



ACM/ICPC Template Manual

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0 头文件

```
1 // 巨菜的ACMer-Happy233
2
3 #include <bits/stdc++.h>
4
5 using namespace std;
6
7 //-----
8 typedef long long ll;
9 typedef vector<int> vi;
10 typedef pair<int, int> pii;
11 #define pw(x) (1ll << (x))
12 #define sz(x) ((int)(x).size())
13 #define all(x) (x).begin(),(x).end()
14 #define rep(i, l, r) for(int i=(l);i<(r);++i)
15 #define per(i, l, r) for(int i=(r)-1;i>=(l);--i)
16 #define mst(t, v, n) memset(t, v, sizeof(decltype(*(t)))) * (n))
17 #define sf(x) scanf("%d", &(x))
18 //---debug array *(ll(*)[10])ptr
19
20 using namespace std;
21
22 const double pi = acos(-1);
```

0.1 stdc++

```
1 // C
2 #ifndef _GLIBCXX_NO_ASSERT
3 #include <cassert>
4 #endif
5 #include <cctype>
6 #include <cerrno>
7 #include <cfloat>
8 #include <ciso646>
9 #include <climits>
10 #include <locale>
11 #include <cmath>
12 #include <csetjmp>
13 #include <csignal>
14 #include <cstdarg>
15 #include <cstddef>
16 #include <cstdio>
17 #include <cstdlib>
18 #include <cstring>
19 #include <ctime>
20
21 #if __cplusplus >= 201103L
22 #include <complex>
23 #include <cfenv>
24 #include <cinttypes>
25 #include <cstdalign>
26 #include <stdbool>
27 #include <stdint>
28 #include <tgmath>
29 #include <uchar>
30 #include <wchar>
31 #include <wctype>
```

```
32 #endif
33
34 // C++
35 #include <algorithm>
36 #include <bitset>
37 #include <complex>
38 #include <deque>
39 #include <exception>
40 #include <fstream>
41 #include <functional>
42 #include <iomanip>
43 #include <ios>
44 #include <iosfwd>
45 #include <iostream>
46 #include <istream>
47 #include <iterator>
48 #include <limits>
49 #include <list>
50 #include <locale>
51 #include <map>
52 #include <memory>
53 #include <new>
54 #include <numeric>
55 #include <ostream>
56 #include <queue>
57 #include <set>
58 #include <sstream>
59 #include <stack>
60 #include <stdexcept>
61 #include <streambuf>
62 #include <string>
63 #include <typeinfo>
64 #include <utility>
65 #include <valarray>
66 #include <vector>
67
68 #if __cplusplus >= 201103L
69 #include <array>
70 #include <atomic>
71 #include <chrono>
72 #include <codecvt>
73 #include <condition_variable>
74 #include <forward_list>
75 #include <future>
76 #include <initializer_list>
77 #include <mutex>
78 #include <random>
79 #include <ratio>
80 #include <regex>
81 #include <scoped_allocator>
82 #include <system_error>
83 #include <thread>
84 #include <tuple>
85 #include <typeindex>
86 #include <type_traits>
87 #include <unordered_map>
88 #include <unordered_set>
89 #endif
```

1 字符串

1.1 KMP

```

1  template<class elemType>
2  inline void kmp_nxt(elemType &T, vector<int> &nxt) {
3      nxt[0] = -1;
4      for (int i = 1; i < T.size(); i++) {
5          int j = nxt[i - 1];
6          while (j >= 0 && T[i - 1] != T[j]) j = nxt[j];
7          if (j >= 0 && T[i - 1] == T[j]) nxt[i] = j + 1;
8          else nxt[i] = 0;
9      }
10 }
11
12 template<class elemType>
13 inline int kmp_count(elemType &S, elemType &T) {
14     vector<int> nxt(T.size());
15     kmp_nxt(T, nxt);
16     int index, count = 0;
17     for (index = 0; index < S.size(); ++index) {
18         int pos = 0;
19         int iter = index;
20         while (pos < T.size() && iter < S.size()) {
21             if (S[iter] == T[pos]) {
22                 ++iter;
23                 ++pos;
24             } else {
25                 if (pos == 0) ++iter;
26                 else pos = nxt[pos - 1] + 1;
27             }
28         }
29         if (pos == T.size() && (iter - index) == T.size()) ++count;
30     }
31     return count;
32 }
33
34 template<class elemType>
35 inline void kmp_next(elemType T[], int count, vector<int> &nxt) {
36     nxt[0] = -1;
37     for (int i = 1; i < count; i++) {
38         int j = nxt[i - 1];
39         while (j >= 0 && T[i - 1] != T[j]) j = nxt[j];
40         if (j >= 0 && T[i - 1] == T[j]) nxt[i] = j + 1;
41         else nxt[i] = 0;
42     }
43 }
44
45 template<class elemType>
46 inline int kmp_count(elemType S[], int c1, elemType T[], int c2) {
47     vector<int> nxt(c2);
48     kmp_nxt(T, c2, nxt);
49     int index, count = 0;
50     for (index = 0; index < c1; ++index) {
51         int pos = 0;
52         int iter = index;
53         while (pos < c2 && iter < c1) {
54             if (S[iter] == T[pos]) {
55                 ++iter;

```

```
56         ++pos;
57     }
58     else {
59         if (pos == 0) ++iter;
60         else pos = nxt[pos - 1] + 1;
61     }
62 }
63 if (pos == c2 && (iter - index) == c2) ++count;
64 }
65 return count;
66 }
```

2 动态规划

2.1 01Bag

```

1 void dp(int n, int m) {
2     // n=物品个数
3     for (int i = 0; i < n; i++) {
4         // m=背包最大容量
5         for (int j = m; j >= wei[i]; j--)
6             // wei=大小 val=价值
7             f[j] = max(f[j], f[j - wei[i]] + val[i]);
8     }
9 }

```

2.2 BagProblem

```

1 #define N 1000
2 // val=价值 wei=重量 num=数量
3 int val[N], wei[N], num[N], f[N];
4 // n=种类个数 m=背包最大值
5
6 // 01背包
7 void dp1(int n, int m) {
8     for (int i = 0; i < n; i++) {
9         for (int j = m; j >= wei[i]; j--)
10             f[j] = max(f[j], f[j - wei[i]] + val[i]);
11     }
12 }
13
14 // 完全背包
15 void dp2(int n, int m) {
16     //初始化看要求
17     for (int i = 0; i <= m; i++) {
18         f[i] = INF;
19     }
20     f[0] = 0;
21     //若要求恰好装满背包, 那在初始化时除了f[0]=0其它f[1..V]均=-∞
22     //若没要求背包装满, 只希望价格大, 初始化时应将f[0..V]=0
23     for (int i = 0; i < n; i++)
24         for (int j = wei[i]; j <= m; j++)
25             f[j] = max(f[j], f[j - wei[i]] + val[i]);
26 }
27
28 // 多重背包
29 void dp3(int n, int m) {
30     for (int i = 0; i < n; i++)
31         for (int k = 0; k < num[i]; k++)
32             for (int j = m; j >= wei[i]; j--)
33                 f[j] = max(f[j], f[j - wei[i]] + val[i]);
34 }

```

2.3 FullBag

```

1 /*
2 完全背包问题的特点是, 每种物品可以无限制的重复使用, 可以选择放或不放。
3 完全背包问题描述:
4 有N物品和一个容量为V的背包。第i件物品的重量是wei[i], 价值是val[i]。

```



```

5  */
6
7  #include <stdio>
8  #define INF 0x3fffffff
9  #define N 10047
10 int f[N],val[N],wei[N];
11 int min(int a,int b)
12 {
13     return x<y?x:y;
14 }
15 int main()
16 {
17     int t,i,j,k,E,F,m,n;
18     scanf("%d",&t);
19     while(t-->0)
20     {
21         scanf("%d%d",&E,&F);
22         int c = F-E;
23         for(i = 0 ; i <= c ; i++)
24             f[i]=INF;
25         scanf("%d",&n);
26         for(i = 0 ; i < n ; i++)
27         {
28             scanf("%d%d",&val[i],&wei[i]); //val[i]为面额, wei[i]为重量
29         }
30         f[0]=0; //因为此处假设的是小猪储钱罐 恰好装满 的情况
31         //注意初始化 (要求恰好装满背包, 那么在初始化时除了f[0]为0其它f[1..V]均设为-∞,
32         //这样就可以保证最终得到的f[N]是一种恰好装满背包的最优解。
33         //如果并没有要求必须把背包装满, 而是只希望价格尽量大, 初始化时应该将f[0..V]全部设为0)
34         for(i = 0 ; i < n ; i++)
35         {
36             for(j = wei[i] ; j <= c ; j++)
37             {
38                 f[j] = min(f[j],f[j-wei[i]]+val[i]); //此处求的是最坏的情况所以用min, 确定最少
39                 //的钱,当然最后就用max了, HEHE
40             }
41         }
42         if(f[c] == INF)
43             printf("This is impossible.\n");
44         else
45             printf("The minimum amount of money in the piggy-bank is %d.\n",f[c]);
46     }
47     return 0;
48 } //此代码为HDU1114;

```

2.4 MultiBag

```

1  //多重背包(MultiplePack): 有N种物品和一个容量为V的背包。
2  //第i种物品最多有n[i]件可用, 每件费用是c[i], 价值是w[i]。
3  //求解将哪些物品装入背包可使这些物品的费用总和不超过背包容量,
4  //且价值总和最大。
5  //HDU 2191
6
7  #include <stdio>
8  #include <cstring>
9  #define N 247
10 int max(int x,int y){

```

```

11     return x>y?x:y;
12 }
13 int main() {
14     int t,n,m,i,j,k;
15     int w[N],pri[N],num[N],f[N];
16     while(~scanf("%d",&t)){
17         while(t--){
18             memset(f,0,sizeof(f));
19             scanf("%d%d",&n,&m);//n为总金额, m为大米种类
20             for(i = 0 ; i < m ; i++){
21                 scanf("%d%d%d",&pri[i],&w[i],&num[i]);//num[i]为每种大米的袋数
22             }
23             for(i = 0 ; i < m ; i++){
24                 for(k = 0 ; k < num[i] ; k++){
25                     for(j = n ; j >= pri[i]; j--){
26                         f[j] = max(f[j],f[j-pri[i]]+w[i]);
27                     }
28                 }
29             }
30             printf("%d\n",f[n]);
31         }
32     }
33     return 0;
34 }

```

2.5 Maze01

```

1 struct Maze01 {
2     // 原始01矩阵 1-n 1-m
3     bool a[N][N];
4     // 以(i,j)向上最大高度的最大子矩阵的左右高
5     int l[N][N], r[N][N], h[N][N];
6     // 最大连续前缀1的左端位置, 如果(i,j)为0则ml=j+1
7     int ml[N][N];
8     // 矩阵大小
9     int n, m;
10
11     void prework() {
12         for (int i = 1; i <= m; i++) {
13             l[0][i] = 0;
14             r[0][i] = m;
15         }
16         for (int i = 1; i <= n; i++) {
17             int maxl = 1;
18             int maxr = m;
19             for (int j = 1; j <= m; j++) {
20                 if (a[i][j] == 0) {
21                     maxl = j + 1;
22                     h[i][j] = l[i][j] = 0;
23                 } else {
24                     h[i][j] = h[i - 1][j] + 1;
25                     l[i][j] = max(maxl, l[i - 1][j]);
26                 }
27                 ml[i - 1][j] = maxl;
28                 ml[i][j] = j + 1;
29             }
30             for (int j = m; j >= 1; --j) {
31                 if (a[i][j] == 0) {

