#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input : abcPPdfaPPPPP

#### Queue

$$q = \begin{bmatrix} a & b & & & \\ 0 & 1 & 2 & 3 & 4 & 5 \\ & front = 0 & \\ & rear = & 1 & & \end{bmatrix}$$

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

Input : abcPPdfaPPPPP

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

Input: abcPPdfaPPPPP

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

#### Queue

#### Push

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

#### Queue

$$q = \begin{array}{|c|c|c|c|c|c|}\hline c & d & f & a \\\hline 0 & 1 & 2 & 3 & 4 & 5 \\\hline front = 2 \\ rear = & 5 \\\hline \end{array}$$

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

#### Queue

$$q = \boxed{\begin{array}{c|cccc} & d & f & a \\ \hline 0 & 1 & 2 & 3 & 4 & 5 \\ \hline & front = 3 & \\ & rear = & 5 & \\ \hline \end{array}}$$

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

#### Queue

$$q = \boxed{\begin{array}{c|cccc} & f & a \\ \hline 0 & 1 & 2 & 3 & 4 & 5 \\ \hline front = 4 \\ rear = & 5 \\ \hline \end{array}}$$

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

Output : abcdf

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

Output : abcdfa

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

Output : abcdfaE

## $Queues \\ \textit{-} Implementation$

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPP

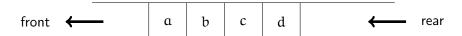
Output : abcdfaE

**Empty** 

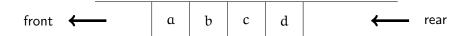
front > rear

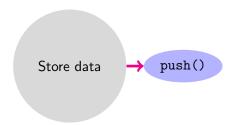
## $Data\ Structures \\ -\ Queues$

# $Data\ Structures \\ -\ Queues$

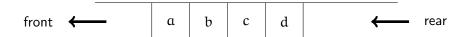


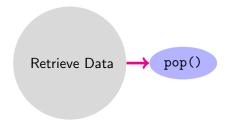
## Data Structures - Queues





## Data Structures - Queues





# $Queues \\ \textit{- Implementation}$

### Queues

### $\hbox{\it -} Implementation$

#### Queue

$$q =$$
 $0 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5$ 
 $front = 0$ 
 $rear = -1$ 

## $Queues \\ \textit{-} Implementation$

#### Queue

#### Push

rear + +;q[rear] = a;

## $Queues \\ \textit{-} Implementation$

#### Queue

#### Push

```
rear + +;

q[rear] = a;
```

#### Pop

```
t = q[front];

front + +;
```

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

Input: abcPPdfaPPPPPabcPabcd

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd

#### Queue

$$q = \begin{bmatrix} a & b & & & \\ & 0 & 1 & 2 & 3 & 4 & 5 \\ & & front = 0 & & \\ & & rear = & 1 & & \\ \end{bmatrix}$$

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

Input: abcPPdfaPPPPPabcPabcd

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

Input: abcPPdfaPPPPPabcPabcd

#### Queue

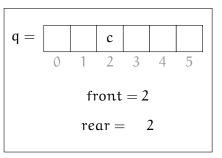
#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

Input: abcPPdfaPPPPPabcPabcd

#### Queue



#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd

#### Queue

$$q = \begin{array}{|c|c|c|c|c|c|c|}\hline & c & d & \\ \hline & 0 & 1 & 2 & 3 & 4 & 5 \\ \hline & front = 2 \\ & rear = & 3 \\ \hline \end{array}$$

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd

#### Queue

$$q = \boxed{\begin{array}{c|cccc} c & d & f \\ \hline 0 & 1 & 2 & 3 & 4 & 5 \\ \hline front = 2 \\ rear = & 4 \\ \hline \end{array}}$$

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

Input: abcPPdfaPPPPPabcPabcd

#### Queue

$$q = \begin{array}{|c|c|c|c|c|c|c|}\hline & c & d & f & a \\ \hline & 0 & 1 & 2 & 3 & 4 & 5 \\ \hline & front = 2 \\ & rear = & 5 \\ \hline \end{array}$$

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd

#### Queue

#### Push

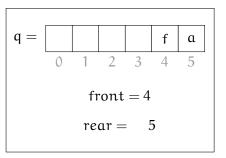
$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd

