



ACM/ICPC Template Manual

QUST

hxx

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0 Include

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1 Math

1.1 Prime

1.1.1 Eratosthenes Sieve

$O(n \log \log n)$ maxn
 $notprime[i] = 0/1 \quad 0 \quad 1$

1
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4
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9

1.1.2 Euler Sieve

$O(n)$ phi[] prime[] tot
n

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1.1.3 Prime Factorization

$fact[i][0]^{fact[i][1]}$ i

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1.1.4 Miller Rabin

$O(s \log n)$ 2^{63} , s

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1.1.5 Segment Sieve

$[a, b)$

is_prime[i-a]=true i
 $a < b \leq 10^{12}, b - a \leq 10^6$

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1.2 Euler phi

1.2.1 Euler

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1.2.2 Sieve

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1.3 Basic Number Theory

1.3.1 Extended Euclidean

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1.3.2 $ax+by=c$

$$\begin{aligned} &: X = x + k * dx, Y = y - k * dy \\ &x \quad , \quad 0 \end{aligned}$$

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1.3.3 Multiplicative Inverse Modulo

$$\text{exgcd } a \ m \ , \ \text{gcd}(a, m) == 1.$$

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6

$$a < p - p \quad ,$$

1

1

1.4 Modulo Linear Equation

1.4.1 Chinese Remainder Theory

$$\begin{aligned} X &= r_i \pmod{m_i}; \quad m_i \\ X &= re + k * mo \end{aligned}$$

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1.4.2 ExCRT

$$X = r_i \pmod{m_i}; m_i$$

$$X = re + k * mo;$$

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1.5 Combinatorics

1.5.1 Combination

$$0 \leq m \leq n \leq 1000$$

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9
10
11

$$0 \leq m \leq n \leq 10^5, \quad p$$

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9
10
11

1.5.2 Lucas

$1 \leq n, m \leq 1000000000, 1 < p < 100000, p$

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8
9 ~
10
11
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13
14
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17
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21
22

1.5.3 Big Combination

$0 \leq n \leq 10^9, 0 \leq m \leq 10^4, 1 \leq k \leq 10^9 + 7$

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1.5.4 Polya

$$N * N = \sum_{i=1}^n \sum_{j=1}^n \sum_{d|\gcd(i,j)} \frac{c^{\frac{n^2+3}{4}} + c^{\frac{n^2+1}{2}} + 2c^{\frac{n+1}{2}} + 2c^{\frac{n(n+1)}{2}}}{\frac{m^8+17m^4+6m^2}{24}, \frac{m^4+11m^2}{12}}$$

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1.6 Fast Power

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1.7 Mobius Inversion

1.7.1 Mobius

$$F(n) = \sum_{d|n} f(d) \Rightarrow f(n) = \sum_{d|n} \mu(d) F\left(\frac{n}{d}\right)$$

$$F(n) = \sum_{n|d} f(d) \Rightarrow f(n) = \sum_{n|d} \mu\left(\frac{d}{n}\right) F(d)$$

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1.7.2 Number of Coprime-pair

n ($n \leq 100000$), n

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1.7.3 VisibleTrees

$\gcd(x, y) = 1$, $x \leq n, y \leq m$

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1.8 Fast Transformation

1.8.1 FFT

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13 ( )
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21 ,
22 ,
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30 ^ ,
31 ,
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1.8.2 NTT

$$P \rightarrow G \rightarrow P \quad G^{\frac{P-1}{n}} \quad w_n = e^{\frac{2i\pi}{n}} \quad P \rightarrow G \quad 1.11$$

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1.8.3 FWT

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9 ^

10 ^
 11 ^
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 21 ^
 22 ^
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 24 ^
 25 ^
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1.9 Numerical Integration

1.9.1 Adaptive Simpson's Rule

$$\int_a^b f(x)dx \approx \frac{b-a}{6}[f(a) + 4f(\frac{a+b}{2}) + f(b)]$$

$$|S(a, c) + S(c, b) - S(a, b)|/15 < \epsilon$$

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 2
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 4
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 7
 8 ()
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 10
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 12
 13
 14

