KMP

PREFIX SUFFIX

- **PREFIX**
- Pattern = ABCABE

- A
- AB
- ABC
- ABCA
- ABCAB
- ABCABE

- **SUFFIX**
- Pattern = ABCABE

- E
- BE
- ABE
- CABE
- BCABE
- ABCABE

PI[] OF “ABCABE”

I	SUBSTRING	PI[I]
0	A	0
1	AB	0
2	ABC	0
3	**A**BC**A**	1
4	**AB**C**AB**	2
5	ABCABE	0

PI[] OF “ABCABDABCABEABC”

I	SUBSTRING	PI[I]
0	A	0
1	AB	0
2	ABC	0
3	**A**BC**A**	1
4	**AB**C**AB**	2
5	ABCABD	0
6	**A**BCABD**A**	1
7	**AB**CABD**AB**	2
8	**ABC**ABD**ABC**	3
9	**ABCA**BD**ABCA**	4
10	**ABCAB**D**ABCAB**	5
11	ABCABDABCABE	0
12	**A**BCABDABCABE**A**	1
13	**AB**CABDABCABE**AB**	2
14	**ABC**ABDABCABE**ABC**	3

abcdabcef

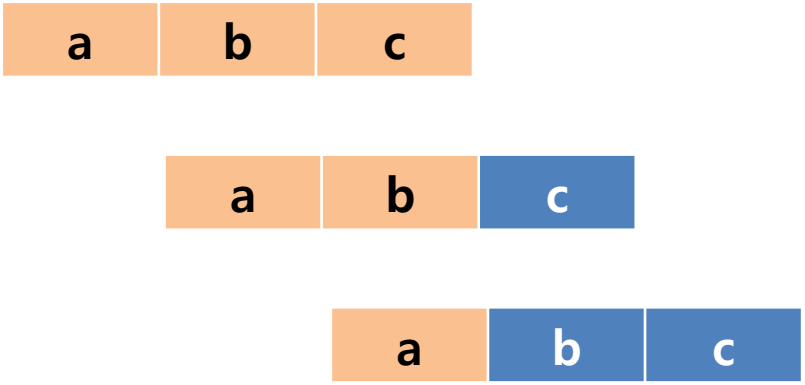
i	0	1	2	3	4	5	6	7	8
Pattern [i]	a	b	c	d	a	b	c	e	f
NEXT[i]	-1	0	0						

