ICPC Notebook

template

hash.sh

```
# 使い方: sh hash.sh -> コピペ -> Ctrl + D
# コメント・空白・改行を削除して md5 でハッシュする
g++ -dD -E -P -fpreprocessed - | tr -d '[:space:]' | md5sum | cut -c-6
```

settings.sh

```
# CLion の設定
Settings → Build → CMake → Reload CMake Project
add_compile_options(-D_GLIBCXX_DEBUG)
# Caps Lock を Ctrl に変更
setxkbmap -option ctrl:nocaps
```

template.hpp

md5: 136d85

```cpp
#include <bits/stdc++.h>
using namespace std;
using ll = long long;
const ll INF = LLONG_MAX / 4;
#define rep(i, a, b) for(ll i = a; i < (b); i++)
#define all(a) begin(a), end(a)
#define sz(a) ssize(a)
bool chmin(auto& a, auto b) { return a > b ? a = b, 1 : 0; }
bool chmax(auto& a, auto b) { return a < b ? a = b, 1 : 0; }

int main() {
  cin.tie(0)->sync_with_stdio(0);
  // your code here...
}
```

data-structure

BIT.hpp

md5: 8133c8

```cpp
struct BIT {
  vector<ll> a;
  BIT(ll n) : a(n + 1) {}
  void add(ll i, ll x) {  // A[i] += x
    i++;
    while(i < sz(a)) {
      a[i] += x;
      i += i & -i;
    }
  }
  ll sum(ll r) {
    ll s = 0;
    while(r) {
      s += a[r];
      r -= r & -r;
    }
    return s;
  }
  ll sum(ll l, ll r) {  // sum of A[l, r)
    return sum(r) - sum(l);
  }
};
```

FastSet.hpp

md5: 2cb8c9

```cpp
// using u64 = uint64_t;
const u64 B = 64;
struct FastSet {
  u64 n;
  vector<vector<u64>> a;
  FastSet(u64 n_) : n(n_) {
    do a.emplace_back(n_ = (n_ + B - 1) / B);
    while(n_ > 1);
  }
  // bool operator[](ll i) const { return a[0][i / B] >> (i % B) & 1; }
  void set(ll i) {
```

```
    for(auto& v : a) {
      v[i / B] |= 1ULL << (i % B);
      i /= B;
    }
  }
  void reset(ll i) {
    for(auto& v : a) {
      v[i / B] &= ~(1ULL << (i % B));
      if(v[i / B]) break;
      i /= B;
    }
  }
  ll next(ll i) { // i を超える最小の要素
    rep(h, 0, sz(a)) {
      i++;
      if(i / B >= sz(a[h])) break;
      u64 d = a[h][i / B] >> (i % B);
      if(d) {
        i += countr_zero(d);
        while(h--) i = i * B + countr_zero(a[h][i]);
        return i;
      }
      i /= B;
    }
    return n;
  }
  ll prev(ll i) { // i より小さい最大の要素
    rep(h, 0, sz(a)) {
      i--;
      if(i < 0) break;
      u64 d = a[h][i / B] << (~i % B);
      if(d) {
        i -= countl_zero(d);
        while(h--) i = i * B + __lg(a[h][i]);
        return i;
      }
      i /= B;
    }
    return -1;
  }
};
```

math

BinaryGCD.hpp

md5: f3ab31

```
u64 ctz(u64 x) { return countr_zero(x); }
u64 binary_gcd(u64 x, u64 y) {
  if(!x || !y) return x | y;
  u64 n = ctz(x), m = ctz(y);
  x >>= n, y >>= m;
  while(x != y) {
    if(x > y) x = (x - y) >> ctz(x - y);
    else y = (y - x) >> ctz(y - x);
  }
  return x << min(n, m);
}
```

