

STRING

- Sequence of characters
- Small Set
- contiguous integer value 'a' to 'z' and 'A' to 'Z' in both ASCII and UTF-16

C/C++

char:- ASCII
8 Bit

Java

UTF-16
16 Bit

Also supports wchar_t

char x = 'a'

cout << (int)x; // 97

Print the frequencies of character in sorted order

string str = "geeksforgeeks";

int count[26] = {0};

for (int i=0; i < str.length(); i++)
 count[str[i] - 'a']++;

for (int i=0; i < 26; i++) {
 if (count[i] > 0) {
 cout << (char)(i + 'a') << " ";
 cout << count[i];
 }
}

O/P

e	4
f	1
g	2
k	2
o	1
r	1
s	2

Strings in C++ (char arrays)

char str[] = "gfg"

func

strlen → gives length of string

compiler →

g f g \0

if we give definite size

str[6] = "gfg"

g f g \0 \0 \0

• String (a/b) → Arbitrary types

compare strings lexicographically $res = \text{strcmp}(a/b)$

if $a < b$ then $res < 0$
 if $a = b$ then $res = 0$
 if $a > b$ then $res > 0$

• strcpy (a/b)

To copy another string we have to use strcpy
`strcpy(str, "ggg")`

I can't do this
`char str[5];`
`str = "ggg";`
`cout << str;`
 str is an address and we can't assign anything directly to an address.

C++ String

- Richer library
- supports operators - equations like $+$, $<$, $>$, $=$, $<=$, $>=$ are possible
- can assign a string letter
- do not have to worry about size
- C++ strings are ~~static~~ objects of classes.

* str.length() → length of string

* str.substring (start, length) →



length of string you want

"geeksforgs" → (1,3) → eee
 "biddyt" → (2,3) code

str.find("eek")

→ substring

→ Returns index of first occurrence of substring string :: npos.

string str = "geeksforgs"

str.find("eek"); → 1

str.find("kfg"); → 3

strcmp

In C++ we have $=$, $>$, $<$

Reading string from console

string str;

cin >> str

cout << str;

case 2

user entered - sandeep |ain
 output - sandeep

case 1

user entered → sandeep
 output → sandeep

Reason: whenever we entered a ' ' (space) at the ~~str~~ cin operator stops reading the character.

For this purpose we use getline

string str;

getline (cin, str)

↓
 it will stop reading the character after you presses enter

it can also accept an optional character.
`getline(cin, str, 'g')`

stop when you see 'g'

Anagram of Each other

→ checking if two strings are permutation of each other

→ Every character in the first string should be present in the second and the frequency must also be same.

S1 = "listen", S2 = "silent"

O/P → Yes

S1 = "aabc", S2 = "baac"

O/P → NO.

Naive Approach $O(n \log n)$

sort both the string and then compare them.

sort(S1.begin(), S1.end())

sort(S2.begin(), S2.end())

return (S1 == S2);

↑
we can immediately return false if length is not same

Efficient solution

we create a count array and then used characters of string as indexes.

on each occurrence of character in 1st string we increment the count of that character and on each occurrence of ~~same~~ character in second string we decrement the count.

best anagram (string s1, string s2)

// check for length

int count[COUNT] = {0};

for (int i=0; i < length; i++) {

count[S1[i]]++;

count[S2[i]]--;

}

if (for (int i=0; i < n; i++) if (count[i] != 0) return false;

Leftmost repeating character

I/P: str = "geekforgeeks"

O/P → 0 'g' is the first repeating char.

I/P → str = "abcde"

O/P = 1 'b' is the first repeating

I/P → str = "abcd"

O/P = -1

I/P → str = "abba"

O/P = 0

Naive Approach

Run two loops and check if particular character appears in the string after it.

$O(n^2)$

Effective approach

use character as indexes and even run another loop to check count[STR[i]] > 1 → return i;

const int CHAR = 256;

int getLeftmostRep (string str) {

int count[CHAR] = {0};

for (int i=0; i < str.length(); i++) {

count[str[i]]++;

}

for (int i=0; i < str.length(); i++) {

if (count[str[i]] > 1)

return i;

}

return -1;

Effective Approach (To solve in one traversal)

We use an array which is initialised as -1 and whenever we see a character we store its first index into that array.

