ACM-ICPC Template

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1 Dynamic Programming

1.1 LCS - Longest Common Subsequence

```
int LCS() // O(N*N)
{//字符串纠正到以 1 为下标
    int f[N][N];
    int res = 0;
    for(int i = 1; i < lena; i++)
        for(int j = 1; j < lenb; j++)
        {
            if(a[i] == a[j]) f[i][j] = f[i-1][j-1] + 1;
            else f[i][j] = max(f[i-1][j], f[i][j-1]);
            res = max(res, f[i][j]);
        }
    return res;
}

int LCS() // O(NlogN)
{//把 LCM 转化为 LIS 来做
// 1 2 5 9 3 -->> 1 2 3 4 5
// 1 5 3 9 2 -->> 1 3 5 4 2 -->> 对这个序列跑LIS()
    //------change------
        //这里就要针对数据自己想尽办法转化了
        for(int i = 1; i <= n; i++) h[a[i]] = i;
        for(int i = 1; i <= n; i++) b[i] = h[b[i]];
    //------end------
    return LIS();
}
```

1.2 LIS - Longest Increasing Subsequence

```
int f[N];
int LIS()//O(N*N)
{
    for(int i = 1; i <= n; i++)
        for(int j = i-1; j >= 1; j--)
            if(a[i] > a[j]) f[i] = max(f[i], f[j] + 1);
    int res = 0;
    for(int i = 1; i <= n; i++) res = max(res, f[i]);
    return res;
}

int c[N], len = 0;
int LIS()//(NlogN)
{
    for(int i = 1; i <= n; i++)
    {
        //------find------
            int l = 1, r = len, mid;
            while(l <= r)
            {
```

```
                mid = (l + r) / 2;
                if(a[i] > c[mid]) l = mid + 1;
                else r = mid - 1;
            }
        //------end------
        c[l] = a[i];
        len = max(len, l);
    }
    return len;
}
```

1.3 Maximum Continuous Subsequence Sum

```
int MaxSubSum()
{
    int f[N], res;
    for(int i = 1; i <= n; i++)
    {
        f[i] = max(a[i], f[i-1] + a[i]);
        res = max(res, f[i]);
    }
    return res;
}

int MaxSubSum()
{
    int res = 0, now = 0;
    for(int i = 1; i <= n; i++)
    {
        now += a[i];
        res = max(res, now);
        if(now < 0) now = 0;
    }
    return res;
}
```

1.4 数位 dp

```
int predoing(LL a, int *num)
{
    int le = 0;
    while(a)
    {
        num[++le] = a % 10;
        a /= 10;
    }
    return le;
}
int calc(int pos, int d, int u, int last)
{
    if(pos == 0) return 1;
```

```
14      int &res = f[pos][d][u][last];
15      if(res != -1) return res;
16      res = 0;
17      int st = d ? L[pos] : 0;
18      int ed = u ? R[pos] : 9;
19      for(int i = st; i <= ed; i++)
20          if(合法) res += calc(pos - 1, d && i == L[pos], u && i == R[pos
            ], i);
21      return res;
22  }
```

2 Math

2.1 GCD && LCM

2.1.1 GCD - Greatest Common Divisor

```
1  int gcd(int a, int b) { return b ? gcd(b, a % b) : a; }
```

2.1.2 LCM - Least Common Multiple

```
1  inline int lcm(int a, int b) { return a / gcd(a, b) * b; }
```

2.1.3 E_GCD - Extended Greatest Common Divisor

```
1  ax + by = 1
2  bx1 + (a%b)y1 = 1    ==>   bx + (a-a/b*b)y = 1
3    ==> ay1 + b(x1-a/b*y1) = 1
4  对应  ax  + by          = 1
5
6  int egcd(int a, int b, int &x, int &y)
7  {
8      if(b == 0)
9      {
10         x = 1; y = 0;
11         return a;
12     }
13     int x1, y1;
14     int e = egcd(b, a%b, x1, y1);
15     x = y1;
16     y = x1 - a / b * y1;
17     return e;
18 }
```

2.2 Prime

2.2.1 Make Prime List

```
void make_prime_list(int maxp) // O(2*N)
{
    for(int i = 2; i <= maxp; i++)
    {
        if(!h[i]) pri[l++] = i;
        for(int j = 0; j < l && pri[j] <= maxp / i; j++)
        {
            h[i * pri[j]] = true;
            if(i % pri[j] == 0) break;
        }
    }
}
```

2.2.2 Prime Factor

```
void factor()
{
    make_prime_list();
    for(int j = 0; j < Cnt && pri[j]*pri[j] <= n; j++)
    {
        if(n % pri[j] == 0)
        {
            printf("%d␣", pri[j]);
            while(n % pri[j] == 0) n /= pri[j];
        }
    }
    if(n!=1) printf("%d",n);
}
```

2.3 Fast Power

```
//x^y  % mod
int mul(int x, LL y, int mod) // 递归
{
    if(y == 1) return x;
    if(y & 1) return (mul((x * (LL)x) % mod, y / 2, mod) * (LL)x)%mod;
    else return mul((x * (LL)x) % mod, y / 2, mod) % mod;
}
int mul(int x, int y, int mod) // 非递归
{
    int s = 1;
    int ss = x;
    while(y)
    {
        if(y & 1) s = s * ss;
        y /= 2;
        ss *= ss;
    }
    return s;
}
```

3 Datastructure

3.1 Leftist Tree

```
//很多时候需要配合并查集一起使用
int getroot(int x){return f[x]==x ? x : f[x]=getroot(f[x]);}

//把x和y合并在一起，其实就是把y插入x
int merge(int x,int y)//返回合并后子树的根
{
    if(!x || !y) return x|y;
    if(A[x] < A[y]) swap(x,y);//大根堆，如果y比x大，与其让y插入x，
       不如让x插入y
    R[x]=merge(R[x],y);//始终往右子树合并
    f[R[x]] = x;//更新并查集
    if(D[R[x]] > D[L[x]]) swap(L[x],R[x]);//保持左偏树性质
    D[x] = D[R[x]] + 1;
    若还有其他维护信息也需要更新;
    return x;//返回根
}

int del(int x)
{
    int t = merge(L[x],R[x]);
    f[L[x]] = L[x]; f[R[x]] = R[x];//更新并查集
    L[x] = R[x] = D[x] = 0;
    return t;
}
```

