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1 DP

1.1 LCS

```

1 #include <bits/stdc++.h>
2 #define IOS
   ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
3 using namespace std;
4 string s1, s2;
5 int dp[505][505];
6 int main(){
7     IOS
8     cin >> s1 >> s2;
9     memset(dp, 0, sizeof(dp));
10    int l1 = s1.size(), l2 = s2.size();
11    for(int i = 1; i <= l1; i++){
12        for(int j = 1; j <= l2; j++){
13            if(s1[i-1] == s2[j-1]) dp[i][j] =
14                dp[i-1][j-1] + 1;
15            else dp[i][j] = max(dp[i-1][j], dp[i][j-1]);
16        }
17    }
18    cout << dp[l1][l2] << '\n';
19    return 0;
20 }
```

1.2 LIS $O(n^2)$

```

1 #include <bits/stdc++.h>
2 #define IOS
   ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
3 using namespace std;
4 typedef long long ll;
5 int main(){
6     IOS
7     int arr[100];
8     int n;
9     cin >> n;
10    for(int i = 0; i < n; i++) cin >> arr[i];
11    int dp[100];
12    for(int i = 0; i < n; i++) dp[i] = 1;
13    for(int i = 0; i < n; i++){
14        for(int j = 0; j < i; j++){
15            if(arr[i] > arr[j])
16                dp[i] = max(dp[j] + 1, dp[i]);
17        }
18    }
19    int ans = 1;
20    for(int i = 0; i < n; i++) ans = max(ans, dp[i]);
21    cout << ans << '\n';
22
23    return 0;
24 }
```

1.3 LIS $O(n \log n)$

```

1 class Solution {
2 public:
3     int lengthOfLIS(vector<int>& nums) {
4         vector<int> v;
5         int n = nums.size();
6         for(int i = 0; i < n; i++){
7             int p = lower_bound(v.begin(), v.end(),
8                                 nums[i]) - v.begin();
9             if(p == v.size()) v.push_back(nums[i]);
10            else v[p] = nums[i];
11        }
12        return v.size();
13    };
14 }
```

1.4 LIS $O(n \log n)$

```

1 for(int i=0;i<num.size();i++){
2     if(lis.empty()||lis.back()<num[i]){
3         lis.push_back(num[i]);
4         dp[i]=lis.size();
5     }
6     else{
7         auto iter=lower_bound(all(lis),num[i]);
8         dp[i]=iter-lis.begin()+1;
9         *iter=num[i];
10    }
11 }
12 int length=lis.size();
13 for(int i=num.size()-1;i>=0;i--){
14     if(dp[i]==length){
15         ans.push_back(num[i]);
16         length--;
17     }
18 }
```

2 Prime

2.1 質數篩 CPP

```

1 bitset<MAXN> prime_bool;
2 vector<ll> prime;
3 void find_prime(){
4     prime_bool.set();
5     for(int i=2;i<MAXN;i++){
6         if(prime_bool[i]){
7             prime.push_back(i);
8         }
9         for(auto j:prime){
10             if(j*i>=MAXN)
11                 break;
12             prime_bool[j*i]=0;
13             if(i%j==0)
14                 break;
15         }
16     }
17 }

```

2.2 質數篩 PY

```

1 is_prime = n * [1]
2 is_prime[0] = is_prime[1] = 0
3
4 for i in range(2, n):
5     if is_prime[i]:
6         for j in range(2, n):
7             if i * j >= n:
8                 break
9             is_prime[i * j] = 0

```

2.3 單一質數

```

1 bool prime(int n){
2     if(n < 2) return false;
3     if(n <= 3) return true;
4     if(!(n % 2) || !(n % 3)) return false;
5     for(int i = 5; i * i <= n; i += 6)
6         if(!(n % i) || !(n % (i + 2))) return false;
7     return true;
8 }

```

2.4 egcd CPP

```

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

```

2.5 egcd PY

```

1 def egcd(a: int, b: int) -> Tuple[int, int, int]:
2     """return (g, x, y) such that a*x + b*y = g =
3         gcd(a, b)"""
4     """x % y"""
5     if a == 0:
6         return (b, 0, 1)
7     else:
8         b_div_a, b_mod_a = divmod(b, a)
9         g, x, y = egcd(b_mod_a, a)
10        return (g, y - b_div_a * x, x)