If we see a character whose corresponding value in + array is not -1, we get to know that this is repeating character. To get the leftmost we take the minimum of all repeating.

```
int leftmost(string str) {
    int f_index[CHAR];
    fill(f_index, f_index + CHAR, -1);
    int res = INT_MAX;
    for (int i = 0; i < str.length(); i++) {
        int fi = f_index[str[i]];
        if (fi == -1)
            f_index[str[i]] = i;
        else
            res = min(res, fi);
    }
    return (res == INT_MAX) ? -1 : res;
}
```

Effective Approach-2

We traverse from right side

```
int leftmost(string str) {
    bool visited[CHAR];
    fill(visited, visited + CHAR, false);
    int res = -1;
    for (int i = str.length() - 1; i >= 0; i--) {
        if (visited[str[i]])
            res = i;
        else
            visited[str[i]] = true;
    }
    return res;
}
```

Index of Leftmost Non-Repeating Char

I/P → "geekforgeeks";
O/P → 5
I/P → aabba
O/P → -1

1st Solution

Make an array count and then store frequencies of every character.
Now just traverse on the array and check if its count is 1 (return i).

2nd Solution

We will make an array named status
if status[str[i]] = -1 (unvisited)
status[str[i]] = -2 (repeated)
status[str[i]] = > 0 (element is present only once).

int nonRep(string str)

```
int count[CHAR];
fill(count, count + CHAR, -1);
for (int i = 0; i < str.length(); i++) {
    if (count[str[i]] == -1)
        count[str[i]] = i;
    else
        count[str[i]] = -2;
}

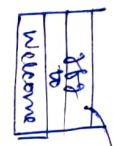
// Requires one traversal of string
// and one traversal of count array (O(2N))
for (int i = 0; i < CHAR; i++) {
    if (count[i] > 0)
        res = min(res, count[i]);
}
return res;
```

Reverse Words in a String

I/P: "Welcome to gfg"
O/P: "gfg to Welcome"

Naive Solution

Push the words inside the stack and then pop the words reverse until appending space



gfg + " " + to + " " + Welcome.

Auxiliary space $\rightarrow O(n)$.

Effective Solution

We reverse individual words and then we reverse the whole string.

I/P $\rightarrow$ "Welcome to gfg"

$\rightarrow$ "emecleW ot gfg"

gfg to welcome. $\leftarrow$ Required string

void reverseWord(char str[], int n)

int start = 0

for (int end = 0; end < n; end++)

if (str[start] == ' ')

reverse (start, end-1, str);

start = end+1;

}

reverse (start, n-1, str);

reverse (0, n-1, str);

for reversing
reverse word

void reverse (char str[], int low, int high) {

while (low < high) {

swap (str[low], str[high]);

low++;

high--;

}

If we use character array and get its size having size of operator, we will get one extra as compiler adds 'n' at end, so we can call the function get(str, n-1);

Overview of Pattern Searching

I/P - "helloworld" pattern $\rightarrow$ "eks"

O/P = 2, 10

I/P $\rightarrow$ "AAAAAA" AAA

O/P $\rightarrow$ 0, 1, 2

I/P $\rightarrow$ ABCDEFGABD

O/P $\rightarrow$ not present

Pattern Searching Algorithm

Naive :- $O((n-m+1)*m)$.

when all characters are different

$\rightarrow O(n)$.