3.2 Partition Tree

```
struct Parti{int val, left;} val[30][N];
void build_tree(int d, int l, int r)
{
    if(l == r) return;
    int m = (l + r) >> 1, same = m - l + 1;
    int lcnt = l, rcnt = m + 1;
    for(int i = l; i <= r; i++)
        if(val[d][i].val < sorted[m]) same--;
    for(int i = l; i <= r; i++)
    {
        int flag = 0;
        if((val[d][i].val < soted[m]) || (val[d][i].val == sorted[m] &&
            same))
        {
            flag = 1;
            val[d + 1][lcnt++] = val[d][i];
            if(val[d][i].val == sorted[m]) same--;
        }
        else val[d][rcnt++] = val[d][i];
        val[d][i].left = val[d][i - 1].left + flag;
    }
```

```
    build_tree(d + 1, l, m);
    build_tree(d + 1, m + 1, r);
}
int query(int d, int l, int r, int x, int y, int k)
{
    if(l == r) return val[d][l].val;
    int m = (l + r) >> 1;
    int lx = val[d][x - 1].left - val[d][l - 1].left; //[l,x-1] to left
    int ly = val[d][y].left - val[d][x - 1].left; //[x,y] to left
    int rx = (x - 1 - l + 1) - lx; //[l,x-1] to right
    int ry = (y - x + 1) - ly; //[x,y] to right
    if(ly >= k) return query(d+1, l, m, l-1+lx+1, l-1+lx+ly, k);
    else return query(d+1, m+1, r, m+1-1+rx+1, m+1-1+rx+ry, k-ly);
}
```

3.3 Treap

3.3.1 @ Array

```
#include <cstdio>
#include <cstdlib>
#include <ctime>
// BZOJ 1503 郁闷的出纳员
const int N = 100000 + 10;

int m, Limit;
int L[N], R[N], S[N], fix[N], key[N];
int root, total, leave;

void rotate_left(int &p)
{
    int tmp = R[p];
    R[p] = L[tmp];
    int zsize = S[L[tmp]];
    S[p] = S[p] - S[tmp] + zsize;
    L[tmp] = p;
    S[tmp] = S[tmp] - zsize + S[p];
    p = tmp;
}
void rotate_right(int &p)
{
    int tmp = L[p];
    L[p] = R[tmp];
    int zsize = S[R[tmp]];
    S[p] = S[p] - S[tmp] + zsize;
    R[tmp] = p;
    S[tmp] = S[tmp] - zsize + S[p];
    p = tmp;
}

void insert(int &p, int x)
{
```

```
34      if(!p)
35      {
36          p = ++total;
37          L[p] = R[p] = 0;
38          S[p] = 1;
39          fix[p] = rand();
40          key[p] = x;
41          return;
42      }
43      S[p]++;
44      if(x < key[p])
45      {
46          insert(L[p], x);
47          if(fix[L[p]] > fix[p]) rotate_right(p);
48      }
49      else {
50          insert(R[p], x);
51          if(fix[R[p]] > fix[p]) rotate_left(p);
52      }
53  }
54
55  void remove(int &p, int limit)
56  {
57      if(!p) return;
58      if(key[p] < limit)
59      {
60          leave += S[L[p]] + 1;
61          p = R[p];
62          remove(p, limit);
63      }
64      else{
65          remove(L[p], limit);
66          S[p] = S[L[p]] + S[R[p]] + 1;
67      }
68  }
69
70  int kth(int &p, int k)
71  {
72      if(k <= S[L[p]]) return kth(L[p], k);
73      else if(k == S[L[p]] + 1) return key[p];
74      else return kth(R[p], k - S[L[p]] - 1);
75  }
76
77  int main()
78  {
79      srand(time(0));
80      scanf("%d%d", &m, &Limit);
81      int delta = 0;
82      while(m--)
83      {
84          char op; int x;
85          scanf(" %c%d", &op, &x);
86          if(op == 'I')
```

```
87          {
88              if(x < Limit) continue;
89              insert(root, x - delta);
90          }
91          else if(op == 'A') delta += x;
92          else if(op == 'S')
93          {
94              delta -= x;
95              remove(root, Limit - delta);
96          }
97          else {
98              x = S[root] - x + 1;
99              if(x <= 0) puts("-1");
100             else printf("%d\n", kth(root, x) + delta);
101         }
102     }
103     printf("%d\n", leave);
104     return 0;
105 }
```

3.3.2 @ Pointer

```
1  #include <cstdio>
2  #include <cstdlib>
3  #include <ctime>
4  // BZOJ 1503 郁闷的出纳员
5  int m, Limit;
6  struct Treap{
7      int fix, key, size;
8      Treap *left, *right;
9  }*root;
10 int leave;
11
12 void rotate_left(Treap *&p)
13 {
14     Treap *tmp = p -> right;
15     p -> right = tmp -> left;
16     int zsize = tmp -> left ? tmp -> left -> size : 0;
17     p -> size = p -> size - tmp -> size + zsize;
18     tmp -> left = p;
19     tmp -> size = tmp -> size - zsize + p -> size;
20     p = tmp;
21 }
22 void rotate_right(Treap *&p)
23 {
24     Treap *tmp = p -> left;
25     p -> left = tmp -> right;
26     int zsize = tmp -> right ? tmp -> right -> size : 0;
27     p -> size = p -> size - tmp -> size + zsize;
28     tmp -> right = p;
29     tmp -> size = tmp -> size - zsize + p -> size;
30     p = tmp;
```

```
}

void insert(Treap *&p, int x)
{
    if(!p)
    {
        p = new Treap;
        p -> fix = rand();
        p -> key = x;
        p -> size = 1;
        p -> left = 0;
        p -> right = 0;
        return;
    }
    if(x < p -> key)
    {
        insert(p -> left, x);
        p -> size++;
        if(p -> left -> fix > p -> fix) rotate_right(p);
    }
    else {
        insert(p -> right, x);
        p -> size++;
        if(p -> right -> fix > p -> fix) rotate_left(p);
    }
}

void remove(Treap *&p, int L)
{
    if(!p) return;
    if(p -> key < L)
    {
        leave += (p -> left ? p -> left -> size : 0) + 1;
        p = p -> right;
        remove(p, L);
    }
    else {
        remove(p -> left, L);
        int lsize = p -> left ? p -> left -> size : 0;
        int rsize = p -> right ? p -> right -> size : 0;
        p -> size = lsize + rsize + 1;
    }
}

int kth(Treap *&p, int k)
{
    int Lsize = p -> left ? p -> left -> size : 0;
    if(k <= Lsize) return kth(p -> left, k);
    else if(k == Lsize + 1) return p -> key;
    else return kth(p -> right, k - Lsize - 1);
}

int main()
```

```
{
    srand(time(0));
    scanf("%d%d", &m, &Limit);
    int delta = 0;
    while(m--)
    {
        char op; int x;
        scanf(" %c%d", &op, &x);
        if(op == 'I')
        {
            if(x < Limit) continue;
            insert(root, x - delta);
        }
        else if(op == 'A') delta += x;
        else if(op == 'S')
        {
            delta -= x;
            remove(root, Limit - delta);
        }
        else {
            int tot = root ? root -> size : 0;
            x = tot - x + 1;
            if(x <= 0) puts("-1");
            else printf("%d\n", kth(root, x) + delta);
        }
    }
    printf("%d\n", leave);
    return 0;
}
```