```

3 Graph

3.1 Floyd Warshall

```

1 int n, rd, l, r, v;
2 cin >> n >> rd;
3 vector<vector<int>> dp(n + 1, vector<int>(n + 1,
4     1e9));
5 for(int i = 0; i < rd; i++){
6     cin >> l >> r >> v;
7     dp[l][r] = dp[r][l] = v;
8     //每條路皆雙向
9 }
10 //以下即 Floyd-Warshall
11 for(int k = 1; k <= n; k++){
12     for(int i = 1; i <= n; i++){
13         for(int j = 1; j <= n; j++){
14             dp[i][j] = min(dp[i][k] + dp[k][j],
15                 dp[i][j]);
16             //窮舉所有鬆弛可能
17         }
18     }
19 }
20 cin >> l >> r;
21 cout << dp[l][r];

```

3.2 Bellman Ford

```

1 #include <bits/stdc++.h>
2 #define IOS
3 ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
4 #define INF 0x3f3f3f3f
5 using namespace std;
6 typedef long long ll;
7 struct Edge{
8     int x, y, t;
9 };
10 int dis[1005];
11 int main(){
12     IOS
13     int c;
14     cin >> c;
15     while(c--){
16         vector<Edge> edge;
17         int n, m;
18         cin >> n >> m;
19         for(int i = 0; i <= n; i++) dis[i] = INF;
20         dis[0] = 0;
21         for(int i = 0; i < m; i++){
22             int x, y, t;
23             cin >> x >> y >> t;
24             edge.push_back({x, y, t});
25         }
26         for(int i = 0; i < n - 1; i++){
27             for(int j = 0; j < m; j++){
28                 if(dis[edge[j].x] + edge[j].t <
29                     dis[edge[j].y]){
30                     dis[edge[j].y] = dis[edge[j].x] + edge[j].t;
31                 }
32             }
33         }
34         bool judge = true;
35         for(auto e : edge){
36             if(dis[e.x] + e.t < dis[e.y]){
37                 judge = false;
38                 break;
39             }
40         }
41         cout << (judge ? "not possible" : "possible") <<
42             '\n';
43     }
44     return 0;

```

43 }

3.3 SPFA

```

1 #define mem(x) memset(x, 0, sizeof(x))
2 struct road{
3     int r, val;
4 };
5 int main(){
6     int n, e, l, r, v;
7     cin >> n >> e;
8     vector<int> dp(n + 1, 1e9);
9     vector<road> rd[n + 1];
10    for(int i = 0; i < e; i++){
11        cin >> l >> r >> v;
12        rd[l].push_back({r, v});
13        rd[r].push_back({l, v});
14    }
15    cin >> l >> r;
16    dp[l] = 0;
17    queue<int> que;
18    que.push(l);
19    bool check[n + 1]; mem(check);
20    int cnt[n + 1]; mem(cnt);
21    while(!que.empty()){
22        int tmp = que.front(); que.pop();
23        check[tmp] = 0, cnt[tmp]++;
24        if(cnt[tmp] >= n) {cout << "neg cycle\n"; break;}
25        for(auto & i : rd[tmp]){
26            if(dp[i.r] > dp[tmp] + i.val){
27                dp[i.r] = dp[tmp] + i.val;
28                if(!check[i.r]) check[i.r] = 1, que.push(i.r);
29            }
30        }
31    }
32    for(auto & i : dp) cout << i << ' ';
33    return 0;
34 }

```

3.4 Dijkstra

```

1 #include <iostream>
2 #include <algorithm>
3 #include <vector>
4 #include <queue>
5 #define IOS
6     ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
7 #define INF 2147483647
8 using namespace std;
9 int n, m;
10 vector<pair<int, int>> adj[100005];
11 bool visited[100005] = {false};
12 priority_queue<pair<int, int>> pq;
13 int dis[100005], parent[100005];
14 void solve(){ // Dijkstra
15     dis[0] = 0;
16     for(int i = 1; i < n; i++) dis[i] = INF;
17     pq.push(make_pair(0, 0));
18     while(!pq.empty()){
19         auto node = pq.top();
20         pq.pop();
21         int v = node.second; // parent
22         if(visited[v]) continue;
23         visited[v] = true;
24         for(auto i : adj[v]){
25             int vertex = i.first, weight = i.second;
26             if(visited[vertex]) continue;
27             if(dis[v] + weight < dis[vertex]){
28                 dis[vertex] = dis[v] + weight;
29                 parent[vertex] = v;
30                 pq.push(make_pair(-dis[vertex],
31                     vertex));
32             }
33         }
34     }
35 }

