     int mid = (tr[rt].l + tr[rt].r)>>1;
80     if(r <= mid)
81         update(rt<<1,l,r,add);
82     else if(l >mid)
83         update(rt<<1|1,l,r,add);
84     else{
85         update(rt<<1,l,mid,add);
86         update(rt<<1|1,mid+1,r,add);
87     }
88     up(rt);
89 }
90 }S;
91 void sol(){
92     sort(l,l+tot);
93     S.build(1,0,A.tot-2);
94     S.update(1,A.fd(l[0].s),A.fd(l[0].e)-1,l[0].f);
95     ll ans = 0;
96     fr(i , 1 ,tot){
97         ans += (ll(l[i].y - l[i-1].y))*ll(S.tr[1].len);
98         S.update(1, A.fd(l[i].s),A.fd(l[i].e)-1,l[i].f);
99     }
100     printf("%lld\n",ans);
101 }

```

4 图论

4.1 前向星

```

1  const int N = 1010;const int M = 2010;
2  struct Edg
3  {
4      int u,v,w,nxt;
5  }edg[M];
6  int tote,head[N];
7  void init(){
8      tote = 0;
9      memset(head,-1,sizeof(head));
10 }
11 inline void addedg(int u,int v){
12     edg[tote].u=u;edg[tote].v=v;edg[tote].nxt=head[u];head[u]=tote++;
13 };
14 inline void addedg(int u,int v,int w){
15     edg[tote].u=u;edg[tote].v=v;edg[tote].w=w;edg[tote].nxt=head[u];
16     head[u]=tote++;
17 };

```

4.2 并差集

```

1  struct DisjointSet{
2      int fa[N];
3      int tot;
4      void init(int n){
5          fr(i , 0 ,n){
6              fa[i] = i;
7          }
8          tot = 0;
9      }
10     int find(int x){
11         return x==fa[x]?x:fa[x]=find(fa[x]);
12     };
13     void un(int x,int y){
14         int fx = find(x);
15         int fy = find(y);
16         if(fx != fy){
17             fa[fy] = fx;
18             tot--;
19         }
20     }
21 }DS;

```

4.3 spfa

```

1  bool spfa(int s){
2      for(i = 1; i <= n; ++i) d[i] = INF;
3      d[s] = 0;
4      q.push(s);

```

```

5   while(不为空q){
6       u = q.front();
7       q.pop();
8       for all edge(u, v, e)
9           if(d[v] > d[u] + e){
10              d[v] = d[u] + e;
11              if(不在中vq) { //这里用vst
12                  q.push(v);
13                  if(入队次数v==n) return false;
14              }
15          }退出队列
16
17      }
18      return true;
19  }

```

4.4 LCA

```

1  const int MAXM = 16;
2  const int MAXN = 1 << MAXM;
3  struct LCA {
4      vector<int> e[MAXN];
5      int d[MAXN], p[MAXN][MAXM];
6      void dfs_(int v, int f) {
7          p[v][0] = f;
8          for (int i = 1; i < MAXM; ++i) {
9              p[v][i] = p[p[v][i - 1]][i - 1];
10         }
11         for (int i = 0; i < (int)e[v].size(); ++i) {
12             int w = e[v][i];
13             if (w != f) {
14                 d[w] = d[v] + 1;
15                 dfs_(w, v);
16             }
17         }
18     }
19
20     void init(int n) { //vector<int> e[MAXN]
21         //copy(e, e + n, this->e);
22         d[0] = 0;
23         dfs_(0, 0);
24     }
25
26     int up_(int v, int m) {
27         for (int i = 0; i < MAXM; ++i) {
28             if (m & (1 << i)) {
29                 v = p[v][i];
30             }
31         }
32         return v;
33     }
34 }

```

```

35 int lca(int a, int b) {
36     if (d[a] > d[b]) {
37         swap(a, b);
38     }
39     b = up_(b, d[b] - d[a]);
40     if (a == b) {
41         return a;
42     } else {
43         for (int i = MAXM - 1; i >= 0; --i) {
44             if (p[a][i] != p[b][i]) {
45                 a = p[a][i];
46                 b = p[b][i];
47             }
48         }
49         return p[a][0];
50     }
51 }
52 void add(int u, int v){
53     e[u].push_back(v);
54 }
55 } lca;

```

4.5 Dinic

```

1  const int pN=2000,eN=3000000;
2  struct Edge{
3      int u,v,nxt;
4      int w;
5  }e[eN];
6
7  int en,head[pN];
8
9  void init(){
10     memset(head,-1,sizeof(head));
11     en=0;
12 }
13 void add(int u,int v,int w){
14     e[en].u=u;e[en].v=v;e[en].w=w;e[en].nxt=head[u];head[u]=en++;
15     e[en].u=v;e[en].v=u;e[en].w=0;e[en].nxt=head[v];head[v]=en++;
16 }
17
18 int cur[pN],sta[pN],dep[pN];
19 int max_flow(int n,int s,int t){
20     int tr,flow = 0;
21     int i,u,v,f,r,top; //即是ffront 队列的头部
22     int j;
23     while(1){
24         memset(dep,-1,n*sizeof(int));
25         for( f = dep[ sta[0] = s ] = 0 ,r = 1;f != r;){
26             for( u = sta[f++],i = head[u];i != -1;i = e[i].nxt){
27                 if (e[i].w && dep[ v = e[i].v ] == -1){
28                     dep[v] = dep[u] + 1;

```

