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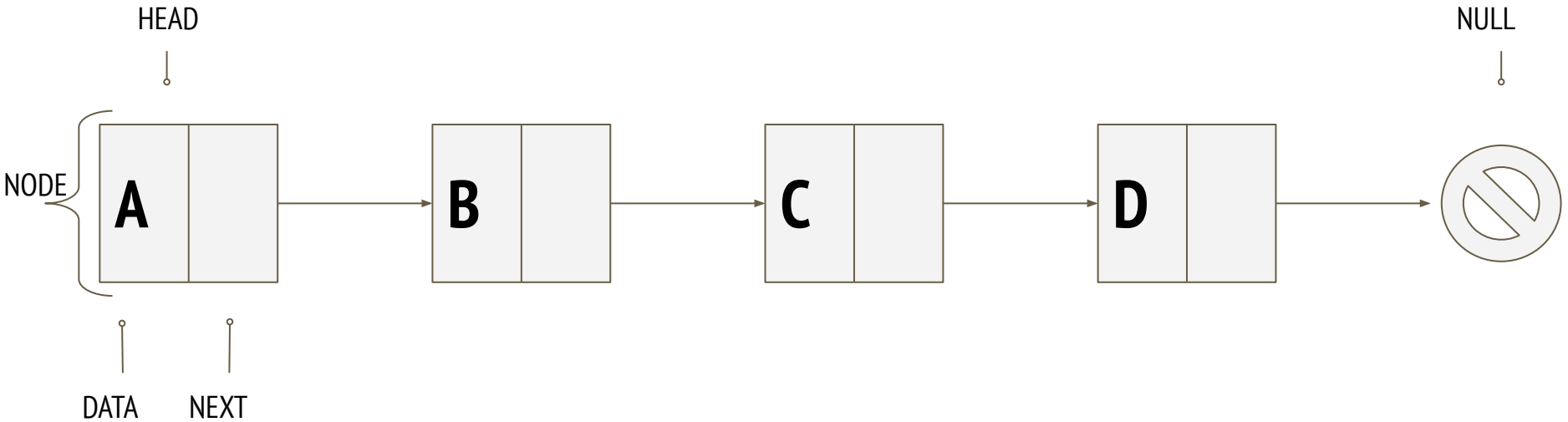
# Linked Lists

## Introduction

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# Linked List (Singly Linked List)