ExtGCD.hpp

md5: c3fa9b

```
// returns gcd(a, b) and assign x, y to integers
// s.t. ax + by = gcd(a, b) and |x| + |y| is minimized
ll extgcd(ll a, ll b, ll& x, ll& y) {
  // assert(a >= 0 && b >= 0);
  if(!b) return x = 1, y = 0, a;
  ll d = extgcd(b, a % b, y, x);
  y -= a / b * x;
  return d;
}
```

modint

BarrettReduction.hpp

md5: 2ca7f3

```
// using u64 = uint64_t;
struct Barrett {  // mod < 2^32
  u64 m, im;
  Barrett(u64 mod) : m(mod), im(-1ULL / m + 1) {}
  // input: a * b < 2^64, output: a * b % mod
  u64 mul(u64 a, u64 b) const {
    a *= b;
    u64 x = ((__uint128_t)a * im) >> 64;
    a -= x * m;
    if((ll)a < 0) a += m;
    return a;
  }
};
```

modint.hpp

md5: 81b530

```
const ll mod = 998244353;
struct mm {
  ll x;
  mm(ll x_ = 0) : x(x_ % mod) {
    if(x < 0) x += mod;
  }
  friend mm operator+(mm a, mm b) { return a.x + b.x; }
  friend mm operator-(mm a, mm b) { return a.x - b.x; }
  friend mm operator*(mm a, mm b) { return a.x * b.x; }
  friend mm operator/(mm a, mm b) { return a * b.inv(); }
  // 4 行コピペ  Alt + Shift + クリックで複数カーソル
  friend mm& operator+=(mm& a, mm b) { return a = a.x + b.x; }
  friend mm& operator-=(mm& a, mm b) { return a = a.x - b.x; }
  friend mm& operator*=(mm& a, mm b) { return a = a.x * b.x; }
  friend mm& operator/=(mm& a, mm b) { return a = a * b.inv(); }
  mm inv() const { return pow(mod - 2); }
  mm pow(ll b) const {
    mm a = *this, c = 1;
    while(b) {
      if(b & 1) c *= a;
      a *= a;
      b >>= 1;
    }
    return c;
  }
};
```

FPS

FFT.hpp

md5: 3138c7

```
// {998244353, 3}, {1811939329, 13}, {2013265921, 31}
mm g = 3;  // 原始根
void fft(vector<mm>& a) {
  ll n = sz(a), lg = __lg(n);
  assert((1 << lg) == n);
  vector<mm> b(n);
  rep(l, 1, lg + 1) {
    ll w = n >> l;
    mm s = 1, r = g.pow(mod >> l);
    for(ll u = 0; u < n / 2; u += w) {
      rep(d, 0, w) {
        mm x = a[u << 1 | d], y = a[u << 1 | w | d] * s;
        b[u | d] = x + y;
        b[n >> 1 | u | d] = x - y;
      }
      s *= r;
    }
    swap(a, b);
  }
}
vector<mm> conv(vector<mm> a, vector<mm> b) {
  if(a.empty() || b.empty()) return {};
```

```
  size_t s = sz(a) + sz(b) - 1, n = bit_ceil(s);
  // if(min(sz(a), sz(b)) <= 60) 愚直に掛け算
  a.resize(n);
  b.resize(n);
  fft(a);
  fft(b);
  mm inv = mm(n).inv();
  rep(i, 0, n) a[i] *= b[i] * inv;
  reverse(1 + all(a));
  fft(a);
  a.resize(s);
  return a;
}
```