```

```
32         maxr = j - 1;
33         r[i][j] = m;
34     } else {
35         r[i][j] = min(maxr, r[i - 1][j]);
36     }
37 }
38 }
39 }
40
41 // 单调栈
42 pii st[N];
43
44 int calc() {
45     prework();
46     int ans = 0;
47     for (int i = 1; i <= n; i++) {
48         int top = 0;
49         for (int j = 1; j <= m; j++) {
50             if (h[i][j] == 0) continue;
51             if (top == 0 || st[top] != make_pair(l[i][j], r[i][j])) {
52                 st[++top] = make_pair(l[i][j], r[i][j]);
53             }
54             while (top && st[top].second == j) {
55                 int pos = st[top--].first;
56                 if (pos < ml[i][j]) {
57                     // l[i][j]-r[i][j]为底, h[i][j]为高
58                     // 可以得到所有的唯一子矩阵, 不存在maze1完全属于maze2
59                     ans++;
60                 }
61             }
62         }
63     }
64     return ans;
65 }
66 } dp;
```

3 数据结构

3.1 BTree

```

1  template<class T>
2
3  struct TreeNode {
4      T value;
5      TreeNode *left;
6      TreeNode *right;
7  };
8
9  template<class T>
10 TreeNode<T> *createTree(const T *pre, const T *in, const int len) {
11     TreeNode<T> *t = NULL;
12     if (len > 0) {
13         t = new TreeNode<T>;
14         t->value = pre[0];
15         int index;
16         for (index = 0; index < len; index++) {
17             if (in[index] == pre[0]) {
18                 break;
19             }
20         }
21         if (index == len) {
22             index = -1;
23         }
24         t->left = createTree(pre + 1, in, index);
25         t->right = createTree(pre + index + 1, in + index + 1, len - index - 1);
26     }
27     return t;
28 }
29
30 template<class T>
31 int preOrder(TreeNode<T> *root, queue<T> &out) {
32     if (root) {
33         int count = 1;
34         out.push(root->value);
35         count += preOrder(root->left, out);
36         count += preOrder(root->right, out);
37         return count;
38     } else {
39         return 0;
40     }
41 }
42
43 template<class T>
44 int inOrder(TreeNode<T> *root, queue<T> &out) {
45     if (root) {
46         int count = 1;
47         count += inOrder(root->left, out);
48         out.push(root->value);
49         count += inOrder(root->right, out);
50         return count;
51     } else {
52         return 0;
53     }
54 }
55

```

```
56 template<class T>
57 void postOrder(TreeNode<T> *root, queue<T> &out) {
58     if (root) {
59         postOrder(root->left, out);
60         postOrder(root->right, out);
61         out.push(root->value);
62     } else {
63         return;
64     }
65 }
66
67 template<class T>
68 T *convertQueueToArray(queue<T> &out, int len) {
69     T *list = new T[len];
70     int now = 0;
71     while (!out.empty() && now < len) {
72         list[now] = out.front();
73         out.pop();
74         now++;
75     }
76     return list;
77 }
78
79 template<class T>
80 void destroyTree(TreeNode<T> *root) {
81     if (root) {
82         destroyTree(root->left);
83         destroyTree(root->right);
84         delete root;
85     } else return;
86 }
87
88 template<class T>
89 void insertIntoBSTree(TreeNode<T> *root, const T &value) {
90     if (!root) {
91         return;
92     }
93     if (value < root->value) {
94         if (root->left) {
95             insertIntoTree(root->left, value);
96         } else {
97             root->left = new TreeNode<T>;
98             root->left->value = value;
99             root->left->left = NULL;
100             root->left->right = NULL;
101         }
102     } else if (value > root->value) {
103         if (root->right) {
104             insertIntoTree(root->right, value);
105         } else {
106             root->right = new TreeNode<T>;
107             root->right->value = value;
108             root->right->left = NULL;
109             root->right->right = NULL;
110         }
111     }
112 }
113
114 template<class T>
```

```

115 TreeNode<T> *createBSTree(T *list, int len) {
116     if (len < 1) {
117         return NULL;
118     }
119     TreeNode<T> *root = new TreeNode<char>;
120     root->value = list[0];
121     root->left = NULL;
122     root->right = NULL;
123     for (int i = 1; i < len; i++) {
124         insertIntoBSTree(root, list[i]);
125     }
126     return root;
127 }

```

3.2 pbds-bbtree

```

1 // RBTREE 红黑树
2 #include <ext/pb_ds/tree_policy.hpp>
3 #include <ext/pb_ds/assoc_container.hpp>
4 // 红黑树
5 __gnu_pbds::tree<int, null_type, less<int>, rb_tree_tag,
6     tree_order_statistics_node_update> t;
7 // null_type无映射(低版本g++为null_mapped_type)
8 // 类似multiset
9 __gnu_pbds::tree<int, null_type, less_equal<int>, rb_tree_tag,
10     tree_order_statistics_node_update> t;
11 find_by_order(size_t order);
12 // 结点更新
13 tree_order_statistics_node_update
14 insert(p);
15 erase(it);
16 // 求k在树中是第几大:
17 order_of_key(p);
18 // 找到第order小的迭代器
19 find_by_order(order);
20 // 前驱
21 lower_bound(p);
22 // 后驱
23 upper_bound(p);
24 // 合并
25 a.join(b);
26 // 分割 key小于等于v的元素属于a, 其余的属于b
27 a.split(v, b);
28 // 优先队列
29 #include <ext/pb_ds/priority_queue.hpp>
30 #include <ext/pb_ds/assoc_container.hpp>
31 // 操作类似于stl的优先队列
32 typedef __gnu_pbds::priority_queue<node, greater<node>, __gnu_pbds::thin_heap_tag> heap;
33 ;
34 heap::point_iterator; // 指向元素的指针

```

3.3 树状数组

```

1 const int N = 1000005;
2 struct BITree {
3     int n;

```

```

4    ll c[N];
5
6    void init(int _n) {
7        n = _n;
8        memset(c, 0, sizeof(ll) * ++n);
9    }
10
11   void change(int pos, ll v) {
12       for (int i = pos; i < n; i += i & (-i))
13           c[i] += v;
14   }
15
16   ll query(int x) {
17       ll ans = 0;
18       for (int i = x; i > 0; i -= i & (-i))
19           ans += c[i];
20       return ans;
21   }
22
23   void update(int l, int r, ll v) {
24       change(l, v);
25       change(r + 1, -v);
26   }
27 };

```

3.4 二维树状数组

```

1    const int N = 2005;
2
3    inline int lowbit(const int &x) {
4        return x & -x;
5    }
6
7    struct TdBITree {
8        int n, m;
9        ll c[N][N];
10
11       void init(int n, int m) {
12           this->n = n;
13           this->m = m;
14           memset(c, 0, sizeof(c))
15       }
16
17       void init(int n, int m, ll v) {
18           this->n = n;
19           this->m = m;
20           rep(x, 1, N) {
21               rep(y, 1, N) {
22                   c[x][y] = (x * y + (x - lowbit(x)) * (y - lowbit(y)) - x * (y - lowbit(
23                   y)) - (x - lowbit(x)) * y) * v;
24               }
25           }
26
27       void change(int x, int y, ll v) {
28           for (int i = x; i <= n; i += lowbit(i))
29               for (int j = y; j <= m; j += lowbit(j))
30                   c[i][j] += v;

```

```

31     }
32
33     ll query(int x, int y) {
34         ll ans = 0;
35         for (int i = x; i >= 1; i -= lowbit(i))
36             for (int j = y; j >= 1; j -= lowbit(j))
37                 ans += c[i][j];
38         return ans;
39     }
40
41     ll solve(int x1, int y1, int x2, int y2) {
42         return query(x2, y2) - query(x1 - 1, y2) - query(x2, y1 - 1) + query(x1 - 1, y1
43         - 1);
44     }
45 };

```

3.5 线段树

```

1  // hdu 6562
2  struct TreeNode {
3      int l, r;
4      int lson, rson;
5      ll sum;
6      ll len;
7      ll laz1, laz2, laz3;
8
9      inline void init(int a, int b, int ls, int rs) {
10         lson = ls;
11         rson = rs;
12         l = a, r = b;
13         sum = 0;
14         len = 1;
15         laz1 = laz2 = 0;
16         laz3 = 1;
17     }
18
19     inline int mid() {
20         return (l + r) >> 1;
21     }
22
23     inline int width() {
24         return r - l + 1;
25     }
26
27     inline void add(ll val) {
28         sum = (sum * 10 + val * len * 10 + val * width()) % MOD;
29         len = (len * 100) % MOD;
30         // 右懒惰
31         laz1 = (laz1 * 10 + val) % MOD;
32         // 左懒惰
33         laz2 = (laz2 + val * laz3) % MOD;
34         // 长度懒惰
35         laz3 = (laz3 * 10) % MOD;
36     }
37 };
38
39 struct SegTree {
40     int tot;

```



```

41     TreeNode node[N << 1];
42
43     inline void init() {
44         tot = 0;
45     }
46
47     inline void up(int k) {
48         TreeNode &nd = node[k];
49         nd.sum = (node[nd.lson].sum + node[nd.rson].sum) % MOD;
50         nd.len = (node[nd.lson].len + node[nd.rson].len) % MOD;
51     }
52
53     inline void push(int k) {
54         TreeNode &nd = node[k];
55         if (nd.laz3 == 1) return;
56         TreeNode &lson = node[nd.lson];
57         TreeNode &rson = node[nd.rson];
58
59         lson.sum = (nd.laz1 * lson.width() + lson.sum * nd.laz3 + nd.laz2 * lson.len %
MOD * nd.laz3) % MOD;
60         lson.len = (lson.len * nd.laz3 % MOD * nd.laz3) % MOD;
61         lson.laz1 = (lson.laz1 * nd.laz3 + nd.laz1) % MOD;
62         lson.laz2 = (nd.laz2 * lson.laz3 + lson.laz2) % MOD;
63         lson.laz3 = (lson.laz3 * nd.laz3) % MOD;
64
65         rson.sum = (nd.laz1 * rson.width() + rson.sum * nd.laz3 + nd.laz2 * rson.len %
MOD * nd.laz3) % MOD;
66         rson.len = (rson.len * nd.laz3 % MOD * nd.laz3) % MOD;
67         rson.laz1 = (rson.laz1 * nd.laz3 + nd.laz1) % MOD;
68         rson.laz2 = (nd.laz2 * rson.laz3 + rson.laz2) % MOD;
69         rson.laz3 = (rson.laz3 * nd.laz3) % MOD;
70
71         nd.laz1 = nd.laz2 = 0;
72         nd.laz3 = 1;
73     }
74
75     void build(int k, int l, int r) {
76         TreeNode &nd = node[k];
77         nd.init(l, r, tot + 1, tot + 2);
78         tot += 2;
79         if (l == r) {
80             return;
81         }
82         int mid = nd.mid();
83         build(nd.lson, nd.l, mid);
84         build(nd.rson, mid + 1, nd.r);
85         up(k);
86     }
87
88     void change(int k, int l, int r, ll val) {
89         TreeNode &nd = node[k];
90         if (nd.l == l && nd.r == r) {
91             nd.add(val);
92             return;
93         }
94         push(k);
95         int mid = nd.mid();
96         if (r <= mid) {
97             change(nd.lson, l, r, val);

```

```

98     } else if (l > mid) {
99         change(nd.rson, l, r, val);
100    } else {
101        change(nd.lson, l, mid, val);
102        change(nd.rson, mid + 1, r, val);
103    }
104    up(k);
105 }
106
107 ll query(int k, int l, int r) {
108     TreeNode &nd = node[k];
109     if (nd.l == l && nd.r == r) {
110         return nd.sum;
111     }
112     push(k);
113     int mid = nd.mid();
114     ll ans = 0;
115     if (r <= mid) {
116         ans += query(nd.lson, l, r);
117     } else if (l > mid) {
118         ans += query(nd.rson, l, r);
119     } else {
120         ans += query(nd.lson, l, mid);
121         ans += query(nd.rson, mid + 1, r);
122     }
123     return ans % MOD;
124 }
125 } tree;

```

3.6 二维线段树

```

1
2 const int N = 1005;
3
4 struct SegTree {
5
6     inline int son(int k, int x) {
7         return (k << 2) - 2 + x;
8     }
9
10    struct node {
11        int l, r;
12
13        node() = default;
14
15        node(int a, int b) : l(a), r(b) {}
16
17        inline int mid() {
18            return (l + r) >> 1;
19        }
20
21        inline node left() {
22            return node(l, mid());
23        }
24
25        inline node right() {
26            return node(mid() + 1, r);
27        }