Robin Karp :- $O((n-m+1)*m)$ $\leftarrow$ preprocess pattern

KMP :- $O(n)$

suffix tree :- $O(m)$

preprocess text $\rightarrow$ word return we have to find all occurrences of pattern

no preprocessing $m \rightarrow$ pattern length $n \rightarrow$ text length $m \leq n$

2 for two ends of pattern

Naive Pattern Searching

We slide the ~~text~~ pattern over the text and check if it matches with the substring

void patsearching (string txt, string pat) {

```
int n = txt.length();
int m = pat.length();
string curr = txt.substr(0, m);
for (int i = 0; i < n - m; i++) {
```

```
    int n = txt.length();
    int m = pat.length();
    string curr = txt.substr(0, m);
    for (int i = m; i < n; i++) {
        curr
```

int patsearching (string txt, string pat) {

```
int n = txt.length();
int m = pat.length();
for (int i = 0; i < n - m; i++) {
    int j;
    for (int j = 0; j < m; j++)
        if (pat[j] != txt[i+j])
            break;
    if (j == m)
        cout << i << " ";
}
```

Time comp $\rightarrow O((n-m+1) * m)$

Improve Naive Algorithm $\rightarrow$ when pattern is distinct

txt $\rightarrow$ ABCA B C D
pat $\rightarrow$ A B C D

similar to naive, we match the pat with the text but if it is in naive we move the pattern by 1 every time. Here as the pattern is distinct we can move the pattern by j times if j is the no of char matched.

void printchar (string txt, string pat) {

```
int n = patsee.txt.length();
int m = pat.length();
for (int i = 0; i < n - m; i++) {
```

```
    int j = 0;
    for (j = 0; j < m; j++)
        if (pat[j] != txt[i+j])
            break;
    if (j == m)
        print(i);
    if (j == 0)
        } — naive
    else
        i = i + j; } shift by j
```

Rabin Karp Algorithm

We don't directly compare every window with pattern. We compute the hash of pattern and windows of text. If hash value match we compare the character.

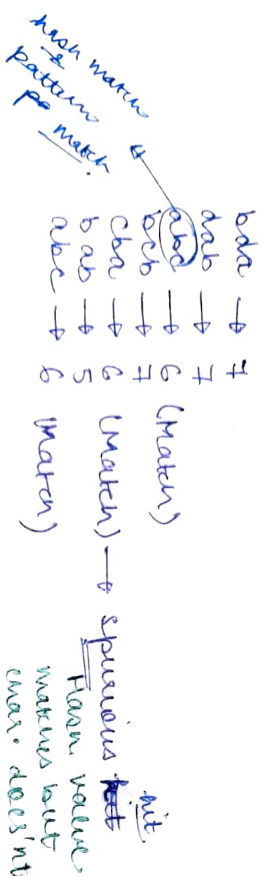
hash-function → sum of ascii value of character

let the ascii values of
 $a \rightarrow 1$
 $b \rightarrow 2$
 $c \rightarrow 3$
 $d \rightarrow 4$
 $e \rightarrow 5$

text = "ababababab"
 pat = "abc"

P → hash value of pattern $(1+2+3) = 6$

ababababab → $1+2+4 = 7$



If hash value of window matches, we match individual characters.

We can compute next hash by previous hash - this is also known as rolling hash.

$$t_{i+1} = t_i + \text{text}[i+m] - \text{text}[i];$$

In simple hash, we have problem of spurious hits.

To reduce the chances of matching hash with window is not same with pattern we use another more effective hash function.

* It was the concept of weighted sum.

let the string be $a_0 a_1 a_2 a_3 \dots a_{n-1} a_n \dots a_{2n-1}$.

To the hash value for this string would be

we have to calculate hash for a particular window only.

$$a_{i-2} \times d^2 + a_{i-1} \times d^1 + a_i \times d^0$$

$d = \text{no. of character in text}$

supposing that pattern is of size 3.