3.4 Size Balanced Tree

```
int A[N], S[N], L[N], R[N], root, total;
void rotate_left(int &x)
{
    int y = R[x];
    R[x] = L[y];
    L[y] = x;
    S[y] = S[x];
    S[x] = S[L[x]] + S[R[x]] + 1;
    x = y;
}
void rotate_right(int &x)
{
    int y = L[x];
    L[x] = R[y];
    R[y] = x;
    S[y] = S[x];
    S[x] = S[L[x]] + S[R[x]] + 1;
    x = y;
}

```

```
21 void maintain(int &p, bool flag)
22 {
23     if(flag)//调整右边
24     {
25         if(S[R[R[p]]] > S[L[p]] rotate_left(p);
26                 else if(S[R[L[p]]] > S[L[p]])
27         {
28             rotate_right(R[p]);
29                 rotate_left(p);
30             }
31             else return;
32             }
33     else
34     {
35         if(S[L[L[p]]] > S[R[p]]) rotate_right(p);
36         else if(S[L[R[p]]] > S[R[p]])
37         {
38             rotate_left(L[p]);
39             rotate_right(p);
40         }
41         else return;
42     }
43     maintain(L[p], 0);
44     maintain(R[p], 1);
45     maintain(p, 0);
46     maintain(p, 1);
47 }
48
49 void insert(int &p, int e)
50 {
51     if(!p)
52     {
53         p = ++total;
54         L[p] = R[p] = 0;
55         A[p] = e; S[p] = 1;
56         return;
57     }
58     S[p]++;
59     if(e < A[p]) insert(L[p], e);
60     else insert(R[p], e);
61     maintain(p, k >= A[p]);
62 }
63
64 int getmin()
65 {
66     for(int x = root; L[x]; x = L[x]);
67     return A[x];
68 }
69 int getmax()
70 {
71     for(int x = root; R[x]; x = R[x]);
72     return A[x];
73 }
```

```
74 int kth(int &p, int k)
75 {
76     int tmp = S[L[p]] + 1;
77     if(k == tmp) return A[p];
78     else if(k < tmp) return kth(L[p], k);
79     else return kth(R[p], k - tmp);
80 }
```

4 Graph

4.1 Shortest path

4.1.1 Dijkstra

```
1  void dijkstra()
2  {
3      memset(dist, 0, sizeof(dist));
4      while(!Q.empty())
5      {
6          int x = Q.top().second; Q.pop();
7          if(done[x]) continue;
8          done[x] = 1;
9          for(Link p = head[x]; p; p = p->next)
10             if(dist[p->y] > dist[x] + p->z)
11             {
12                 dist[p->y] = dist[x] + p->z;
13                 Q.push(make_pair(dist[p->y], p->y));
14             }
15     }
16 }
```

4.1.2 Spfa

```
1  void spfa()
2  {
3      memset(dist, 0x3f, sizeof(dist));
4      Q.push(S);//S为源点
5      while(!Q.empty())
6      {
7          int x = Q.front();
8          Q.pop(); inQ[x] = 0;
9          for(Link p = head[x]; p; p = p->next)
10             if(dist[p->y] > dist[x] + p->z)
11             {
12                 dist[p->y] = dist[x] + p->z;
13                 if(!inQ[p->y])
14                 {
15                     Q.push(p->y);
16                     inQ[p->y] = 1;
17                 }
18             }
```

```
    }
}
```

4.1.3 Floyd

```
void floyd()
{
    for(int k = 1; k <= n; k++) // 这里可以看作是一个加边的过程
        for(int i = 1; i <= n; i++)
            for(int j = 1; j <= n; j++)
                map[i][j] = min(map[i][j], map[i][k] + map[k][j]);
}

// 最小环
void MinCircle()
{
    cap[] = map[];
    int circle = 0x3f3f3f3f;
    for(int k = 1; k <= n; k++)
    {
        for(int i = 1; i < k; i++)
            for(int j = i+1; j < k; j++)
                circle = min(circle, map[i][j] + cap[j][k]+cap[k][i]);
        for(int i = 1; i <= n; i++)
            for(int j = 1; j <= n; j++)
                map[i][j] = min(map[i][j], map[i][k] + map[k][j]);
    }
    return circle == 0x3f3f3f3f ? -1 : circle;
}

// floyd判圈法 （大白书 p44）
void Circle()
{
    int ans = k;
    int k1 = k, k2 = k;
    do{
        k1 = next(k1);
        k2 = next(k2); ans = max(ans, k2);
        k2 = next(k2); ans = max(ans, k2);
    }while(k1 != k2);
    return ans;
}
```

4.2 Minimum Spanning Tree

4.2.1 Prim

```
void prime()
{
    memset(dist, 0, sizeof(dist));
    int res = 0;
```

```
    while(!Q.empty())
    {
        int x = Q.top().second;
        if(done[x]) {Q.pop(); continue;}
        res += Q.top().first;
        Q.pop();
        for(Link p = head[x]; p; p = p->next)
            if(dist[p->y] > p->z)
            {
                dist[p->y] = p->z;
                Q.push(make_pair(dist[p->y], p->y));
            }
    }
}
```

