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# Competitive programming

- Elydeck

→ Prime sieve

Sieve of erathestheres

Make an array (bool) of size n.
Mark all true.

| T | T | T | T | T | T | T | T | T | T | T |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

A[0] = false;  A[1] = false;

We need to find all primes from 2 to n.

```
for (i = 2; i * i <= n; i++)
  {
      if (A[i] == true) {
         for (j = i * i; j <= n; j += i)
          {
              A[j] = false;
          }
      }
  }
```

print those index which are marked true.

Time - complexity = n log log n

# Finding GCD

## Euclid's algorithm

$gcd(a, b) = gcd(b, a \% b)$ when $a > b$

Learn it as "bab"

$gcd(a, 0) = a$

## → Extended euclid's algorithm

$gcd(a, b) = ax + by$

we need to find $x$ & $y$.

$ax + by = gcd(a, b)$ —— i)

Also, $gcd(a, b) = gcd(b, a \% b)$ —— ii)

From i) & ii)

$ax + by = gcd(b, a \% b)$ —— iii)

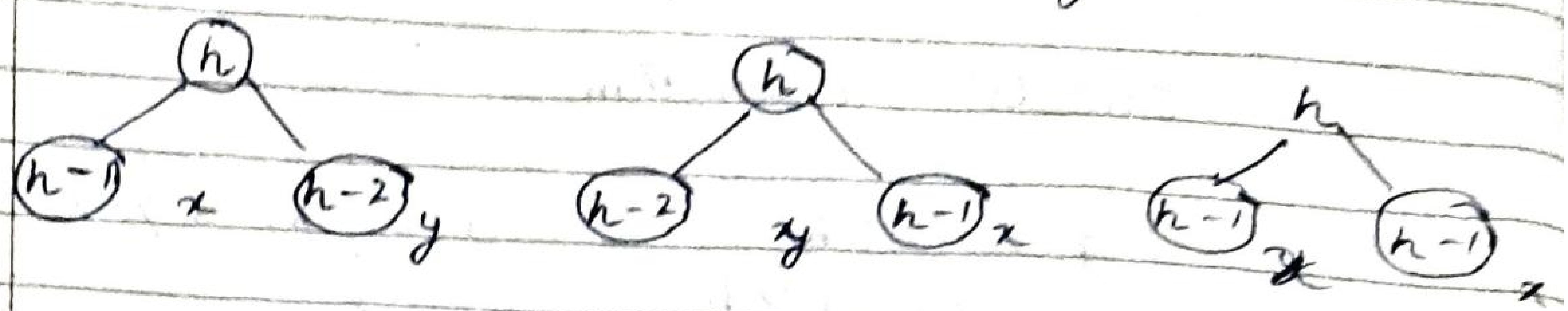
$\Rightarrow bx_1 + (a \% b) y_1 = gcd(a, b) = ax + by$

$\Rightarrow bx_1 + \left\{a - \left(\frac{a}{b}\right)\left[\cancel{\frac{a}{b}}\right] \cdot b\right\} y_1 = ax + by$

$\Rightarrow$ On comparing, we get

$\boxed{x = y_1}$ , $\boxed{y = x_1 - \left[\frac{a}{b}\right] y_1}$

→ Number of balanced Binary Tree




~~ans = 2x + y~~

```
int balanceBT(int h) {
    if (h==0 || h==1) {
        return 1;
    }
    int m=pow(10, 9) + 7;
    int x= balanceBT (h-1);
    int y= balanceBT (h-2);
    long res1 = (long) x*x;
    long res2= (long) x*y*2;
    int ans1 = (int) (res1 % m);
    int ans2 = (int) (res2 % m);
    return (ans1 + ans2) % m;
}
```

Balance = $|LH - RH| \leq 1$

$(h-1) \rightarrow x$

$(h-2) \rightarrow y$

ans = $x^* x + x^* y + x^* y$

$= x^2 + 2xy$

Modulo inverse

$a \times b = 1$

$b = \frac{1}{a}$ (multiplicative inverse)

Multiplicative mod inverse

$(A \cdot B) \% m = 1$

We have to find B.

