Hashing 2 October
Wednesday, 27 October 2021 8:30 PM

Hashing 2

Q Given a string S & an int. K. Find whether S can be represented as a concatenation of K same strings.

→ Allowed to rearrange chars in S.

K K = 3

S : " a b b b a b b "

abb | abb | abb

a - z
A - Z

S = " a b b b a a " K = 2

ab   ab   ab

freq [ch] % k == 0

$f(i:0 \to n-1)$ {
  freq [s[i]] ++

O(N)

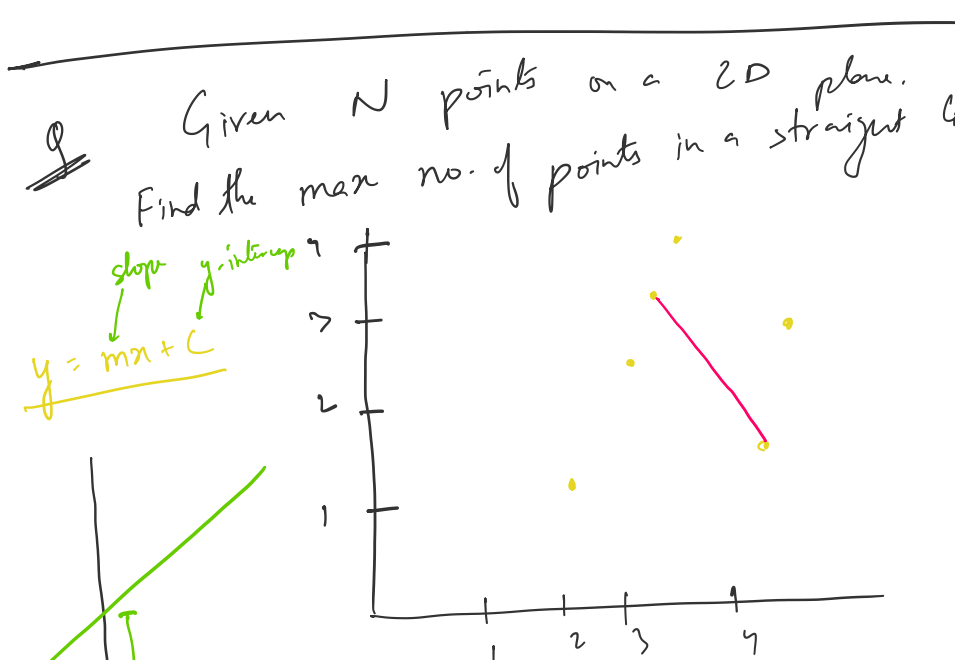
Iterate over the 26 ... check ... % k == 0   O(K)

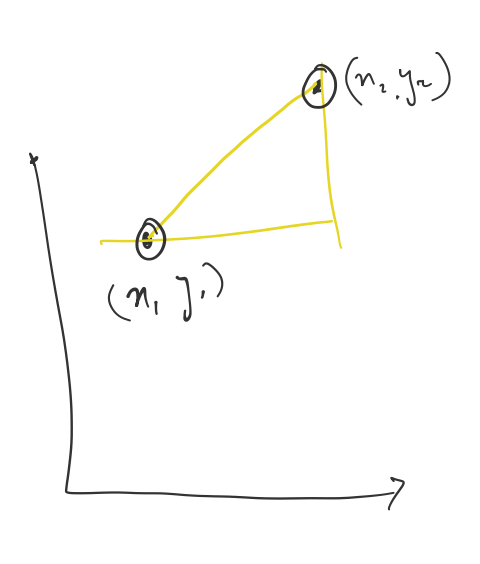
TC : O(N + K)

SC : O(K)   min (N, K)

Q Given N points in a 2D plane. Find the max no. of points in a straight line.

y = mx + c





$m = \frac{y_2 - y_1}{x_2 - x_1}$

y = mx + c

$y_1 = \left(\frac{y_2 - y_1}{x_2 - x_1}\right) x_1 + c$

$y_1 = \frac{x_1 y_2 - x_1 y_1}{x_2 - x_1} + c$

c = y_1 − ( )

