

Gungnir's Standard Code Library

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Chapter 1

计算几何

1.1 二维

1.1.1 基础

```
1 typedef double DB;
2 const DB eps = 1e-8;
3
4 __inline int sign(DB x) {
5     return x < -eps ? -1 : ( x > eps ? 1 : 0 );
6 }
7 __inline DB msqrt(DB x) {
8     return sign(x) > 0 ? sqrt(x) : 0;
9 }
10
11 struct Point {
12     DB x, y;
13     __inline Point(): x(0), y(0) {}
14     __inline Point(DB x, DB y): x(x), y(y) {}
15     __inline Point operator+(const Point &rhs) const {
16         return Point(x + rhs.x, y + rhs.y);
17     }
18     __inline Point operator-(const Point &rhs) const {
19         return Point(x - rhs.x, y - rhs.y);
20     }
21     __inline Point operator*(DB k) const {
22         return Point(x * k, y * k);
23     }
24     __inline Point operator/(DB k) const {
25         assert(sign(k));
26         return Point(x / k, y / k);
27     }
28 };
29
30 __inline DB dot(const P& a, const P& b) {
31     return a.x * b.x + a.y * b.y;
32 }
33
34 __inline DB det(const P& a, const P& b) {
```

```

35     return a.x * b.y - a.y * b.x;
36 }

```

1.1.2 凸包

```

1  __inline void clear(std::vector<Point>& v) {
2      v.clear();
3      std::vector<Point>(v).swap(v);
4  }
5
6  struct Convex {
7      int n;
8      std::vector<Point> a, upper, lower;
9      void make_shell(const std::vector<Point>& p,
10                     std::vector<Point>& shell) { // p needs to be sorted.
11          clear(shell); int n = p.size();
12          for (int i = 0, j = 0; i < n; i++, j++) {
13              for (; j >= 2 && sign(det(shell[j-1] - shell[j-2],
14                                     p[i] - shell[j-2])) <= 0; --j) shell.pop_back();
15              shell.push_back(p[i]);
16          }
17      }
18      void make_convex() {
19          std::sort(a.begin(), a.end());
20          make_shell(a, lower);
21          std::reverse(a.begin(), a.end());
22          make_shell(a, upper);
23          a = lower;
24          for (std::vector<Point>::iterator it = upper.begin(); it != upper.end(); it++)
25              if (!(*it == *a.rbegin()) && !(*it == *a.begin()))
26                  a.push_back(*it);
27          n = a.size();
28      }
29      void init(const std::vector<Point>& _a) {
30          clear(a); a = _a; n = a.size();
31          make_convex();
32      }
33      void read(int _n) { // Won't make convex.
34          clear(a); n = _n; a.resize(n);
35          for (int i = 0; i < n; i++)
36              a[i].read();
37      }
38      std::pair<DB, int> get_tangent(
39          const std::vector<Point>& convex, const Point& vec) {
40          int l = 0, r = (int)convex.size() - 2;
41          assert(r >= 0);
42          for (; l + 1 < r; ) {
43              int mid = (l + r) / 2;
44              if (sign(det(convex[mid + 1] - convex[mid], vec)) > 0)
45                  r = mid;
46              else l = mid;
47          }
48          return std::max(std::make_pair(det(vec, convex[r]), r),
49                          std::make_pair(det(vec, convex[0]), 0));