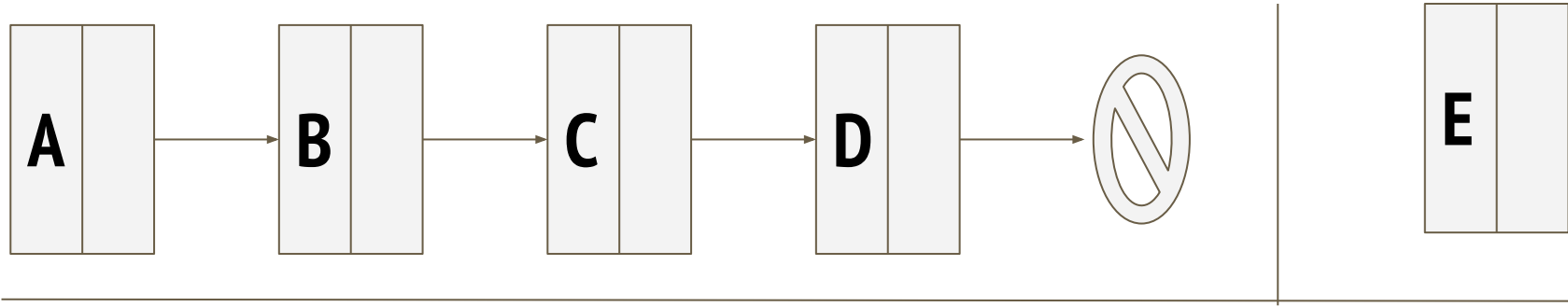


# Array vs. Linked List

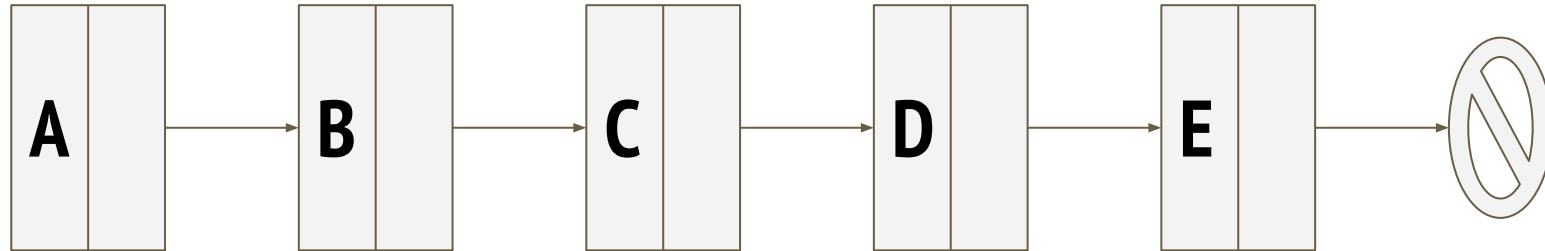
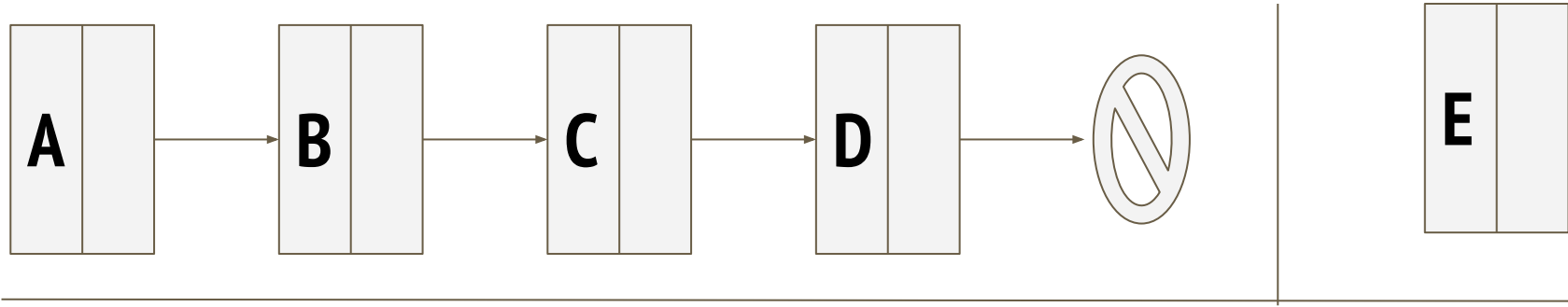
	Array	Linked List
Insertion/Deletion	$O(n)$	$O(1)$
Access Element	$O(1)$	$O(n)$

