No.	1	2	3	4	5	6	7	8	9	10	11	12	Marks	Examiner
Mark Awarded														

Please start writing from below :

STRING MATCHING

Naive string matching

→ Basic algo

eg:

string: a b c d e f g h (1 2 3 4 5 6 7 8)

pattern: d e f (1 2 3)

① a b c d e f g h
d e f

② a b c d e f g h
d e f

③ a b c d e f g h
d e f

④ a b c d e f g h
d e f

- If pattern is not matching shift the pattern by one unit
- shift it till we get a hit
- once we find the hit check the next character once found then done

eg2

string a b c d a b c a b c d f

pattern a b c d f

1 2 3 4 5

pass1.

a b c d a b c a b c d f

matching move i and j

a b c d f

matching move i & j

a b c d f

matching move i & j

a b c d f

uptill here it is matching

a b c d a b c a b c d f

not matching → move i to 2nd position

Pass2 a b c d a b c a b c d f

a b c d f

again starting matching

when i is shifted to 2nd position it is the waste of time. (moved to 5 and shifted back to 1)

a b c d a b c a b c d f
1 2 3 4 5 6 7 8 9 10 11 12

a b c d f
j

a b c d a b c a b c d f
j

a b c d f
j j

a b c d a b c a b c d f
a b c d f
j

a b c d a b c a b c d f.
a b c d f
j

a b c d a b c a b c d f.
a b c d f X
i j

a b c d a b c a b c d f
a b c d f
j

a b c d a b c a b c d f.
a b c d f
i j

a b c d a b c a b c d f
a b c j d f

Similarly d f it will check.

So at the position at which the string where pattern is p. matched is 8 9 10 11 12

Worst case

n String a a a a a a a b
1 2 3 4 5 6 7 8

m pattern a a a b
1 2 3 4

does study the pattern only shifting the pattern by one if not matching

If size of string n and pattern is m
O(m×n) complexity (Naive).

⟹ Knuth-Morris-Pratt (KMP algo)

Pattern a b c d a b c

prefix ⇒ a, ab, abc, abcd.

Suffix ⇒ c, bc, abc, dabc

Is there any string prefix same as suffix. (idea of KMP)

Eg π or LPS

P_1: a b c d a b e a b f
0 0 0 0 1 2 0 1 2 0

P_2 = a b c d e a b f a b c
0 0 0 0 0 1 2 0 1 2 3

P_3 = a a b c a d a a b e
0 1 0 0 1 0 1 2 0 0

P_4 = a a a a b a a c d
0 1 2 3 0 1 2 0 0

String: a b a b c a b c a b a b a b c
1 2 3 4 5 6 7 8 9 10 11 12 13 14
1 2 3 4 5

pattern:

a	b	a	b	d
0	0	1	2	0

n

string

i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	a	b	a	b	c	a	b	c	a	b	a	b	a	b	d

m

pattern

j	1	2	3	4	5
	a	b	a	b	d
0	0	0	1	2	0

Complexity

$O(m+n)$ $O(m+n)$

π table Search

i=1 i=a } matched then move i=2

j+1=1 j+1=a } j+1=2

j=0, j=1

i=2=b } matched then move i=3

j=1 j+1=2=b } j+1=3

j=2

i=3=a } matched then move i=4

j=2 j+1=3=a } j+1=4

i=4=b } matched i=5

j=3, j+1=4=b } j+1=5

i=5=d } not matched.

j=4, j+1=5=c }

0	1	2	3	4	5
	a	b	a	b	d
	0	0	1	2	0

j

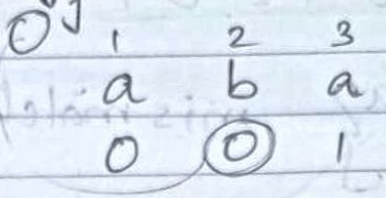
Visit the index (2)

0	1	2	3	4	5
	a	b	a	b	d
	0	0	1	2	0

j

$j=2$ $i=5$

$j+1=3$ } not matched
$=b$ compare c

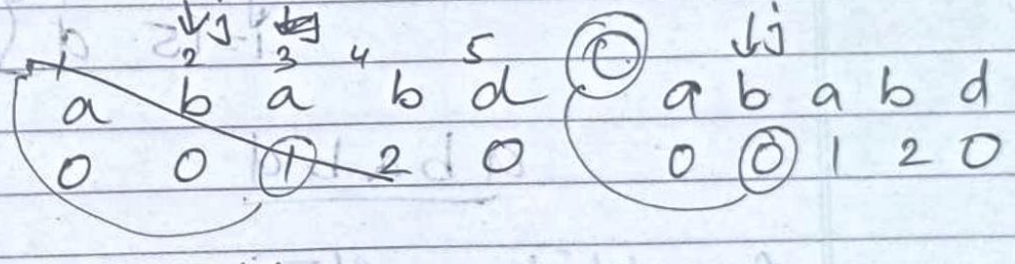


$j=0=a$ } not matched but can't move j
$i=5=c$ } beyond zero so move $i=6$

$i=6=a$ } matched move $i=7$ and $j=j+1=2$
$j+1=0=a$ }

$i=7=b$ } matched move $i=8$ and $j=j+1=3$
$j=1=b$ }

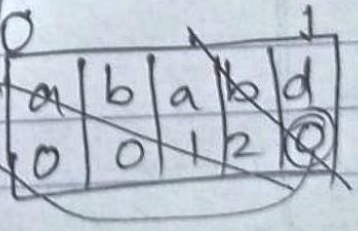
$i=8=c$ } not matched
$j=2=a$ }



$i=8$ } not matched
$j=0$ } a }

$i=9$ a move $i=10$ b move $i=11$ a move $i=12$ b
$j=1$ a $j=2$ b $j=3$ a $j=4$ b

move $i=13$ a, } not matched
$j=5$ d, }



	1	2	3	4	5
	a	b	a	b	d
0	0	0	1	2	0

j=3 a } match more j=4 | b }
i=1 3 a } j=14 b }

match more . j=5 d } match
i=15 d }

a b a b d

Complexity String n
pattern m

O(n+m)

π table search.