```

```

31     }
32 }
33 int maxd = -1, cnt = 0;
34 for(int i = 0; i < n; i++){
35     if(dis[i] < INF){
36         if(dis[i] > maxd) maxd = dis[i];
37     }
38     else cnt++;
39 }
40 cout << maxd << '\n' << cnt << '\n';
41 }
42 int main(){
43     IOS
44     cin >> n >> m;
45     for(int i = 0; i < m; i++){
46         int u, v, w;
47         cin >> u >> v >> w;
48         adj[u].push_back(make_pair(v, w));
49         adj[v].push_back(make_pair(u, w));
50     }
51     solve();
52
53     return 0;
54 }

```

3.5 Kruskal's Algorithm

```

1 #include <bits/stdc++.h>
2 #define IOS
3     ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
4 using namespace std;
5 int parent[100005];
6 struct Edge{
7     int u, v, w;
8     bool operator < (Edge &b){
9         return w < b.w;
10    }
11 };
12 int query(int a){
13     if(parent[a] == -1) return a;
14     return parent[a] = query(parent[a]);
15 }
16 bool merge(int a, int b){
17     int r1 = query(a);
18     int r2 = query(b);
19     if(r1 == r2) return false;
20     if(parent[r1] < parent[r2]) parent[r2] = r1;
21     else parent[r1] = r2;
22     return true;
23 }
24 int main(){
25     IOS
26     int n, m;
27     memset(parent, -1, sizeof(parent));
28     cin >> n >> m;
29     vector<Edge> adj;
30     for(int i = 0; i < m; i++){
31         int u, v, w;
32         cin >> u >> v >> w;
33         adj.push_back({u, v, w});
34     }
35     sort(adj.begin(), adj.end());
36     // for(int i = 0; i < m; i++) cout << adj[i].w << '
37     ';
38     int cost = 0, n_edge = 0;
39     for(Edge e : adj){
40         if(merge(e.u, e.v)){
41             cost += e.w;
42             n_edge++;
43         }
44     }
45     if(n_edge == n - 1) cout << cost << '\n';
46     else cout << -1 << '\n';
47
48     return 0;
49 }

```

3.6 Prim's Algorithm

```

1 #include <iostream>
2 #include <queue>
3 #include <algorithm>
4 #include <cstring>
5 #define IOS
6 ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
7 using namespace std;
8 int n, m, dis[10005], parent[10005];
9 bool visited[10005] = {false};
10 vector<pair<int, int>> adj[10005];
11 int main(){
12     IOS
13     // freopen("input.in", "r", stdin);
14     cin >> n >> m;
15     memset(dis, 0x3f3f3f3f, sizeof(dis));
16     memset(parent, -1, sizeof(parent));
17     for(int i = 0; i < m; i++){
18         int u, v, w;
19         cin >> u >> v >> w;
20         adj[u].push_back({v, w});
21         adj[v].push_back({u, w});
22     }
23     int start = 0;
24     dis[start] = 0;
25     priority_queue<pair<int, int>, vector<pair<int, int>>, greater<pair<int, int>>> pq;
26     pq.push({dis[start], start});
27     while(!pq.empty()){
28         pair<int, int> cur = pq.top();
29         pq.pop();
30         if(visited[cur.second]) continue;
31         visited[cur.second] = true;
32         for(auto i : adj[cur.second]){
33             if(visited[i.first]) continue;
34             if(dis[i.first] > i.second){
35                 dis[i.first] = i.second;
36                 parent[i.first] = cur.second;
37                 pq.push({dis[i.first], i.first});
38             }
39         }
40     }
41     int cost = 0, err = 0;
42     for(int i = 0; i < n; i++){
43         if(dis[i] < 0x3f3f3f3f) cost += dis[i];
44         else err++;
45     }
46     cout << (err ? -1 : cost) << "\n";
47     // for(int i = 0; i < n; i++) cout << dis[i] << ' ';
48     return 0;
49 }