```

29         sta[r++] = v; //将入队列v 向后标号法
30         if (v == t){
31             f = r;
32             break;
33         }
34     }
35 }
36 }
37 if (-1 == dep[t]) break;
38 memcpy(cur, head, n * sizeof(int));
39 for (i = s, top = 0; ;){
40     if (i == t){
41         for( j = 0 , tr = inf; j < top; ++j){ //找出一条增广路的最小边
            权
42             if (e[ sta[j] ].w < tr){
43                 tr = e[ sta[ f = j ] ].w; //一个简单优化每一次不用从头开始
                    找增广
44             }
45         }
46         for( j = 0; j < top; ++j){
47             e[ sta[j] ].w -= tr;
48             e[ sta[j]^1 ].w += tr;
49         }
50         flow += tr;
51         i = e[ sta[top = f] ].u;
52     }
53     for(j = cur[i]; cur[i] != -1; j = cur[i] = e[cur[i]].nxt) //
        为当前的栈顶元
        素i
54         if (e[j].w && dep[i] + 1 == dep[e[j].v]) break; //找到了一条
            路径最短的增广边

55
56     if (cur[i] != -1){ //就是这个点还有出度
57         sta[ top++ ] = cur[i];
58         i = e[ cur[i] ].v;
59     }
60     else{
61         if (top == 0) break;
62         dep[i] = -1;
63         i = e[sta[--top]].u;
64     }
65 }
66 }
67 return flow;
68 }

```

4.6 sap

这里是与 dinic 不同的地方不用每次的 bfs 而是充分利用以前的距离标号的信息有这个定理：从源点到汇点的最短路一定是用允许弧构成。所以每次扩展路径都找允许弧，如果 i 没有允许弧就更新 $dis[i] = \min dis[j] + 1$ 或者 $r[i][j]$ 大于 0)；

```
1 #define inf 1000000000
```



```

2  using namespace std;
3
4  const int pN=5000,eN=100000;
5
6  struct Edge{
7      int u,v,nxt;
8      int w;
9  }e[eN];
10
11  int en,head[pN];
12
13  void init(){
14      memset(head,-1,sizeof(head));
15      en=0;
16  }
17  void add(int u,int v,int w){
18      e[en].u=u;e[en].v=v;e[en].w=w;e[en].nxt=head[u];head[u]=en++;
19      e[en].u=v;e[en].v=u;e[en].w=0;e[en].nxt=head[v];head[v]=en++;
20  }
21  int dep[pN],gap[pN],que[pN]; //gap 每一次重标号时若出现了断层，则可以证明
    无可行流，此时可以直接退出算法 st
22  void BFS(int n,int s,int t){
23      memset(dep,-1,n * sizeof(int));
24      memset(gap, 0 ,n * sizeof (int));
25      gap[0] = 1;
26      int f = 0,r = 0,u,v;
27      dep[ t ] = 0; que[r ++] = t; //从后外前面标号
28      while(f != r){
29          u = que[f ++];
30          if ( f == pN) f = 0;
31          for(int i = head[u];i != -1;i = e[i].nxt){
32              v = e[i].v;
33              if (e[i].w != 0 || dep[v] != -1) continue; //如果容量为0 就根
                本到不到它
34              que[ r++ ] = v;
35              if (r == pN) r = 0;
36              dep[ v ] = dep[ u ] + 1;
37              ++ gap[dep[ v ]]; //这里的就是每一层有多少个点gap
38          }
39      }
40  }
41
42  int cur[pN],sta[pN];
43  int sap(int n,int s,int t){ //为总的点个数n 包括源点和汇点
44      int flow = 0;
45      BFS(n,s,t);
46      int top = 0,u = s,i;
47      memcpy(cur,head,n*sizeof(int)); //当前弧
48      while( dep[s] < n){
49          if ( u == t){
50              int tmp = inf;

```

```

51     int pos;
52     for(i = 0; i < top; i++){
53         if (tmp > e[ sta[i] ].w){
54             tmp = e[ sta[i] ].w;
55             pos = i;
56         }
57     }
58     for(i = 0; i < top; ++i){
59         e[ sta[i] ].w -= tmp;
60         e[ sta[i]^1 ].w += tmp;
61     }
62     flow += tmp;
63     top = pos;
64     u = e[sta[top]].u;
65 }
66 if(u != t && gap[dep[u] - 1] == 0) break; //gap 优化出现断层后
    直接退出
67 for(i = cur[u] ; i != -1 ; i = e[i].nxt) //当前弧优化 因
    为以前的弧绝对不满足要求
68     if(e[i].w != 0 && dep[u] == dep[e[i].v] + 1) break; //找到了一条最短增广路
69 if (i != -1) cur[ u ] = i, sta[top++] = i, u = e[i].v;
70 else{
71     //这里与不同dinic
72     int mn = n;
73     for (i = head[u] ; i != -1; i = e[i].nxt){
74         if ( e[i].w != 0 && mn > dep[ e[i].v ] ){
75             mn = dep[ e[i].v ] ;
76             cur[u] = i;
77         }
78     }
79     -- gap[ dep[u] ];
80     dep[u] = mn + 1;
81     ++ gap[ dep[u] ];
82     if (u != s) u = e[sta[--top]].u;
83 }
84 }
85 return flow;
86 }

```

4.7 费用流

