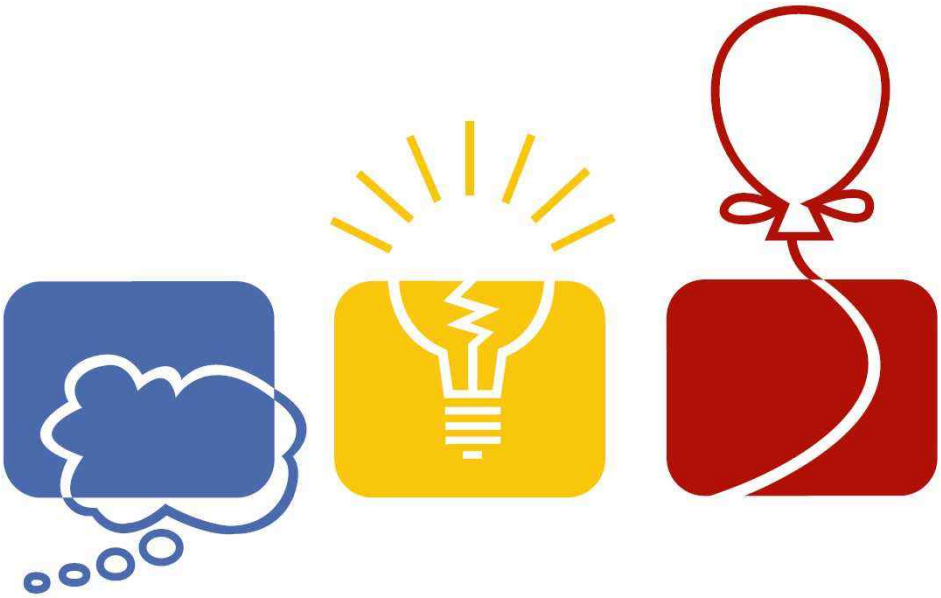

ACM/ICPC Template Manaual

QUST

hxk

August 3, 2018

Contents

0 Include

1 Math

1.1 Prime

1.1.1 Eratosthenes Sieve

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

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

1.1.2 Eular Sieve

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

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23
24
25
26
```

1.1.3 Prime Factorization

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

1.1.4 Miller Rabin

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

1.1.5 Segment Sieve

$[a, b)$

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

1.2 Eular phi

1.2.1 Eular

1.2.2 Sieve

1.3 Basic Number Theory

1.3.1 Extended Euclidean

5
6
7

1.3.2 ax+by=c

: $X = x + k * dx, Y = y–k * dy$
x , 0

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13

1.3.3 Multiplicative Inverse Modulo

exgcd a m , $gcd(a, m) == 1$.

1
2
3
4
5
6

$a < p$ p ,

1

1

1.4 Modulo Linear Equation

1.4.1 Chinese Remainder Theory

$X = r_i(modm_i)$; m_i
$X = re + k * mo$

1
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8
9

1.4.2 ExCRT

$X = r_i(mod m_i)$; m_i
$X = re + k * mo$;

1.5 Combinatorics

1.5.1 Combination

$0 \le m \le n \le 1000$

$0 \le m \le n \le 10^5$, p

~

1.5.2 Lucas

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

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9  ~
10
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13
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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 , i $gcd(i,n)$
$N*N$,$c^{n^2}+2c^{\frac{n^2+3}{4}}+c^{\frac{n^2+1}{2}}+2c^{n\frac{n+1}{2}}+2c^{\frac{n(n+1)}{2}}$
,$\frac{m^8+17m^4+6m^2}{24}$,$\frac{m^4+11m^2}{12}$

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1.6 Fast Power

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1.7 Mobius Inversion

1.7.1 Mobius

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

1
2
3
4
5

1.7.2 Number of Coprime-pair

$n \quad (n \leq 100000), \quad n$

1.7.3 VisibleTrees

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

1.8 Fast Transformation

1.8.1 FFT

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11
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13   (      )
14
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21          ,
22     ,
23
24
25
26
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28
29
30     ^ ,
31   ,
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41
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43
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45
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47
48
49
50
51
52
53
```

1.8.2 NTT

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

```

```

1.8.3 FWT

```

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ˆ
```

```
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^
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^
```

1.9 Numerical Integration

1.9.1 Adaptive Simpson's Rule

$\int_a^b f(x)dx \approx \frac{b-a}{6}[f(a)+4f(\frac{a+b}{2})+f(b)]$
$|S(a,c)+S(c,b)-S(a,b)|/15 < \epsilon$

```
    (    )
```