```

3.7 LCA

```

1 #include <bits/stdc++.h>
2 #define IOS
3 ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
4 #define INF 0x3f3f3f3f
5 using namespace std;
6 typedef long long ll;
7 const int N = 2e5 + 5;
8 int n, q;
9 vector<int> vec[N];
10 int p[20][N], in[N], out[N];
11 bool valid(int a, int b){
12     return (in[a] <= in[b] && out[b] <= out[a]);
13 }
14 void dfs(int cur, int par){
15     static int t = 0;
16     p[0][cur] = par;
17     in[cur] = t++;
18     for(auto e : vec[cur]){
19         dfs(e, cur);
20     }
21     out[cur] = t;
22 }

```

```

19 }
20 out[cur] = t++;
21 }
22 int lca(int a, int b){
23     if(valid(a, b)) return a;
24     for(int i = 19; i >= 0; i--){
25         if(!valid(p[i][a], b)) a = p[i][a];
26     }
27     return p[0][a];
28 }
29 int main(){
30     IOS
31     cin >> n >> q;
32     for(int i = 2; i <= n; i++){
33         int e;
34         cin >> e;
35         vec[e].push_back(i);
36     }
37     dfs(1, 1);
38     for(int i = 1; i < 20; i++){
39         for(int j = 1; j <= n; j++){
40             p[i][j] = p[i - 1][p[i - 1][j]];
41         }
42     }
43     while(q--){
44         int u, v;
45         cin >> u >> v;
46         cout << lca(u, v) << '\n';
47     }
48     return 0;
49 }
50 }

```

3.8 Topological Sort

```

1 #include <bits/stdc++.h>
2 #define IOS
3 ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
4 using namespace std;
5 typedef long long ll;
6 vector<int> vec[200005];
7 int ind[100005];
8 int main(){
9     IOS
10     int n, m;
11     cin >> n >> m;
12     memset(ind, 0, sizeof(ind));
13     for(int i = 0; i < m; i++){
14         int a, b;
15         cin >> a >> b;
16         ind[b]++;
17         vec[a].push_back(b);
18     }
19     queue<int> q;
20     for(int i = 1; i <= n; i++){
21         if(ind[i] == 0) q.push(i);
22     }
23     vector<int> top;
24     while(!q.empty()){
25         int cur = q.front();
26         q.pop();
27         top.push_back(cur);
28         for(auto e : vec[cur]){
29             ind[e]--;
30             if(ind[e] == 0){
31                 q.push(e);
32             }
33         }
34     }
35     if(top.size() == n){
36         for(auto i : top) cout << i << ' ';
37         cout << '\n';
38     }
39     else cout << "IMPOSSIBLE" << '\n';
40     return 0;

```

41 }

4 RMQ

4.1 Segment Tree

```

1 #include <bits/stdc++.h>
2 #define IOS
3   ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
4 #define L(x) (x << 1)
5 #define R(x) ((x << 1) | 1)
6 using namespace std;
7 typedef long long ll;
8 ll seg[500005 << 2], lazy[500005 << 2];
9 int n, q;
10 void init(){
11     memset(seg, 0, sizeof(seg));
12     memset(lazy, 0, sizeof(lazy));
13 }
14 void build(int x, int l, int r){
15     if(l == r){
16         cin >> seg[x];
17         return;
18     }
19     int mid = (l + r) >> 1;
20     build(L(x), l, mid);
21     build(R(x), mid + 1, r);
22     seg[x] = seg[L(x)] + seg[R(x)];
23 }
24 void push(int pos, int size){
25     lazy[L(pos)] += lazy[pos];
26     lazy[R(pos)] += lazy[pos];
27     seg[pos] = seg[pos] + lazy[pos] * size;
28     lazy[pos] = 0;
29 }
30 void modify(int x, int l, int r, int ql, int qr, int val){
31     if(lazy[x]) push(x, (r - l) + 1);
32     // seg[x] = seg[L(x)] + (mid - l) * lazy[L(x)] +
33     // seg[R(x)] + (r - mid) * lazy[R(x)];
34     seg[x] += val * (qr - ql + 1);
35     if(ql <= l && qr >= r){
36         lazy[x] += val;
37         return;
38     }
39     int mid = (l + r) >> 1;
40     if(qr <= mid) modify(L(x), l, mid, ql, qr, val);
41     else if(ql > mid) modify(R(x), mid + 1, r, ql, qr, val);
42     else{
43         modify(L(x), l, mid, ql, mid, val);
44         modify(R(x), mid + 1, r, mid + 1, qr, val);
45     }
46 }
47 ll query(int x, int l, int r, int ql, int qr){
48     if(ql <= l && qr >= r) return seg[x] + lazy[x] *
49     (r - l);
50     if(lazy[x]) push(x, (r - l) + 1);
51     int mid = (l + r) >> 1;
52     if(qr <= mid) return query(L(x), l, mid, ql, qr);
53     else if(ql > mid) return query(R(x), mid + 1, r, ql, qr);
54     else return query(L(x), l, mid, ql, mid) +
55     query(R(x), mid + 1, r, mid + 1, qr);
56 }
57 int main(){
58     IOS
59     init();
60     cin >> n;
61     build(1, 1, n);
62     cin >> q;
63     while(q--){
64         int v, x, y, k;
65         cin >> v;