$c = \frac{x_2 y_1 - \cancel{x_1 y_1} - (x_1 y_2 - \cancel{x_1 y_1})}{x_2 - x_1}$

$\boxed{c = \frac{x_2 y_1 - x_1 y_2}{x_2 - x_1}}$

for 2 points O(N²)
(m, c) O(N)
for all points : i
check if they satisfy
  cnt ++
ans = max (ans, cnt);

TC : O(N³)

SC : O(1)

Edge case

m = $\frac{y_2 - y_1}{x_2 - x_1}$

c :

$m = \frac{18}{24} = \frac{3}{4}$ {3, 4}

$\frac{4}{10}$ $\frac{2}{5}$

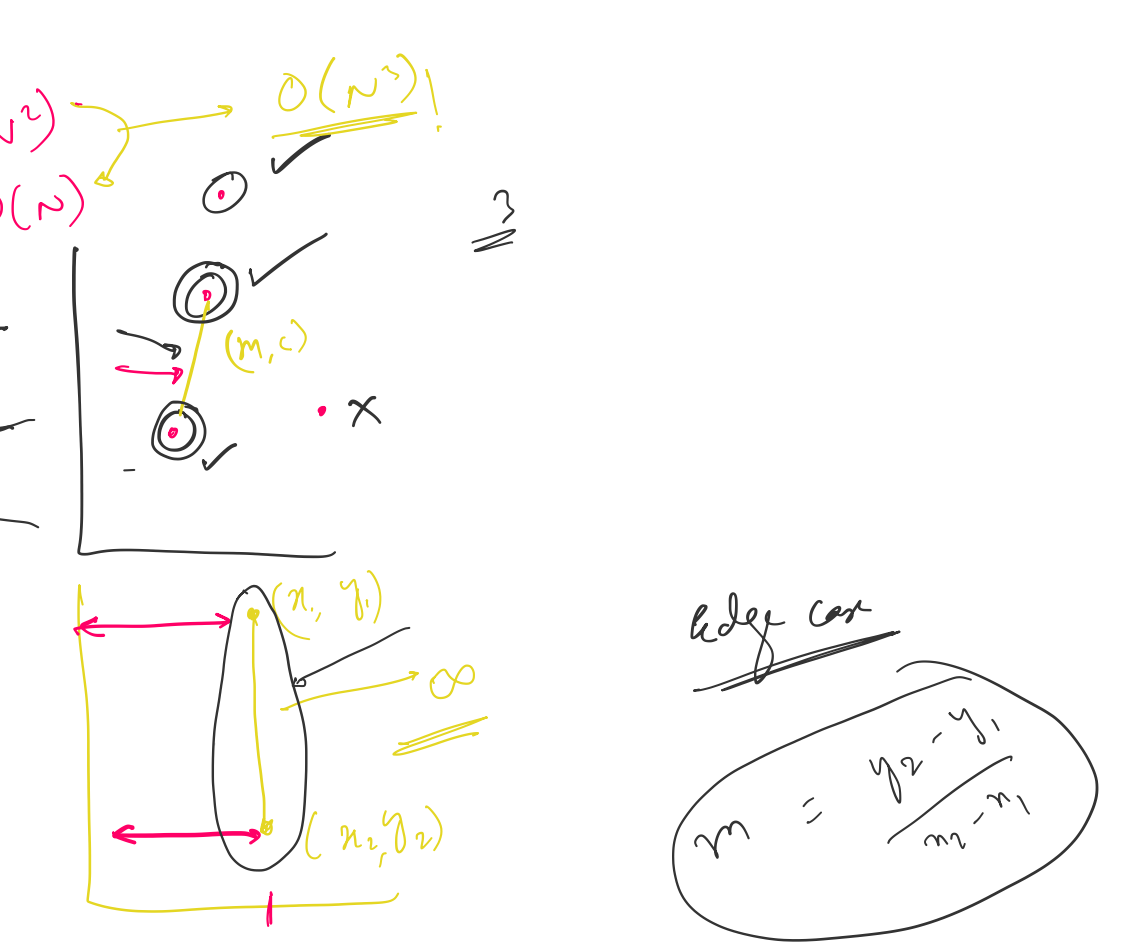
$\frac{18}{24}$ 0.4

$\frac{36}{20}$ $\frac{9}{5}$

$m = \frac{a}{b}$ =

$\frac{a}{b} \Rightarrow \frac{a / \gcd(a,b)}{b / \gcd(a,b)}$ { , }

y = mx + c



∀ (i, j)
freq [(m, c)] ++
(2, 3) → 3
(1, 3) → 1

(m, c)   6

max F = x_{C_2}

F = x_{C_2}

$F = \frac{x(x-1)}{2}$