1.9.2 Berlekamp-Massey

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1.10 Others

n , , m

1
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3
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5
6

n^n

1
2
3
4
5
6

$n!$

1
2
3
4
5

1.11 Formula

1. : $n = \prod_{i=1}^k p_i^{a_i}$,
 - (a) $f(n) = \prod_{i=1}^k (a_i + 1)$
 - (b) $g(n) = \prod_{i=1}^k (\sum_{j=0}^{a_i} p_i^j)$
2. n $n\varphi(n)/2$
3. $\gcd(n, i) = 1, \gcd(n, n - i) = 1 (1 \leq i \leq n)$
4. : $D(n) = (n - 1)(D(n - 2) + D(n - 1)) = \sum_{i=2}^n \frac{(-1)^k n!}{k!} = [\frac{n!}{e} + 0.5]$
5. : p is prime $\Rightarrow (p - 1)! \equiv -1 \pmod{p}$
6. : $\gcd(a, n) = 1 \Rightarrow a^{\varphi(n)} \equiv 1 \pmod{n}$
7. : $\gcd(n, p) = 1 \Rightarrow a^n \equiv a^{n \% \varphi(p)} \pmod{p}$
8. : n $\pi(n), \lim_{n \rightarrow \infty} \pi(n) = \frac{n}{\ln n}$
9. : x $N = \log_{10}(n) + 1$
10. $n! \approx \sqrt{2\pi n} (\frac{n}{e})^n$
11. $a > 1, m, n > 0, \gcd(a^m - 1, a^n - 1) = a^{\gcd(m, n)} - 1$
12. $a > b, \gcd(a, b) = 1, \gcd(a^m - b^m, a^n - b^n) = a^{\gcd(m, n)} - b^{\gcd(m, n)}$

$$G = \gcd(C_n^1, C_n^2, \dots, C_n^{n-1}) = \begin{cases} n, & n \text{ is prime} \\ 1, & n \text{ has multy prime factors} \\ p, & n \text{ has single prime factor } p \end{cases}$$

$$\gcd(\text{Fib}(m), \text{Fib}(n)) = \text{Fib}(\gcd(m, n))$$

13. $\gcd(m, n) = 1, :$

(a) $m * n - m - n$

(b) $N = \frac{(m-1)(n-1)}{2}$

14. $(n+1)lcm(C_n^0, C_n^1, \dots, C_n^{n-1}, C_n^n) = lcm(1, 2, \dots, n+1)$

15. $p \text{ , } (x+y+\dots+w)^p \equiv x^p + y^p + \dots + w^p \pmod{p}$

16. $:1, 1, 2, 5, 14, 42, 132, 429, 1430, 4862, 16796, 58786, 208012$

$$h(0) = h(1) = 1, h(n) = \frac{(4n-2)h(n-1)}{n+1} = \frac{C_{2n}^n}{n+1} = C_{2n}^n - C_{2n}^{n-1}$$

17. $:B_n = -\frac{1}{n+1} \sum_{i=0}^{n-1} C_{n+1}^i B_i$

$$\sum_{i=1}^n i^k = \frac{1}{k+1} \sum_{i=1}^{k+1} C_{k+1}^i B_{k+1-i} (n+1)^i$$

18. FFT

$r \cdot 2^k + 1$	r	k	g
3	1	1	2
5	1	2	2
17	1	4	3
97	3	5	5
193	3	6	5
257	1	8	3
7681	15	9	17
12289	3	12	11
40961	5	13	3
65537	1	16	3
786433	3	18	10
5767169	11	19	3
7340033	7	20	3
23068673	11	21	3
104857601	25	22	3
167772161	5	25	3
469762049	7	26	3
998244353	119	23	3
1004535809	479	21	3
2013265921	15	27	31
2281701377	17	27	3
3221225473	3	30	5
75161927681	35	31	3
77309411329	9	33	7
206158430209	3	36	22
2061584302081	15	37	7
2748779069441	5	39	3
6597069766657	3	41	5
39582418599937	9	42	5
79164837199873	9	43	5
263882790666241	15	44	7
1231453023109121	35	45	3
1337006139375617	19	46	3
3799912185593857	27	47	5
4222124650659841	15	48	19
7881299347898369	7	50	6
31525197391593473	7	52	3
180143985094819841	5	55	6
1945555039024054273	27	56	5
4179340454199820289	29	57	3

2 String Processing

2.1 KMP

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2.2 ExtendKMP

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2.3 Manacher

$O(n)$

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6 \$
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2.4 Aho-Corasick Automaton

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38 ~
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2.5 Suffix Array

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2.6 Suffix Automation

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31 ~
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3 Data Structure

3.1 Binary Indexed Tree

$O(\log n)$

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13
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3.2 Segment Tree

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6   , ( )
7   ,
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```