```

```

50 }
51 int binary_search(Point u, Point v, int l, int r) {
52     int s1 = sign(det(v - u, a[l % n] - u));
53     for (; l + 1 < r; ) {
54         int mid = (l + r) / 2;
55         int smid = sign(det(v - u, a[mid % n] - u));
56         if (smid == s1) l = mid;
57         else r = mid;
58     }
59     return l % n;
60 }
61 // 求凸包上和向量 vec 叉积最大的点, 返回编号, 共线的多个切点返回任意一个
62 int get_tangent(Point vec) {
63     std::pair<DB, int> ret = get_tangent(upper, vec);
64     ret.second = (ret.second + (int)lower.size() - 1) % n;
65     ret = std::max(ret, get_tangent(lower, vec));
66     return ret.second;
67 }
68 // 求凸包和直线 u, v 的交点, 如果不相交返回 false, 如果有则是和 (i, next(i)) 的交点, 交在点上不确
    ↪ 定返回前后两条边其中之一
69 bool get_intersection(Point u, Point v, int &i0, int &i1) {
70     int p0 = get_tangent(u - v), p1 = get_tangent(v - u);
71     if (sign(det(v - u, a[p0] - u)) * sign(det(v - u, a[p1] - u)) <= 0) {
72         if (p0 > p1) std::swap(p0, p1);
73         i0 = binary_search(u, v, p0, p1);
74         i1 = binary_search(u, v, p1, p0 + n);
75         return true;
76     }
77     else return false;
78 }
79 };

```


Chapter 2

数论

2.1 求逆元

```
1 void ex_gcd(long long a, long long b, long long &x, long long &y) {
2     if (b == 0) {
3         x = 1;
4         y = 0;
5         return;
6     }
7     long long xx, yy;
8     ex_gcd(b, a % b, xx, yy);
9     y = xx - a / b * yy;
10    x = yy;
11 }
12
13 long long inv(long long x, long long MODN) {
14     long long inv_x, y;
15     ex_gcd(x, MODN, inv_x, y);
16     return (inv_x % MODN + MODN) % MODN;
17 }
```

2.2 中国剩余定理

```
1 // 返回 (ans, M), 其中 ans 是模 M 意义下的解
2 std::pair<long long, long long> CRT(const std::vector<long long>& m, const std::vector<long long, long
   ↳ long>& a) {
3     long long M = 1, ans = 0;
4     int n = m.size();
5     for (int i = 0; i < n; i++) M *= m[i];
6     for (int i = 0; i < n; i++) {
7         ans = (ans + (M / m[i]) * a[i] % M * inv(M / m[i], m[i])) % M; // 可能需要大整数相乘取模
8     }
9     return std::make_pair(ans, M);
10 }
```


Chapter 3

图论

3.1 基础

```
1 struct Graph { // Remember to call .init()!
2     int e, nxt[M], v[M], adj[N], n;
3     bool base;
4     __inline void init(bool _base, int _n = 0) {
5         assert(n < N);
6         n = _n; base = _base;
7         e = 0; memset(adj + base, -1, sizeof(*adj) * n);
8     }
9     __inline int new_node() {
10         adj[n + base] = -1;
11         assert(n + base + 1 < N);
12         return n++ + base;
13     }
14     __inline void ins(int u0, int v0) { // directional
15         assert(u0 < n + base && v0 < n + base);
16         v[e] = v0; nxt[e] = adj[u0]; adj[u0] = e++;
17         assert(e < M);
18     }
19     __inline void bi_ins(int u0, int v0) { // bi-directional
20         ins(u0, v0); ins(v0, u0);
21     }
22 };
```

3.2 KM

```
1 struct KM {
2     // Truly  $O(n^3)$ 
3     // 邻接矩阵，不能连的边设为 -INF，求最小权匹配时边权取负，但不能连的还是 -INF，使用时先对 1 -> n
4     // 调用 hungary()，再 get_ans() 求值
5     int w[N][N];
6     int lx[N], ly[N], match[N], way[N], slack[N];
7     bool used[N];
8     void init() {
9         for (int i = 1; i <= n; i++) {
10             match[i] = 0;
```

```

10         lx[i] = 0;
11         ly[i] = 0;
12         way[i] = 0;
13     }
14 }
15 void hungary(int x) {
16     match[0] = x;
17     int j0 = 0;
18     for (int j = 0; j <= n; j++) {
19         slack[j] = INF;
20         used[j] = false;
21     }
22
23     do {
24         used[j0] = true;
25         int i0 = match[j0], delta = INF, j1 = 0;
26         for (int j = 1; j <= n; j++) {
27             if (used[j] == false) {
28                 int cur = -w[i0][j] - lx[i0] - ly[j];
29                 if (cur < slack[j]) {
30                     slack[j] = cur;
31                     way[j] = j0;
32                 }
33                 if (slack[j] < delta) {
34                     delta = slack[j];
35                     j1 = j;
36                 }
37             }
38         }
39         for (int j = 0; j <= n; j++) {
40             if (used[j]) {
41                 lx[match[j]] += delta;
42                 ly[j] -= delta;
43             }
44             else slack[j] -= delta;
45         }
46         j0 = j1;
47     } while (match[j0] != 0);
48
49     do {
50         int j1 = way[j0];
51         match[j0] = match[j1];
52         j0 = j1;
53     } while (j0);
54 }
55
56 int get_ans() {
57     int sum = 0;
58     for(int i = 1; i <= n; i++) {
59         if (w[match[i]][i] == -INF) ; // 无解
60         if (match[i] > 0) sum += w[match[i]][i];
61     }
62     return sum;
63 }