4.2.2 Kruskal

```
void prime()
{
    sort(edge, edge+Cnt, cmp);
    int res = 0;
    for(int i = 0; i < Cnt; i++)
    {
        if(getroot(edge[i].x) == getroot(edge[i].y)) continue;
        merge(edge[i].x, edge[i].y);
        res += edge[i].z;
    }
}
```

4.3 Tarjan - Strong Union

```
void dfs(int x)
{
    now[x] = low[x] = ++dfstime;
    hash[x] = 1;
    st.push(x); inst[x] = 1;
    for(int i = 1; i <= n; i++)
        if(map[x][i])
        {
            if(!hash[i])
            {
                dfs(i);
                low[x] = min(low[x], low[i]);
            }
            else if(inst[i]) low[x] = min(low[x], now[i]);
        }
    if(low[x] == now[x])
    {
        while(!st.empty())
        {
            int u = st.top();
```

```
            st.pop(); inst[u] = 0;
            belong[u] = number;
            if(u == x) break;
        }
        numer++;
    }
}
void tarjan()
{
    for(int i = 1; i <= n; i++)
        if(!hash[i]) dfs(i);
    if(!st.empty()) // 这是一个未知bug   栈中还会剩下一个强连通分量
    {
        while!st.empty())
        {
            int u = st.top();
            st.pop();
            belong[u] = number;
        }
        number++;
    }
}
```

4.4 LCA

4.4.1 Tarjan

```
// poj 1330 (changed something)
// LCA tarjan
#include <cstdio>
#include <cstring>

const int N = 10000 + 10;

int n;
struct Link{int y, idx; Link *next;}*head[N], *ask[N];
int tx, ty;
bool in[N], vis[N];
int f[N];
int ans[N]; // Query Answer

void inLink(int x, int y)
{
    Link *p = new Link;
    p -> y = y;
    p -> next = head[x];
    head[x] = p;
}
void inAsk(int x, int y, int idx)
{
    Link *p = new Link;
    p -> y = y;
```

```
26      p -> idx = idx;
27      p -> next = ask[x];
28      ask[x] = p;
29  }
30
31  int getroot(int x)
32  {
33      return f[x] == x ? x : f[x] = getroot(f[x]);
34  }
35
36  void LCA(int x)
37  {
38      vis[x] = 1;
39      f[x] = x;
40      for(Link *p = ask[x]; p; p = p -> next)
41          if(vis[p->y]) ans[p->idx] = getroot(p->y);
42      for(Link *p = head[x]; p; p = p -> next)
43          if(!vis[p->y])
44          {
45              LCA(p->y);
46              f[p->y] = x;
47          }
48  }
49
50  int main()
51  {
52      int T; scanf("%d", &T);
53      while(T--)
54      {
55          memset(head, 0, sizeof(head));
56          memset(ask, 0, sizeof(ask));
57          memset(in, 0, sizeof(in));
58          memset(vis, 0, sizeof(vis));
59          scanf("%d", &n);
60          for(int i = 1; i <= n; i++) f[i] = i;
61          for(int i = 1; i < n; i++)
62          {
63              int x, y;
64              scanf("%d%d", &x, &y);
65              inLink(x, y);
66              in[y] = 1;
67          }
68          int q = 1;// the number of query
69          for(int i = 1; i <= q; i++)
70          {
71              int x, y; scanf("%d%d", &x, &y);
72              inAsk(x, y, i); inAsk(y, x, i);
73          }
74          int root = -1;
75          for(int i = 1; i <= n; i++)
76              if(!in[i]) {root = i; break;}
77          LCA(root);
78          for(int i = 1; i <= q; i++)
```

```
79              printf("%d\n", ans[i]);
80      }
81      return 0;
82  }
```

4.4.2 Doubling Algorithm

还不会...

4.5 Bipartite Graph

4.5.1 Maximal Matching - The Hungarian algorithm

```
1   int ttt = 0; // 全局时间戳变量
2
3   bool search(int x)
4   {
5       for(int i = 1; i <= m; i++)
6           if(map[x][i] && vis[i] != ttt)
7           {
8               vis[i] = ttt;
9               if(pre[i] == -1 || search(pre[i]))
10              {
11                  pre[i] = x;
12                  return 1;
13              }
14          }
15      return 0;
16  }
17
18  int match()
19  {
20      int res = 0;
21      for(int i = 1; i <= n; i++)
22      {
23          ++ttt; // 这里不用memset节省时间
24          res += search(i);
25      }
26      return res;
27  }
```

4.5.2 Optimal Matching - KM

不会... 用费用流解决

4.6 Network Flow

4.6.1 Maximum Flow - isap

```
1   //   h[x] :   点 x 在第 h[x] 层
2   //   v[k] :   第 k 层有 v[k] 个点
```

```
3  int sap(int x, int flow)
4  {
5      if(x == n) return flow;
6      int res = 0;
7      for(int i = S; i <= T; i++)
8          if(g[x][i] && h[x] == h[i] + 1)
9          {
10             int t = sap(i, min(g[x][i], flow - res));
11             res += t; g[x][i] -= t; g[i][x] += t;
12             if(res == flow) return res;
13             if(h[S] >= T) return res;
14         }
15     //if(h[S] >= T) return res;
16     if((--v[h[x]]) == 0) h[S] = T;
17     ++v[++h[x]];
18     return res;
19 }
20 int main()
21 {
22     v[0] = T;
23     int maxflow = 0;
24     while(h[S] < T) maxflow += sap(1, inf);
25     reutrn 0;
26 }
```