a	b

a	b

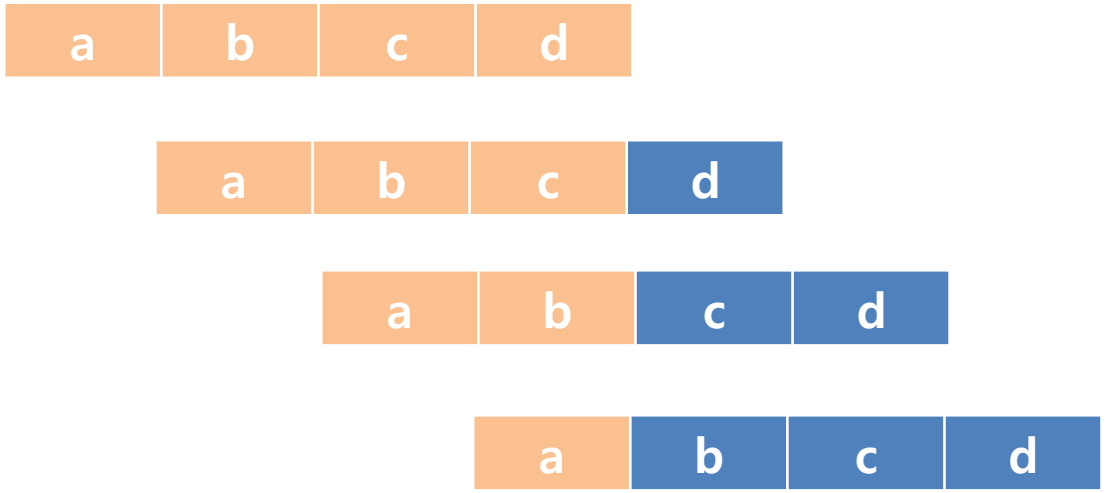
abcdabcef

i	0	1	2	3	4	5	6	7	8
Pattern [i]	a	b	c	d	a	b	c	e	f
NEXT[i]	-1	0	0	0					



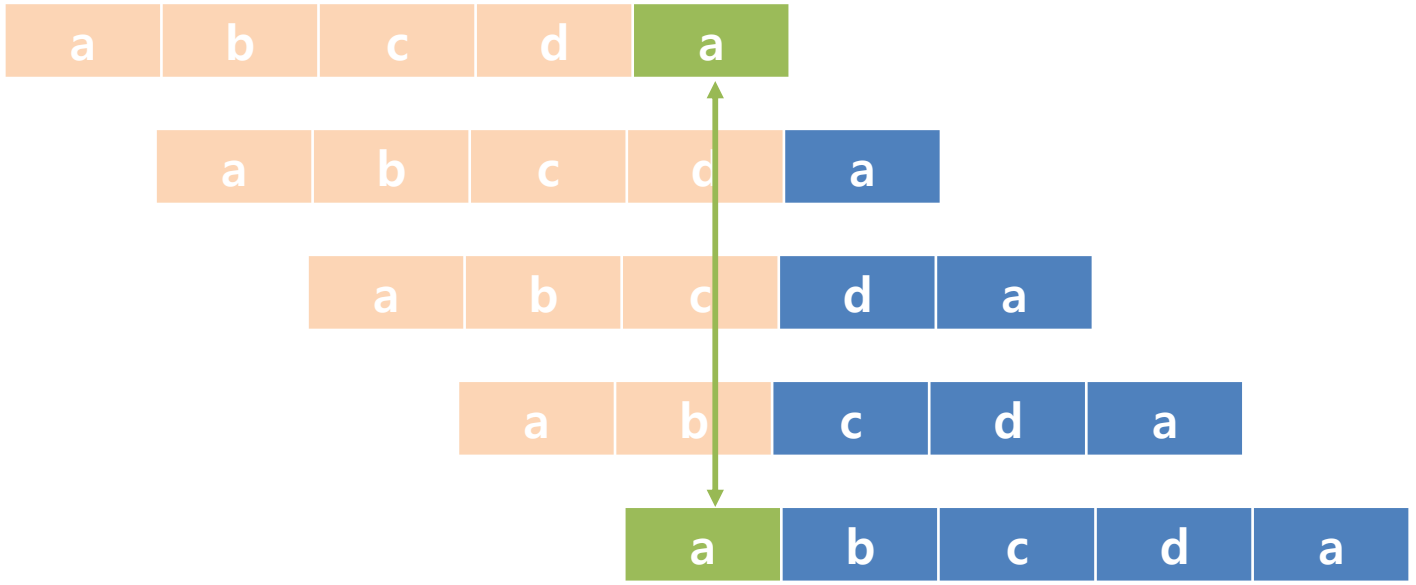
abcdabcef

i	0	1	2	3	4	5	6	7	8
Pattern [i]	a	b	c	d	a	b	c	e	f
NEXT[i]	-1	0	0	0	0				



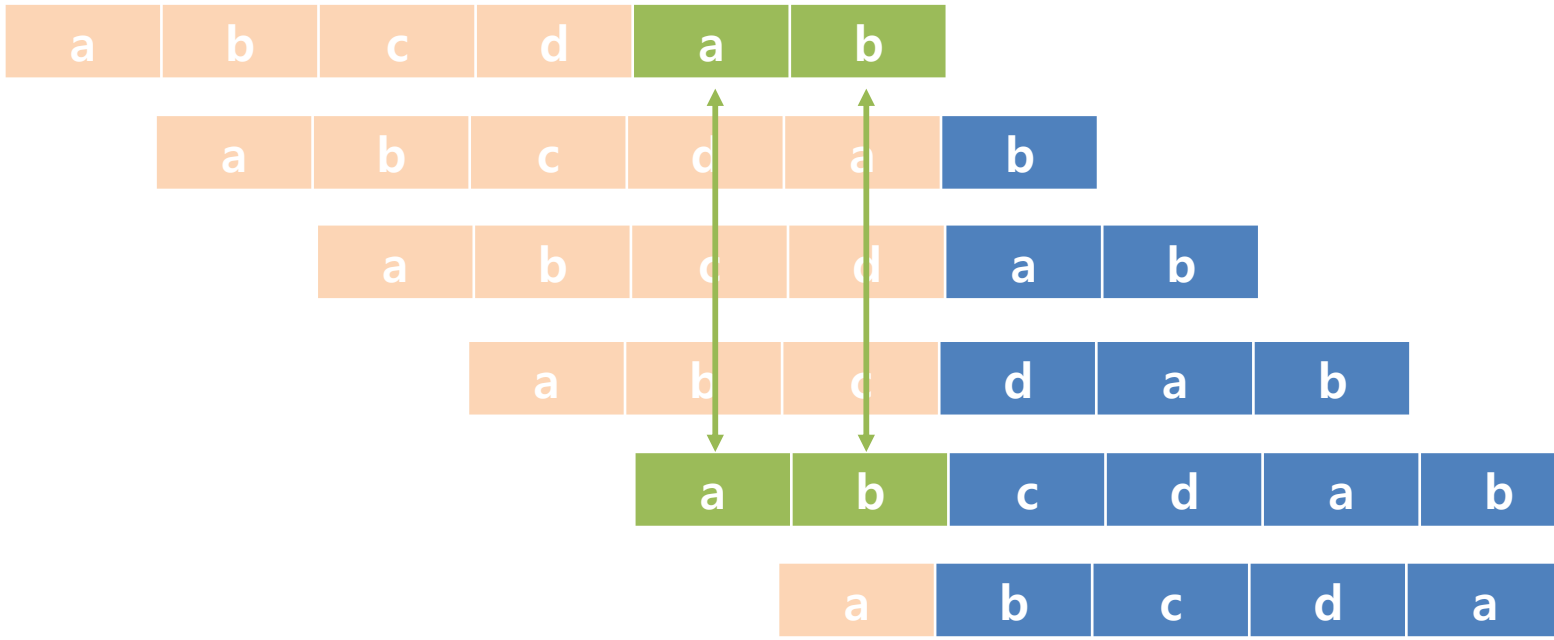
abcdabcef

i	0	1	2	3	4	5	6	7	8
Pattern [i]	a	b	c	d	a	b	c	e	f