* we can also use the concept of rolling hash here

$$t_{i+1} = d(t_i - \text{text}[i] \times d^{m-1}) + \text{text}[i+m]$$

understanding → let str = "abc" → To move the window 1 step ahead.
 $\neq \text{text} = \text{"abcde"}$

also we'll multiply $\leftarrow$ and we'll add $d \times d^0 = d$. we have to subtract $a \times (d^{m-1} \times d^0)$.

$$\text{text} \rightarrow a_{n-1} a_{n-2} \dots a_{t+1} \dots a_t a_{t-1} \dots a_2 a_1 a_0$$

$$\text{let curr window} = a_t a_{t-1} a_{t-2}$$

$$\text{hash} = a_t \times d^2 + a_{t-1} \times d^1 + a_{t-2} \times d^0$$

$$\text{next hash} = a_{t-1} \times d^2 + a_{t-2} \times d^1 + a_{t-3} \times d^0$$

rem

we will store the known value under modulo q
 $q \rightarrow$ prime number

we try to choose bigger values because
 $let\ q = 13$

hash range $\rightarrow (0, 12)$

we precompute pattern and first remainder known
 we can calculate now by a simple formula

```

P = 0
for (i = 0; i < m; i++) {
    P = P * d + pat[i]
    at i = 0: P = pat[0]
    at i = 1: P = pat[0] * d + pat[1]
    at i = 2: P = pat[0] * d^2 + pat[1] * d + pat[2]
    ...
}

```

we also precompute $(d^{m+1}) \% q \rightarrow$ this value is used in calculating next remainder. known.

void reverseHash (pat, text, m, n) {

```

    int h = 1;
    for (int i = 1; i <= m-1; i++) {
        h = (h * P) % q;
    }
    int p = 0, t = 0;
    for (int i = 0; i < m; i++) {
        P = (P * d + pat[i]) % q;
        t = (t * d + pat[i]) % q;
    }
    for (int i = 0; i <= m-n; i++) {

```

because known value may be large & can produce integer overflow

Algorithm

void ReverseHash (int pat, text, m, n) {

```

    int h = 1;
    for (int i = 1; i <= m-1; i++) {
        h = (h * d) % q;
    }

```

using known's rule:
 int p = 0, t = 0;
 for (int i = 0; i < m; i++) {
 P = (P * d + pat[i]) % q;
 t = (t * d + text[i]) % q;
 }

```

    for (int i = 0; i <= m-n; i++) {

```

check for spurious int
 if (P == t) {
 bool flag = true;
 for (int i = 0; i < m; i++) {
 if (text[i+i] != pat[i]) {
 flag = false;
 break;
 }
 if (flag == true) {
 print(i);
 }
 }
 }

calculating next known
 if (i < m-m) {
 t = ((d * (t - text[i] * h) + text[i+m])) % q;
 if (t < 0) t = t + q;
 }

Constructing longest possible prefix suffix array

I/P $\rightarrow$ "ababac"

O/P $\rightarrow$ {0, 0, 1, 2, 0, 1}

I/P $\rightarrow$ "aaaa"

O/P $\rightarrow$ {0, 1, 2, 3}

for string ababac

(a) at $i=0$
 prefix $\rightarrow$ "a"
 suffix $\rightarrow$ "a" $\rightarrow$ ①

(ab) at $i=1$
 prefix $\rightarrow$ "ab"
 suffix $\rightarrow$ "b", "ba", "a" $\rightarrow$ ②

(abab) at $i=2$
 prefix $\rightarrow$ "abab"
 suffix $\rightarrow$ "b", "ab", "bab", "abab" $\rightarrow$ ①

(ababac) at $i=3$
 prefix $\rightarrow$ "ababac"
 suffix $\rightarrow$ "c", "ac", "bac", "abac", "ababac" $\rightarrow$ ②

ababac at $i=4$
 prefix $\rightarrow$ "ababac"
 suffix $\rightarrow$ "c", "ac", "bac", "abac", "ababac", "ababac" $\rightarrow$ ①

O/P $\rightarrow$ {0, 0, 1, 2, 0, 1}

for all characters same $\rightarrow$ {0, 1, 2, ..., n-1}

for all characters distinct $\rightarrow$ {0, 0, 0, ..., 0, 0}

str $\rightarrow$ "abcacabad"

O/P $\rightarrow$ {0, 0, 1, 0, 1, 2, 3, 0}

str $\rightarrow$ "abcacabad"

O/P $\rightarrow$ {0, 0, 0, 1, 2, 3}

Naive Approach $O(n^3)$

We check for every index whether their prefix and suffix match.