```

```
64 } km;
```

3.3 点双连通分量

bcc.forest is a set of connected tree whose vertices are chequered with cut-vertex and BCC.

```
1  const bool BCC_VERTEX = 0, BCC_EDGE = 1;
2  struct BCC { // N = N0 + M0. Remember to call init(&raw_graph).
3      Graph *g, forest; // g is raw graph ptr.
4      int dfn[N], DFN, low[N];
5      int stack[N], top;
6      int expand_to[N]; // Where edge i is expanded to in expanded graph.
7      // Vertex i expanded to i.
8      int compress_to[N]; // Where vertex i is compressed to.
9      bool vertex_type[N], cut[N], compress_cut[N], branch[M];
10     //std::vector<int> BCC_component[N]; // Cut vertex belongs to none.
11     __inline void init(Graph *raw_graph) {
12         g = raw_graph;
13     }
14     void DFS(int u, int pe) {
15         dfn[u] = low[u] = ++DFN; cut[u] = false;
16         if (!g->adj[u]) {
17             cut[u] = 1;
18             compress_to[u] = forest.new_node();
19             compress_cut[compress_to[u]] = 1;
20         }
21         for (int e = g->adj[u]; ~e; e = g->nxt[e]) {
22             int v = g->v[e];
23             if ((e ^ pe) > 1 && dfn[v] > 0 && dfn[v] < dfn[u]) {
24                 stack[top++] = e;
25                 low[u] = std::min(low[u], dfn[v]);
26             }
27             else if (!dfn[v]) {
28                 stack[top++] = e; branch[e] = 1;
29                 DFS(v, e);
30                 low[u] = std::min(low[v], low[u]);
31                 if (low[v] >= dfn[u]) {
32                     if (!cut[u]) {
33                         cut[u] = 1;
34                         compress_to[u] = forest.new_node();
35                         compress_cut[compress_to[u]] = 1;
36                     }
37                     int cc = forest.new_node();
38                     forest.bi_ins(compress_to[u], cc);
39                     compress_cut[cc] = 0;
40                     //BCC_component[cc].clear();
41                     do {
42                         int cur_e = stack[--top];
43                         compress_to[expand_to[cur_e]] = cc;
44                         compress_to[expand_to[cur_e^1]] = cc;
45                         if (branch[cur_e]) {
46                             int v = g->v[cur_e];
47                             if (cut[v])
```

```

48         forest.bi_ins(cc, compress_to[v]);
49     else {
50         //BCC_component[cc].push_back(v);
51         compress_to[v] = cc;
52     }
53 }
54 } while (stack[top] != e);
55 }
56 }
57 }
58 }
59 void solve() {
60     forest.init(g->base);
61     int n = g->n;
62     for (int i = 0; i < g->e; i++) {
63         expand_to[i] = g->new_node();
64     }
65     memset(branch, 0, sizeof(*branch) * g->e);
66     memset(dfn + g->base, 0, sizeof(*dfn) * n); DFN = 0;
67     for (int i = 0; i < n; i++)
68         if (!dfn[i + g->base]) {
69             top = 0;
70             DFS(i + g->base, -1);
71         }
72 }
73 } bcc;
74
75 bcc.init(&raw_graph);
76 bcc.solve();
77 // Do something with bcc.forest ...