$ax^2 + bx + c = 0$ $x^2 - x - 2F = 0$

$= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$x = \frac{1 + \sqrt{1 + 8F}}{2}$

O(N²)

TC : O(N³)

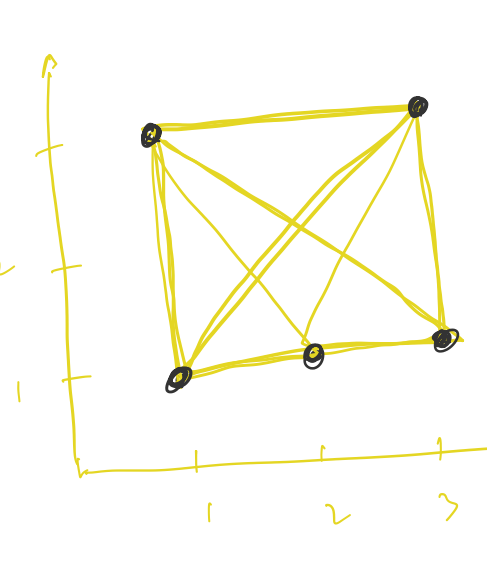
SC : O(N²)

TC : O(N²)

SC : O(N)

$m_1 \to 3$
$m_2 \to 1$
$m_3 \to 1$
O(N)

Q Given n points in a 2D plane. Find the no. of right angled Δ. s.t. 1 side is ∥ to x axis & 1 side is ∥ to y axis.



3 pts

∀ (i, j, k)

$z^2 = x^2 + y^2$

cnt ++

$h^2 = p^2 + b^2$

TC : O(N³)

SC : O(1)

(x_3, y_3)
(x_1, y_1) (x_2, y_2)

if ($x_1 == x_3$ && $y_1 == y_2$)

f (i: 0 → n−1)
f (j: i+1 → n−1)
f (k: j+1 → n−1)

(x_1, y_1)
(x_2, y_2)
(x_1, y_1)
$x_1 == x_2$
$y_1 == y_2$

∀ (i, j) : hypo
check if
++
++

set < pair<int, int> >

TC : O(N²)

SC : O(N)