For example $\rightarrow$ let $i = 5$

We only consider = ababac

We start by last index

ie, $i=5$ — we know the max. possible length of prefix is $i-1$

We will compare

arr[i] with arr[n-len+i]

for $i \geq 5$

for $i=3$
 a[0], a[1]
 a[1], a[2]
 a[2], a[3]

int longestPrefixSuffix(str, n)

for (int len = n-1; len > 0; len--) {

bool flag = true;

for (int i=0; i < len; i++) {

if (str[i] != str[n-len+i]) {

flag = false;

break;

}

if (flag == true)

return len;

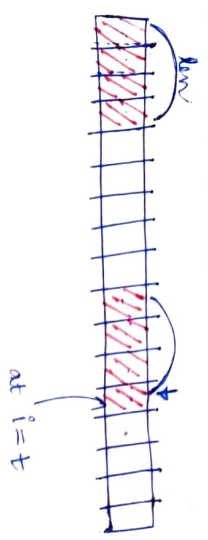
return 0;

len = 1 (len same)

```
void funLPS (str, lps[]) {
    for (int i=0; i < str.length(); i++) {
        lps[i] = longestPrefix (str, i+1);
    }
}
```

$O(n^3)$

$O(N)$ solution



next at $i = t+1$
 if $str[len] = str[i]$ then $O/P \rightarrow len+1$

we compare $str[len]$ and $str[i]$

if $str[len] == str[i]$ then $lps[i] = lps[i-1] + 1$

but if they are not same

$O(N)$ solution

let $lps[i-1] = len$
 then len chars must be matching.

if $str[len] == str[i]$ then $lps[i] = len + 1$

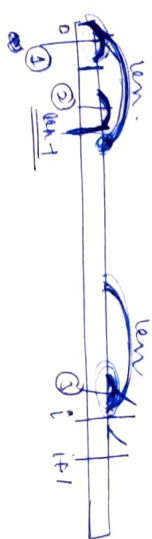
if they do not match

i) $len = 0$
 then we don't have any common substring $lps[i] = 0$

ii) else

we know that
 characters from
 0 to $len-1$
 are from $[i-len)$ to i

we will recursive call $lps[len-1]$



since ① = ②
 and ② = ③

so ① = ③ if $str[lps[len-1]] == str[i]$ then $lps[i] = lps[len-1]$

Basic idea

① if $str[i]$ and $str[len]$ match $lps[i] = len + 1$
 ② if they do not match

(a) $len == 0$

$lps[i] = 0$

(b) else

$len = lps[len-1]$

we now compare $str[len]$ and $str[i]$ if they match $\rightarrow lps[i] = len$ else recursively call.

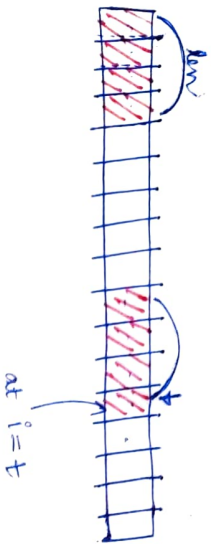
void funLPS (str, lps[]) {

for (int i=0; i < str.length(); i++) {

lps[i] = longestPrefix (str, i+1);

$O(n^3)$

$O(N)$ solution



not at $i=t+1$

if str[len] == str[i] then $lps[i] \rightarrow len+1$

but str[i] != str[i] then $lps[i] \rightarrow 0$

~~the length of the longest prefix is the length of the longest prefix~~

we compare str[len] and str[i]

if str[len] == str[i] then $lps[i] = lps[i-1] + 1$

but if they are not same

$O(N)$ solution

let $lps[i-1] = len$

then len chars must be matching.