4.6.2 Minimum Cost Maximum Flow - spfa

```
1  struct EG{int from,to,flow,cost,next;}edge[M];
2
3  void add_edge(int a,int b,int c,int d)
4  {
5      edge[L]=(EG){a,b,c,+d,head[a]};
6      head[a]=L++;
7      edge[L]=(EG){b,a,0,-d,head[b]};
8      head[b]=L++;
9  }
10
11 bool spfa()
12 {
13     memset(inQ, 0, sizeof(inQ));
14     memset(dist, 0x3f, sizeof(dist));
15     dist[S] = 0;
16     q.push(S);
17     while(!q.empty())
18     {
19         int x = q.front();
20         q.pop();
21         inQ[x] = 0;
22         for(int i = head[x]; i != -1; i = edge[i].next)
23             if(edge[i].flow && dist[edge[i].to] > dist[x] + edge[i].
                   cost)
24             {
```

```
                pre[edge[i].to] = i;
                dist[edge[i].to] = dist[x] + edge[i].cost;
                if(!inQ[edge[i].to])
                {
                    inQ[edge[i].to] = 1;
                    q.push(edge[i].to);
                }
            }
    }
    return dist[T] != inf;
}
void MFMC()
{
    memset(head, -1, sizeof(head));
    建图调用 add_edge();

    int mincost = 0, maxflow = 0;
    while(spfa())
    {
        int res = inf;
        for(int i = T; i != S; i = edge[pre[i]].from)
        {
            res = min(res, edge[pre[i]].flow);
        }
        for(int i = T; i != S; i = edge[pre[i]].from)
        {
            edge[pre[i]].flow -= res;
            edge[pre[i] ^ 1].flow += res;
        }
        maxflow += res;
        mincost += res * dist[T];
    }
}
```

5 Geometry

5.1 Convex Hull

```
//◆◆□°◆ μ◆list[0~n-1]
//□°◆½◆◆stack[0~top-1]
Point list[Maxn];
int Stack[Maxn],top;
bool _cmp (Point p1,Point p2)
{
    double tmp=(p1-list[0])^(p2-list[0]);
    if (fuhao(tmp)>0) return true;
    else if (fuhao(tmp)==0&&fuhao(dist(p1,list[0])-dist(p2,list[0]))
       <=0)
        return true;
    else    return false;
}
```

```
13 void Graham(int n)
14 {
15     Point p0;
16     int k=0;
17     p0=list[0];
18     for (int i=1;i<n;++i)
19     {
20         if ((p0.y>list[i].y)||(p0.y==list[i].y&&p0.x>list[i].x))
21         {
22             p0=list[i];
23             k=i;
24         }
25     }
26     swap(list[k],list[0]);
27     sort(list+1,list+n,_cmp);
28     if (n==1)
29     {
30         top=1;
31         stack[0]=0;
32         return;
33     }
34     if (n==2)
35     {
36         top=2;
37         stack[0]=0;
38         stack[1]=1;
39         return;
40     }
41     stack[0]=0;
42     stack[1]=1;
43     top=2;
44     for (int i=2;i<n;++i)
45     {
46         while (top>1 && fuhao((list[stack[top-1]]-list[stack[top-2]])^(
               list[i]-list[stack[top-2]]))<=0)
47             top--;
48         stack[top++]=i;
49     }
50 }
```