1.9.2 Berlekamp-Massey

1.10 Others

n , , m

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. $gcd(n, i) = 1,\ gcd(n, n - i) = 1(1 \le i \le n)$
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. $:p\ is\ prime\ \Rightarrow (p-1)! \equiv -1(mod\ p)$
6. $:gcd(a, n) = 1 \Rightarrow a^{\varphi(n)} \equiv 1(mod\ n)$
7. $:gcd(n, p) = 1 \Rightarrow a^n \equiv a^{n\%\varphi(p)}(mod\ p)$
8. : n $\pi(n), \lim_{n\to\infty} \pi(n) = \frac{n}{\ln n}$
9. : x $N = log10(n) + 1$
10. $n! \approx \sqrt{2\pi n}(\frac{n}{e})^n$
11. $a > 1, m, n > 0,\quad gcd(a^m - 1, a^n - 1) = a^{gcd(m,n)} - 1$
12. $a > b, gcd(a, b) = 1,\quad gcd(a^m - b^m, a^n - b^n) = a^{gcd(m,n)} - b^{gcd(m,n)}$

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

$gcd(Fib(m), Fib(n)) = Fib(gcd(m, n))$

13. $gcd(m,n)=1$, :
    (a) $m*n-m-n$
    (b) $N=\frac{(m-1)(n-1)}{2}$
14. $(n+1)lcm(C_n^0, C_n^1, ..., C_n^{n-1}, C_n^n) = lcm(1,2,...,n+1)$
15. p , $(x+y+...+w)^p \equiv x^p+y^p+...+w^p(mod\ p)$
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

$r\ 2^k+1$	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

2.2 ExtendKMP

2.3 Manacher

O(n)

$

2.4 Aho-Corasick Automaton

~

~

2.5 Suffix Array

```
1
2
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5          ~
6
7
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13
14  ~
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26  ~
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33        ,    ,
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45
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47
48
49
50
51
52
53
54
55
56
57
```

2.6 Suffix Automation

~

~

3 Data Structure

3.1 Binary Indexed Tree

$O(\log n)$

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

3.2 Segment Tree

```
1
2
3
4
5
6    , (  )
7    ,
8
9
```

3.2.1 Single-point Update

```
1
2
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6
7
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9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
```

3.2.2 Interval Update

,

3.3 Splay Tree

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3.4 Functional Segment Tree

k

3.5 Sparse Table

RMQ

3.6 Heavy-Light Decomposition

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3.7 Link-Cut Tree

```
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  ^
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45  ^
46
47
48
49
50
```

4 Graph Theory

4.1 Union-Find Set

4.2 Minimal Spanning Tree

4.2.1 Kruskal

4.2.2 Prim

```
~
```

4.3 Shortest Path

4.3.1 Dijkstra

```
    ( )
```

,

4.3.2 Bellman-Ford

4.4 Topo Sort

Ans ,G ,deg ,map
1, 0

4.5 LCA

4.5.1 Tarjan

Tarjan
$O(n+q)$

4.5.2 DFS+ST

DFS+ST
$O(nlogn + q)$

4.6 Depth-First Traversal

4.6.1 Biconnected-Component

```
!
,
```

4.6.2 Strongly Connected Component

```
```

4.6.3 2-SAT

```
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```

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29 ˆ
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4.7 Eular Path

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

4.7.1 Fleury

,

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

4.8 Bipartite Graph Matching

1.

2. =|G|-
   $N \times N$, , , ;
   (,); , .
   :

   (a) ;

   (b) $p_1, p_2, ...p_k$, p_1 ,p_k , , $p_1, p2, ...p_k$.

   , G .
   : =|G|- ;

3. = -
   :

4.8.1 Hungry(Matrix)

:$O(VE)$.
0

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

4.8.2 Hungry(List)

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

4.8.3 Hopcroft-Carp

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

```
1
2
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10
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47
48
49
50
51
52
53
54
```

4.8.4 Hungry(Multiple)

4.8.5 Kuhn-Munkres

~

4.9 Network Flow

4.9.1 EdmondKarp

```
16
17
18
19
20
21
22
23
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25
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45
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48
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50
51 ^
52
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54
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```

4.9.2 Dinic

```
1
2
3
4   , (    ),
5    ^
6   ,
7
8
9
10
11
12
13
```

^

4.9.3 ISAP

```
, (    ),
  ^
  ,
```

```
^
```

4.9.4 MinCost MaxFlow

^

5 Computational Geometry

5.1 Basic Function

```

^
```

5.2 Position

5.2.1 Point-Point

```

```

5.2.2 Line-Line

```

^
^
^^
```

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
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7
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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

```
~
ˆ
```

5.4 Integer Points

5.4.1 On Segment

```
```

5.4.2 On Polygon Edge

```
```

5.4.3 Inside Polygon

```
```

5.5 Circle

5.5.1 Circumcenter

```
```

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
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6
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12
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14
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39
```

6.1.3 Longest Common Increase

6.2 Digit Statistics

7 Others

7.1 Matrix

7.1.1 Matrix FastPow

7.1.2 Gauss Elimination

,

7.2 Tricks

7.2.1 Stack-Overflow

7.2.2 Fast-Scanner

```

```

7.2.3 Strok-Sscanf

```

```

7.3 Mo Algorithm

, , $\sqrt{x}$,

```

```

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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25 ~
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104 ~
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110     ^
111 ^
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```
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7.5 VIM

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