```

1  const int inf = 0xffffffff;
2  #define M 200001
3  #define maxx 2000
4  class MCMF{
5  public:
6      struct T{
7          int u, v, w;
8          int nxt, cost;
9      }edge[M];

```

```

10  int en;
11  int visit[M], pre[M], dist[M], que[M], vis[M], pos[M];
12  void init(){
13      memset(vis,-1,sizeof(vis));
14      en=0;
15  }
16  void add(int u, int v, int w, int cost)
17  {
18      edge[en].u = u, edge[en].v = v, edge[en].w = w, edge[en].cost =
          cost;
19      edge[en].nxt = vis[u], vis[u] = en++;
20      edge[en].u = v, edge[en].v = u, edge[en].w = 0, edge[en].cost =
          -cost;
21      edge[en].nxt = vis[v], vis[v] = en++;
22  }
23  bool spfa(int n,int s,int t){
24      int v,k;
25      for (int i = 0;i <= n; i++){
26          pre[i] = -1,visit[i] = 0;
27      }
28      int f = 0,r = 0;
29      for (int i = 0;i <= n; ++i) dist[i] = -1;
30      que[r++] = s;pre[s] = s;dist[s] = 0;visit[s] = 1;
31      while(f != r){
32          int u = que[f++];
33          visit[u] = 0;
34          for (k = vis[u] ;k != -1;k = edge[k].nxt){
35              v = edge[k].v;
36              if (edge[k].w && dist[u] + edge[k].cost > dist[v]){
37                  dist[v] = dist[u] + edge[k].cost;
38                  pre[v] = u;
39                  pos[v] = k;    //是哪一条边到大的v 巧妙呀值得学习一下 ~~~
40                  if (! visit[v]){
41                      visit[v] = 1;
42                      que[r++] = v;
43                  }
44              }
45          }
46      }
47      if (pre[t] != -1 &&dist[t] > -1) return 1;
48      return 0;
49  }
50  int mnCostFlow(int n,int s,int t){
51      if (s == t){}
52      int flow =0,cost =0;
53      while(spfa(n,s,t)){
54          int u,mn = inf;
55          for( u = t;u != s; u = pre[u])
56              if (mn > edge[pos[u]].w) mn = edge[pos[u]].w;
57          flow += mn;
58          cost += dist[t] * mn;

```

```
59         for(u = t;u != s;u = pre[u]){
60             edge[pos[u]].w -= mn;
61             edge[pos[u]^1].w += mn;
62         }
63     }
64     return cost;
65 }
66 }mcf;
```

5 计算几何

5.1 动态凸包

```

1  const double eps = 1e-9;
2  typedef pair<int,int> pii;
3
4  struct dynamic_Convex{
5      map<int,int> cvex[2]; //cvex[0] upper contex line, cvex[1] lower
        convex line
6      map<int,int>::iterator p,q,it;
7      double cross(pii a,pii b,pii c){
8          return (double(b.first - a.first)) * (double(c.second - a.
                second))
9              - (double(b.second - a.second))*(double(c.first - a.first));
10     }
11     bool IsUnderUpper(map<int,int> &st,int x,int y){ //check if the
        point is under the upper convex line
12         if( !st.size()) return false;
13         if (x < st.begin()->first || x > (--st.end()->first ) return
            false;
14         if (st.find(x) != st.end()) return y <= st[x];
15         p = st.upper_bound(x);
16         q = p;q--;
17         return !(cross(make_pair(x,y) , *q,*p) > eps);
18     }
19     void insUpperConvex(map<int,int> &st, int x,int y){ //insert a
        point to upper convex line
20         if( IsUnderUpper(st,x,y) ) return ;
21         st[x] = y;
22         p = st.upper_bound(x);
23         it = p;it--;
24         if ( p!=st.end()){
25             q = p;q++;
26             while(q != st.end() && cross(make_pair(x,y) , *p, *q) >=eps )
                {
27                 st.erase(p);p = q;q++;
28             }
29         }
30         if ( it != st.begin() ){
31             p = it;p--;q = p ;q--;
32             while(p != st.begin() && cross(make_pair(x,y),*q,*p) > -eps){
33                 st.erase(p);p = q;q--;
34             }
35         }
36     }
37     bool judge(int x,int y){ //check if the poing is in the convex
        hull
38         return IsUnderUpper(cvex[0],x,y) && IsUnderUpper(cvex[1],x,-y);
39     }
40     void ins(int x,int y){ //insert a point to convex hull;

```

```
41     insUpperConvex(cvex[0],x,y);
42     insUpperConvex(cvex[1],x,-y);
43 }
44 }dc;
```