5.2 All

```
1  #include <cstdio>
2  #include <cstdlib>
3  #include <cstring>
4  #include <cmath>
5  #include <algorithm>
6  #include <utility>
7  using std::max;
8  using std::min;
9  using std::sort;
10 using std::swap;
```

```
11 using std::pair;
12 using std::make_pair;
13 const double eps = 1e-8, inf = 1e20;
14 const double pi = 4.0 * atan(1.0);
15 #define Degree(_rad) (180.0 / pi * (_rad))
16
17 int fuhao(double x)
18 {
19     if (fabs(x)<eps) return 0;
20     if (x<0) return -1;
21     else return 1;
22 }
23
24 ////////////////////////   Point && Vector
      ////////////////////////
25 struct Point{
26     double x, y;
27     Point (){}
28     Point (double _x,double _y):x(_x),y(_y){}
29     void init(double a, double b) { x = a; y = b; }
30
31     // basic calc
32         bool operator == (const Point &b) const
33         {
34             return !fuhao(x - b.x) && !fuhao(y - b.y);
35         }
36         Point operator + (const Point &b) const
37         {
38             return Point(x + b.x, y + b.y);
39         }
40         Point operator - (const Point &b) const
41         {
42             return Point(x - b.x, y - b.y);
43         }
44         Point operator * (const double &b) const
45         {
46             return Point(x * b, y * b);
47         }
48
49         Point Rotate(Point p, double alpha) // alpha E [0, +oo) 逆时针
50         {
51             double x0 = p.x, y0 = p.y;
52             double tx = x - x0, ty = y - y0;
53             double nx = tx * cos(alpha) - ty * sin(alpha);
54             double ny = tx * sin(alpha) + ty * cos(alpha);
55             nx += x0; ny += y0;
56             return Point(nx, ny);
57         }
58
59     // Vector
60         double operator *(const Point &b)const
61         {// Dot
62             return x * b.x + y * b.y;
```

```
63          }
64          double operator ^ (const Point &b)const
65          {// Cross
66              return x * b.y - y * b.x;
67          }
68          double Abs() { return sqrt(x * x + y * y); }
69  };
70  double Dist(const Point &a, const Point &b) { return (a - b).Abs(); }
71  typedef Point Vector;
72
73  double Angle(Vector a, Vector b)
74  {
75      return acos(a * b / a.Abs() / b.Abs());
76  }
77  Vector Get_H(Vector A)
78  { // 求与向量垂直的单位向量   使用前确保不为0向量
79      // A != Vector(0.0, 0.0);
80      double L = A.Abs();
81      return Vector(-A.y / L, A.x / L);
82  }
83
84  ////////////////////////////      E - N - D
       ////////////////////////////
85
86
87  ////////////////////////////         Line
       ////////////////////////////
88  struct Line{
89      Point s,e;
90      Line() {}
91      Line(Point ss, Point ee)
92      {
93          s = ss; e = ee;
94      }
95
96      // 两直线的关系：重合0，  平行1，  相交2 并返回交点
97      pair<int,Point> operator &(const Line &b) const
98      {
99          Point ans = s;
100         if(fuhao((s-e)^(b.s-b.e))==0)
101         {
102             if (fuhao((s-b.e)^(b.s-b.e))==0)
103                 return make_pair(0,ans);//重合
104             else return make_pair(1,ans);//平行
105         }
106         double t = ((s-b.s)^(b.s-b.e)) / ((s-e)^(b.s-b.e));
107         ans.x += (e.x-s.x) * t;
108         ans.y += (e.y-s.y) * t;
109         return make_pair(2,ans);//相交
110     }
111 };
112 ////////////////////////////      E - N - D
       ////////////////////////////
```

```
113
114 //判断线段相交
115 bool inter(Line l1,Line l2)
116 {
117     return
118     max(l1.s.x,l1.e.x) >= min(l2.s.x,l2.e.x) &&
119     max(l1.s.y,l1.e.y) >= min(l2.s.y,l2.e.y) &&
120     max(l2.s.x,l2.e.x) >= min(l1.s.x,l1.e.x) &&
121     max(l2.s.y,l2.e.y) >= min(l1.s.y,l1.e.y) &&
122     fuhao((l2.s-l1.e)^(l1.s-l1.e)) * fuhao((l2.e-l1.e)^(l1.s-l1.e))<=0
        &&
123     fuhao((l1.s-l2.e)^(l2.s-l2.e)) * fuhao((l1.e-l2.e)^(l2.s-l2.e))<=0;
124 }
125 //判断直线与线段相交
126 bool Seg_inter_line(Line l1,Line l2)//l1为直线 l2为线段
127 {
128     return fuhao((l2.s-l1.e)^(l1.s-l1.e))*fuhao((l2.e-l1.e)^(l1.s-l1.e)
        )<=0;
129 }
130 //点到直线距离
131 //返回点到直线最近的点
132 Point PointToLine(Point P,Line L)
133 {
134     Point ans;
135     double t=((P-L.s)*(L.e-L.s))/((L.e-L.s)*(L.e-L.s));
136     ans.x=L.s.x+(L.e.x-L.s.x)*t;
137     ans.y=L.s.y+(L.e.y-L.s.y)*t;
138     return ans;
139 }
140 //点到线段距离
141 //返回点到线段最近的点
142 Point NearestPointToLineSeg(Point P,Line L)
143 {
144     Point ans;
145     double t = ((P-L.s)*(L.e-L.s)) / ((L.e-L.s)*(L.e-L.s));
146     if (t>=0&&t<=1)
147     {
148         ans.x = L.s.x + (L.e.x-L.s.x)*t;
149         ans.y = L.s.y + (L.e.y-L.s.y)*t;
150     }
151     else {
152         if (Dist(P,L.s)<Dist(P,L.e))
153             ans = L.s;
154         else    ans = L.e;
155     }
156     return ans;
157 }
158 //多边形面积
159 double CalcArea(Point p[],int n)
160 {
161     double ans=0;
162     for (int i=0;i<n;++i)
163         ans+=(p[i]^p[(i+1)%n])/2;
```

```
164     return fabs(ans);
165 }
166 //判断点在线段上
167 bool OnSeg(Point P,Line L)
168 {
169     return
170             fuhao((L.s-P)^(L.e-P))==0 &&
171             fuhao((P.x-L.s.x)*(P.x-L.e.x))<=0 &&
172             fuhao((P.y-L.s.y)*(P.y-L.e.y))<=0;
173 }
174 //三点求圆心坐标
175 Point waixin(Point a,Point b,Point c)
176 {
177     double a1=b.x-a.x,b1=b.y-a.y,c1=(a1*a1+b1*b1)/2;
178     double a2=c.x-a.x,b2=c.y-a.y,c2=(a2*a2+b2*b2)/2;
179     double d=a1*b2-a2*b1;
180     return Point(a.x+(c1*b2-c2*b1)/d,a.y+(a1*c2-a2*c1)/d);
181 }
182
183
184 ////////////////////////// Graham
    //////////////////////////
185 //求凸包 点list[0~n-1]
186 //凸包结果Stack[0~top-1]
187 const int Maxn = 100;///////////////here!!
188 Point list[Maxn]; //////////?!?!?!?!补全Maxn
    !?!?!?!?!?!?!?!?!?!?!
189 int Stack[Maxn],top;
190 bool _cmp (Point p1,Point p2)
191 {
192     double tmp=(p1-list[0])^(p2-list[0]);
193     if (fuhao(tmp)>0) return true;
194     else if (fuhao(tmp)==0&&fuhao(Dist(p1,list[0])-Dist(p2,list[0]))
        <=0)
195         return true;
196     else    return false;
197 }
198 void Graham(int n)
199 {
200     Point p0;
201     int k=0;
202     p0=list[0];
203     for (int i=1;i<n;++i)
204     {
205         if ((p0.y>list[i].y)||(p0.y==list[i].y&&p0.x>list[i].x))
206         {
207             p0=list[i];
208             k=i;
209         }
210     }
211     swap(list[k],list[0]);
212     sort(list+1,list+n,_cmp);
213     if (n==1)
```

```
214     {
215         top=1;
216         Stack[0]=0;
217         return;
218     }
219     if (n==2)
220     {
221         top=2;
222         Stack[0]=0;
223         Stack[1]=1;
224         return;
225     }
226     Stack[0]=0;
227     Stack[1]=1;
228     top=2;
229     for (int i=2;i<n;++i)
230     {
231         while (top>1 && fuhao((list[Stack[top-1]]-list[Stack[top-2]])^(
               list[i]-list[Stack[top-2]]))<=0)
232             top--;
233         Stack[top++]=i;
234     }
235 }
236 ////////////////////////////      E - N - D
       ////////////////////////////
237
238
239 ////////////////////////////          Area
       ////////////////////////////
240 double PolygonArea(Point *pp, int nn) // pp[0, n-1]
241 {
242     double ans_area = 0.0;
243     for(int i = 1; i < nn-1; i++)
244     {
245         ans_area += (pp[i] - pp[0]) ^ (pp[i+1] - pp[0]);
246     }
247     return fabs(ans_area / 2);
248 }
249 ////////////////////////////      E - N - D
       ////////////////////////////
250
251 ////////////////////////////     点在多边形内
       ////////////////////////////
252 int isPointInPolygon(Point p, Point *poly, int nn)
253 {
254     int w = 0;
255     for(int i = 0; i < n; i++)
256     {
257         if(OnSeg(p, Line(poly[i], poly[(i+1)%n]))) return -1; // 边界上
258         int k = fuhao((poly[(i+1)%n] - poly[i]) ^ (p - poly[i]));
259         int d1 = fuhao(poly[i].y - p.y);
260         int d2 = fuhao(poly[(i+1)%n].y - p.y);
261         if(k > 0 && d1 <= 0 && d2 > 0) wn++;
```

```
262         if(k < 0 && d1 > 0 && d2 <= 0) wn--;
263     }
264     if(wn != 0) return 1; //内部
265     return 0; // 外部
266 }
267 ////////////////////////////      E - N - D
       //////////////////////////
268
269
270 int main()
271 {
272 }
```