#### Queue



#### Push

$$rear + +;$$
 $q[rear] = a;$ 

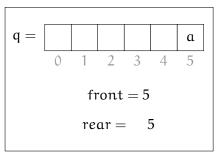
#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd

Output: abcd

#### Queue



#### Push

$$rear + +;$$
 $q[rear] = a;$ 

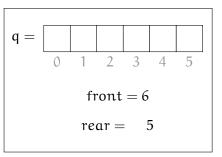
#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd

Output: abcdf

#### Queue



#### Push

$$rear + +;$$
 $q[rear] = a;$ 

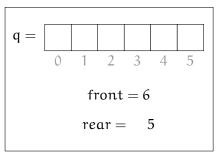
#### Pop

$$\begin{split} t &= q[front]; \\ front &++; \end{split}$$

Input: abcPPdfaPPPPPabcPabcd

Output: abcdfa

#### Queue



#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd

Output: abcdfaE

#### Queue

#### Push

$$rear + +;$$
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd

Output : abcdfaE

Empty

### Queue

#### Push

$$rear + +;$$
  
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd Full

Output : abcdfaE

rear == n - 1

Empty

### Queue

#### Push

$$rear + +;$$
  
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd Full

Output : abcdfaE

rear == n - 1

**Empty** 

# $Queues \\ \textit{-} Implementation$

### Queue

#### Push

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd Full

Output : abcdfaE

rear == n - 1

**Empty** 

### Queue

#### Push

$$rear + +;$$
  
 $q[rear] = a;$ 

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd Full

Output : abcdfaE

rear == n - 1

Empty

#### Queue

#### Push

#### Pop

Input: abcPPdfaPPPPPabcPabcd Full

Output : abcdfaE

rear == n - 1

**Empty** 

### Queue

#### Push

#### Pop

$$t = q[front];$$
  
 $front + +;$ 

Input: abcPPdfaPPPPPabcPabcd Full

Output : abcdfaE

$$rear == n - 1$$

Empty

# Circular Queues

 $\hbox{\it -} Implementation$ 

Queue

$$q =$$
 $0 1 2 3 4 5$ 
 $front = 0$ 
 $rear = -1$ 

Queue

Push

$$rear + +;$$
 $q[rear] = a;$ 

Pop

```
t = q[front];
front + +;
```

Empty

# Circular Queues

# $-\ Implementation$

#### Queue

### Push

```
 \begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}
```

# Pop

```
t = q[front];
front + +;
```

# Empty

# Circular Queues

# - Implementation

#### Queue

### Push

```
\begin{aligned} \text{rear} &= (\text{rear} + 1)\%6; \\ \text{q}[\text{rear}] &= \text{a}; \end{aligned}
```

# Pop

```
t = q[front]; \\ front = (front + 1)\%6
```

# Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

Output :abcdfaE

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

Output :abcdfaE

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

Output :abcdfaE

Empty

#### Queue

$$q = \begin{bmatrix} a & & & & & \\ 0 & 1 & 2 & 3 & 4 & 5 \\ & front = 0 & & \\ & rear = & 0 & & \\ \end{bmatrix}$$

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

Output :abcdfaE

Empty

#### Queue

$$q = \begin{bmatrix} a & b & & & \\ & 0 & 1 & 2 & 3 & 4 & 5 \\ & & front = 0 & & \\ & rear = & 1 & & & \\ \end{bmatrix}$$

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

Output :abcdfaE

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

Output :abcdfaE

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

Output :abcdfaEa

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

Output :abcdfaEa

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

Output :abcdfaEa

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

Output :abcdfaEa

Empty

#### Queue

$$q = \boxed{\begin{array}{c|cccc} d & b & c & a & b & c \\ \hline 0 & 1 & 2 & 3 & 4 & 5 \\ \hline & front = 1 & \\ & rear = & 0 & \\ \hline \end{array}}$$

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input :abcPPdfaPPPPPabcPabcde