```

```

28
29     inline bool in(int x) {
30         return x >= l && x <= r;
31     }
32
33     inline bool more() {
34         return l < r;
35     }
36
37     bool operator==(const node &t) {
38         return l == t.l && r == t.r;
39     }
40 };
41
42 ll c[N << 2][N << 2];
43 ll ans[N << 4];
44 ll laz[N << 4];
45
46 inline void up(int k, bool x, bool y) {
47     int s = (k << 2) - 2;
48     ll t = 0;
49     if (x) t += ans[s] + ans[s + 1] + laz[s] + laz[s + 1];
50     if (y) t += ans[s + 2] + ans[s + 3] + laz[s + 2] + laz[s + 3];
51     ans[k] = t;
52 }
53
54 inline void push(int k) {
55     int s = (k << 2) - 2;
56     laz[s] += laz[k];
57     laz[s + 1] += laz[k];
58     laz[s + 2] += laz[k];
59     laz[s + 3] += laz[k];
60     ans[k] += laz[k];
61     laz[k] = 0;
62 }
63
64 void build(node x, node y, int k) {
65     laz[k] = 0;
66     if (x.more() && y.more()) {
67         ans[k] = c[x.l][y.l];
68         return;
69     }
70     ans[k] = 0;
71     bool ax = false;
72     bool ay = false;
73     if (x.more()) {
74         build(x.left(), y, son(k, 0));
75         build(x.right(), y, son(k, 1));
76     }
77     if (y.more()) {
78         build(x, y.left(), son(k, 2));
79         build(x, y.right(), son(k, 3));
80     }
81     up(k, x.more(), y.more());
82 }
83
84 void change(node x, node y, int k, node l, node r, ll v) {
85     if (x == l && y == r) {
86         laz[k] += v;

```

```

87         return;
88     }
89     push(k);
90     if (x.more()) {
91         if (l.r <= x.mid()) {
92             change(x.left(), y, son(k, 0), l, r, v);
93         } else if (l.l > x.mid()) {
94             change(x.right(), y, son(k, 1), l, r, v);
95         } else {
96             change(x.left(), y, son(k, 0), node(l.l, x.mid()), r, v);
97             change(x.right(), y, son(k, 1), node(x.mid() + 1, l.r), r, v);
98         }
99     }
100     if (y.more()) {
101         if (r.l <= y.mid()) {
102             change(x, y.left(), son(k, 2), l, r, v);
103         } else if (r.r > y.mid()) {
104             change(x, y.right(), son(k, 3), l, r, v);
105         } else {
106             change(x, y.left(), son(k, 2), l, node(r.l, y.mid()), v);
107             change(x, y.right(), son(k, 3), l, node(y.mid() + 1, r.r), v);
108         }
109     }
110     up(k, x.more(), y.more());
111 }
112
113 ll query(node x, node y, int k, node l, node r) {
114     if (x == l && y == r) {
115         return ans[k] + laz[k];
116     }
117     push(k);
118     ll t = 0;
119     if (x.more()) {
120         if (l.r <= x.mid()) {
121             t += query(x.left(), y, son(k, 0), l, r);
122         } else if (l.l > x.mid()) {
123             t += query(x.right(), y, son(k, 1), l, r);
124         } else {
125             t += query(x.left(), y, son(k, 0), node(l.l, x.mid()), r);
126             t += query(x.right(), y, son(k, 1), node(x.mid() + 1, l.r), r);
127         }
128     }
129     if (y.more()) {
130         if (r.l <= y.mid()) {
131             t += query(x, y.left(), son(k, 2), l, r);
132         } else if (r.r > y.mid()) {
133             t += query(x, y.right(), son(k, 3), l, r);
134         } else {
135             t += query(x, y.left(), son(k, 2), l, node(r.l, y.mid()));
136             t += query(x, y.right(), son(k, 3), l, node(y.mid() + 1, r.r));
137         }
138     }
139     return t;
140 }
141 };

```

3.7 树状数组求逆序对

```

1 BITree t;
2 int n;
3 pii a[N];
4
5 void solve() {
6     t.init(n);
7     for (int i = 1; i <= n; i++) {
8         int x;
9         cin >> x;
10        a[i] = make_pair(x, i);
11    }
12    sort(a + 1, a + n + 1);
13    ll ans = 0;
14    for (int i = 1; i <= n; i++) {
15        t.change(a[i].second, 1);
16        ans += (i - t.query(a[i].second));
17    }
18    cout << ans << endl;
19 }

```

3.8 ST

```

1 // 只需要取值
2 struct ST {
3     int ck[N];
4     int dp[20][N];
5
6     void init(int n, int squ[]) {
7         ++n;
8         ck[0] = -1;
9         for (int i = 1; i <= n; i++) {
10            ck[i] = ck[i - 1] + ((i & (i - 1)) == 0 ? 1 : 0);
11        }
12        for (int i = 0; i < n; i++) {
13            dp[0][i] = squ[i];
14        }
15        for (int k = 1; k <= ck[n]; k++) {
16            int dk = k - 1;
17            for (int i = 0; i + (1 << k) - 1 < n; i++) {
18                dp[k][i] = max(dp[dk][i], dp[dk][i + (1 << dk)]);
19            }
20        }
21    }
22
23    int query(int l, int r) {
24        if (l > r) swap(l, r);
25        int k = ck[r - l + 1];
26        return max(dp[k][l], dp[k][r - (1 << k) + 1]);
27    }
28 };
29
30 // 可得到下标
31 struct ST {
32     int ck[N];
33     int rmq[N];
34     int dp[20][N];
35
36     void init(int n, int squ[]) {

```

```

37     ++n;
38     ck[0] = -1;
39     for (int i = 1; i <= n; i++) {
40         ck[i] = ck[i - 1] + ((i & (i - 1)) == 0 ? 1 : 0);
41     }
42     memcpy(rmq, squ, sizeof(int) * n);
43     for (int i = 0; i < n; i++) {
44         dp[0][i] = i;
45     }
46     for (int k = 1; k <= ck[n]; k++) {
47         int dk = k - 1;
48         for (int i = 0; i + (1 << k) - 1 < n; i++) {
49             int a = dp[dk][i];
50             int b = dp[dk][i + (1 << dk)];
51             dp[k][i] = rmq[a] < rmq[b] ? a : b;
52         }
53     }
54 }
55
56 int query(int l, int r) {
57     if (l > r) swap(l, r);
58     int k = ck[r - l + 1];
59     int a = dp[k][l];
60     int b = dp[k][r - (1 << k) + 1];
61     return rmq[a] < rmq[b] ? a : b;
62 }
63 };

```

3.9 笛卡尔树

```

1  // 笛卡尔树, 静态建树, 区间最值跳转
2  struct CartesianTree {
3      int rt; // 根节点
4      pii ch[N]; // 左右儿子
5      int st[N]; // 单调栈
6
7      void build(int n, int p[]) {
8          rt = 0;
9          int t = 0;
10         for (int i = 1; i <= n; i++) {
11             // 决定了大于还是小于
12             while (t && p[st[t]] > p[i]) --t;
13             if (t) {
14                 // 成为上一个点的右儿子
15                 // 前一个点成为自己的左子节点
16                 ch[st[t]].second = i;
17                 ch[i].first = t;
18             } else { // 自己作为根节点
19                 ch[i].first = rt;
20                 rt = i;
21             }
22             st[++t] = i;
23         }
24     }
25 } dika;

```

3.10 DancingLinks

```

1 // Dancing Links
2 struct DLX {
3     int n, m, size;
4     int U[MaxNode], D[MaxNode], L[MaxNode], R[MaxNode], Row[MaxNode], Col[MaxNode];
5     int H[MaxN], S[MaxM];
6     int ansd, ans[MaxN];
7
8     void init(int _n, int _m) {
9         n = _n;
10        m = _m;
11        for (int i = 0; i <= m; i++) {
12            S[i] = 0;
13            U[i] = D[i] = i;
14            L[i] = i - 1;
15            R[i] = i + 1;
16        }
17        R[m] = 0;
18        L[0] = m;
19        size = m;
20        for (int i = 0; i <= n; i++) {
21            H[i] = -1;
22        }
23    }
24
25    void Link(int r, int c) {
26        ++S[Col[++size] = c];
27        Row[size] = r;
28        D[size] = D[c];
29        U[D[c]] = size;
30        U[size] = c;
31        D[c] = size;
32        if (H[r] < 0) {
33            H[r] = L[size] = R[size] = size;
34        } else {
35            R[size] = R[H[r]];
36            L[R[H[r]]] = size;
37            L[size] = H[r];
38            R[H[r]] = size;
39        }
40    }
41
42    void remove(int c) {
43        L[R[c]] = L[c];
44        R[L[c]] = R[c];
45        for (int i = D[c]; i != c; i = D[i]) {
46            for (int j = R[i]; j != i; j = R[j]) {
47                U[D[j]] = U[j];
48                D[U[j]] = D[j];
49                --S[Col[j]];
50            }
51        }
52    };
53
54    void resume(int c) {
55        for (int i = U[c]; i != c; i = U[i])
56            for (int j = L[i]; j != i; j = L[j])
57                ++S[Col[U[D[j]] = D[U[j]] = j]];
58        L[R[c]] = R[L[c]] = c;
59    }

```

```

60
61 bool Dance(int d) {
62     if (R[0] == 0) {
63         for (int i = 0; i < d; i++) {
64             printf("%d%c", ans[i], " \n"[i == d - 1]);
65         }
66         return true;
67     }
68     int c = R[0];
69     for (int i = R[0]; i != 0; i = R[i]) if (S[i] < S[c]) c = i;
70     remove(c);
71     for (int i = D[c]; i != c; i = D[i]) {
72         ans[d] = Row[i];
73         for (int j = R[i]; j != i; j = R[j]) remove(Col[j]);
74         if (Dance(d + 1)) return true;
75         for (int j = L[i]; j != i; j = L[j]) resume(Col[j]);
76     }
77     resume(c);
78     return false;
79 }
80 };

```

3.11 主席树

```

1 struct SegTree {
2     int num[N];
3     int c[M];
4     ll s[M];
5     pii ran;
6     int tot = 0;
7     int lson[M], rson[M];
8
9     int build(int l, int r) {
10         int k = ++tot;
11         s[k] = c[k] = 0;
12         if (l == r) {
13             return k;
14         }
15         int mid = (l + r) >> 1;
16         lson[k] = build(l, mid);
17         rson[k] = build(mid + 1, r);
18         return k;
19     }
20
21     int init(int l, int r) {
22         ran = pii(l, r);
23         tot = 0;
24         return build(l, r);
25     }
26
27     int update(int rt, int p) {
28         int val = num[p];
29         int l, r;
30         tie(l, r) = ran;
31         int k = ++tot;
32         int tmp = k;
33         c[k] = c[rt] + 1, s[k] = s[rt] + val;
34         while (l < r) {

```



```
35         int mid = (l + r) >> 1;
36         if (p <= mid) {
37             lson[k] = ++tot;
38             rson[k] = rson[rt];
39             k = lson[k], rt = lson[rt];
40             r = mid;
41         } else {
42             lson[k] = lson[rt];
43             rson[k] = ++tot;
44             k = rson[k], rt = rson[rt];
45             l = mid + 1;
46         }
47         c[k] = c[rt] + 1, s[k] = s[rt] + val;
48     }
49     return tmp;
50 }
51
52 pll query(int a, int b, int h) {
53     int l, r;
54     tie(l, r) = ran;
55     int cs = c[a] - c[b];
56     int cnt = 0;
57     ll sum = 0;
58     while (l < r) {
59         int mid = (l + r) >> 1;
60         if (h <= mid) {
61             a = lson[a], b = lson[b];
62             r = mid;
63         } else {
64             cnt += c[lson[a]] - c[lson[b]];
65             sum += s[lson[a]] - s[lson[b]];
66             a = rson[a], b = rson[b];
67             l = mid + 1;
68         }
69     }
70     cs -= cnt;
71     sum += cs * num[l];
72     return pll(sum, cs);
73 }
74 } tree;
```