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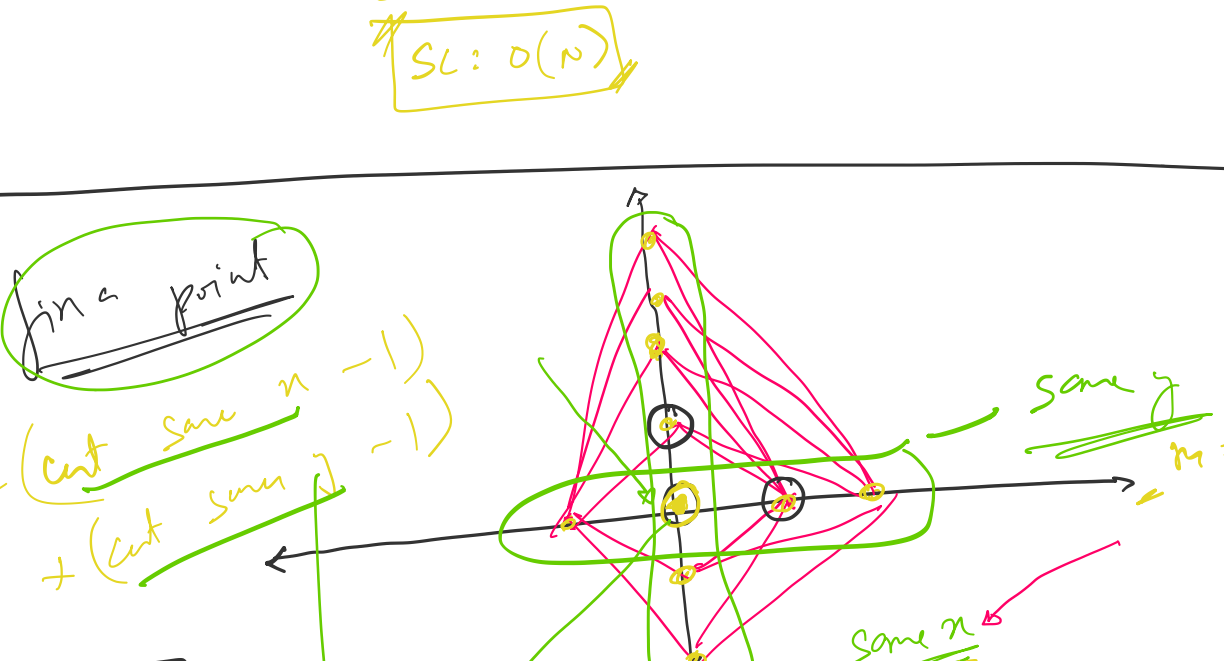
for a point
ans += (cnt same x − 1) × (cnt same y − 1)



same y   same x

(x, y)
n = 4
n = 7
(n−1) × (m−1)
6 × 3 = 18

TC : O(N)

SC : O(N)

(0, 0)
(1, 3)
(3, 4)
(1, 4)
(1, 2)

hm_x : { 1 : 3, 3 : 1 }   O(1)

hm_y = { 2 : 1, 4 : 2, 7 : 1 }   O(1)

Q Given n points. Count the no. of rectangles with sides ∥ to x & y axis.

∀ (i, j, k, l)

(x_1, y_1) (x_2, y_2) (x_3, y_3) (x_4, y_4)

$x_1 == x_4$
$x_2 == x_3$
$y_1 == y_2$
$y_3 == y_4$

TC : O(N³)

SC : O(N)

Polynomial Rolling Hash

a − z : 97 − 122
ASCII A − Z : 65 − 90
0 − 9 : 48 − 57

"abc"
a → 1
b → 2
z → 26

"bac"
"cab"
"acb"

1 2 3 = $1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$

0 1 2
abc = (a × 26⁰ + b × 26¹ + c × 26²) % M

cba = 726   27 : P_1 31

prime $10^9 + 7$ $10^9 + 9$

$\boxed{h(s) = \left(s[0] + s[1] \times P + s[2] \times P^2 + \dots + s[n-1] P^{n-1}\right) \% M}$