```

3.4 边双连通分量

```

1 struct BCC {
2     Graph *g, forest;
3     int dfn[N], low[N], stack[N], tot[N], belong[N], vis[N], top, dfs_clock;
4     // tot[] is the size of each BCC, belong[] is the BCC that each node belongs to
5     pair<int, int> ori[M]; // bridge in raw_graph(raw node)
6     bool is_bridge[M];
7     __inline void init(Graph *raw_graph) {
8         g = raw_graph;
9         memset(is_bridge, false, sizeof(*is_bridge) * g -> e);
10        memset(vis + g -> base, 0, sizeof(*vis) * g -> n);
11    }
12    void tarjan(int u, int from) {
13        dfn[u] = low[u] = ++dfs_clock; vis[u] = 1; stack[++top] = u;
14        for (int p = g -> adj[u]; ~p; p = g -> nxt[p]) {
15            if ((p ^ 1) == from) continue;
16            int v = g -> v[p];
17            if (vis[v]) {
18                if (vis[v] == 1) low[u] = min(low[u], dfn[v]);
19            } else {
20                tarjan(v, p);

```

```
21         low[u] = min(low[u], low[v]);
22         if (low[v] > dfn[u]) is_bridge[p / 2] = true;
23     }
24 }
25 if (dfn[u] != low[u]) return;
26 tot[forest.new_node()] = 0;
27 do {
28     belong[stack[top]] = forest.n;
29     vis[stack[top]] = 2;
30     tot[forest.n]++;
31     --top;
32 } while (stack[top + 1] != u);
33 }
34 void solve() {
35     forest.init(g -> base);
36     int n = g -> n;
37     for (int i = 0; i < n; ++i)
38         if (!vis[i + g -> base]) {
39             top = dfs_clock = 0;
40             tarjan(i + g -> base, -1);
41         }
42     for (int i = 0; i < g -> e / 2; ++i)
43         if (is_bridge[i]) {
44             int e = forest.e;
45             forest.bi_ins(belong[g -> v[i * 2]], belong[g -> v[i * 2 + 1]], g -> w[i * 2]);
46             ori[e] = make_pair(g -> v[i * 2 + 1], g -> v[i * 2]);
47             ori[e + 1] = make_pair(g -> v[i * 2], g -> v[i * 2 + 1]);
48         }
49 }
50 } bcc;
```


Chapter 4

技巧

4.1 真正的释放 STL 容器内存空间

```
1 // vectors for example.
2 std::vector<int> v;
3 // Do something with v...
4 v.clear(); // Or having erased many.
5 std::vector<int>(v).swap(v);
```

4.2 无敌的大整数相乘取模

Time complexity $O(1)$.

```
1 // 需要保证 x 和 y 非负
2 long long mult(long long x, long long y, long long MODN) {
3     long long t = (x * y - (long long)((long double)x / MODN * y + 1e-3) * MODN) % MODN;
4     return t < 0 ? t + MODN : t;
5 }
```

4.3 无敌的读入优化

```
1 // getchar() 读入优化 << 关同步 cin << 此优化
2 // 用 isdigit() 会小幅变慢
3 namespace Reader {
4     const int L = (1 << 15) + 5;
5     char buffer[L], *S, *T;
6     __inline void get_char(char &ch) {
7         if (S == T) {
8             T = (S = buffer) + fread(buffer, 1, L, stdin);
9             if (S == T) {
10                 ch = EOF;
11                 return ;
12             }
13         }
14         ch = *S++;
15     }
```

```
16  __inline void get_int(int &x) {  
17      char ch; bool neg = 0;  
18      for (; get_char(ch), ch < '0' || ch > '9'; ) neg ^= ch == '-';  
19      x = ch - '0';  
20      for (; get_char(ch), ch >= '0' && ch <= '9'; )  
21          x = x * 10 + ch - '0';  
22      if (neg) x = -x;  
23  }  
24 }
```