$(A \cdot B) \% m = 1$

$\Rightarrow ((A \% m) \cdot (B \% m)) \% m = 1$

$\Rightarrow \because (a \cdot b) \% m = ((a \% m) \cdot (b \% m)) \% m$

$\Rightarrow 1 \leq B \leq m - 1$

$(a \cdot b) \% m = 1$

$\Rightarrow$ ~~$(a \cdot b) \% m - 1 = 0$~~

$a \cdot b \equiv 1$

$\Rightarrow a \cdot b - 1 \equiv 0$ (multiple of m)

$= a \cdot b - 1 \equiv mq$

$= a \cdot b + mQ = 1$

$= a \cdot b + mQ = 1$

$= gcd(a, m) = 1$

$(ax + by) = gcd(a, b)$

mod inverse (a, m)

= b

matlab a me kya multiply kre aur m se mod kre ki ans = 1.

modinverse (a, m) = b

$$\Rightarrow (a \times ?) \% m = 1$$

we have to find this only

→ Hard question

$$ax + by = d$$

a & b item se d banana hai
Need to find number of pairs possible of (x, y) for such

$$ax + by = d$$

$$ax = \underbrace{d - by}$$

This term must be divisible by x.

$$0 \le y \le \frac{d}{b}, \qquad 0 \le x \le \frac{d}{a}$$

$ax = d - by$

$d$

let us assume $y_1$ to be minimum value for such condition to be hold.

$d \rightarrow$ fixed

$b \rightarrow$ fixed

$y \rightarrow$ can change.

$ax = d - by_1$

Next term, $d - b(y_1 + a)$

$d - b(y_1 + 2a)$

$d - b(y_1 + 3a)$

$\vdots$

$d - b(y_1 + na)$

On comparing with maximum value of $y$

$$y_1 + na = \frac{d}{b}$$

$$na = \frac{d}{b} - y_1$$

$$\boxed{n = \frac{\frac{d}{b} - y_1}{a}}$$

Total terms $= 1 + n$

Now we need to find $y_1$

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$$(d - by_1) \% a = 0$$

$$\Rightarrow d \% a - (by_1) \% a = 0$$

$y_1$

$$\Rightarrow d \% a - [(b \% a) \cdot (y_1 \% a)] \% a = 0 \quad \text{--- i)}$$

$$ax + by = d$$

$$y = \frac{d - ax}{b}$$

For smallest value,

$$y_1 \% a = \left(\frac{d - ax}{b}\right) \% a$$

$$= \left(\frac{d}{b}\right) \% a - \frac{(ax)}{b} \% a$$

$$y_1 \% a = \left(\frac{d}{b}\right) \% a \quad \text{--- ii)}$$

i) & ii)

$$\Rightarrow d \% a - \left[ [b \% a] \cdot \left(\frac{d}{b}\right) \% a \right] \% a = 0$$

$$\Rightarrow d \% a - \left[ \left(b \cdot \frac{d}{b}\right) \% a \right] \% a = 0$$

$$- \quad d \% a - (d \% a) \% a = 0$$

this holds

$$y_1 = \left(\frac{d}{b}\right) \% a$$

$$= d^{*} \text{mod inverse}(b, a)$$

```
... g = gcd (a,b);
if (d % g == 1) {
    cout << 0 << endl;
  }
if (d == 0) {
    cout << 1 << end;
  }
  a/= g;
  b/= g;
  d/= g;
long value= ((d % a) * modInverse(b,a)) % a;
long firstvalue = d/b
if (d < y1 * b) {
    cout << 0 << end;
  }
else {
  long n= (firstValue - y1) / a;
  cout << 1+n << end;
}
```

$$y_1 = \left(\frac{d}{b}\right) \% a$$

$$ax + by = d$$

$$\frac{ax}{g} + \frac{by}{g} = \frac{d}{g}$$

$$\Rightarrow \quad Ax + By = D$$

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→ Advanced GCD

$\gcd(a, b) = \gcd(b, a \% b)$

both must be integers

$\gcd(10^{240}, 40) = \gcd(40, 10^{240} \% 40)$

Input as string.

ex- $(23567) \% 40$

$= (0 * 10 + 2) \% 40 = 2$

$(2 * 10 + 3) \% 40 = 23$

$(23 * 10 + 5) \% 40 =$

$2356 \% 40 = (235 * 10 + 6) \% 40$

$= ((235 * 10) \% 6 + 6 \% 40) \% 40$

$= ($from previous $+ 6 \% 40) \% 40$

```
ll gcdLarge (ll a, string b) {
    ll mod = 0;
    for (int i=0; i < b.size(); i++) {
        mod = (mod * 10 + b[i] - '0') % a;
    }
    return mod;
}
```