```

```

62     if(v == 1){
63         cin >> x >> y >> k;
64         modify(1, 1, n, x, y, k);
65     }
66     else{
67         cin >> x >> y;
68         ll ans = query(1, 1, n, x, y);
69         cout << ans << '\n';
70     }
71 }
72
73 return 0;

```

4.2 BIT

```

1 // BIT
2 #include <bits/stdc++.h>
3 #include <ext/pb_ds/assoc_container.hpp>
4 #include <ext/pb_ds/tree_policy.hpp>
5 // #include <ext/pb_ds/detail/standard_policies.hpp>
6 #define IOS
7   ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
8 #define INF 0x3f3f3f3f
9 #define lowbit(x) x&(-x)
10 using namespace std;
11 using namespace __gnu_pbds;
12 typedef long long ll;
13 const int N = 2e5 + 5;
14 ll bit[N], n, q;
15 ll query(int idx){
16     ll sum = 0;
17     for(int i = idx; i > 0; i -= lowbit(i))
18         sum += bit[i];
19     return sum;
20 }
21 void update(ll val, int idx){
22     for(int i = idx; i <= n; i += lowbit(i))
23         bit[i] += val;
24 }
25 int main(){
26     IOS
27     cin >> n >> q;
28     for(int i = 1; i <= n; i++){ // 1-based
29         ll in;
30         cin >> in;
31         update(in, i);
32     }
33     while(q--){
34         ll o, a, b;
35         cin >> o >> a >> b;
36         if(o == 1){
37             ll u = query(a) - query(a - 1);
38             update(b - u, a);
39         }
40         else{
41             cout << query(b) - query(a - 1) << '\n';
42         }
43     }
44     return 0;
45 }

```

4.3 Sparse Table

```

1 #include <bits/stdc++.h>
2 #define IOS
3   ios_base::sync_with_stdio(false);cin.tie(0);cout.tie(0);
4 #define INF 0x3f3f3f3f
5 using namespace std;
6 typedef long long ll;
7 const int N = 5e5 + 5;
8 int n, m, arr[N], dp[35][N];

```

```

8 void sparse_table(int n){
9     for(int i = 1; i <= 31; i++){
10         for(int j = 0; (j + (1LL << (i - 1))) < n; j++){
11             dp[i][j] = max(dp[i - 1][j], dp[i - 1][j
12                 + (1LL << (i - 1))]);
13         }
14     }
15     int query(int l, int r){
16         int idx = __lg(r - l + 1);
17         return max(dp[idx][l], dp[idx][r - (1LL << idx) +
18             1]);
19     }
20     int main(){
21         IOS
22         cin >> n;
23         for(int i = 0; i < n; i++) cin >> arr[i];
24         for(int i = 0; i < n; i++) dp[0][i] = arr[i];
25         sparse_table(n);
26         while(m--){
27             int l, r;
28             cin >> l >> r;
29             if(l > r) swap(l, r);
30             l--, r--;
31             cout << query(l, r) << '\n';
32         }
33         return 0;
34     }
35 }

```

5 Uncategorized

5.1 快速幂

```

1 #include <bits/stdc++.h>
2 #define IOS
3 ios_base::sync_with_stdio(false); cin.tie(0); cout.tie(0);
4 using namespace std;
5 typedef long long ll;
6 ll mod = 1000000007;
7 ll fast_pow(int base, int exp){
8     ll res = 1;
9     while(exp > 0){
10         if(exp & 1) res = res * base % mod;
11         base = base * base % mod;
12         exp >>= 1;
13     }
14     return res;
15 }
16 int main(){
17     IOS
18     int base = 3, exp = 15;
19     cout << fast_pow(base, exp) << '\n';
20     return 0;
21 }