3.2.1 Single-point Update

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3.2.2 Interval Update

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3.3 Splay Tree

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3.4 Functional Segment Tree

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3.5 Sparse Table

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RMQ

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3.6 Heavy-Light Decomposition

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3.7 Link-Cut Tree

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19 ^
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27 ^
28 ^
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4 Graph Theory

4.1 Union-Find Set

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4.2 Minimal Spanning Tree

4.2.1 Kruskal

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4.2.2 Prim

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4.3 Shortest Path

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4.3.1 Dijkstra

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4.3.2 Bellman-Ford

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4.4 Topo Sort

Ans ,G ,deg ,map
1, 0

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4.5 LCA

4.5.1 Tarjan

Tarjan

$O(n + q)$

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4.5.2 DFS+ST

DFS+ST

$O(n \log n + q)$

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4.6 Depth-First Traversal

4.6.1 Biconnected-Component

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4.6.2 Strongly Connected Component

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4.6.3 2-SAT

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28 ^
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4.7 Euler Path

- :
 - : ()
 - :
 - : (,),
- G
 - G
 - G () 0 2.
- G
 - G
 - G
- G
 - G
 - u 1,v 1, (u ,v)
- G
 - G
 - G

4.7.1 Fleury

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4.8 Bipartite Graph Matching

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2. $=|G| -$

$N \times N$, , , ;

(,); , .

:

(a) ;

(b) p_1, p_2, \dots, p_k , p_1, p_k , , p_1, p_2, \dots, p_k .

, G .

: $=|G| -$;

3. $= -$

:

4.8.1 Hungry(Matrix)

: $O(VE)$.

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4.8.2 Hungry(List)

```
init()  
    addedge(u,v)
```

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4.8.3 Hopcroft-Carp

$$O(\sqrt{n} * E)$$
$$uN, (0)$$

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4.8.4 Hungry(Multiple)

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4.8.5 Kuhn-Munkres

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4.9 Network Flow

[illegible]

4.9.1 EdmondKarp

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4.9.2 Dinic

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4.9.3 ISAP

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4.9.4 MinCost MaxFlow

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5 Computational Geometry

5.1 Basic Function

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5.2 Position

5.2.1 Point-Point

1

5.2.2 Line-Line

1
2
3
4
5 ^
6 ^
7 ^^
8
9
10
11

5.2.3 Segment-Segment

```
1
2
3
4
5
6
7
8  ^^
9  ^^
10
```

5.2.4 Line-Segment

```
1
2
3
4  ^^
5
```

5.2.5 Point-Line

```
1
2
3
4
5
6
7
```

5.2.6 Point-Segment

```
1
2
3
4
5
6
7
8
9
10
```

5.2.7 Point on Segment

```
1
2
3
4  ^
5
6
7
```

5.3 Polygon

5.3.1 Area

```
1
2
3
4 ^
5
6
```

5.3.2 Point in Convex

```
1
2
3
4
5
6
7
8
9 ^
10
11
12
13
14
```

5.3.3 Point in Polygon

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

5.3.4 Judge Convex

```
1
2  ~
3
4
5
6
7
8
9  ^
10
11
12
13
```

5.4 Integer Points

5.4.1 On Segment

```
1
```

5.4.2 On Polygon Edge

```
1
2
3
4
5
6
7
```

5.4.3 Inside Polygon

```
1
2
3
4
5
6
7
```

5.5 Circle

5.5.1 Circumcenter

```
1
2
3
4
5
6
7
```


6 Dynamic Programming

6.1 Subsequence

6.1.1 Max Sum

```
1      ,
2
3
4
5
6
7
8
```

6.1.2 Longest Increase

```
1      , ,
2
3
4
5
6
7
8
9
10
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12
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15
16
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21
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```

6.1.3 Longest Common Increase

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6.2 Digit Statistics

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35 ,
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7 Others

7.1 Matrix

7.1.1 Matrix FastPow

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16
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19
20
```

7.1.2 Gauss Elimination

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14
15
16
17
18
19
20
21
```

7.2 Tricks

7.2.1 Stack-Overflow

```
1
2
```

7.2.2 Fast-Scanner

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

7.2.3 Strok-Sscanf

```
1
2
3
4
5
6
7
8
9
```

7.3 Mo Algorithm

, , \sqrt{x} ,

```
1
2
3
4
5
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11
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13
14
15
16
17
```

7.4 BigNum

7.4.1 High-precision

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52 ~
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7.4.2 Complete High-precision

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139 ~
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141
142

7.5 VIM

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18 ~
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