FFT_fast.hpp

md5: c8c567

```
// modint を u32 にして加減算を真面目にやると速い
mm g = 3;  // 原始根
void fft(vector<mm>& a) {
  ll n = sz(a), lg = __lg(n);
  static auto z = [] {
    vector<mm> z(30);
    mm s = 1;
    rep(i, 2, 32) {
      z[i - 2] = s * g.pow(mod >> i);
      s *= g.inv().pow(mod >> i);
    }
    return z;
  }();
  rep(l, 0, lg) {
    ll w = 1 << (lg - l - 1);
    mm s = 1;
    rep(k, 0, 1 << l) {
      ll o = k << (lg - l);
      rep(i, o, o + w) {
        mm x = a[i], y = a[i + w] * s;
        a[i] = x + y;
        a[i + w] = x - y;
      }
      s *= z[countr_zero<uint64_t>(~k)];
    }
  }
}
// コピペ
void ifft(vector<mm>& a) {
  ll n = sz(a), lg = __lg(n);
  static auto z = [] {
    vector<mm> z(30);
    mm s = 1;
    rep(i, 2, 32) {  // g を逆数に
      z[i - 2] = s * g.inv().pow(mod >> i);
      s *= g.pow(mod >> i);
    }
    return z;
  }();
  for(ll l = lg; l--;) {  // 逆順に
    ll w = 1 << (lg - l - 1);
    mm s = 1;
    rep(k, 0, 1 << l) {
      ll o = k << (lg - l);
      rep(i, o, o + w) {
        mm x = a[i], y = a[i + w];  // *s を下に移動
        a[i] = x + y;
        a[i + w] = (x - y) * s;
      }
      s *= z[countr_zero<uint64_t>(~k)];
    }
  }
}
vector<mm> conv(vector<mm> a, vector<mm> b) {
  if(a.empty() || b.empty()) return {};
  size_t s = sz(a) + sz(b) - 1, n = bit_ceil(s);
  // if(min(sz(a), sz(b)) <= 60) 愚直に掛け算
  a.resize(n);
  b.resize(n);
  fft(a);
  fft(b);
  mm inv = mm(n).inv();
  rep(i, 0, n) a[i] *= b[i] * inv;
  ifft(a);
  a.resize(s);
  return a;
}
```

graph

graph/tree

flow

燃やす埋める.md

変形前の制約	変形後の制約
x が 0 のとき z 失う	(x, T, z)
x が 0 のとき z 得る	無条件で z 得る; (S, x, z)
x が 1 のとき z 失う	(S, x, z)
x が 1 のとき z 得る	無条件で z 得る; (x, T, z)
$x, y, \ldots$ がすべて 0 のとき z 得る	無条件で z 得る; $(S, w, z), (w, x, \infty), (w, y, \infty)$
$x, y, \ldots$ がすべて 1 のとき z 得る	無条件で z 得る; $(w, T, z), (x, w, \infty), (y, w, \infty)$

string

KMP.hpp

md5: 886c63

```
// kmp[i] := max{ l ≤ i | s[:l] == s[(i+1)-l:i+1] }
// abacaba -> 0010123
auto KMP(string s) {
  vector<ll> p(sz(s));
  rep(i, 1, sz(s)) {
    ll g = p[i - 1];
    while(g && s[i] != s[g]) g = p[g - 1];
    p[i] = g + (s[i] == s[g]);
  }
  return p;
}
```

Manacher.hpp

md5: 5882fb

```
// 各位置での回文半径を求める
// aaabaaa -> 1214121
// 偶数長の回文を含めて直径を知るには，N+1 個の $ を挿入して 1 を引く
// $a$a$a$b$a$a$a$ -> 123432181234321
auto manacher(string s) {
  ll n = sz(s), i = 0, j = 0;
  vector<ll> r(n);
  while(i < n) {
    while(i >= j && i + j < n && s[i - j] == s[i + j]) j++;
    r[i] = j;
    ll k = 1;
    while(i >= k && i + k < n && k + r[i - k] < j) {
      r[i + k] = r[i - k];
      k++;
    }
    i += k, j -= k;
  }
  return r;
}
```