4 图论

4.1 Graph

```

1  #define forg(i, h, eg) for(int i = (h); ~i; i = (eg[i]).nxt)
2
3  struct Edge {
4      int e, nxt;
5      ll v;
6      Edge() = default;
7      Edge(int a, ll b, int c = 0) : e(a), v(b), nxt(c) {}
8
9      bool operator<(const Edge &a) const {
10         return (a.v == v ? e < a.e : v < a.v);
11     }
12 };
13
14 const ll INF = ll(1e11);
15 const int N = int(1e5 + 10);
16 const int M = int(3e5 + 10);
17
18 struct Graph {
19     Edge eg[M];
20     int head[N];
21     int cnt;
22
23     void init(int n) {
24         memset(head, -1, sizeof(int) * ++n);
25         cnt = 0;
26     }
27
28     inline void addEdge(int x, int y, ll v = 0) {
29         eg[cnt] = Edge(y, v, head[x]);
30         head[x] = cnt++;
31     }
32 } gh;

```

4.2 Dijkstra

```

1  int dist[N];
2  int path[N];
3
4  void bfs(int s, int n) {
5      n++;
6      rep(i, 0, n) dist[i] = INF;
7      memset(path, -1, sizeof(int) * n);
8      dist[s] = 0;
9      path[s] = s;
10     // 注意优先队列默认less运算, 但选择最大的作为top, 注意cmp!!!
11     priority_queue<Edge, vector<Edge>, greater<Edge>> q;
12     q.push(Edge(s, dist[s]));
13     while (!q.empty()) {
14         Edge f = q.top();
15         q.pop();
16         for (int i = gh.head[f.e]; ~i; i = gh.eg[i].nxt) {
17             Edge &t = gh.eg[i];
18             if (dist[t.e] > f.v + t.v) {
19                 dist[t.e] = f.v + t.v;

```

```

20         path[t.e] = f.e;
21         q.push(Edge(t.e, dist[t.e]));
22     }
23 }
24 }
25 }
26
27 #include <ext/pb_ds/priority_queue.hpp>
28 #include <ext/pb_ds/assoc_container.hpp>
29 typedef __gnu_pbds::priority_queue<Edge, greater<Edge>> heap;
30 // 使用该模板, 需要注意因为使用了greater, 所以需要重载大于运算
31 // 默认pairing_heap_tag
32 // push O(1), pop O(logn) modify O(logn) erase O(logn) join O(1)
33 // 可选thin_heap_tag
34 // push O(1), pop O(logn) modify O(1) erase O(logn) join O(n)
35
36 heap::point_iterator its[N];
37 int cnt[N];
38
39 void bfs(int s, int n) {
40     n++;
41     rep(i, 0, n) dist[i] = INF;
42     memset(cnt, 0, sizeof(int) * n);
43     dist[s] = 0;
44     cnt[s] = 1;
45     heap q;
46     its[s] = q.push(Edge(s, dist[s]));
47     while (!q.empty()) {
48         Edge f = q.top();
49         q.pop();
50         for (int i = gh.head[f.e]; ~i; i = gh.eg[i].nxt) {
51             Edge &t = gh.eg[i];
52             its[t.e] = 0;
53             int v = f.v + t.v;
54             if (dist[t.e] > v) {
55                 dist[t.e] = v;
56                 if (its[t.e] != 0) {
57                     q.modify(its[t.e], Edge(t.e, dist[t.e]));
58                 } else {
59                     its[t.e] = q.push(Edge(t.e, dist[t.e]));
60                 }
61                 cnt[t.e] = cnt[f.e];
62             } else if (dist[t.e] == v) {
63                 (cnt[t.e] += cnt[f.e]) %= 100003;
64             }
65         }
66     }
67 }

```

4.3 spfa

```

1 vector<int> dist;
2 vector<vector<node>> eg;
3 vector<int> path;
4
5 bool spfa(int n, int start) {
6     dist.assign(n, INF);
7     dist[start] = 0;

```

```

8     deque<int> q;
9     q.push_back(start);
10    path.assign(n, -1);
11    vector<int> cnt(n, 0);
12    vector<bool> flag(n, false);
13    cnt[start] = flag[start] = true;
14    while (!q.empty()) {
15        const int now = q.front();
16        q.pop_front();
17        flag[now] = false;
18        for (auto i: eg[now]) {
19            if (dist[i.x] > dist[now] + i.d) {
20                dist[i.x] = dist[now] + i.d;
21                path[i.x] = now;
22                if (!flag[i.x]) {
23                    if (n == ++cnt[i.x]) return false;
24                    //队列非空且优于队首 (SLF)
25                    if (!q.empty() && dist[i.x] < dist[q.front()]) {
26                        q.push_front(i.x);
27                    } else {
28                        q.push_back(i.x);
29                    }
30                    flag[i.x] = true;
31                }
32            }
33        }
34    }
35    return true;
36 }

```

4.4 Dinic

```

1 struct Dinic {
2     Graph gh;
3     // 点的范围[0, n)
4     int n;
5     // 弧优化
6     int cur[N], dis[N];
7
8     Dinic(){};
9
10    // 设置N
11    void init(int _n) {
12        n = _n;
13        gh.init(n);
14    }
15
16    // 加流量
17    void addFlow(int x, int y, ll f) {
18        gh.addEdge(x, y, f);
19        gh.addEdge(y, x, 0);
20    }
21
22    bool bfs(int s, int e) {
23        memset(dis, -1, sizeof(int) * n);
24        int q[N];
25        int l, r;
26        l = r = 0;

```

```

27     dis[s] = 0;
28     q[r++] = s;
29     while (l < r) {
30         int f = q[l++];
31         for (int i = gh.head[f]; ~i; i = gh.eg[i].nxt) {
32             if (gh.eg[i].v > 0 && dis[gh.eg[i].e] == -1) {
33                 dis[gh.eg[i].e] = dis[f] + 1;
34                 q[r++] = gh.eg[i].e;
35             }
36         }
37     }
38     return dis[e] > 0;
39 }
40
41 ll dfs(int s, int e, ll mx) {
42     if (s == e || mx == 0) {
43         return mx;
44     }
45     ll flow = 0;
46     for (int &k = cur[s]; ~k; k = gh.eg[k].nxt) {
47         auto &eg = gh.eg[k];
48         ll a;
49         if (eg.v > 0 && dis[eg.e] == dis[s] + 1 && (a = dfs(eg.e, e, min(eg.v, mx)))
50     )) {
51         eg.v -= a;
52         gh.eg[k ^ 1].v += a;
53         flow += a;
54         mx -= a;
55         if (mx <= 0) break;
56     }
57     return flow;
58 }
59
60 ll max_flow(int s, int e) {
61     ll ans = 0;
62     while (bfs(s, e)) {
63         memcpy(cur, gh.head, sizeof(int) * n);
64         ans += dfs(s, e, INF);
65     }
66     return ans;
67 }
68 } dinic;

```

4.5 hungry

```

1  #define N 105
2  #define M 10005
3  int n, m, k;
4  pii eg[M * 2];
5  int result[N * 2];
6  int head[N * 2];
7  int cnt = 0;
8
9  void addEdge(int x, int y) {
10     eg[cnt].first = y;
11     eg[cnt].second = head[x];
12     head[x] = cnt++;

```

```

13 }
14
15 bool vis[M * 2] = {false};
16
17 int dfs(int x) {
18     for (int i = head[x]; ~i; i = eg[i].second) {
19         int y = eg[i].first;
20         if (!vis[y]) {
21             vis[y] = true;
22             if (result[y] == -1 || dfs(result[y])) {
23                 result[y] = x;
24                 return 1;
25             }
26         }
27     }
28     return 0;
29 }
30
31 int MaxMatch() {
32     int ans = 0;
33     memset(result, -1, sizeof(result));
34     rep(i, 1, n + 1) {
35         memset(vis, 0, sizeof(vis));
36         ans += dfs(i);
37     }
38     return ans;
39 }
40
41 void solve() {
42     scanf("%d%d", &m, &k);
43     memset(head, -1, sizeof(head));
44     cnt = 0;
45     rep(i, 0, k) {
46         int x, y;
47         scanf("%d%d", &x, &y);
48         addEdge(x, y);
49     }
50     int ans = MaxMatch();
51     printf("%d\n", ans);
52 }

```

4.6 MinSpanTree

```

1  /*
2  * Prim 求 MST
3  * 耗费矩阵 cost[][], 标号从 0 开始, 0~n-1
4  * 返回最小生成树的权值, 返回 -1 表示原图不连通
5  */
6  const int INF = 0x3f3f3f3f;
7  const int N = 110;
8  bool vis[N];
9  int lowc[N]; //点是 0 n-1
10 int prim(int cost[][N], int n) {
11     int ans = 0;
12     memset(vis, false, sizeof(vis));
13     vis[0] = true;
14     for (int i = 1; i < n; i++) lowc[i] = cost[0][i];
15     for (int i = 1; i < n; i++) {

```

```

16     int minc = INF;
17     int p = -1;
18
19     for (int j = 0; j < n; j++)
20         if (!vis[j] && minc > lowc[j]) {
21             minc = lowc[j];
22             p = j;
23         }
24     if (minc == INF) return -1; // 原图不连通
25     ans += minc;
26     vis[p] = true;
27     for (int j = 0; j < n; j++)
28         if (!vis[j] && lowc[j] > cost[p][j])
29             lowc[j] = cost[p][j];
30 }
31 return ans;
32 }

```

4.7 MinCostMaxFlow

```

1 struct Edge {
2     int e, nxt;
3     ll flow, cost;
4
5     Edge() {}
6
7     Edge(int a, ll b, ll c, int d = 0) : e(a), flow(b), cost(c), nxt(d) {}
8 };
9
10 const ll INF = 1000000;
11 const int N = int(1e5 + 10);
12 const int M = int(1e5 + 10);
13
14 // 前向星
15 struct Graph {
16     Edge eg[M];
17     int head[N];
18     int cnt;
19
20     void init(int n) {
21         memset(head, -1, sizeof(int) * ++n);
22         cnt = 0;
23     }
24
25     inline void addEdge(int x, int y, ll v, ll c) {
26         eg[cnt] = Edge(y, v, c, head[x]);
27         head[x] = cnt++;
28     }
29 };
30
31 struct MinCostMaxFlow {
32     Graph gh;
33     // 点的范围[0, n)
34     int n;
35
36     // 设置N
37     void init(int _n) {
38         n = _n + 1;

```

```

39     gh.init(n);
40 }
41
42 // 加流量, 反向是负的花费
43 void addFlow(int x, int y, ll f, ll c) {
44     // printf("%d->%d: %lld\t%lld\n", x, y, f, c); fflush(stdout);
45     gh.addEdge(x, y, f, c);
46     gh.addEdge(y, x, 0, -c);
47 }
48
49 // 该pre存的是边
50 int pre[N];
51 int dis[N];
52 bool vis[N];
53
54 bool spfa(int s, int e) {
55     queue<int> q;
56     for (int i = 0; i < n; i++) {
57         dis[i] = INF;
58         vis[i] = false;
59         pre[i] = -1;
60     }
61     dis[s] = 0;
62     vis[s] = true;
63     q.push(s);
64     while (!q.empty()) {
65         int u = q.front();
66         q.pop();
67         vis[u] = false;
68         for (int i = gh.head[u]; ~i; i = gh.eg[i].nxt) {
69             Edge &eg = gh.eg[i];
70             if (eg.flow > 0 && dis[eg.e] > dis[u] + eg.cost) {
71                 dis[eg.e] = dis[u] + eg.cost;
72                 pre[eg.e] = i;
73                 if (!vis[eg.e]) {
74                     vis[eg.e] = true;
75                     q.push(eg.e);
76                 }
77             }
78         }
79     }
80     return pre[e] != -1;
81 }
82
83 pll cal(int s, int e) {
84     ll flow = 0, cost = 0;
85     while (spfa(s, e)) {
86         ll f = INF;
87         for (int i = pre[e]; ~i; i = pre[gh.eg[i ^ 1].e]) {
88             f = min(f, gh.eg[i].flow);
89         }
90         for (int i = pre[e]; ~i; i = pre[gh.eg[i ^ 1].e]) {
91             gh.eg[i].flow -= f;
92             gh.eg[i ^ 1].flow += f;
93             cost += gh.eg[i].cost;
94         }
95         flow += f;
96     }
97     return make_pair(flow, cost);

