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Problem	Tags
01 A	
02 B	
03 C	
04 D	
05 E	
06 F	
07 G	
08 H	
09 I	
10 J	
11 K	
12 L	
13 M	

```

29 // Algorithm
30 // Algorithm
31 // Circle - Circle
32 // Algorithm
33 // Algorithm
34 // Algorithm
35 // Algorithm
36 // Algorithm
37 // Line - Point
38 // Algorithm
39 // Algorithm
40 // Algorithm
41 // Algorithm
42 // Algorithm
43 // Segment - Point
44 // Algorithm
45 // Algorithm
46 // Algorithm
47 // Algorithm
48 // Algorithm

```

### 1.3 Circle Generation

Time	Meeting Description	Chk
030	All Problems Read. Write Tags.	
060	Ace Decided. Choose Coder.	
120	Decide & Order Solveable Problems	
150	Status Check	
180	Status Check	
210	Status Check	
240	Status Check	
270	Status Check	

```

1 // From 3 Points
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // From 1 Line 2 Points
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // From 2 Lines 1 Point
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // From 3 Lines
20 // Algorithm
21 // Algorithm
22 // Algorithm
23 // Algorithm
24 // Algorithm

```

## 1 2D Geometry

### 1.1 Primitives

```

1 typedef complex<double> point;
2 struct circle {
3     point c; double r;
4     circle(point c, double r):c(c),r(r){}
5     circle(){}
6 };
7 double cross(const point &a, const point &b) {
8     return imag(conj(a)*b);
9 }
10 double dot(const point &a, const point &b) {
11     return real(conj(a)*b);
12 }

```

### 1.4 Heron Triangle Area

```

1 // Formula
2 // Formula
3 // Formula

```

### 1.2 Intersections

```

1 // Line - Line
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Line - Segment
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Segment - Segment
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Circle - Line
20 // Algorithm
21 // Algorithm
22 // Algorithm
23 // Algorithm
24 // Algorithm
25 // Circle - Segment
26 // Algorithm
27 // Algorithm
28 // Algorithm

```

### 1.5 Polygon Centroid

```

1 for(int i = 1; i < n-1; i++) {
2     pt ai = pts[i] - pts[i-1],
3     ib = pts[i+1] - pts[i];
4     area += (conj(ai)*ib).imag();
5 }

```

### 1.6 Point In Polygon

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 1.7 Convex Hull

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 1.8 Line Segment Set Intersection

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm
21 // Algorithm
22 // Algorithm
23 // Algorithm
24 // Algorithm
25 // Algorithm
26 // Algorithm
27 // Algorithm
28 // Algorithm
29 // Algorithm
30 // Algorithm
31 // Algorithm
32 // Algorithm
33 // Algorithm
34 // Algorithm
35 // Algorithm
36 // Algorithm
37 // Algorithm
38 // Algorithm
39 // Algorithm
40 // Algorithm
41 // Algorithm
42 // Algorithm
43 // Algorithm
44 // Algorithm
45 // Algorithm
46 // Algorithm
47 // Algorithm
48 // Algorithm
49 // Algorithm

```

## 1.9 Voronoi Diagrams

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm

```

```

9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 2 3D Geometry

### 2.1 Primitives

```

1 // Code
2 // Code
3 // Code
4 // Code
5 // Code
6 // Code
7 // Code
8 // Code
9 // Code
10 // Code
11 // Code
12 // Code
13 // Code
14 // Code
15 // Code

```

### 2.2 Convex Hull

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

### 2.3 Great Circle Distance

```

1 // Code
2 // Code
3 // Code
4 // Code
5 // Code
6 // Code
7 // Code
8 // Code
9 // Code
10 // Code

```

## 3 Combinatorics

### 3.1 Basics

```

1 // catalan numbers
2 long long C(int n) {
3     return (C(n-1)*2*n*(2*n-1))/(n*(n+1));
4     return NCR(2*n, n) - NCR(2*n, n+1);
5     return NCR(2*n, n)/(n+1);
6 }
7 // derangements
8 long long D(int n) {
9     return n*D(n-1) + pow(-1, n);
10    return (n-1)*(D(n-1) + D(n-2));
11 }
12 // iterate over all subsets with < m elements

```