NEXT[i]	-1	0	0	0	0	1			



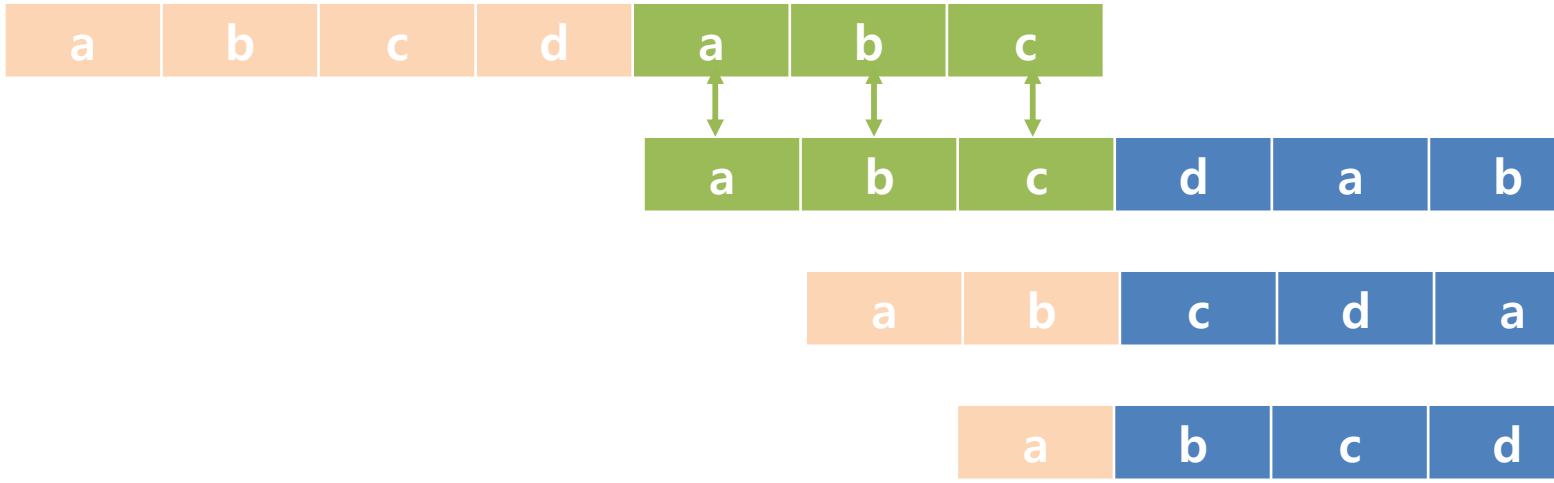
abcdabcef

i	0	1	2	3	4	5	6	7	8
Pattern [i]	a	b	c	d	a	b	c	e	f
NEXT[i]	-1	0	0	0	0	1	2		



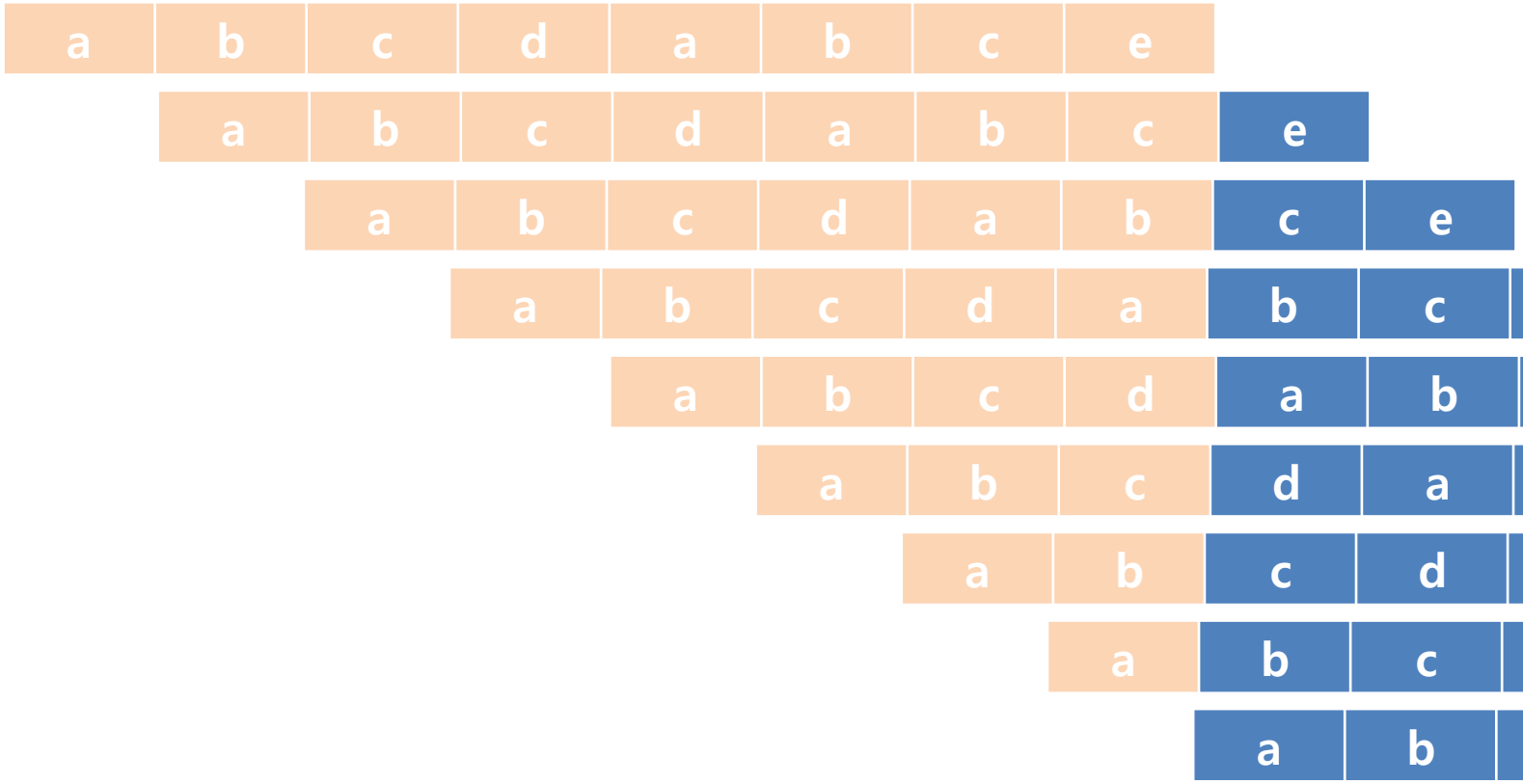
abcdabcef

i	0	1	2	3	4	5	6	7	8
Pattern [i]	a	b	c	d	a	b	c	e	f
NEXT[i]	-1	0	0	0	0	1	2	3	



abcdabcef

i	0	1	2	3	4	5	6	7	8
Pattern [i]	a	b	c	d	a	b	c	e	f