```



```

98     }
99
100 } network;
101
102 // vector图存
103 struct MinCostMaxFlow {
104     vector<Edge> g[N];
105     // 点的范围[0, n)
106     int n = 0;
107
108     // 设置N
109     void init(int _n) {
110         rep(i, 0, n) {
111             g[i].clear();
112         }
113         n = _n + 1;
114     }
115
116     // 加流量, 反向是负的花费
117     void addFlow(int x, int y, int f, int c) {
118         g[x].push_back(Edge(y, f, c, g[y].size()));
119         g[y].push_back(Edge(x, 0, -c, g[x].size() - 1));
120     }
121
122     // 该pre存的是(点,边)
123     pii pre[N];
124     int dis[N];
125     bool vis[N];
126     int h[N];
127
128     int cnt = 0;
129
130     bool bfs(int s, int e) {
131         priority_queue<pii, vector<pii>, greater<pii>> q;
132         for (int i = 0; i < n; i++) {
133             dis[i] = INF;
134             vis[i] = false;
135             pre[i] = pii(-1, -1);
136         }
137         dis[s] = 0;
138         q.push(pii(0, s));
139         while (!q.empty()) {
140             pii f = q.top();
141             int u = f.second;
142             q.pop();
143             if (f.first != dis[u]) continue;
144             for (int i = 0; i < sz(g[u]); i++) {
145                 auto &eg = g[u][i];
146                 if (eg.flow == 0) continue;
147                 int v = eg.e;
148                 int cost = eg.cost + dis[u] + h[u] - h[v];
149                 if (dis[v] > cost) {
150                     cnt++;
151                     dis[v] = cost;
152                     pre[v] = pii(u, i);
153                     q.push(pii(dis[v], v));
154                 }
155             }
156         }

```

```

157     for (int i = 0; i < n; i++) {
158         h[i] += dis[i];
159     }
160     return pre[e].second != -1;
161 }
162
163 pii cal(int s, int e, int limit) {
164     int flow = 0, cost = 0;
165     memset(h, 0, sizeof(int) * n);
166     cnt = 0;
167     while (limit) {
168         if (!bfs(s, e)) break;
169         int f = INF;
170         for (int i = e; ~pre[i].second; i = pre[i].first) {
171             f = min(f, g[pre[i].first][pre[i].second].flow);
172         }
173         for (int i = e; ~pre[i].second; i = pre[i].first) {
174             g[pre[i].first][pre[i].second].flow -= f;
175             g[i][g[pre[i].first][pre[i].second].nxt].flow += f;
176         }
177         cost += f * h[e];
178         flow += f;
179         limit -= f;
180     }
181     return make_pair(flow, cost);
182 }
183
184 } network;

```

4.8 ISAP

```

1 struct ISAP {
2     Graph gh;
3     // 点的范围[0, n)
4     int n;
5     // 弧优化
6     int cur[N], dis[N];
7     ISAP() {};
8     // 设置N
9     void init(int _n) {
10         n = _n;
11         gh.init(n);
12     }
13
14     // 加流量
15     inline void addFlow(int x, int y, ll f) {
16         gh.addEdge(x, y, f);
17         gh.addEdge(y, x, 0);
18     }
19
20     int dep[N]; // 记录距离标号
21     int gap[N]; // gap常数优化
22     int q[N]; // 数组模拟队列
23
24     void bfs(int s, int e) {
25         memset(dep, -1, sizeof(int) * n);
26         memset(gap, 0, sizeof(int) * n);
27         gap[0] = 1;

```

```

28     dep[e] = 0;
29     int l = 0, r = 0;
30     q[r++] = e;
31     while (l < r) {
32         int u = q[l++];
33         for (int i = gh.head[u]; ~i; i = gh.eg[i].nxt) {
34             int v = gh.eg[i].e;
35             if (~dep[v]) continue;
36             q[r++] = v;
37             dep[v] = dep[u] + 1;
38             gap[dep[v]]++;
39         }
40     }
41 }
42
43 ll st[N]; // 栈优化
44
45 ll max_flow(int s, int e) {
46     bfs(s, e);
47     memcpy(cur, gh.head, sizeof(int) * n);
48     int top = 0;
49     int u = s;
50     ll ans = 0;
51     while (dep[s] < N) {
52         if (u == e) {
53             ll mf = INF;
54             int sel = 0;
55             for (int i = 0; i < top; i++) {
56                 if (mf > gh.eg[st[i]].v) {
57                     mf = gh.eg[st[i]].v;
58                     sel = i;
59                 }
60             }
61
62             for (int i = 0; i < top; i++) {
63                 gh.eg[st[i]].v -= mf;
64                 gh.eg[st[i] ^ 1].v += mf;
65             }
66             ans += mf;
67             top = sel;
68             u = gh.eg[st[top] ^ 1].e;
69             continue;
70         }
71         bool flag = false;
72         int v = 0;
73         for (int i = cur[u]; ~i; i = gh.eg[i].nxt) {
74             v = gh.eg[i].e;
75             if (gh.eg[i].v > 0 && dep[v] + 1 == dep[u]) {
76                 flag = true;
77                 cur[u] = i;
78                 break;
79             }
80         }
81         if (flag) {
82             st[top++] = cur[u];
83             u = v;
84             continue;
85         }
86         int mind = N;

```

```

87         for (int i = gh.head[u]; ~i; i = gh.eg[i].nxt) {
88             if (gh.eg[i].v > 0 && dep[gh.eg[i].e] < mind) {
89                 mind = dep[gh.eg[i].e];
90                 cur[u] = i;
91             }
92         }
93         gap[dep[u]]--; // 当前层无法连通, 降层
94         if (!gap[dep[u]]) return ans; // 断层结束运算
95         dep[u] = mind + 1; // 进入更高层
96         gap[dep[u]]++;
97         if (u != s) u = gh.eg[st[--top] ^ 1].e;
98     }
99     return ans;
100 }
101 } isap;

```

4.9 树链剖分

```

1  struct TreeChain {
2      int top[N]; // 链条顶端点ID
3      int fa[N]; // 父亲节点
4      int son[N]; // 重儿子
5      int deep[N]; // 深度
6      int num[N]; // 儿子节点数 (包括自己)
7
8
9      int p[N]; // 在线段树中的ID,
10     int fp[N]; // 线段树中ID对应的点
11     int tot;
12
13     void dfs(int u, int pre, int d) {
14         num[u] = 1;
15         deep[u] = d;
16         fa[u] = pre;
17         for (int i = gh.head[u]; ~i; i = gh.eg[i].nxt) {
18             int v = gh.eg[i].e;
19             if (v == pre) continue;
20             dfs(v, u, d + 1);
21             num[u] += num[v];
22             if (son[u] == -1 || num[v] > num[son[u]]) {
23                 son[u] = v;
24             }
25         }
26     }
27
28     void getpos(int u, int sp) {
29         top[u] = sp;
30         p[u] = tot++;
31         fp[p[u]] = u;
32         if (son[u] == -1) return;
33         getpos(son[u], sp);
34         for (int i = gh.head[u]; ~i; i = gh.eg[i].nxt) {
35             int v = gh.eg[i].e;
36             if (v == son[u] || v == fa[u]) continue;
37             getpos(v, v);
38         }
39     }
40 }

```

```

41     void build(int start, int root, int n) {
42         memset(son, -1, sizeof(int) * ++n);
43         tot = start; // start是线段树中的ID起始数值
44         dfs(root, 0, 0);
45         getpos(root, root);
46     }
47 } treec;
48
49 // 树状数组, 如果无需在线查询可以使用差分树
50 BITree tree;
51
52 // 点权修改
53 void change1(int u, int v, ll val) {
54     int f1 = treec.top[u];
55     int f2 = treec.top[v];
56     while (f1 != f2) {
57         if (treec.deep[f1] < treec.deep[f2]) {
58             swap(f1, f2);
59             swap(u, v);
60         }
61         tree1.update(treec.p[f1], treec.p[u], val);
62         u = treec.fa[f1];
63         f1 = treec.top[u];
64     }
65     if (treec.deep[u] > treec.deep[v]) {
66         swap(u, v);
67     }
68     tree1.update(treec.p[u], treec.p[v], val);
69 }
70
71 // 边权修改
72 void change2(int u, int v, ll val) {
73     int f1 = treec.top[u];
74     int f2 = treec.top[v];
75     while (f1 != f2) {
76         if (treec.deep[f1] < treec.deep[f2]) {
77             swap(f1, f2);
78             swap(u, v);
79         }
80         tree2.update(treec.p[f1], treec.p[u], val);
81         u = treec.fa[f1];
82         f1 = treec.top[u];
83     }
84     if (treec.deep[u] > treec.deep[v]) {
85         swap(u, v);
86     }
87     tree2.update(treec.p[treec.son[u]], treec.p[v], val);
88 }

```

4.10 倍增 LCA

```

1  const int MAX_DEP = 20;
2
3  // 倍增 $2^k$ 的父亲
4  int fa[N][MAX_DEP];
5
6  // 倍增LCA
7  int lca(int u, int v) {

```

```

8     if (dep[u] > dep[v]) {
9         swap(u, v);
10    }
11    int hu = dep[u], hv = dep[v];
12    int tu = u, tv = v;
13    for (int det = hv - hu, i = 0; det; det >>= 1, i++) {
14        if (det & 1)
15            tv = fa[tv][i];
16    }
17    if (tu == tv) {
18        return tu;
19    }
20    for (int i = MAX_DEP - 1; i >= 0; i--) {
21        if (fa[tu][i] == fa[tv][i]) {
22            continue;
23        }
24        tu = fa[tu][i];
25        tv = fa[tv][i];
26    }
27    return fa[tu][0];
28 }
29
30 // 动态更新节点的父亲属性
31 void lineFa(int u, int v) {
32     fa[u][0] = v;
33     for (int i = 1; i < MAX_DEP; i++) {
34         v = fa[u][i] = fa[v][i - 1];
35     }
36 }

```

4.11 Tarjan

```

1  int dfn[N], low[N], st[N], belong[N], num[N];
2  bool inst[N];
3  int idx, top, scc;
4
5  void tarjan(int u) {
6      dfn[u] = low[u] = ++idx;
7      st[top++] = u;
8      inst[u] = true;
9      for (int i = gh.head[u]; i != -1; i = gh.eg[i].nxt) {
10         int v = gh.eg[i].e;
11         if (!dfn[v]) {
12             tarjan(v);
13             low[u] = min(low[u], low[v]);
14         } else if (inst[v]) {
15             low[u] = min(low[u], dfn[v]);
16         }
17     }
18     int v;
19     if (dfn[u] == low[u]) {
20         scc++;
21         do {
22             v = st[--top];
23             inst[v] = false;
24             belong[v] = scc;
25             num[scc]++;
26         } while (u != v);

```

```

27     }
28 }

```

4.12 支配树

```

1  const int MAX_DEP = 20;
2
3  // 注意0,1点的边界问题
4  struct DominatorTree {
5      int deg[N]; // 入度
6      int dep[N]; //
7      int dfn[N];
8      int st[N];
9      int tot;
10
11     // 拓扑序, 要保证root是入度为0
12     void bfs(Graph &gh, int root) {
13         queue<int> q;
14         q.push(root);
15         tot = 0;
16         while (!q.empty()) {
17             int u = q.front();
18             q.pop();
19             dfn[u] = ++tot;
20             st[tot] = u;
21             for (i = gh.head[u], gh.eg) {
22                 int v = gh.eg[i].e;
23                 if ((--deg[v]) == 0) {
24                     q.push(v);
25                 }
26             }
27         }
28     }
29
30     // 倍增2^k的父亲
31     int fa[N][MAX_DEP];
32
33     // 倍增LCA
34     int lca(int u, int v) {
35         if (dep[u] > dep[v]) {
36             swap(u, v);
37         }
38         int hu = dep[u], hv = dep[v];
39         int tu = u, tv = v;
40         for (int det = hv - hu, i = 0; det; det >>= 1, i++) {
41             if (det & 1)
42                 tv = fa[tv][i];
43         }
44         if (tu == tv) {
45             return tu;
46         }
47         for (int i = MAX_DEP - 1; i >= 0; i--) {
48             if (fa[tu][i] == fa[tv][i]) {
49                 continue;
50             }
51             tu = fa[tu][i];
52             tv = fa[tv][i];
53         }