```

13 for (int i = 0; i < (1<<n); i=Integer.bitCount(i) < m ? i
    +1 : (i|(i-1))+1)
14 // iterate over all the subsets
15 for (int i=0; i < (1<<n); i++)
16 // iterate over all the subsets of the i-th subset
17 for(int i2 = i; i2 > 0; i2 = (i2-1) & i)

```

## 4 Data Structures

### 4.1 Palindromic Tree

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

### 4.2 Treap

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm
21 // Algorithm
22 // Algorithm
23 // Algorithm
24 // Algorithm
25 // Algorithm
26 // Algorithm
27 // Algorithm
28 // Algorithm
29 // Algorithm
30 // Algorithm

```

### 4.3 Sparse Array

```

1 // Code
2 // Code
3 // Code
4 // Code
5 // Code
6 // Code
7 // Code
8 // Code
9 // Code
10 // Code
11 // Code
12 // Code
13 // Code
14 // Code
15 // Code

```

### 4.4 Skip Lists

```

1 // Code
2 // Code
3 // Code
4 // Code
5 // Code
6 // Code
7 // Code
8 // Code
9 // Code
10 // Code
11 // Code
12 // Code
13 // Code
14 // Code
15 // Code
16 // Code
17 // Code
18 // Code
19 // Code
20 // Code
21 // Code
22 // Code

```

### 4.5 BIT + Search

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

### 4.6 Segment Tree + Lazy Propagation

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm
21 // Algorithm
22 // Algorithm
23 // Algorithm
24 // Algorithm
25 // Algorithm
26 // Algorithm
27 // Algorithm
28 // Algorithm
29 // Algorithm
30 // Algorithm

```

### 4.7 Weighted Union Disjoint Sets

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm

```

```

5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm

```

## 5 Game Theory

### 5.1 Nim Game

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

### 5.2 Grundy Numbers

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

### 5.3 General Josephus Problem

## 6 General Mathematics

### 6.1 Inclusion-Exclusion Patterns

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

### 6.2 Determinant

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm

```

### 6.3 Gaussian Elimination

```

1 double* GaussianElimination(int N, double **mat) {
2     int i, j, k, L; double t;
3     for (i = 0; i < N - 1; i++) {
4         L = i;
5         for (j = i + 1; j < N; j++)
6             if (fabs(mat[j][i]) > fabs(mat[L][i]))
7                 L = j;
8         for (k = i; k <= N; k++)
9             swap(mat[i][k], mat[L][k]);
10        for (j = i + 1; j < N; j++)
11            for (k = N; k >= i; k--)
12                mat[j][k] -= (mat[i][k] * mat[j][i]) / mat[i][i];
13    }
14    double *res = new double[N];
15    for (j = N - 1; j >= 0; j--) {
16        for (t = 0.0, k = j + 1; k < N; k++)
17            t += mat[j][k] * res[k];
18        res[j] = (mat[j][N] - t) / mat[j][j];
19    }
20    return res;
21 }

```

### 6.4 Fast Fourier-Transform

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

### 6.5 Misc. Formulas

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm
21 // Algorithm
22 // Algorithm
23 // Algorithm
24 // Algorithm
25 // Algorithm
26 // Algorithm
27 // Algorithm
28 // Algorithm
29 // Algorithm
30 // Algorithm

```

## 7 Graph Theory

### 7.1 Articulation Points & Bridges

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm

```

```

14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 7.2 SCC

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 7.3 2-SAT

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 7.4 Edmonds-Karp Max Flow

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 7.5 Dinic's Max Flow

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm

```

```

6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 7.6 Min-Cost Max Flow

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 7.7 Euler Cycles

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 7.8 Maximum Matching

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 7.9 HL Decomposition

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm

```

## 7.10 Modelling Inequalities

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

## 7.11 Max Flow Tricks

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm

```

## 7.12 Bellman Ford

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

## 7.13 Stable Marriage

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm

```

## 7.14 Maximum Assignment

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm

```

# 8 Linear Programming

## 8.1 Simplex

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm
21 // Algorithm
22 // Algorithm
23 // Algorithm
24 // Algorithm
25 // Algorithm
26 // Algorithm
27 // Algorithm
28 // Algorithm
29 // Algorithm
30 // Algorithm
31 // Algorithm

```

# 9 Number Theory

## 9.1 Extended GCD

```

1 long long gcd( long long a, long long b )
2 { return( b == 0 ? a : gcd( b, a % b ) ); }
3 //USED BY: egcd, msolve, inverse, ldioph
4 template< class Int > struct Triple {
5     Int d, x, y;
6     Triple(Int q, Int w, Int e):d(q), x(w), y(e){}
7 };
8 //USED BY: msolve, inverse, ldioph
9 template< class Int > Triple< Int > egcd( Int a, Int b ) {
10     if( !b ) return Triple< Int >( a, Int( 1 ), Int( 0 ) );
11     Triple< Int > q = egcd( b, a % b );
12     return Triple< Int >( q.d, q.y, q.x - a / b * q.y );
13 }

```

## 9.2 Modular Inverse

```

1 //solves ax = 1 (mod n).
2 template< class Int > Int inverse( Int a, Int n ) {
3     Triple< Int > t = egcd( a, n );
4     if( t.d > Int( 1 ) ) return Int( 0 );
5     Int r = t.x % n;
6     return( r < Int( 0 ) ? r + n : r );
7 }

```

## 9.3 Modular Linear Equation

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

#### 9.4 Linear Diophantine Equation

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

#### 9.5 Modular Powers

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

#### 9.6 Sieve of Eratosthenes

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

#### 9.7 Primality Testing & Factoring

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

#### 9.8 Euler Phi

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

#### 9.9 Chinese Remainder

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm

```

```

7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

#### 9.10 Discrete Logarithm

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm

```

#### 9.11 Tortoise & Hare

```

1 // mu = start of cycle, lambda = cycle length
2 ii floyd(int x0) {
3     int tortoise = f(x0), hare = f(f(x0));
4     while(tortoise != hare)
5         tortoise = f(tortoise), hare = f(f(hare));
6     int mu = 0; hare = x0;
7     while(tortoise != hare)
8         tortoise = f(tortoise), hare = f(hare), mu++;
9     int lambda = 1; hare = f(tortoise);
10    while(tortoise != hare)
11        hare = f(hare), lambda++;
12    return ii(mu, lambda);
13 }

```

#### 9.12 Pollard Rho

### 10 Search

#### 10.1 Binary Search

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm

```

#### 10.2 Ternary Search

```

1 long double min() {
2     long double lo = -1e6, hi = 1e6, res = 3e6;
3     while(fabs(lo-hi) > EPS) {
4         long double left = (hi-lo)/3 + lo, right = (2*(hi-
5             lo))/3 + lo;
6         long double resL = F(left), resR = F(right);
7         if(resL < resR)
8             hi = right;
9         else
10            lo = left;
11        res = min(res, min(resL, resR));
12    }
13    return res;

```

### 11 Strings

#### 11.1 Aho Corasick

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm

```



```

10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm

```

## 11.2 Hashing

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm

```

## 11.3 Z-Algorithm

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm

```

## 11.4 KMP + Periods

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm

```

## 11.5 Manacher

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm
21 // Algorithm

```

## 11.6 Suffix Array

```

1 // Algorithm
2 // Algorithm
3 // Algorithm
4 // Algorithm
5 // Algorithm
6 // Algorithm
7 // Algorithm
8 // Algorithm
9 // Algorithm
10 // Algorithm
11 // Algorithm
12 // Algorithm
13 // Algorithm
14 // Algorithm
15 // Algorithm
16 // Algorithm
17 // Algorithm
18 // Algorithm
19 // Algorithm
20 // Algorithm
21 // Algorithm
22 // Algorithm
23 // Algorithm
24 // Algorithm
25 // Algorithm
26 // Algorithm
27 // Algorithm
28 // Algorithm
29 // Algorithm
30 // Algorithm

```