RollingHash.hpp

md5: adb8d3

```
// using u64 = uint64_t;
const u64 mod = INF;
u64 add(u64 a, u64 b) {
  a += b;
  if(a >= mod) a -= mod;
```

```
  return a;
}
u64 mul(u64 a, u64 b) {
  auto c = (__uint128_t)a * b;
  return add(c >> 61, c & mod);
}
random_device rnd;
const u64 r = ((u64)rnd() << 32 | rnd()) % mod;
struct RH {
  ll n;
  vector<u64> hs, pw;
  RH(string s) : n(sz(s)), hs(n + 1), pw(n + 1, 1) {
    rep(i, 0, n) {
      pw[i + 1] = mul(pw[i], r);
      hs[i + 1] = add(mul(hs[i], r), s[i]);
    }
  }
  u64 get(ll l, ll r) const { return add(hs[r], mod - mul(hs[l], pw[r - l])); }
};
```

SuffixArray.hpp

md5: 1d70ce

```
// returns pair{sa, lcp}
// sa 長さ n : s[sa[0]:] < s[sa[1]:] < ... < s[sa[n-1]:]
// lcp 長さ n-1 : lcp[i] = LCP(s[sa[i]:], s[sa[i+1]:])
auto SA(string s) {
  ll n = sz(s) + 1, lim = 256;
  // assert(lim > ranges::max(s));
  vector<ll> sa(n), lcp(n), x(all(s) + 1), y(n), ws(max(n, lim)), rk(n);
  iota(all(sa), 0);
  for(ll j = 0, p = 0; p < n; j = max(1LL, j * 2), lim = p) {
    p = j;
    iota(all(y), n - j);
    rep(i, 0, n) if(sa[i] >= j) y[p++] = sa[i] - j;
    fill(all(ws), 0);
    rep(i, 0, n) ws[x[i]]++;
    rep(i, 1, lim) ws[i] += ws[i - 1];
    for(ll i = n; i--;) sa[--ws[x[y[i]]]] = y[i];
    swap(x, y);
    p = 1;
    x[sa[0]] = 0;
    rep(i, 1, n) {
      ll a = sa[i - 1], b = sa[i];
      x[b] = (y[a] == y[b] && y[a + j] == y[b + j]) ? p - 1 : p++;
    }
  }
  rep(i, 1, n) rk[sa[i]] = i;
  for(ll i = 0, k = 0; i < n - 1; lcp[rk[i++]] = k) {
    if(k) k--;
    while(s[i + k] == s[sa[rk[i] - 1] + k]) k++;
  }
  sa.erase(begin(sa));
  lcp.erase(begin(lcp));
  return pair{sa, lcp};
}
```

Zalgorithm.hpp

md5: b20b04

```
// Z[i] := LCP(s, s[i:])
// abacaba -> 7010301
auto Z(string s) {
  ll n = sz(s), l = -1, r = -1;
  vector<ll> z(n, n);
  rep(i, 1, n) {
    ll& x = z[i] = i < r ? min(r - i, z[i - l]) : 0;
    while(i + x < n && s[i + x] == s[x]) x++;
    if(i + x > r) l = i, r = i + x;
  }
  return z;
}
```

algorithm

geometry

memo

Primes.md

□□□□□

n	10^2	10^3	10^4	10^5	10^6	10^7	10^8	10^9
$\pi(n)$	25	168	1229	9592	78498	6.6×10^5	5.8×10^6	5.1×10^7

□□□□□

$\leq n$	10^3	10^4	10^5	10^6	10^7	10^8	10^9
x	840	7560	83160	720720	8648640	73513440	735134400
$d^0(x)$	32	64	128	240	448	768	1344

$\leq n$	10^{10}	10^{11}	10^{12}	10^{13}	10^{14}	10^{15}	10^{16}	10^{17}	10^{18}
$d^0(x)$	2304	4032	6720	10752	17280	26880	41472	64512	103680

□□□□

n	2	3	5	7	11	13	17	19	23	29
$n\#$	2	6	30	210	2310	30030	510510	9699690	2.2×10^8	6.5×10^9

□□

5!	6!	7!	8!	9!	10!	11!	12!
120	720	5040	40320	362880	3628800	4.0×10^7	4.8×10^8