```

5.2 矩陣快速幂

```

1 #include <bits/stdc++.h>
2 #define IOS
3 ios_base::sync_with_stdio(false); cin.tie(0); cout.tie(0);
4 #define INF 0x3f3f3f3f
5 using namespace std;
6 typedef long long ll;
7 ll mod = 1000000007;
8 struct Matrix{
9     ll mat[2][2] = {{0}};
10     Matrix operator * (Matrix &inp){
11         Matrix tmp;
12         for(int i = 0; i < 2; i++){

```

```

12             for(int j = 0; j < 2; j++){
13                 for(int k = 0; k < 2; k++){
14                     tmp.mat[i][j] = ((tmp.mat[i][j] +
15                         (mat[i][k] % mod) *
16                         (inp.mat[k][j] % mod)) % mod)
17                         % mod;
18                 }
19             }
20         }
21         return tmp;
22     }
23     Matrix base;
24     Matrix fast_pow(int exp){
25         if(exp == 1) return base;
26         if(exp % 2 == 0){
27             Matrix res = fast_pow(exp >> 1);
28             return res * res;
29         }
30         Matrix res = fast_pow(exp >> 1);
31         return base * res * res;
32     }
33     int main(){
34         IOS
35         base.mat[0][0] = 1;
36         base.mat[0][1] = 4;
37         base.mat[1][0] = 2;
38         base.mat[1][1] = 3;
39         Matrix output = fast_pow(10);
40         for(int i = 0; i < 2; i++){
41             for(int j = 0; j < 2; j++){
42                 cout << output.mat[i][j] << ' ';
43             }
44             cout << '\n';
45         }
46         return 0;
47     }

```

5.3 快速計算費氏數列

```

1 #include <bits/stdc++.h>
2 #define IOS
3 ios_base::sync_with_stdio(false); cin.tie(0); cout.tie(0);
4 #define INF 0x3f3f3f3f
5 using namespace std;
6 typedef long long ll;
7 ll mod = 1000000007;
8 struct Matrix{
9     ll mat[2][2] = {{0}};
10     Matrix operator * (Matrix &inp){
11         Matrix tmp;
12         for(int i = 0; i < 2; i++){
13             for(int j = 0; j < 2; j++){
14                 for(int k = 0; k < 2; k++){
15                     tmp.mat[i][j] = ((tmp.mat[i][j] +
16                         (mat[i][k] % mod) *
17                         (inp.mat[k][j] % mod)) % mod)
18                         % mod;
19                 }
20             }
21         }
22         return tmp;
23     }
24     Matrix base;
25     Matrix fast_pow(int n){
26         if(n == 1) return base;
27         if(n % 2 == 0){
28             Matrix res = fast_pow(n >> 1);
29             return res * res;
30         }
31         Matrix res = fast_pow(n >> 1);
32         return base * res * res;
33     }
34     int main(){

```

```

32 |     IOS
33 |     base.mat[0][0] = 1;
34 |     base.mat[0][1] = 1;
35 |     base.mat[1][0] = 1;
36 |     base.mat[1][1] = 0;
37 |     Matrix output = fast_pow(20);
38 |     cout << output.mat[0][0] << '\n';
39 |
40 |     return 0;
41 | }

```

6 常用小扣

6.1 01 背包問題

```

1 | // 01 backpack
2 | for(int i=1;i<=n;i++){
3 |     for(int j=x;j>=w[i];j--){
4 |         dp[j]=max(dp[j],dp[j-w[i]]+v[i]);
5 |     }
6 | }

```

6.2 Topological

```

1 | //拓鋪
2 | int N, M, u, v, deg[MAXN];    // deg[i] 紀錄點 i
   | 被連入邊數
3 | vector<int> edge[MAXN];
4 |
5 | /*----- 1. 計算 indegree -----*/
6 | cin >> N >> M;
7 | while(M--){
8 | {
9 |     cin >> u >> v;
10 |    edge[u].push_back(v);
11 |    ++deg[v];
12 | }
13 |
14 | /*----- 2. 將 indegree 為 0 的點放入 queue 中
   | -----*/
15 | queue<int> q;                // 紀錄待拔點
16 | for(int i = 0; i < N; ++i)
17 |     if(deg[i] == 0)
18 |         q.push(i);
19 |
20 | /*----- 3. 重複拔點，直到 queue 清空 -----*/
21 | while(!q.empty()){
22 | {
23 |     int cur = q.front(); q.pop();
24 |     cout << cur << "\n";
25 |     for(int i: edge[cur])
26 |     {
27 |         --deg[i];                // 3-1.
   |         相連點 indegree 減一
28 |         if(deg[i] == 0) q.push(i);    // 3-2. 若該點
   |         indegree 減至 0，則放入 queue 中
29 |     }
30 | }