6 String

6.1 Manacher

```
1  #include <cstdio>
2  #include <algorithm>
3  // HDU 3068
4  const int N = 110000 + 10;
5
6  char t[N], s[2*N];
7  int n, p[2*N];
8
9  void pre(char *origin, char *str, int &_len)
10 {
11     _len = 0;
12     str[_len++] = '$';
13     for(int i = 0; origin[i]; i++)
14     {
15         str[_len++] = '#';
16         str[_len++] = origin[i];
17     }
18     str[_len++] = '#';
19     str[_len] = 0;
20     //puts(str);
21 }
22
23 void getPi(char *str, int _len, int *_P)
24 {
25     int mx = 0, id;
26     for(int i = 1; i < _len; i++)
27     {
28         if(mx > i) _P[i] = std::min(_P[2*id-i], mx-i);
29         else _P[i] = 1;
30         for(; str[i+_P[i]] == str[i-_P[i]]; _P[i]++) ;
31         if(_P[i] + i > mx)
32         {
33             mx = _P[i] + i;
34             id = i;
```

```
        }
    }
}

int main()
{
    while(scanf("%s", t) == 1)
    {
        pre(t, s, n);
        getPi(s, n, p);
        int res = 1;
        for(int i = 1; i < n; i++)
            res = std::max(res, p[i]-1);
        printf("%d\n", res);
    }
    return 0;
}
```

6.2 KMP

```
void getnext(char *t)
{
    memset(next, 0, sizeof(next));
    next[0] = -1;
    int j = 0, k = -1;
    int len = strlen(t);
    while(j < len)
    {
        if(k == -1 || t[j] == t[k]) next[++j] = ++k;
        else k = next[k];
    }
}
void kmp()
{
    getnext();
    int lens = strlen(s), lent = strlen(t);
    int i = 0, j = 0;
    while(i < lens)
    {
        if(j == -1 || s[i] == t[j]) i++, j++;
        else j = next[j];
        if(j == lent) return j - lent;
    }
    return -1;
}
```

6.3 Suffix Array

```
int sa[N], rank[N];
int c[N], tmp[N];
int height[N];
```

```
bool cmp(int *r, int a, int b, int l)
{
    return r[a] == r[b] && r[a + l] == r[b + l];
}
void DA(int n, int m) //n为长度，m为字串的最大值。均为开区间
{
    int i, j, p, *x = rank, *y = tmp;
    memset(c, 0, sizeof(c));
    for(i = 0; i < n; i++) c[ x[i] = s[i] ] ++;
    for(i = 1; i < m; i++) c[i] += c[i - 1];
    for(i = n - 1; i >= 0; i--) sa[ --c[x[i]] ] = i;
    for(j = 1, p = 0; p < n; j *= 2, m = p)
    {
        for(p = 0, i = n - j; i < n; i++) y[p++] = i;
        for(i = 0; i < n; i++) if(sa[i] >= j) y[p++] = sa[i] - j;
        memset(c, 0, sizeof(c));
        for(i = 0; i < n; i++) c[ x[y[i]] ]++;
        for(i = 1; i < m; i++) c[i] += c[i - 1];
        for(i = n - 1; i >= 0; i--) sa[ --c[x[y[i]]] ] = y[i];
        swap(x, y); x[sa[0]] = 0;
        for(i = 1, p = 1; i < n; i++)
            if(x[i]) x[sa[i]] = cmp(y, sa[i - 1], sa[i], j) ? p - 1 : p
               ++;
    }
    for(i = 0; i < n; i++) rank[sa[i]] = i;
    int k = 0;
    for(i = 0; i < n; height[x[i++]] = k)
        for(k ? k-- : 0, j = sa[x[i] - 1]; s[i + k] == s[j + k]; k++);
}
int main()
{
    读入字串s，n=s的长度
    s[n++]='$';//最后加入一个不存在的值，排除超界情况
    DA(n,m);
}
```

