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 -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: e173ef

```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) {
    if(a <= b) return 0;
    a = b;
    return 1;
}
bool chmax(auto& a, auto b) {
    if(a >= b) return 0;
    a = b;
    return 1;
}

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

data-structure

BIT.hpp

md5: 1fe3e2

```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: 928ece

```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

modint

BarrettReduction.hpp
md5: b61c28

```cpp
// 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: ade70b

```cpp
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: 81edb3

```cpp
// {998244353, 3}, {754974721, 11}, {167772161, 3}, {469762049,
3}, {2130706433, 3}
mm g = 3;  // 原始根
void fft(vector<mm>& a) {
    ll n = sz(a), lg = bit_width<size_t>(n) - 1;
    //   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: 91085e

```cpp
// {998244353, 3}, {754974721, 11}, {167772161, 3}, {469762049,
3}, {2130706433, 3}
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: e9357f

```cpp
// kmp[i] := max{ l ≤ i | s[:l] == s[(i+1)-l:i+1] }
// abacaba -> 0010123
vector<ll> 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: ec4be5

```cpp
// {even-length, odd-length} palindromes
// even-length は長さ n+1 : 両端を中心とするものが含まれていることに注
意
// aaabaaa -> {01100110, 0103010}
auto manacher(string s) {
    ll n = sz(s);
    array p = {vector<ll>(n + 1), vector<ll>(n)};
    rep(z, 0, 2) for(ll i = 0, l = 0, r = 0; i < n; i++) {
        ll t = r - i + !z;
        if(i < r) p[z][i] = min(t, p[z][l + t]);
        ll L = i - p[z][i], R = i + p[z][i] - !z;
        while(L >= 1 && R + 1 < n && s[L - 1] == s[R + 1]) {
            p[z][i]++;
            L--;
            R++;
        }
        if(R > r) {
            l = L;
            r = R;
        }
    }
    return p;
}
```

RollingHash.hpp   md5: 41625f

```cpp
// 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) {
```

```cpp
    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) {
        for(ll i = 0; i < n; i++) {
            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: 447222

```cpp
// 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: f563e6

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

<div style="color:white;background:#5b9bbf;">**algorithm**</div>

<div style="color:white;background:#5b9bbf;">**geometry**</div>

<div style="color:white;background:#5b9bbf;">**memo**</div>

Primes.md

素数の個数

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

高度合成数

$\leq n$	10^3	10^4	10^5	10^6	10^7	10^8	10^9
x	840	7560	83160	720720	8648640	73513440	735134400

$\leq n$	10^3	10^4	10^5	10^6	10^7	10^8	10^9
$d^0(x)$	32	64	128	240	448	768	1344
factorization	3111	3311	33111	421111	631111	5311111	6321111

$\leq n$	10^{10}	10^{11}	10^{12}	10^{13}	10^{14}	10^{15}
$d^0(x)$	2304	4032	6720	10752	17280	26880
factor	53211111	63221111	642111111	6321111111	5422111111	64211111111

$\leq n$	10^{16}	10^{17}	10^{18}
$d^0(x)$	41472	64512	103680
factor	83221111111	632211111111	842211111111