a → 0
z → 25

a → 1
z → 26

a
0 = 0

a a a
0 + 0 × 25¹ + 0 × 25² = 0

---

n strings

% M

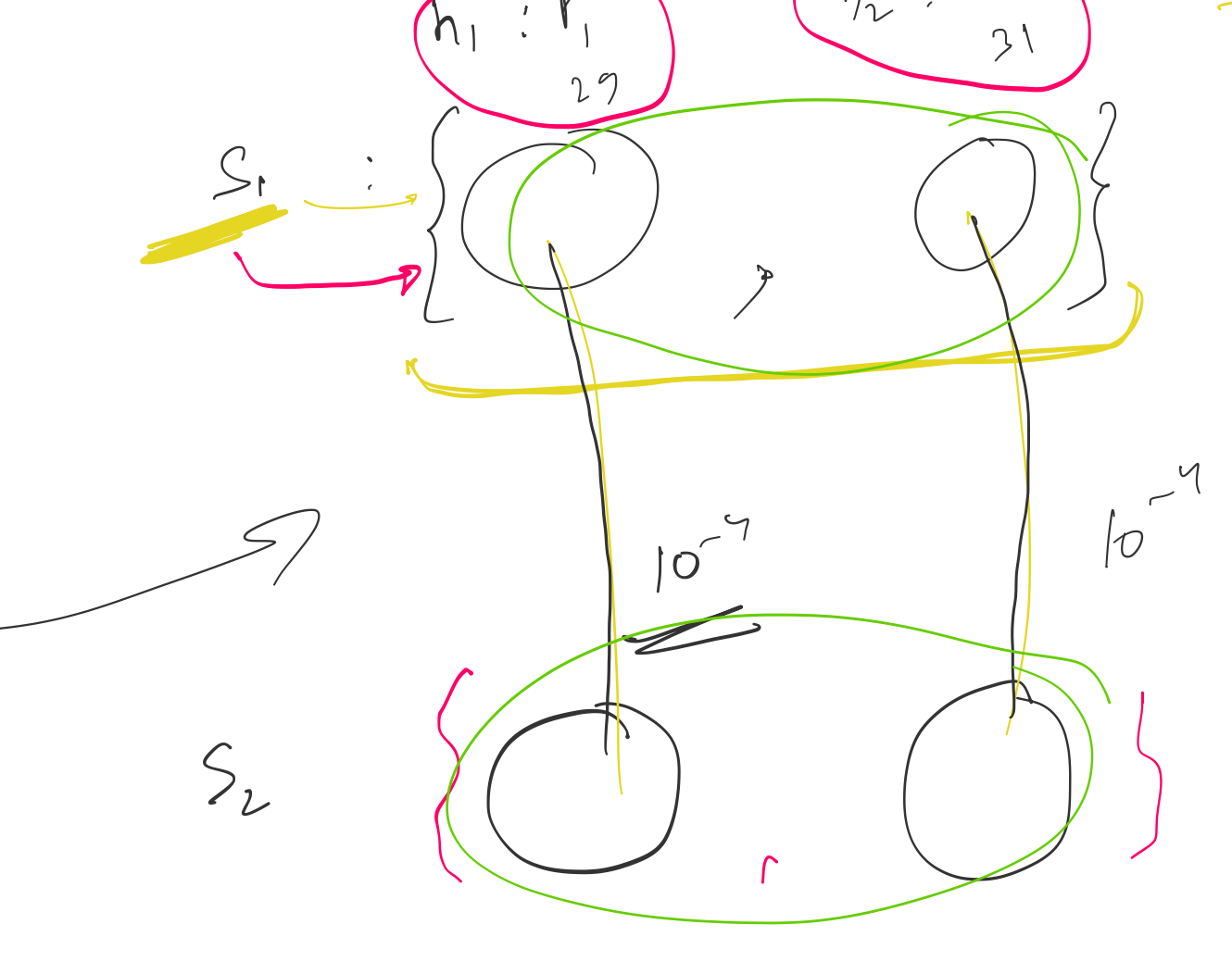
0
1/M
2/M
n/M

1
2
3
n+1

N → 10⁵

M → 10⁹

$\frac{10^5}{10^9} = 10^{-4}$ $\frac{1}{10{,}000}$



$10^{-4} \times 10^{-4}$

$= 10^{-8}$

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h (s [i −− j])

$\left(s[i] + s[i+1] \times P^1 + s[i+2] \times P^2 + \dots + s[j] \times P^{j-i}\right) \% M \to x$

h (s [i+1 −−− j+1])

$\left(s[i+1] + s[i+2] \times P + \dots + s[j+1] P^{j-i}\right) \% M \to y$

$y = \left(\left(\frac{x - s[i]}{P}\right) + s[j+1] \cdot P^{j-i}\right) \% M$

log (M)

Q Given a text T and a pattern P. Check if the pattern P exists in the text T ?

N : T = " a b c b a b a "
M : P = " c b a "

% P

BF : O(N × M)

TC : O(NM)

10^{10}

O(M)

+ O(N . log P)

TC : O(M + N log P)

N, M < 10⁵   10⁵   10⁵ × 10

≈ 10⁶