# Linked Lists : Insertion

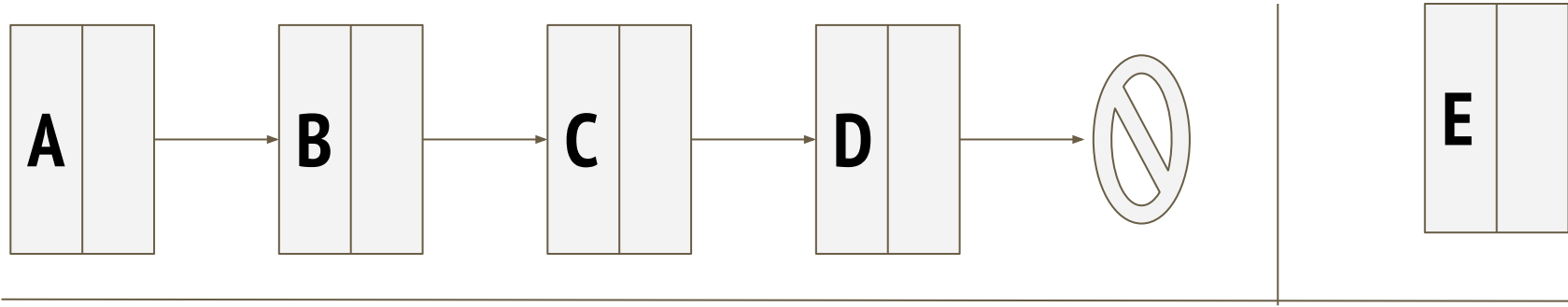
# Singly Linked List: Append



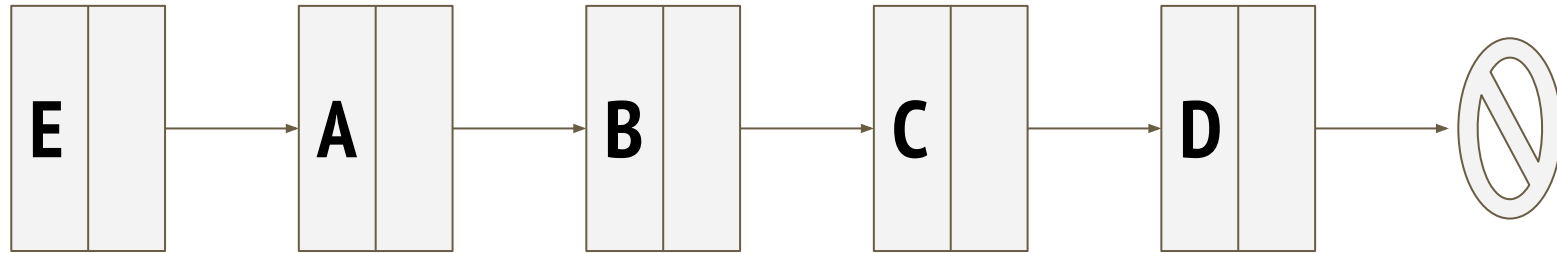
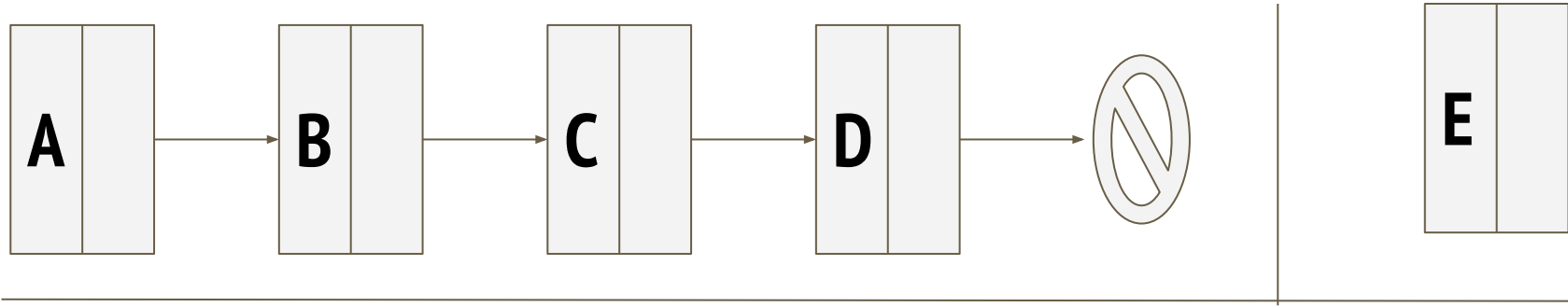
# Singly Linked List: Append



