

Codebook Note

1. Basic

1.1 Pragma IO

Description

Pragma, fast read and write

1.2 Debug Macro

Description

Debug Macro

2. Data Structure

2.1 Heavy-Light Decomposition

Description

$O(n \log^2(n))$ tree decomposition

Test Status

Passed [CSES - Path Queries II](#)

2.2 Centroid Decomposition

Description

Centroid decomposition

Test Status

Passed [TIOJ 1171 . 我要成為海賊王](#)

2.3 Link Cut Tree

Description

Tree decomposition in $O(n \log n)$

Test Status

Passed [P3690 【模板】动态树 \(LCT \)](#)

2.4 LiChaoST

Description

Insert $ax + b$, find $\min(f(x))$ in $O(\log n)$

Test Status

Passed [Library Checker - Segment Add Get Min](#) (Tight)

2.5 Leftist Heap

Description

Support merging heaps and deletion of an arbitrary node in $O(\log n)$

Can be made persistent

Test Status

Used in [Library Checker - K-th Shortest Walk](#)

2.6 Treap

Description

Merge split treap

Test Status

Used in [Library Checker - Range Reverse Range Sum](#)

2.7 Chtholly Tree

Description

Store intervals

Test Status

N/A

2.8 Persistent Segment Tree

Description

Persistent segment tree

Test Status

Used in [Library Checker - Range Kth Smallest](#)

2.9 Range Chmin Chmax Add Range Sum

Description

Segment tree beats

Test Status

Passed [Library Checker - Range Chmin Chmax Add Range Sum](#)

2.10 Range Set

Description

Set of ranges

Test Status

N/A

2.11 KD Tree

Description

Store information on higher dimensions

Test Status

N/A

2.12 pbds

Description

pbds tree and heap

Test Status

N/A

3. Graph

3.1 SCC

Description

Tarjan SCC

Test Status

Passed [Library Checker - Strongly Connected Components](#)

3.2 BCC Vertex

Description

Tarjan. Block-cut tree / Round square tree

Test Status

Passed (Only BCC part, not Block-cut tree) [Library Checker - Biconnected Components](#)

3.3 Directed MST

Description

Find the directed MST of a graph in $O(n \log n)$

Test Status

Passed [Library Checker - Directed MST](#)

3.4 Negative Cycle

Description

Bellman-Ford, find negative cycle

Test Status

3.5 Dominator Tree

Description

Find the dominating relationships of vertices in a directed graph in $O(n \log n)$

Test Status

Passed [P5180 【模板】支配树](#)

3.6 Maximum Clique

Description

Enumerate maximal cliques, complexity : $O(N^{3^{N/3}})$

Test Status

Passed [Library Checker - Enumerate Cliques](#)

3.7 Virtual Tree

Description

Build virutal tree and perform queries on trees in $O(k \log n)$, where k is the number of nodes.

Test Status

N/A

3.8 Minimum Steiner Tree

Description

Complexity : $O(n3^k + n^2 2^k)$

Test Status

Passed [P6192 【模板】最小斯坦纳树](#)

4. Flow And Matching

4.1 Dinic

Description

Complexity : $O(n^2 m)$, $O(m\sqrt{n})$ for unit capacity

Test Status

Passed [Library Checker - Matching on Bipartite Graph](#)

4.2 Min Cut Max Flow

Description

Min cut max flow, $O(nmf)$

Test Status

Passed [QQJ #602. 最小费用最大流（随机数据）](#)

4.3 Gomory Hu Tree

Description

Min cut tree, complexity : $O(flow * n)$

Test Status

Passed [P4897 【模板】最小割树（Gomory-Hu Tree）](#)

4.4 Stoer Wagner Min Cut

Description

Find global min cut, complexity : $O(n^3)$

Test Status

Passed [5632 【模板】Stoer-Wagner](#)

4.5 Hopcroft Karp

Description

Bipartite Matching, complexity : $O((n + m)\sqrt{n})$

Test Status

Passed [Library Checker - Matching on Bipartite Graph](#)