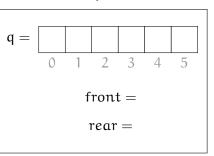
Output :abcdfaEa

Empty

# Circular Queues

# $\hbox{\it -} Implementation$





### Push

```
\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}
```

### Pop

```
t = q[front];
front = (front + 1)\%6
```

### Queue

# Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

# Pop

$$\begin{aligned} t &= q[front];\\ front &= (front+1)\%6 \end{aligned}$$

# Empty

# Circular Queues

# - Implementation



# Push

```
 \begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}
```

# Pop

```
\begin{aligned} t &= q[front]; \\ front &= (front+1)\%6 \end{aligned}
```

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input : abcPPdfaPPPPP

Output:

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input : abcPPdfaPPPPP

Output:

## Empty

$$q = \boxed{\begin{array}{c|cccc} a & b & & \\ \hline 0 & 1 & 2 & 3 & 4 & 5 \\ \hline & front = 0 & \\ & rear = 2 & \\ \hline \end{array}}$$

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input : abcPPdfaPPPPP

Output:

# Empty

# Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$t = q[front]; \\ front = (front + 1)\%6$$

Input : abcPPdfaPPPPP

Output:

## Empty

#### Queue

$$q = \boxed{\begin{array}{c|cccc} a & b & c \\ \hline 0 & 1 & 2 & 3 & 4 & 5 \\ \hline & front = 0 \\ & rear = 3 \end{array}}$$

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input : abcPPdfaPPPPP

Output:

Empty

#### Queue

$$q =$$
 $0 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5$ 
 $1 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5$ 
 $1 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5$ 

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

#### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input : abcPPdfaPPPPP

Output : a

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input : abcPPdfaPPPPP

Output : ab

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input : abcPPdfaPPPPP

Output : ab

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPP

Output : ab

Empty

### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPP

Output : ab

Empty

$$q = \begin{array}{|c|c|c|c|c|}\hline a & & & d & f \\\hline 0 & 1 & 2 & 3 & 4 & 5 \\ \hline & front = 3 & \\ & rear = 0 & \\ \hline \end{array}$$

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPP

Output : abc

Empty

$$q =$$
 $a$ 
 $0 = 1 = 2 = 3 = 4 = 5$ 
 $front = 4$ 
 $rear = 0$ 

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPP

Output: abcd

Empty

$$q = \begin{bmatrix} a & & & & \\ & & & & & \\ & 0 & 1 & 2 & 3 & 4 & 5 \\ & front = 5 & & \\ & rear = 0 & & & \\ \end{bmatrix}$$

### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPP

Output : abcdf

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPP

Output : abcdfa

Empty

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPP

Output: abcdfaE

Empty

### Queue

Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPPabcdef

Output : abcdfaE

Empty

Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPPabcdef

Output : abcdfaE

Empty

#### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPPabcdef

Output : abcdfaE

Empty

Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPPabcdef

Output : abcdfaE

Empty

### Queue

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPPabcdef

Output : abcdfaE

Empty

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPPabcdef

Output : abcdfaE

Empty

$$q = \begin{array}{|c|c|c|c|c|}\hline f & a & b & c & d & e \\\hline 0 & 1 & 2 & 3 & 4 & 5 \\\hline & front = 0 \\& rear = 0 \\\hline \end{array}$$

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPPabcdef

Output : abcdfaE

Empty

#### Push

$$\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$$

### Pop

$$\begin{aligned} \text{front} &= (\text{front} + 1)\%6 \\ t &= q[\text{front}]; \end{aligned}$$

Input: abcPPdfaPPPPPabcdef

Output : abcdfaE

Empty

Queue

Push

rear = (rear + 1)%6;q[rear] = a;

Pop

 $\begin{aligned} front &= (front + 1)\%6 \\ t &= q[front]; \end{aligned}$ 

Full

(rear + 1)%6 == front

Empty

Queue

 a
 b
 c
 d
 e

 0
 1
 2
 3
 4
 5

front = 0

rear = 5

Push

 $\begin{aligned} rear &= (rear + 1)\%6; \\ q[rear] &= a; \end{aligned}$ 

Pop

 $\begin{aligned} front &= (front + 1)\%6 \\ t &= q[front]; \end{aligned}$ 

Capacity

Full

(rear + 1)%6 == front

Empty

front == rear

n-1