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ICPC question

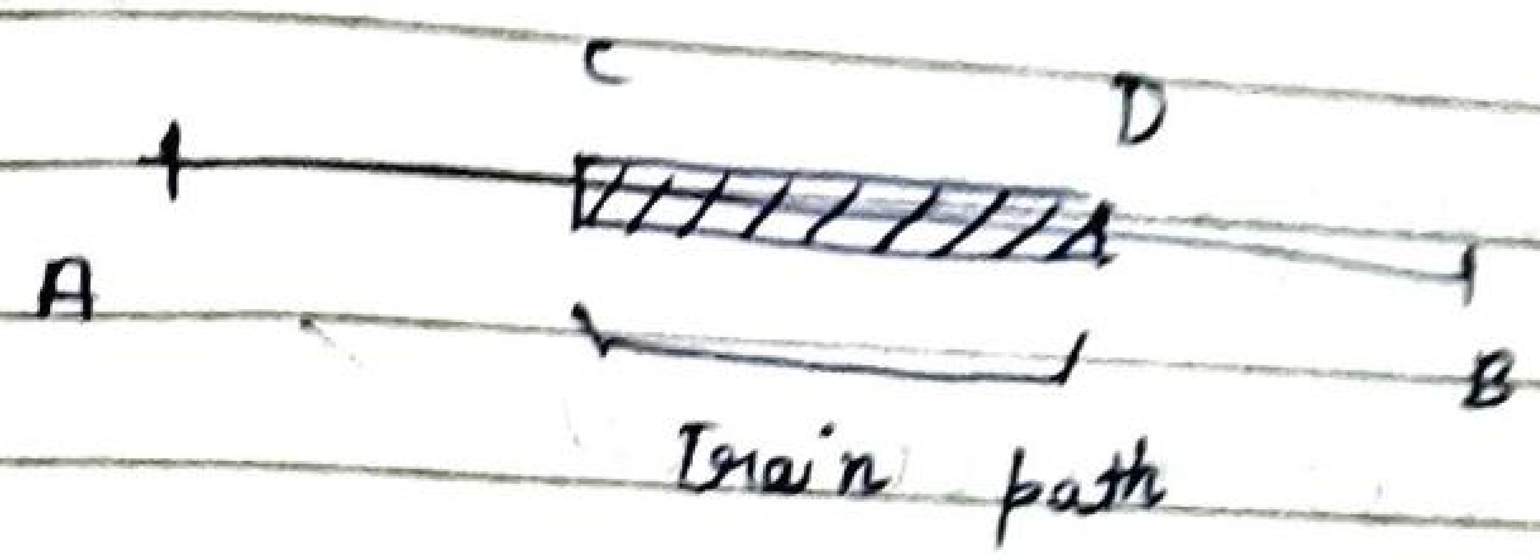
Train or walk


$v_{walk} = \left(\frac{1}{p}\right) m/s$

$v_{train} = \left(\frac{1}{q}\right) m/s$ train starts at $x = y_s$

(From C to D)

$\Downarrow$




Path 1: A to B without train

distance $= |x_A - x_B|$

$s = \frac{D}{t}$

$t = \frac{|x_B - x_A|}{\left(\frac{1}{p}\right)} = p(x_B - x_a)$

Path 2: A to C and go to D then B.

distance $= |x_C - x_A| + |x_D - x_C| + |x_B - x_D|$

$t = p|x_C - x_A| + q|x_D - x_C| + p|x_B - x_D|$

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ans = min ( t1 , t2);

But train starts at t = y.

Path 2

Train ke liye wait kara

Train chut gayi

if AC(time) > y :
can't catch train

Path 1

waiting_ time
= y - p |x_c - x_A|

t2 += waiting_ train

ans = min (t1, t2)

```
cin >> n >> A >> B >> C >> D >> P >> Q >> Y;
int A[n];
for (int i=0; i<n; i++)   cin >> A[i];
int  t1 = p* (abs( A[a] - A[b]));
int  tAC = p* (abs( A[c] - A[a]));
 if  tAC > y {
     // do nothing;    t2 = INT_MAX;
     }
else {
   waiting_ time = y - tAC;
     t2 += waiting_ time;
 }
cout << min(t1, t2) << endl;
```