```

```

54     return fa[tu][0];
55 }
56
57 // 动态更新节点的父亲属性
58 void lineFa(int u, int v) {
59     fa[u][0] = v;
60     for (int i = 1; i < MAX_DEP; i++) {
61         v = fa[u][i] = fa[v][i - 1];
62     }
63 }
64
65 // 建树, op是gh的反向图, 用来寻找其父亲
66 void build(Graph &gh, Graph &op, int n, int root) {
67     memcpy(deg, gh.deg, sizeof(int) * (n + 1));
68     bfs(gh, root);
69     for (int k = 1; k <= tot; k++) {
70         int u = st[k], fath = -1;
71         dep[u] = 0;
72         for (int i = op.head[u]; ~i; i = op.eg[i].nxt) {
73             int v = op.eg[i].e;
74             if (dfn[v] > dfn[u]) continue;
75             fath = (fath == -1 ? v : lca(fath, v));
76         }
77         if (fath == -1) fath = u;
78         lineFa(u, fath);
79         dep[u] = dep[fath] + 1;
80     }
81 }
82 } dtree;

```

4.13 Hopcroft-Karp

```

1  int dis;
2  int linkx[N], linky[N];
3  int dx[N], dy[N];
4  bool vis[N];
5
6  bool searchP(int n) {
7      queue<int> q;
8      dis = INF;
9      mst(dx, -1, n);
10     mst(dy, -1, n);
11     for (int i = 0; i < n; i++) {
12         if (linkx[i] == -1) {
13             q.push(i);
14             dx[i] = 0;
15         }
16     }
17     while (!q.empty()) {
18         int u = q.front();
19         q.pop();
20         if (dx[u] > dis) break;
21         for (int i = gh.head[u]; ~i; i = gh.eg[i].nxt) {
22             int v = gh.eg[i].e;
23             if (dy[v] == -1) {
24                 dy[v] = dx[u] + 1;
25                 if (linky[v] == -1) {
26                     dis = dy[v];

```



```
27         } else {
28             dx[linky[v]] = dy[v] + 1;
29             q.push(linky[v]);
30         }
31     }
32 }
33 }
34 return dis != INF;
35 }
36
37 bool dfs(int u) {
38     for (int i = gh.head[u]; ~i; i = gh.eg[i].nxt) {
39         int v = gh.eg[i].e;
40         if (!vis[v] && dy[v] == dx[u] + 1) {
41             vis[v] = true;
42             if (linky[v] != -1 && dy[v] == dis) continue;
43             if (linky[v] == -1 || dfs(linky[v])) {
44                 linky[v] = u;
45                 linkx[u] = v;
46                 return true;
47             }
48         }
49     }
50     return false;
51 }
52
53
54 int MaxMatch(int n) {
55     int rst = 0;
56     mst(linkx, -1, n);
57     mst(linky, -1, n);
58     while (searchP(n)) {
59         mst(vis, false, n);
60         for (int i = 0; i < n; i++) {
61             if (linkx[i] == -1 && dfs(i)) {
62                 rst++;
63             }
64         }
65     }
66     return rst;
67 }
```

5 博弈

5.1 GameProblem

```

1 // 巴什博弈, 是否先手必胜
2 inline bool bash_game(int n, int m) {
3     // 一堆东西, n个物品, 最多选m个
4     return n % (m + 1);
5 }
6
7 // 威佐夫博弈, 是否先手必胜
8 // 有两堆各若干的物品, 两人轮流从其中一堆取至少一件物品, 至多不限, 或从两堆中同时取相同件物品, 规定最后
   取完者胜利。
9 inline bool wythoff_game(int n, int m) {
10     if (n > m) {
11         swap(n, m);
12     }
13     int temp = floor((n2 - n1) * (1 + sqrt(5.0)) / 2.0);
14     return temp != n1;
15 }
16 // SG函数
17 #define N 1001
18 // f[]: 可以取走的石子个数
19 // sg[]: 0~n的SG函数值
20 int f[N], sg[N], mex[N];
21
22 void getSG(int n) {
23     int i, j;
24     memset(sg, 0, sizeof(sg));
25     for (i = 1; i <= n; i++) {
26         memset(mex, 0, sizeof(mex));
27         for (j = 1; f[j] <= i; j++)
28             mex[sg[i - f[j]]] = 1;
29         for (j = 0; j <= n; j++) { // 求mex{}中未出现的最小的非负整数
30             if (mex[j] == 0) {
31                 sg[i] = j;
32                 break;
33             }
34         }
35     }
36 }
37
38 // Auti-nim 反尼姆游戏
39 // 当先拿完所有石子时候输
40 // 当如下条件时, 先手必胜
41 // 0 : 所有堆的石子数均=1, 且有偶数堆。
42 // 1 : 至少有一个堆的石子数>1, 且石子堆的异或和≠0。

```

6 分治

6.1 IntegerFastPower

```

1 ll fpow(ll x, ll k) {
2     ll base = x, r = 1;
3     for (; k; k >>= 1) {
4         if (k & 1) r = r * base;
5         base = base * base;
6     }
7     return r;
8 }

```

6.2 MatrixFastPower

```

1 #define MAX_N 10
2 #define mod_num 9973
3
4 struct Mat {
5     long long mat[MAX_N][MAX_N];
6     long long n;
7     Mat() {
8         memset(mat, 0, sizeof(mat));
9         n = 0;
10    }
11    Mat(long long n) {
12        memset(mat, 0, sizeof(mat));
13        this->n = n;
14    }
15    void init() {
16        for (int i = 0; i < n; ++i) {
17            mat[i][i] = 1;
18        }
19    }
20    Mat(const long long ** list, long long n) {
21        this->n = n;
22        for (int i = 0; i < n; ++i) {
23            for (int j = 0; j < n; ++j) {
24                mat[i][j] = list[i][j];
25            }
26        }
27    }
28 };
29
30 Mat operator * (Mat a, Mat b) {
31     long long n = a.n;
32     Mat c(n);
33     memset(c.mat, 0, sizeof(c.mat));
34     for (int i = 0; i < n; ++i) {
35         for (int j = 0; j < n; ++j) {
36             for (int k = 0; k < n; ++k) {
37                 c.mat[i][j] += (a.mat[i][k] * b.mat[k][j]) % mod_num;
38                 c.mat[i][j] %= mod_num;
39             }
40         }
41     }
42     return c;
43 }

```

```
44
45 Mat operator ^ (Mat a, int k) {
46     long long n = a.n;
47     Mat c(n);
48     c.init();
49     for (; k; k >>= 1) {
50         if (k & 1) c = c * a;
51         a = a * a;
52     }
53     return c;
54 }
```

7 数论

7.1 线性基

```

1  #define rep(i, l, r) for(int i=(l);i<(r);++i)
2  #define per(i, l, r) for(int i=(r)-1;i>=(l);--i)
3  #define pw(x) (1ll << (x))
4  #define bt(x, i) ((x >> i) & 1)
5  const int LN = 61;
6  struct LB {
7      ll d[LN] = {0}, p[LN] = {0};
8      int g[LN] = {0};
9      int cnt = 0;
10
11      LB() = default;
12
13      ll &operator[](int pos) {
14          return d[pos];
15      }
16
17      const ll &operator[](int pos) const {
18          return d[pos];
19      }
20
21      void insert(ll val, int pos) {
22          per(i, 0, LN) {
23              if (val & pw(i)) {
24                  if (!d[i]) {
25                      d[i] = val;
26                      g[i] = pos;
27                      return;
28                  }
29                  // 贪心保留最右
30                  if (pos > g[i]) {
31                      swap(pos, g[i]);
32                      swap(val, d[i]);
33                  }
34                  val ^= d[i];
35              }
36          }
37      }
38
39      ll query_max(int l) {
40          ll ret = 0;
41          per(i, 0, LN) {
42              if (g[i] >= l)
43                  ret = max(ret, ret ^ d[i]);
44          }
45          return ret;
46      }
47
48      ll query_max() {
49          ll ret = 0;
50          per(i, 0, LN) {
51              ret = max(ret, ret ^ d[i]);
52          }
53          return ret;
54      }
55

```

```

56     ll query_min() {
57         rep(i, 0, LN) {
58             if (d[i]) return d[i];
59         }
60         return 0;
61     }
62
63     bool test(ll x) const {
64         per(i, 0, LN) {
65             if (bt(x, i)) {
66                 if (!d[i]) return false;
67                 x ^= d[i];
68             }
69         }
70         return true;
71     }
72
73     void rebuild() {
74         per(i, 0, LN) {
75             per(j, 0, i) {
76                 if (d[i] & (1LL << j)) d[i] ^= d[j];
77             }
78         }
79         rep(i, 0, LN) {
80             if (d[i]) p[cnt++] = d[i];
81         }
82     }
83
84     ll kth_query(ll k) {
85         int ret = 0;
86         if (k >= pw(cnt)) return -1;
87         per(i, 0, LN) {
88             if (bt(k, 1)) ret ^= p[i];
89         }
90         return ret;
91     }
92 };
93 // 求并集
94 LB operator+(const LB &n1, const LB &n2) {
95     LB ret = n1;
96     per(i, 0, LN)
97         if (n2.d[i])
98             ret.insert(n1.d[i], n1.g[i]);
99     return ret;
100 }
101 // 求交集
102 LB operator^(const LB &n1, const LB &n2) {
103     LB ans = {}, c = n2, d = n2;
104     rep(i, 0, LN) {
105         ll x = n1[i];
106         if (!x) continue;
107         int p = i;
108         ll T = 0;
109         per(j, 0, p + 1) {
110             if (bt(x, j)) {
111                 if (c[j]) {
112                     x ^= c[j];
113                     T ^= d[j];
114                 } else {

```

```

115         p = j;
116         break;
117     }
118 }
119 }
120 if (!x) {
121     ans[i] = T;
122 } else {
123     c[p] = x;
124     d[p] = T;
125 }
126 }
127 return ans;
128 }

```

7.2 FWT

```

1 void FWT(int p[], int n) { // 如果要取模运算记得-x+MOD,*inv
2     for (int i = 1; i < n; i <= 1) {
3         for (int j = 0; j < n; j += (i << 1)) {
4             for (int k = 0; k < i; k++) {
5                 // or{
6                 p[i + j + k] += p[j + k];
7                 // and
8                 p[j + k] += p[i + j + k];
9                 // xor
10                tie(p[j + k], p[i + j + k]) = make_pair(p[j + k] + p[i + j + k], p[j +
11                k] - p[i + j + k]);
12            }
13        }
14    }
15
16 void IFWT(int p[], int n) { // 如果要取模运算记得-x+MOD,*inv
17     for (int i = 1; i < n; i <= 1) {
18         for (int j = 0; j < n; j += (i << 1)) {
19             for (int k = 0; k < i; k++) {
20                 // or
21                 p[i + j + k] -= p[j + k];
22                 // and
23                 p[j + k] -= p[i + j + k];
24                 // xor
25                tie(p[j + k], p[i + j + k]) = make_pair(p[j + k] + p[i + j + k], p[j +
26                k] - p[i + j + k]);
27                p[j + k] = p[j + k] / 2, p[i + j + k] = p[i + j + k] / 2;
28            }
29        }
30    }

```

7.3 FFT

```

1 inline int lowbit(int x) { return x & -x; }
2
3 int calc(int n) {
4     int k = 0;
5     while ((1 << k) < n) k++;