NEXT[i]	-1	0	0	0	0	1	2	3	0



KMP Algorithm π Table Example

ab

i j

i	0	1	2	3	4	5	6	7	8
Pattern	a	b	b	a	b	d	a	a	b
πi	-1	0	0						

```
Pi[0] = -1;
Pi[1] = 0;

i = 0, j = 1

If(Pattern[i] != Pattern[j])
    //.....
    PI[j+1] = .....;
    j = j + 1
```

KMP Algorithm π Table Example

abb

i j

i	0	1	2	3	4	5	6	7	8
Pattern	a	b	b	a	b	d	a	a	b
πi	-1	0	0	0					

KMP Algorithm π Table Example

abb**a**

i j

i	0	1	2	3	4	5	6	7	8
Pattern	a	b	b	a	b	d	a	a	b
πi	-1	0	0	0	1				

```
If(Pattern[i]==Pattern[j])
    Pi[j+1] = Pi[j] + 1;
    i++; j++;
```

KMP Algorithm π Table Example

abb**ab**

i j

i	0	1	2	3	4	5	6	7	8
Pattern	a	b	b	a	b	d	a	a	b
πi	-1	0	0	0	1	2			

```
If(Pattern[i]==Pattern[j])
    Pi[j+1] = Pi[j] + 1;
    i++;  j++;
```