# Singly Linked List: Prepend

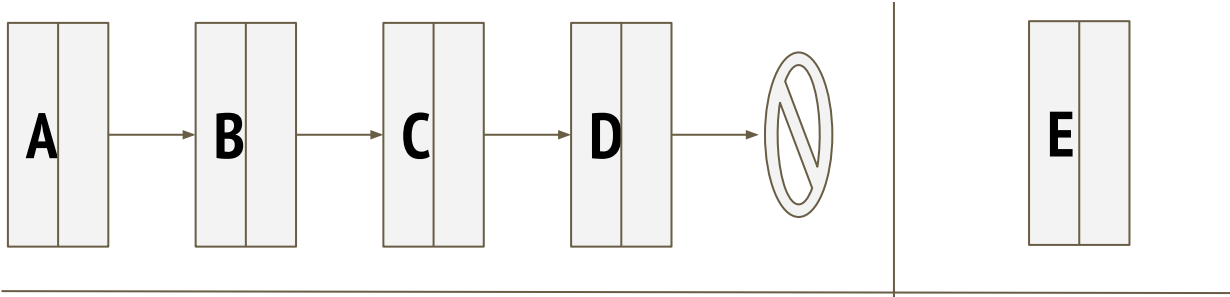


# Singly Linked List: Prepend

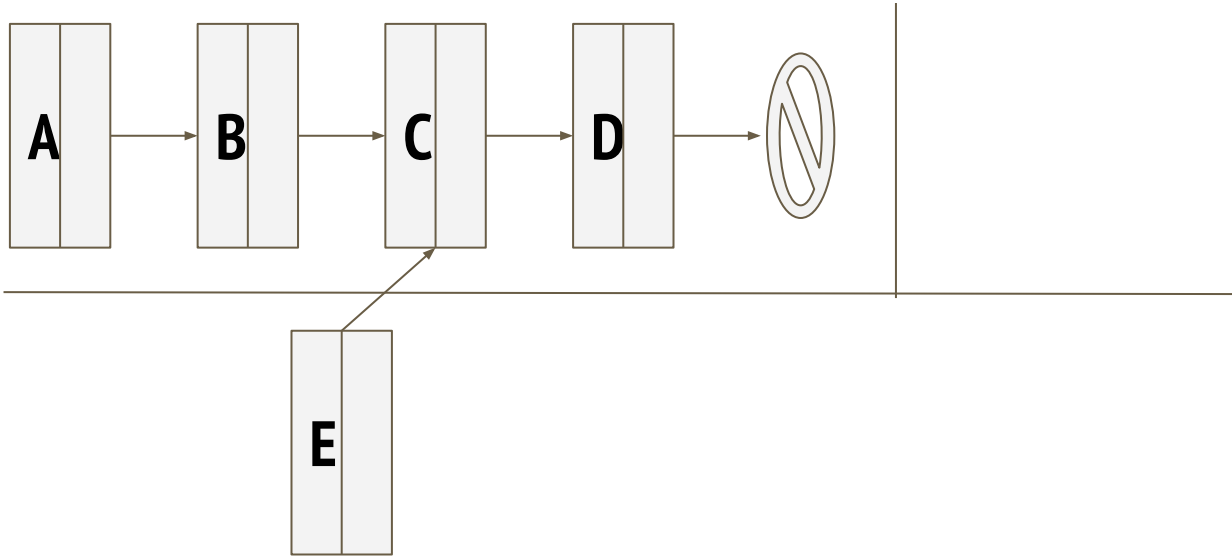




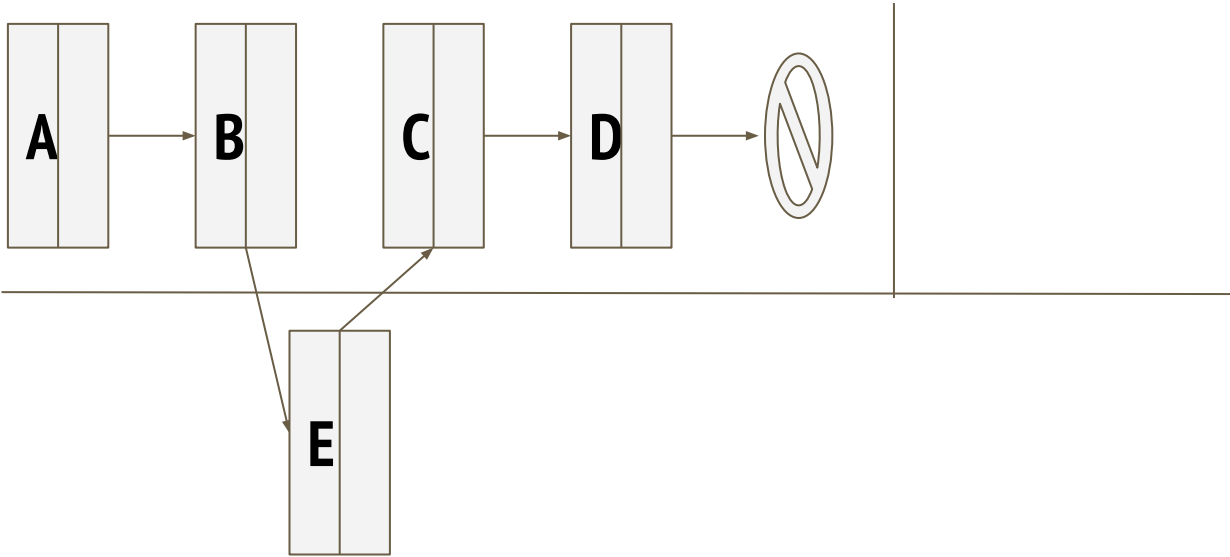
# Singly Linked List: Insert after Node



# Singly Linked List: Insert after Node



# Singly Linked List: Insert after Node



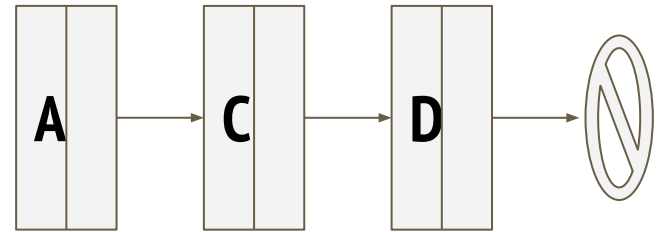
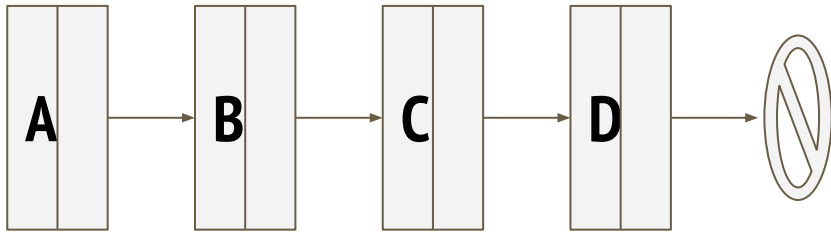