```

6.3 常用

```

1 | while(getline(ss, str, 'm')) //以m分割
2 |     cout << str << endl;
3 | int a, b; char c;
4 | while(ss >> a >> c >> b) //處理像是 -2/9+9/7
5 |     cout << a << " " << c << " " << b << endl;
6 | //輸出 -2 / 9 endl 9 / 7

```

7 Basic

7.1 GCD

```

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

```

7.2 LCM

```

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

```

7.3 Leap Year

```

1 | bool isLeap(int n){
2 |     if(n % 100 == 0)
3 |         if(n % 400 == 0) return true;
4 |         else return false;
5 |     if(n % 4 == 0) return true;
6 |     else return false;
7 | }

```

8 Trick

8.1 求根號和解決 pow 精度問題

```

1 | // when the number is too large, use powl instead of
   | pow
2 | // will provide you more accuracy.
3 | powl(a, b)
4 | (int)round(p, (1.0/n)) //nth root of p

```

8.2 查找和二分搜

```

1 | // will return address of iterator, call result as
   | *iterator;
2 | iterator find(iterator first, iterator last, const
   | T&value);
3 | bool binary_search(iterator first, itee)

```

8.3 $a^b \bmod p$

```

1 | // a^b mod p
2 |
3 | long powmod(long base, long exp, long modulus){
4 |
5 |     base %= modulus;
6 |     long res
7 |
8 | }

```

8.4 $n! \bmod p$

```

1 | // n! mod p
2 |
3 | int factmod(int n, int p){
4 |     long long res = 1;
5 |     while(n > 1){
6 |         res = (res % powmod(p-1, n/p, p)) % p;

```

```

7   for(int i=2;i<=n%p;i++)
8       res = (res * i) % p;
9   n /= p;
10  }
11 }

```

8.5 從 1 ~ n 選 M 個數字

```

1  // n >= m choose m number from 1 ~ n
2  void combination(int n, int m){
3      if (n<m) return;
4
5      int a[50] = {0};
6      int k = 0;
7
8      for(int i=1;i<=m;i++) a[i] = i;
9      while(1){
10         for(int i=1;i<=m;i++)
11             cout << a[i] << " ";
12         cout << endl;
13
14         k = m;
15         while((k>0) && (n-a[k] == m-k)) k --;
16         if(k == 0) break;
17         a[k] ++;
18         for(int i=k;
19             }
20
21
22
23 }

```

8.8 m-ary to 10-ary

```

1  string num = "0123456789ABCDE";
2
3  int mToTen(string n, int m){
4      int multi = 1;
5      int result = 0;
6
7      for(int i = n.size() - 1; i >= 0; i--){
8          result += num.find(n[i]) * multi;
9          multi *= m;
10     }
11     return result;
12 }

```

8.6 二項式係數 Binomial Coefficient (也可以用在 C 幾取幾)

```

1  #define MAXN 100 // largest n or m
2  long binomial_coefficient(n, m) // compute n choose m
3  int n, m;
4  {
5      int i, j;
6      long bc[MAXN][MAXN];
7      for(i = 0; i <= n; i++) bc[i][0] = 1;
8      for(j = 0; j <= n; j++) bc[j][j] = 1;
9      for(i = 1; i <= n; i++)
10         for(j = 1; j < i; j++)
11             bc[i][j] = bc[i - 1][j - 1] + bc[i - 1][j];
12     return bc[n][m];
13 }

```

8.7 LICS

```

1  int a[100] = {0};
2  int b[100] = {0};
3  int f[100] = {0};
4  int n = 0, m = 0;
5  int main(void){
6      cin >> n;
7      for(int i = 1; i <= n; i++) cin >> a[i];
8      cin >> m;
9      for(int i = 1; i <= m; i++) cin >> b[i];
10     for(int i = 1; i <= n; i++){
11         int k = 0;
12         for(int j = 1; j <= m; j++){
13             if(a[i] > b[j] && f[j] > k) k = f[j];
14             else if(a[i] == b[j] && k + 1 > f[j])
15                 f[j] = k + 1;
16         }
17     }

```