KMP Algorithm π Table Example

abbabd

i ✖ j

i	0	1	2	3	4	5	6	7	8
Pattern	a	b	b	a	b	d	a	a	b
πi	-1	0	0	0	1	2			

KMP Algorithm π Table Example

abbabd

i j

i	0	1	2	3	4	5	6	7	8
Pattern	a	b	b	a	b	d	a	a	b
πi	-1	0	0	0	1	2	0		

KMP Algorithm π Table Example

abbabd**a**

i j

i	0	1	2	3	4	5	6	7	8
Pattern	a	b	b	a	b	d	a	a	b
πi	-1	0	0	0	1	2	0	1	

KMP Algorithm π Table Example

i

abbabda**a**

j

i	0	1	2	3	4	5	6	7	8
Pattern	a	b	b	a	b	d	a	a	b
πi	-1	0	0	0	1	2	0	1	

KMP Algorithm π Table Example

i

abbabda**a**

j

i	0	1	2	3	4	5	6	7	8
Pattern	a	b	b	a	b	d	a	a	b
πi	-1	0	0	0	1	2	0	1	1

ABACABABAC

i	0	1	2	3	4	5	6	7	8	9
Pattern [i]	A	B	A	C	A	B	A	B	A	C
Pl[i]	-1	0	1	0	1	2	3	2	3	4

A B A C A B A B A C

KMP Algorithm π Table Example

i	0	1	2	3	4	5	6	7	8	9	10
Pi	a	b	a	a	b	a	b	a	a	b	c
πi	-1	0	0	1	1	2	3	0	1	1	2

i	0	1	2	3	4	5	6	7	8	9
Pi	a	b	a	b	a	b	a	b	c	a
πi	-1	0	0	1	2	3	4	5	6	0

KMP Algorithm

T ABC ABCDAB ABCDABCDABDE
P ABCDABD

i	0	1	2	3	4	5	6
Pi	A	B	C	D	A	B	D
πi	-1	0	0	0	0	1	2

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
A	B	C	D																			

Number of characters matched so far K = 3
p movement k - π [K] = 3 - π[3] = 3 – 0 = 3

KMP Algorithm

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
			A																			

Number of characters matched so far K = 0
p movement k - π [K] = 0 - π[0] = 0 –(-1) = 1

KMP Algorithm

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
				A	B	C	D	A	B	D												

Number of characters matched so far K = 6
p movement k - π [K] = 6 - π [6] = 6 – 2 = 4

KMP Algorithm

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
								A	B	C												

Number of characters matched so far K = 2
p movement k - π [K] = 2 - π [2] = 2- 0 = 2

KMP Algorithm

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
										A												

Number of characters matched so far K = 0
p movement k - π [K] = 0 - π[0] = 0 –(-1) = 1

KMP Algorithm

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
											A	B	C	D	A	B	D					

Number of characters matched so far K = 6
p movement k - π [K] = 6 - π [6] = 6 – 2 = 4

KMP Algorithm

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
															A	B	C	D	A	B	D	

Number of characters matched so far K = 7
p movement k - π [K] =

KMP algorithm

- Pi[i] O(M)
- Pattern Matching O(N+M)

KMP Algorithm π Table Example

i	0	1	2	3	4	5	6	7	8
Pi	a	b	b	a	b	d	a	a	b
πi									

i	0	1	2	3	4	5	6	7	8	9	10
Pi	a	b	a	a	b	a	b	a	a	b	c
πi											

i	0	1	2	3	4	5	6	7	8	9
Pi	a	b	a	b	a	b	a	b	c	a
πi										

KMP Algorithm

T ABC ABCDAB ABCDABCDABDE
P ABCDABD

i	0	1	2	3	4	5	6
Pi	A	B	C	D	A	B	D
πi	-1	0	0	0	0	1	2

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
A	B	C	D																			

Number of characters matched so far K = 3
p movement k - π [K] = 3 - π[3] = 3 – 0 = 3

KMP Algorithm

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
			A																			

Number of characters matched so far K = 0
p movement k - π [K] = 0 - π[0] = 0 –(-1) = 1

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
				A	B	C	D	A	B	D												

Number of characters matched so far K = 6
p movement k - π [K] = 6 - π [6] = 6 – 2 = 4

KMP Algorithm

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
								A	B	C												

Number of characters matched so far K = 2
p movement k - π [K] = 2 - π [2] = 2- 0 = 2

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
										A												

Number of characters matched so far K = 0
p movement k - π [K] = 0 - π[0] = 0 –(-1) = 1

KMP Algorithm

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
											A	B	C	D	A	B	D					

Number of characters matched so far K = 6
p movement k - π [K] = 6 - π [6] = 6 – 2 = 4

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C		A	B	C	D	A	B		A	B	C	D	A	B	C	D	A	B	D	E
															A	B	C	D	A	B	D	

Number of characters matched so far K = 7
p movement k - π [K] =

KMP algorithm

- Pi[i] O(M)
- Pattern Matching O(N+M)

Exercise 1

- KMP ALGORITHM
- Output
  - In the first line, print how many times the Pattern appears in the entire Text. In the second line, the location of the pattern is displayed one after the other

- Input

Output

Text : ABC ABCDAB ABCDABCDABDE
Pattern : ABCDABD

1
16