```

```

6     return k;
7 }
8
9 // FFT
10 const double pi = acos(-1.0);
11
12 const int N = (1 << 20);
13 using Complex = complex<double>;
14
15 void change(Complex p[], int n) {
16     int k = calc(n);
17     n = 1 << k;
18     vector<int> r(n, 0);
19     for (int i = 0; i < n; i++) r[i] = (r[i >> 1] >> 1) | ((i & 1) << (k - 1));
20     for (int i = 0; i < n; i++) if (i < r[i]) swap(p[i], p[r[i]]);
21 }
22
23 void FFT(Complex p[], int n, int type) {
24     change(p, n);
25     for (int mid = 1; mid < n; mid <= 1) { //待合并区间的长度的一半
26         Complex wn(cos(pi / mid), type * sin(pi / mid)); //单位根
27         for (int R = mid << 1, j = 0; j < n; j += R) { //R是区间的长度, j表示前已经到哪个位置
28             Complex w(1, 0); //幂
29             for (int k = 0; k < mid; k++, w = w * wn) { //枚举左半部分
30                 Complex x = p[j + k], y = w * p[j + mid + k]; //蝴蝶效应
31                 p[j + k] = x + y;
32                 p[j + mid + k] = x - y;
33             }
34         }
35     }
36 }

```


8 其他

8.1 BigInteger

```

1 // base and base_digits must be consistent
2 constexpr int base = 1000000000;
3 constexpr int base_digits = 9;
4
5 struct bigint {
6     // value == 0 is represented by empty z
7     vector<int> z; // digits
8
9     // sign == 1 <==> value >= 0
10    // sign == -1 <==> value < 0
11    int sign;
12
13    bigint() : sign(1) {}
14
15    bigint(ll v) { *this = v; }
16
17    bigint &operator=(ll v) {
18        sign = v < 0 ? -1 : 1;
19        v *= sign;
20        z.clear();
21        for (; v > 0; v = v / base) z.push_back((int) (v % base));
22        return *this;
23    }
24
25    bigint(const string &s) { read(s); }
26
27    bigint &operator+=(const bigint &other) {
28        if (sign == other.sign) {
29            for (int i = 0, carry = 0; i < other.z.size() || carry; ++i) {
30                if (i == z.size())
31                    z.push_back(0);
32                z[i] += carry + (i < other.z.size() ? other.z[i] : 0);
33                carry = z[i] >= base;
34                if (carry)
35                    z[i] -= base;
36            }
37        } else if (other != 0 /* prevent infinite loop */) {
38            *this -= -other;
39        }
40        return *this;
41    }
42
43    friend bigint operator+(bigint a, const bigint &b) { return a += b; }
44
45    bigint &operator-=(const bigint &other) {
46        if (sign == other.sign) {
47            if (sign == 1 && *this >= other || sign == -1 && *this <= other) {
48                for (int i = 0, carry = 0; i < other.z.size() || carry; ++i) {
49                    z[i] -= carry + (i < other.z.size() ? other.z[i] : 0);
50                    carry = z[i] < 0;
51                    if (carry)
52                        z[i] += base;
53                }
54                trim();
55            } else {

```

```

56         *this = other - *this;
57         this->sign = -this->sign;
58     }
59     } else {
60         *this += -other;
61     }
62     return *this;
63 }
64
65 friend bigint operator-(bigint a, const bigint &b) {
66     return a -= b;
67 }
68
69 bigint &operator*=(int v) {
70     if (v < 0) sign = -sign, v = -v;
71     for (int i = 0, carry = 0; i < z.size() || carry; ++i) {
72         if (i == z.size()) z.push_back(0);
73         ll cur = (ll) z[i] * v + carry;
74         carry = (int) (cur / base);
75         z[i] = (int) (cur % base);
76     }
77     trim();
78     return *this;
79 }
80
81 bigint operator*(int v) const { return bigint(*this) *= v; }
82
83 friend pair<bigint, bigint> divmod(const bigint &a1, const bigint &b1) {
84     int norm = base / (b1.z.back() + 1);
85     bigint a = a1.abs() * norm;
86     bigint b = b1.abs() * norm;
87     bigint q, r;
88     q.z.resize(a.z.size());
89
90     for (int i = (int) a.z.size() - 1; i >= 0; i--) {
91         r *= base;
92         r += a.z[i];
93         int s1 = b.z.size() < r.z.size() ? r.z[b.z.size()] : 0;
94         int s2 = b.z.size() - 1 < r.z.size() ? r.z[b.z.size() - 1] : 0;
95         int d = (int) (((ll) s1 * base + s2) / b.z.back());
96         r -= b * d;
97         while (r < 0) r += b, --d;
98         q.z[i] = d;
99     }
100
101     q.sign = a1.sign * b1.sign;
102     r.sign = a1.sign;
103     q.trim();
104     r.trim();
105     return {q, r / norm};
106 }
107
108 friend bigint sqrt(const bigint &a1) {
109     bigint a = a1;
110     while (a.z.empty() || a.z.size() % 2 == 1) a.z.push_back(0);
111
112     int n = a.z.size();
113
114     int firstDigit = (int) ::sqrt((double) a.z[n - 1] * base + a.z[n - 2]);

```

```

115     int norm = base / (firstDigit + 1);
116     a *= norm;
117     a *= norm;
118     while (a.z.empty() || a.z.size() % 2 == 1) a.z.push_back(0);
119
120     bigint r = (ll) a.z[n - 1] * base + a.z[n - 2];
121     firstDigit = (int) ::sqrt((double) a.z[n - 1] * base + a.z[n - 2]);
122     int q = firstDigit;
123     bigint res;
124
125     for (int j = n / 2 - 1; j >= 0; j--) {
126         for (;;) --q {
127             bigint r1 = (r - (res * 2 * base + q) * q) * base * base +
128                 (j > 0 ? (ll) a.z[2 * j - 1] * base + a.z[2 * j - 2] : 0);
129             if (r1 >= 0) {
130                 r = r1;
131                 break;
132             }
133         }
134         (res *= base) += q;
135
136         if (j > 0) {
137             int d1 = res.z.size() + 2 < r.z.size() ? r.z[res.z.size() + 2] : 0;
138             int d2 = res.z.size() + 1 < r.z.size() ? r.z[res.z.size() + 1] : 0;
139             int d3 = res.z.size() < r.z.size() ? r.z[res.z.size()] : 0;
140             q = (int) (((ll) d1 * base * base + (ll) d2 * base + d3) / (firstDigit
141 * 2));
142         }
143     }
144     res.trim();
145     return res / norm;
146 }
147
148 bigint operator/(const bigint &v) const {
149     return divmod(*this, v).first;
150 }
151
152 bigint operator%(const bigint &v) const {
153     return divmod(*this, v).second;
154 }
155
156 bigint &operator/=(int v) {
157     if (v < 0) sign = -sign, v = -v;
158     for (int i = (int) z.size() - 1, rem = 0; i >= 0; --i) {
159         ll cur = z[i] + rem * (ll) base;
160         z[i] = (int) (cur / v);
161         rem = (int) (cur % v);
162     }
163     trim();
164     return *this;
165 }
166
167 bigint operator/(int v) const {
168     return bigint(*this) /= v;
169 }
170
171 int operator%(int v) const {
172     if (v < 0) v = -v;

```

```

173     int m = 0;
174     for (int i = (int) z.size() - 1; i >= 0; --i)
175         m = (int) ((z[i] + m * (ll) base) % v);
176     return m * sign;
177 }
178
179 bigint &operator*=(const bigint &v) {
180     return *this = *this * v;;
181 }
182
183 bigint &operator/=(const bigint &v) {
184     return *this = *this / v;
185 }
186
187 bool operator<(const bigint &v) const {
188     if (sign != v.sign)
189         return sign < v.sign;
190     if (z.size() != v.z.size())
191         return z.size() * sign < v.z.size() * v.sign;
192     for (int i = (int) z.size() - 1; i >= 0; i--)
193         if (z[i] != v.z[i])
194             return z[i] * sign < v.z[i] * sign;
195     return false;
196 }
197
198 bool operator>(const bigint &v) const { return v < *this; }
199
200 bool operator<=(const bigint &v) const { return !(v < *this); }
201
202 bool operator>=(const bigint &v) const { return !(*this < v); }
203
204 bool operator==(const bigint &v) const { return !(*this < v) && !(v < *this); }
205
206 bool operator!=(const bigint &v) const { return *this < v || v < *this; }
207
208 void trim() {
209     while (!z.empty() && z.back() == 0) z.pop_back();
210     if (z.empty()) sign = 1;
211 }
212
213 bool isZero() const {
214     return z.empty();
215 }
216
217 friend bigint operator-(bigint v) {
218     if (!v.z.empty()) v.sign = -v.sign;
219     return v;
220 }
221
222 bigint abs() const {
223     return sign == 1 ? *this : -*this;
224 }
225
226 ll longValue() const {
227     ll res = 0;
228     for (int i = (int) z.size() - 1; i >= 0; i--)
229         res = res * base + z[i];
230     return res * sign;
231 }

```

```

232
233     friend bigint gcd(const bigint &a, const bigint &b) {
234         return b.isZero() ? a : gcd(b, a % b);
235     }
236
237     friend bigint lcm(const bigint &a, const bigint &b) {
238         return a / gcd(a, b) * b;
239     }
240
241     void read(const string &s) {
242         sign = 1;
243         z.clear();
244         int pos = 0;
245         while (pos < s.size() && (s[pos] == '-' || s[pos] == '+')) {
246             if (s[pos] == '-') sign = -sign;
247             ++pos;
248         }
249         for (int i = (int) s.size() - 1; i >= pos; i -= base_digits) {
250             int x = 0;
251             for (int j = max(pos, i - base_digits + 1); j <= i; j++)
252                 x = x * 10 + s[j] - '0';
253             z.push_back(x);
254         }
255         trim();
256     }
257
258     friend istream &operator>>(istream &stream, bigint &v) {
259         string s;
260         stream >> s;
261         v.read(s);
262         return stream;
263     }
264
265     friend ostream &operator<<(ostream &stream, const bigint &v) {
266         if (v.sign == -1)
267             stream << '-';
268         stream << (v.z.empty() ? 0 : v.z.back());
269         for (int i = (int) v.z.size() - 2; i >= 0; --i)
270             stream << setw(base_digits) << setfill('0') << v.z[i];
271         return stream;
272     }
273
274     static vector<int> convert_base(const vector<int> &a, int old_digits, int
new_digits) {
275         vector<ll> p(max(old_digits, new_digits) + 1);
276         p[0] = 1;
277         for (int i = 1; i < p.size(); i++)
278             p[i] = p[i - 1] * 10;
279         vector<int> res;
280         ll cur = 0;
281         int cur_digits = 0;
282         for (int v : a) {
283             cur += v * p[cur_digits];
284             cur_digits += old_digits;
285             while (cur_digits >= new_digits) {
286                 res.push_back(int(cur % p[new_digits]));
287                 cur /= p[new_digits];
288                 cur_digits -= new_digits;
289             }