4.6 Kuhn Munkres

Description

Maximum weighted bipartite matching in $O(n^3)$

Test Status

Passed [Library Checker - Assignment Problem](#)

4.7 General Graph Matching

Description

Find maximum matching of a general graph in $O(n^3)$

Test Status

Passed [Library Checker - Matching on General Graph](#)

4.8 Weighted General Graph Matching

Description

Find maximum weighted matching of a general graph in $O(n^3)$

Test Status

Passed [Library Checker - General Weighted Matching](#)

4.9 Flow Models

Description

Useful flow models

5. String

5.1 Z-Value

Description

Max prefix starting at i

Test Status

Passed [CSES - String Functions](#)

5.2 KMP

Description

Max prefix ending at i

Test Status

Passed [CSES - String Functions](#)

5.3 Manacher

Description

Longest Palindrome centered at i

Test Status

Passed [CSES - Longest Palindrome](#)

5.4 Suffix Array

Description

Suffix Array & LCP in $O(n \log n)$

Test Status

Passed [Library Checker - Suffix Array](#).

5.5 SAIS

Description

Suffix Array in $O(n)$

Test Status

Passed [Library Checker - Suffix Array](#).

5.6 Suffix Automaton

Description

Find longest common substring in $O(n)$, distinct k-th substring, enumerate starting positions in $O(ans)$

Test Status

Passed [CSES - Counting Patterns](#)

5.7 Palindrome Tree

Description

Build Palindrome tree (AC / KMP for palindrome) in $O(n)$

Test Status

Passed [ntucpc - 427 . 大字串\(最小回文劃分\)](#)

5.8 AC Automaton

Description

KMP + Trie

Test Status

Passed [CSES - Finding Patterns](#)

5.9 Lyndon Factorization

Description

Factorize a string into simple substrings. Can find minimum cyclic shift in $O(n)$

Test Status

Passed [CSES - Minimal Rotation](#)

6. Math

6.1 Miller Rabin

Description

Check if a number is a prime

Test Status

See Pollard Rho

6.2 Pollard Rho

Description

Find a factor of a non-prime number

Test Status

Passed [Library Checker - Factorize](#)

6.3 EXT GCD

Solve for $ax + by = \gcd(a, b)$

Description

Test Status

N/A

6.4 Chinese Remainder Theorem

Description

Solve for system of modular equation

Test Status

N/A

6.5 Powerful Number Sieve

Description

Find prefix sum of multiplicative functions

Test Status

Passed [P5325 【模板】Min 25 篓](#)

6.6 Min 25 Sieve

Description

Find prefix sum of multiplicative functions

Test Status

Passed [P5325 【模板】Min 25 篓](#)

6.7 Floor Sum

Description

Solve $\sum_{i=0}^n \lfloor \frac{ai+b}{c} \rfloor$, $\sum_{i=0}^n \lfloor \frac{ai+b}{c} \rfloor^2$, $\sum_{i=0}^n i \lfloor \frac{ai+b}{c} \rfloor$ in $O(\log n)$

Test Status

Passed [P5170 【模板】类欧几里得算法](#)

6.8 Euclidean

Description

list the transitions of floor sum

6.9 Big Number

Description

For numbers > int128

Test Status

N/A

6.10 Determinant

Description

Find determinant of a matrix

Test Status

N/A

6.11 Discrete Logarithm

Description

BSGS

Test Status

Passed [Library Checker - Discrete Logarithm](#)

6.12 Berlekamp Massey

Description

Solve linear recurrence problems

Test Status

N/A

6.13 Gaussian Elimination

Description

Solve $Ax = b$ in $O(N^3)$

Test Status

Passed [Library Checker - System of Linear Equations](#)