if str[len] == str[i] then $lps[i] = len + 1$

if they do not match

(i) $len = 0$

then we don't have any common substring $lps[i] = 0$

(ii) else

we know that

characters from

0 to $len-1$ =

char from $[i-len)$ to i

we will recursive call $lps[i-len]$

since ① = ②

and ② = ③

so ① = ③ if str[lps[i-len]] == str[i] then $lps[i] = lps[i-len] + 1$

Basic idea

① $\rightarrow$ if str[i] and str[i-len] match $lps[i] = len + 1$

② $\rightarrow$ if they do not match

(a) $len = 0$

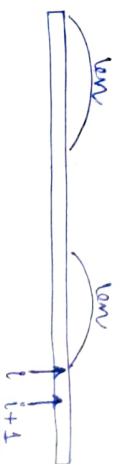
$lps[i] = 0$

(b) else

$len = lps[i-len]$

we now compare str[i-len] and str[i] if they match $\rightarrow lps[i] = len$ else

recursively call.



void findLPS (string str, lps[]) {

int n = str.length(), len = 0;

lps[0] = 0;

int i = 1;

while (i < n) {

if (str[i] == str[len]) {

len++;

lps[i] = len;

i++;

} else {

if (len == 0) {

lps[i] = 0;

i++;

} else {

len = lps[len-1];

→ use keep to reducing length recursively until we fall into the above two cases.

* when characters are distinct $\rightarrow O(n)$

* when we have all char same $\rightarrow O(2n) \rightarrow O(n)$

KMP String Matching

① KMP is introduced to ~~introduce~~ reduce the running of algorithm when there are some matches to the pattern.

$a_1 a_2 a_3 a_4 a_5 a_6 a_7 a_8$
 $m_1 m_2 m_3$
 $a_1 \neq m_1$
 $a_2 = m_2$
 $a_3 \neq m_3$

$t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13}$
 $P_1 P_2 P_3 P_4 P_5 P_6 P_7 P_8$

We know that $t_4 = P_1 / t_5 = P_2 / t_6 = P_3$ but $t_7 \neq P_4$ as the lps [2] i.e. P_3 is 2 (suppose).

Hence $P_1 P_2 = P_2 P_3$.

also $t_5 t_6 = P_2 P_3$

then $t_5 t_6 = P_1 P_2$

instead of shifting by 1 character everytime, we can make a shift of $1 - \text{lps}[i]$.

* we know that the longest proper prefix that could exist is lps[i].

$t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13}$
 $P_1 P_2 P_3 P_4 P_5 P_6 P_7 P_8 P_9 P_{10}$
 $t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13}$
 $t_7 \neq P_7$

Instead of shifting by 1 character everytime we just check lps[i] because if there is a chance that next character will also match with P_1 and so on then lps[i+1] $\rightarrow$ lps[i] i.e. it gives the longest common substring let the lps of $P_6 \rightarrow 4$ then

$ovals \quad P_3 - P_6 = P_1 - P_4$
 $and \quad P_3 - P_6 = t_5 - t_8$
 $then \quad P_1 - P_4 = t_5 - t_8$
 so the next char. with which P_1 will match is t_5

Now and KMP execute similar when the all the pattern in the character is distinct

void KMP (pat, txt) {

int n = txt.length();

int m = pat.length();

int lps[m];

fillLPS (pat, lps);

int i=0, j=0

while (i < N) {

if (pat[i] == txt[j]) { i++; j++; }

else if (j == m) { cout << (i-j); j = lps[j-1]; }

else if (i < N && pat[i] != txt[j]) {

if (j > 0) { i++; }

else { j = lps[j-1]; }

}

txt = abababababababab
pat = ababab

lps = {0,0,1,2,3,3}

i=0 → j++ → 1

i=0,1,2,3,4

j=0,1,2,3

at i=4 and j=4 they don't match

j = lps[3] = 2

j=2

we know that the previous will match so we simply move the pattern forward.

abababababababab
abababababababab

Now i=4 and j=2 don't match
j = lps[1] = 0

j=0

abababababababab
ababab

Now at i=4 and j=0 they don't match, we come to 2nd condⁿ.

i++.

abababababababab
ababab

now at i=6 and j=0 they match
(7,8,9,10) (1,2,3,4)

and j=4 == m.