```

```

290     }
291     res.push_back((int) cur);
292     while (!res.empty() && res.back() == 0) res.pop_back();
293     return res;
294 }
295
296 typedef vector<ll> vll;
297
298 static vll karatsubaMultiply(const vll &a, const vll &b) {
299     int n = a.size();
300     vll res(n + n);
301     if (n <= 32) {
302         for (int i = 0; i < n; i++)
303             for (int j = 0; j < n; j++)
304                 res[i + j] += a[i] * b[j];
305         return res;
306     }
307
308     int k = n >> 1;
309     vll a1(a.begin(), a.begin() + k);
310     vll a2(a.begin() + k, a.end());
311     vll b1(b.begin(), b.begin() + k);
312     vll b2(b.begin() + k, b.end());
313
314     vll a1b1 = karatsubaMultiply(a1, b1);
315     vll a2b2 = karatsubaMultiply(a2, b2);
316
317     for (int i = 0; i < k; i++) a2[i] += a1[i];
318     for (int i = 0; i < k; i++) b2[i] += b1[i];
319
320     vll r = karatsubaMultiply(a2, b2);
321     for (int i = 0; i < a1b1.size(); i++) r[i] -= a1b1[i];
322     for (int i = 0; i < a2b2.size(); i++) r[i] -= a2b2[i];
323
324     for (int i = 0; i < r.size(); i++) res[i + k] += r[i];
325     for (int i = 0; i < a1b1.size(); i++) res[i] += a1b1[i];
326     for (int i = 0; i < a2b2.size(); i++) res[i + n] += a2b2[i];
327     return res;
328 }
329
330 bigint operator*(const bigint &v) const {
331     vector<int> a6 = convert_base(this->z, base_digits, 6);
332     vector<int> b6 = convert_base(v.z, base_digits, 6);
333     vll a(a6.begin(), a6.end());
334     vll b(b6.begin(), b6.end());
335     while (a.size() < b.size()) a.push_back(0);
336     while (b.size() < a.size()) b.push_back(0);
337     while (a.size() & (a.size() - 1)) a.push_back(0), b.push_back(0);
338     vll c = karatsubaMultiply(a, b);
339     bigint res;
340     res.sign = sign * v.sign;
341     for (int i = 0, carry = 0; i < c.size(); i++) {
342         ll cur = c[i] + carry;
343         res.z.push_back((int) (cur % 1000000));
344         carry = (int) (cur / 1000000);
345     }
346     res.z = convert_base(res.z, 6, base_digits);
347     res.trim();
348     return res;

```

```

349     }
350 };

```

8.2 FastIO

```

1  /*
2  * FastIO
3  * 代码模板 !
4  * 如有雷同 !
5  * 纯属巧合 !
6  */
7  namespace FastIO {
8  #define BUF_SIZE 10000000
9  #define OUT_SIZE 10000000
10 #define ll long long
11     //fread->read
12     bool IOerror = 0;
13
14     inline char nc() {
15         static char buf[BUF_SIZE], *p1 = buf + BUF_SIZE, *pend = buf + BUF_SIZE;
16         if (p1 == pend) {
17             p1 = buf;
18             pend = buf + fread(buf, 1, BUF_SIZE, stdin);
19             if (pend == p1) {
20                 IOerror = 1;
21                 return -1;
22             }
23             // {printf("IO error!\n");system("pause");for (;;);exit(0);}
24         }
25         return *p1++;
26     }
27
28     inline bool blank(char ch) { return ch == ' ' || ch == '\n' || ch == '\r' || ch ==
'\t'; }
29
30     inline void read(int &x) {
31         bool sign = 0;
32         char ch = nc();
33         x = 0;
34         for (; blank(ch); ch = nc());
35         if (IOerror) return;
36         if (ch == '-') sign = 1, ch = nc();
37         for (; ch >= '0' && ch <= '9'; ch = nc()) x = x * 10 + ch - '0';
38         if (sign) x = -x;
39     }
40
41     inline void read(ll &x) {
42         bool sign = 0;
43         char ch = nc();
44         x = 0;
45         for (; blank(ch); ch = nc());
46         if (IOerror) return;
47         if (ch == '-') sign = 1, ch = nc();
48         for (; ch >= '0' && ch <= '9'; ch = nc()) x = x * 10 + ch - '0';
49         if (sign) x = -x;
50     }
51
52     inline void read(double &x) {

```

```

53     bool sign = 0;
54     char ch = nc();
55     x = 0;
56     for (; blank(ch); ch = nc());
57     if (I0error) return;
58     if (ch == '-') sign = 1, ch = nc();
59     for (; ch >= '0' && ch <= '9'; ch = nc()) x = x * 10 + ch - '0';
60     if (ch == '.') {
61         double tmp = 1;
62         ch = nc();
63         for (; ch >= '0' && ch <= '9'; ch = nc()) tmp /= 10.0, x += tmp * (ch - '0')
;
64     }
65     if (sign) x = -x;
66 }
67
68 inline void read(char *s) {
69     char ch = nc();
70     for (; blank(ch); ch = nc());
71     if (I0error) return;
72     for (; !blank(ch) && !I0error; ch = nc()) *s++ = ch;
73     *s = 0;
74 }
75
76 inline void read(char &c) {
77     for (c = nc(); blank(c); c = nc());
78     if (I0error) {
79         c = -1;
80         return;
81     }
82 }
83
84 //fwrite->write
85 struct Ostream_fwrite {
86     char *buf, *p1, *pend;
87     Ostream_fwrite() {
88         buf = new char[OUT_SIZE];
89         p1 = buf;
90         pend = buf + OUT_SIZE;
91     }
92     void out(char ch) {
93         if (p1 == pend) {
94             fwrite(buf, 1, OUT_SIZE, stdout);
95             p1 = buf;
96         }
97         *p1++ = ch;
98     }
99     void print(int x) {
100         static char s[15], *s1;
101         s1 = s;
102         if (!x) *s1++ = '0';
103         if (x < 0) out('-'), x = -x;
104         while (x) *s1++ = x % 10 + '0', x /= 10;
105         while (s1-- != s) out(*s1);
106     }
107     void println(int x) {
108         static char s[15], *s1;
109         s1 = s;
110         if (!x) *s1++ = '0';

```



```

111         if (x < 0)out('-'), x = -x;
112         while (x)*s1++ = x % 10 + '0', x /= 10;
113         while (s1-- != s)out(*s1);
114         out('\n');
115     }
116     void print(ll x) {
117         static char s[25], *s1;
118         s1 = s;
119         if (!x)*s1++ = '0';
120         if (x < 0)out('-'), x = -x;
121         while (x)*s1++ = x % 10 + '0', x /= 10;
122         while (s1-- != s)out(*s1);
123     }
124     void println(ll x) {
125         static char s[25], *s1;
126         s1 = s;
127         if (!x)*s1++ = '0';
128         if (x < 0)out('-'), x = -x;
129         while (x)*s1++ = x % 10 + '0', x /= 10;
130         while (s1-- != s)out(*s1);
131         out('\n');
132     }
133     void print(double x, int y) {
134         static ll mul[] = {1, 10, 100, 1000, 10000, 100000, 1000000, 10000000,
100000000,
135                                1000000000, 10000000000LL, 100000000000LL, 1000000000000LL,
136                                10000000000000LL, 100000000000000LL, 1000000000000000LL, 10000000000000000LL};
137         if (x < -1e-12)out('-'), x = -x;
138         x *= mul[y];
139         ll x1 = (ll) floor(x);
140         if (x - floor(x) >= 0.5)++x1;
141         ll x2 = x1 / mul[y], x3 = x1 - x2 * mul[y];
142         print(x2);
143         if (y > 0) {
144             out('.');
145             for (size_t i = 1; i < y && x3 * mul[i] < mul[y]; out('0'), ++i);
146             print(x3);
147         }
148     }
149     void println(double x, int y) {
150         print(x, y);
151         out('\n');
152     }
153     void print(char *s) { while (*s)out(*s++); }
154     void println(char *s) {
155         while (*s)out(*s++);
156         out('\n');
157     }
158     void flush() {
159         if (p1 != buf) {
160             fwrite(buf, 1, p1 - buf, stdout);
161             p1 = buf;
162         }
163     }
164     ~Ostream_fwrite() { flush(); }
165 } Ostream;
166 inline void print(int x) { Ostream.print(x); }

```

```

167     inline void println(int x) { Ostream.println(x); }
168     inline void print(char x) { Ostream.out(x); }
169     inline void println(char x) {
170         Ostream.out(x);
171         Ostream.out('\n');
172     }
173     inline void print(ll x) { Ostream.print(x); }
174     inline void println(ll x) { Ostream.println(x); }
175     inline void print(double x, int y) { Ostream.print(x, y); }
176     inline void println(double x, int y) { Ostream.println(x, y); }
177     inline void print(char *s) { Ostream.print(s); }
178     inline void println(char *s) { Ostream.println(s); }
179     inline void println() { Ostream.out('\n'); }
180     inline void flush() { Ostream.flush(); }
181 };
182 using namespace FastIO;

```

8.3 InputOutputSpeedUp

```

1
2
3  template <class T>
4  inline bool read(T &x) {
5      x = 0;
6      char c = getchar();
7      if(c == EOF) return false;
8      bool f = false;
9      for (; !isdigit(c); c = getchar()) f ^= (c == '-');
10     for (; isdigit(c); c = getchar()) x = x * 10 + (c - '0');
11     x = f ? -x : x;
12     return true;
13 }
14
15 template <class T>
16 inline void write(T x) {
17     if (x < 0) {
18         putchar('-');
19         x = -x;
20     }
21     T y = 1;
22     int len = 1;
23     for (; y <= x / 10; y *= 10) ++len;
24     for (; len; --len, x %= y, y /= 10) putchar(x / y + '0');
25 }

```

8.4 gcd

```

1  ll gcd(ll x, ll y) { // 循环版
2      ll t;
3      while (y){
4          t = x % y;
5          x = y;
6          y = t;
7      }
8      return x;
9  }
10

```

```

11 ll gcd(ll a, ll b) { // 递归版
12     return b == 0 ? a : gcd(b, a % b);
13 }
14
15 // 扩展欧几里得
16 ll exgcd(ll a, ll b, ll &x, ll &y) {
17     if (b == 0) {
18         x = 1, y = 0;
19         return a;
20     }
21     ll q = exgcd(b, a % b, y, x);
22     y -= a / b * x;
23     return q;
24 }

```

8.5 myItoa

```

1 char * myItoa(int value, char* result, int base = 10);
2
3 char * myItoa(int value, char* result, int base) {
4     // check that the base is valid
5
6     if (base < 2 || base > 16) { *result = 0; return result; }
7     char* out = result;
8     int quotient = abs(value);
9     do {
10         const int tmp = quotient / base;
11         *out = "0123456789abcdef"[quotient - (tmp*base)];
12         ++out;
13         quotient = tmp;
14     } while (quotient);
15     // Apply negative sign
16     if (value < 0) *out++ = '-';
17     std::reverse(result, out);
18     *out = 0;
19     return result;
20 }

```

8.6 Permutation

```

1 // 错排问题
2 // D(n) = n! [(-1)^2/2! + ... + (-1)^(n-1)/(n-1)! + (-1)^n/n!].
3 long long table[1000] = {0, 0, 1};
4 void init() {
5     for (int i = 3; i <= 20; i++) {
6         table[i] = (i - 1) * (table[i - 1] + table[i - 2]);
7     }
8 }

```

8.7 prime

```

1 // 普通素数筛
2 const int PMAX = 1000000;
3
4 int prime_count = 0;
5 bool prime_list[PMAX] = { false }; // 元素值为0代表是素数

```

```

6  int prime_table[PMAX] = { 0 };
7
8  void initPrime() {
9      for (int i = 2; i < PMAX; i++) {
10         if (!prime_list[i])
11             prime_table[prime_count++] = i;
12         for (int j = 0, e = PMAX / i;
13             j < prime_count && prime_table[j] < e; j++) {
14             prime_list[i * prime_table[j]] = true;
15             if (i % prime_table[j] == 0) break;
16         }
17     }
18 }
19
20
21 // 可以得到其中一个质因子的素数筛
22 const int PMAX = 1000005;
23
24 int prime_count = 0;
25 int prime_list[PMAX] = {0}; //元素值为0代表是素数
26 int prime_table[PMAX] = {0};
27
28 void initPrime() {
29     for (int i = 2; i < PMAX; i++) {
30         if (!prime_list[i])
31             prime_list[i] = prime_table[prime_count++] = i;
32         for (int j = 0, e = PMAX / i, now;
33             j < prime_count && (now = prime_table[j]) < e; j++) {
34             prime_list[i * now] = now;
35             if (i % now == 0) break;
36         }
37     }
38 }

```

8.8 Hash

```

1  struct Hash {
2      int num[N];
3      int tot;
4
5      void init() { tot = 0; }
6
7      void insert(int x) { num[tot++] = x; }
8
9      void build() {
10         sort(num, num + tot);
11         tot = unique(num, num + tot) - num;
12     }
13
14     inline int operator[](int x) { return lower_bound(num, num + tot, x) - num; }
15 } hs;

```