6.14 Golden Search

Description

Binary search using golden ratio

Test Status

N/A

6.15 Pi Count

Description

Count number of primes $< N$

Test Status

N/A

6.16 Quadratic Residue

Description

Find $x^2 = y \pmod{P}$

Test Status

Passed [Library Checker - Sqrt Mod](#)

6.17 Simplex

Description

Solve linear programming optimization problems

Test Status

N/A

6.18 Simplex Construction

Description

Method of using simplex algorithm

6.19 Theorem

Description

Useful math theorems

7. Polynomials

7.1 NTT

Description

Number Theoretic Transform

Test Status

N/A

7.2 FFT

Description

Fast fourier Transform

Test Status

N/A

7.3 Primes

Description

List some primes

7.4 Fast Walsh Transform

Description

Bitwise AND, OR, XOR convolution in $O(n \log n)$

Test Status

Passed [Library Checker - Bitwise Xor Convolution](#)

7.5 Fast Linear Recursion

Description

Matrix exponentiation

Test Status

N/A

7.6 Polynomial Operations

Description

Multiply, Inverse, Divide, Sqrt, Differentiate, Integrate, Natural Log, Exp, Polypow, Evaluate, Interpolate, Taylor Shift, Sampling Shift

Test Status

Tested Inverse, Exp on Library Checker

8. Geometry

8.1 Basic

Description

Basic geometry template

Test Status

N/A

8.2 Convex Hull

Description

2D Convex Hull

Test Status

Passed [CSES - Convex Hull](#)

8.3 Minkowski Sum

Description

Compute sum of two convex hull

Test Status

N/A

8.4 Intersection of Circle and Line

Description

Find intersection of circle and line

Test Status

N/A

8.5 Intersection of Circles

Description

Find intersection of circles

Test Status

N/A

8.6 Point in Convex

Description

Check if a point is in a convex hull in $O(\log n)$

Test Status

N/A

8.7 Minimum Enclosing Circle

Description

Random, complexity : $O(n)$

Test Status

Passed [P1742 最小圆覆盖](#)

8.8 Rotating Caliper

Description

Rotate on a convex hull

Test Status

N/A

8.9 Rotating sweep line

Description

Sweep line that rotates

Test Status

N/A

8.10 Tangent Line of Two Circles

Description

Compute the tangent line of two circles

8.11 Tangent Point to Hull

Description

Tangent line of a point outside the convex hull to the hull, need cyclic ternary search

8.12 3D Point

Description

3D point template

Test Status

N/A

8.13 3D Convex Hull

Description

Compute 3D convex hull

Test Status

N/A

9. Misc

9.1 Cyclic Ternary Search

Description

Cyclic ternary search

9.2 Binary Search on Fraction

Description

Binary search on fraction

Test Status

N/A

9.3 Random

Description

Custom hash

Test Status

N/A

9.4 Bit Hack

Description

Next permutation on bit

Test Status

N/A

9.5 Dynamic MST

Description

MST with delete edge

Test Status

N/A

9.6 Manhattan MST

Description

MST on plane with manhattan distance

Test Status

N/A

9.7 DP Optimization Conditions

Description

Convex, concave conditions

Test Status

N/A

9.8 Mo's Algo With Modification

Description

Mo's algo with extra dimension of time

Test Status

N/A

9.9 Mo's Algo on Tree

Description

Mo's Algo on tree

Test Status

N/A

9.10 Mo's Algorithm

Description

Some notes on Mo's algorithm

Test Status

N/A

9.11 Hilbert Curve

Description

Optimize Mo's algorithm

Test Status

N/A

9.12 SMAWK

Description

$O(n)$ Dp optimization

Test Status

Passed [CF - 1432M. Milutin's Plums](#)

Passed [Library Checker - Min Plus Convolution \(Convex and Arbitrary\)](#)

9.13 Simulate Annealing

Description

Random, optimizing a function

Test Status

N/A

9.14 Python

Description

Some useful python tools

Test Status

N/A

9.15 Matroid

Description

Notes on matroid intersection

Test Status

N/A