7 Tools

7.1 BigInteger - C++

```
//程序中全部为正整数之间的操作
#include <cstdio>
#include <cstring>
#include <algorithm>
using std::max;

const int base = 10000; // 压4位

struct BigInt{
    int c[1000], len, sign;
    BigInt() { memset(c, 0, sizeof(c)); len = 1; sign = 0; }
```

```
12      void Zero()
13      {
14          while(len > 1 && c[len] == 0) len--;
15          if(len == 1 && c[len] == 0) sign = 0;
16      }
17      void writein(char *s)
18      {
19          int k = 1, L = strlen(s);
20          for(int i = L-1; i >= 0; i--)
21          {
22              c[len] += (s[i]-'0') * k;
23              k *= 10;
24              if(k == base)
25              {
26                  k = 1;
27                  len++;
28              }
29          }
30      }
31      void Read()
32      {
33          char s[5000] = {0};
34          scanf("%s", s);
35          writein(s);
36      }
37      void Print()
38      {
39          if(sign) printf("-");
40          printf("%d", c[len]);
41          for(int i = len-1; i >= 1; i--) printf("%04d", c[i]);
42          printf("\n");
43      }
44      BigInt operator = (int a)
45      {
46          char s[100] = {0};
47          sprintf(s, "%d", a);
48          writein(s);
49          return *this;
50      }
51      bool operator > (const BigInt &b)
52      {
53          if(len != b.len) return len > b.len;
54          for(int i = len; i >= 1; i--)
55          {
56              if(c[i] != b.c[i]) return c[i] > b.c[i];
57          }
58          return 0;
59      }
60      bool operator < (const BigInt &b)
61      {
62          if(len != b.len) return len < b.len;
63          for(int i = len; i >= 1; i--)
64          {
```

```
65              if(c[i] != b.c[i]) return c[i] < b.c[i];
66          }
67          return 0;
68      }
69      bool operator == (const BigInt &b)
70      {
71          if(len != b.len) return 0;
72          for(int i = 1; i <= len; i++)
73              if(c[i] != b.c[i]) return 0;
74          return 1;
75      }
76      bool operator == (const int &a)
77      {
78          BigInt b; b = a;
79          return *this == b;
80      }
81      BigInt operator + (const BigInt &b)
82      {
83          BigInt r; r.len = max(len, b.len) + 1;
84          for(int i = 1; i <= r.len; i++)
85          {
86              r.c[i] += c[i] + b.c[i];
87              r.c[i+1] += r.c[i] / base;
88              r.c[i] %= base;
89          }
90          r.Zero();
91          return r;
92      }
93      BigInt operator + (const int &a)
94      {
95          BigInt b; b = a;
96          return *this + b;
97      }
98      BigInt operator - (const BigInt &b)
99      {
100         BigInt a, c;// a - c
101         a = *this; c = b;
102         if(a < c)
103         {
104             std::swap(a, c);
105             a.sign = 1;
106         }
107         for(int i = 1; i <= len; i++)
108         {
109             a.c[i] -= c.c[i];
110             if(a.c[i] < 0)
111             {
112                 a.c[i] += base;
113                 a.c[i+1]--;
114             }
115         }
116         a.Zero();
117         return a;
```

```
118     }
119     BigInt operator - (const int &a)
120     {
121         BigInt b; b = a;
122         return *this - b;
123     }
124     BigInt operator * (const BigInt &b)
125     {
126         BigInt r; r.len = len + b.len + 2;
127         for(int i = 1; i <= len; i++)
128         {
129             for(int j = 1; j <= b.len; j++)
130             {
131                 r.c[j+i-1] += c[i] * b.c[j];
132             }
133         }
134         for(int i = 1; i <= r.len; i++)
135         {
136             r.c[i+1] += r.c[i] / base;
137             r.c[i] %= base;
138         }
139         r.Zero();
140         return r;
141     }
142     BigInt operator * (const int &a)
143     {
144         BigInt b; b = a;
145         return *this * b;
146     }
147     BigInt operator / (BigInt b)//整除
148     {
149         BigInt t, r;
150         if(b == 0) return r;
151         r.len = len;
152         for(int i = len; i >= 1; i--)
153         {
154             t = t * base + c[i];
155             int div;
156             //-------try-------
157                 int up = 10000, down = 0;
158                 while(up >= down)
159                 {
160                     int mid = (up + down) / 2;
161                     BigInt ccc ; ccc = b * mid;
162                     if(ccc > t) up = mid - 1;
163                     else {
164                         down = mid + 1;
165                         div = mid;
166                     }
167                 }
168             //-------end-------
169             r.c[i] = div;
170             t = t - b * div;
```

```
171         }
172         //最后的t为余数，要用的自己想办法传出去
173         r.Zero();
174         return r;
175     }
176     BigInt operator / (const int &a)
177     {
178         BigInt b; b = a;
179         return *this / b;
180     }
181     BigInt operator % (const BigInt &b)
182     {//其实可以复制上面除法的，这里换一种写法
183         return *this - *this / b * b;
184     }
185     BigInt operator % (const int &a)
186     {
187         BigInt b; b = a;
188         return *this % b;
189     }
190 };
191
192 int main()
193 {
194     return 0;
195 }
```

7.2 C char*

```
1 头文件cstring
2 strlen(s);//获取长度  O(N)
3 strcpy(a+2,b+1)//从b+1开始全部赋值给a+2开始的字符串
4 strncpy(a+2,b+1,2)//从b+1开始赋值2个给a+2开始的字符串
5 strcmp(a,b)//比较a和b的大小，相等返回0，a>b返回正整数
6 strcat(a,b)//相当于string类的 a += b;
7 strstr(a,b)-a;//返回b在a中第一次出现的位置，不存在返回NULL(即0)，由于-a
    ,所以最后应该是-a
```

7.3 C++ std::string

```
1  //====初始化====
2  头文件string并加上std::
3  string s(str);//相当于string s=str;
4  string s(cstr);//把char数组类型的字符串cstr作为s的初值
5  s.clear();//清空，相当于 s="";
6
7  //====长度====
8  s.length();//获取s的长度，O(1)
9  s.size();//一样
10
11 //====插入删除====
12 s.insert(2, "a"); //在s的位置2插入string类字符串"a"
```

```
s.erase(2, 3); //从s的位置2开始删除3个字符

//====查找====
s.find("abc");//查找字符串"abc"在s中第一次出现的位置（据说是KMP实现的）
//s="aabcc"; printf("%d %d\n",(int)s.find("abc"),(int)s.find("aabb"));
//上一行程序应输出 1 -1 （若没找到必须强行转换为int才为 -1 ）
```

7.4 Batch test

7.4.1 @Linux

```
mkdata=mk
filea=a
fileb=b

g++ $mkdata.cpp -o $mkdata
g++ $filea.cpp -o $filea
g++ $fileb.cpp -o $fileb
cas=0
while true; do
    ./$mkdata > $filea.in
    ./$filea < $filea.in > $filea.out
    ./$fileb < $filea.in > $fileb.out
    if ! diff $filea.out $fileb.out
    then
        echo "␣Wrong␣Answer"
        break
    fi
    echo $((cas=cas+1)) "␣Accepted"
done
```

7.4.2 @Windows

```
:loop
    mk > A.in
    A < A.in > A.out
    p < A.in > p.out
    fc A.out p.out
    if errorlevel 1 goto end
    goto loop
:end
    pause
```

7.5 Vimrc Config For Linux

```
set nobackup
set cin
set nu
set st=4
set ts=4
```

```
set sw=4

map <F7> <Esc>:w<CR>:!javac %:r.java<CR>:!java %:r<CR>
imap <F7> <Esc>:w<CR>:!javac %:r.java<CR>:!java %:r<CR>
map <F8> <Esc>:w<CR>:!g++ -g %:r.cpp -o %:r<CR>:!gdb %:r<CR>
imap <F8> <Esc>:w<CR>:!g++ -g %:r.cpp -o %:r<CR>:!gdb %:r<CR>
map <F9> <Esc>:w<CR>:!g++ -g %:r.cpp -o %:r<CR>:!./%:r<CR>
imap <F9> <Esc>:w<CR>:!g++ -g %:r.cpp -o %:r<CR>:!./%:r<CR>
```