hence cout << (10-4) = 6

and j = lps[3] = 2

i=10 and j=3

abababababababab
ababab

they mismatch
j = lps[2] = 1

abababababababab
ababab

they mismatch
j = lps[0] = 0

abababababababab
ababab

i=10 → i=11 (mismatch)
j=0

but

mismatch
j = lps[0] = 0

abababababababab
ababab

mismatch
i++ → i=12
(loop condⁿ false)
out of loop

Time complexity

maximum time i value in the string can be shifted by N times
and the pattern will shift by the text n times
so the complexity will be upper bounded by $O(2n)$

$[O(n)]$

Check if strings are rotations

I/P $\rightarrow$ ABCD & CDAB

ABCD $\rightarrow$ BCDA $\rightarrow$ CDAB

Yes

I/P $\rightarrow$ ABAAA & BAAAA

Yes

BAAAA

I/P $\rightarrow$ ABAB & ABBA

No

Naive solution

Rotate string one by one and check if it matches with s_2 . This is $O(n^2)$ solution

$O(n) \rightarrow$ To rotate the character by 1.

$O(n) \rightarrow$ To compare two strings

Efficient solution

② we can pattern search in a circular manner

① we can concatenate s_1 with itself and then search the pattern in itself

bool areRotations(string s1, string s2) {

if ($s_1.length() \neq s_2.length()$) return false;

return ((s_1+s_2).find(s_2) != string::npos);

}

Anagram search

We have to check if pattern is present or any of its permutation is present in the text.

I/P: text = "geekspgeeks"

pat = "prog"

O/P $\rightarrow$ Yes

I/P: text = "geekspgeeks"

pat = "hack"

O/P $\rightarrow$ NO

These characters were present but they are not contiguous

Naive solution

• If run a naive pattern searching algorithm and instead of searching only pattern we search for anagram.

bool isPresent(string str, string pat) {

int n = str.length();

int m = pat.length();

for (int i = 0; i <= n-m; i++) {

if (isAnagram(str, pat, i))
return true;

return false;

bool isAnagram(string text, string pat, int i) {

int count[CHAR] = 0;

for (int i = 0; i < text.length(); i++) {

count[pat[i]]++;

count[text[i]]--;

}

for (int i = 0; i < CHAR; i++) {

if (count[i] != 0) return false; } return true;

Effective solution

Just a modification of naive approach, we make two count arrays ① → pattern

② → every window

Initially we compute count arrays for 1st window and then pattern

for i in window we just have to $ct[text[i]]++$;

$ct[text[i]]++$;

$ct[text[i-m]]--$;

if ct and cp

match then return true

$O(n * \text{CHAR})$

bool isPresent (string str, string pat)

int $cp[\text{CHAR}] = \{0\}$;

int $ct[\text{CHAR}] = \{0\}$;

for (int $i=0$; $i < \text{pat.length()}; i++)$

$cp[pat[i]]++$;

$cp[pat[i]]++$;

}

for (int $i=\text{pat.length()}; i < \text{str.length()}; i++)$

if ($ct == cp$)

return true;

}

$ct[text[i]]++$;

$ct[text[i - \text{pat.length()}]]--$;

}

return false;

3

Lexicographic Rank of String

I/P: BAC

O/P: 3.

ABC
ACB
→ BAC
BCA

I/P → STRING
O/P → 598

Effective method

R	---	SR	---	STI	---	STRING
I	---	SI	---	STN	---	STRING
N	---	SN	---	STG	---	STRING
G	---	SG	---	STR	---	STRING

$$4 \times 4 + 3 \times 4 + 3 \times 4 + 1 \times 4 + 3 \times 3 + 1 + 2 = 120 \times 4 + 124 \times 4 + 6 \times 3 + 1$$

$$= 480 + 96 + 18 + 1 + 2$$

$$= 597$$

$$597 + 1$$

DCBA → 24

A	---	DA	---	DCA	---	DCBA
B	---	DB	---			
C	---					

$$3 \times 3 + 2 \times 2 + 1 \times 1$$

$$18 + 4 + 1 \Rightarrow 23$$

• count character which are smaller & which are on right