# Linked Lists : Deletion

# Singly Linked List: Delete node

Given a key (data field) delete node with this field.

Assume elements in linked list are unique.

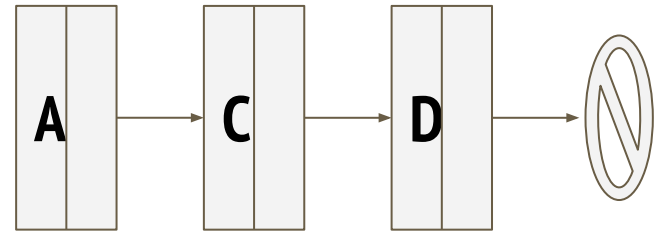
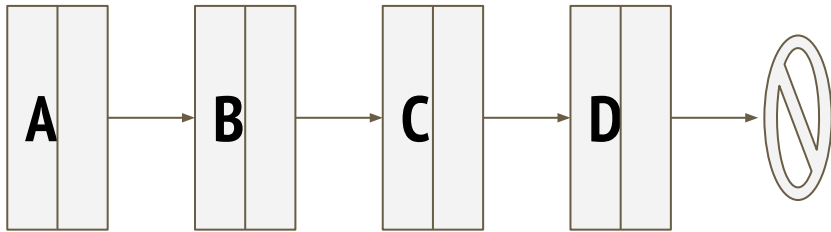
Example: Delete node with data field "B":



# Singly Linked List: Delete node

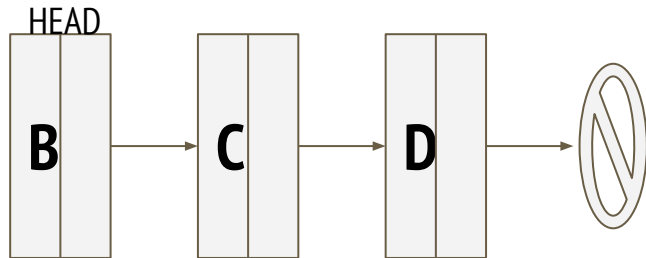
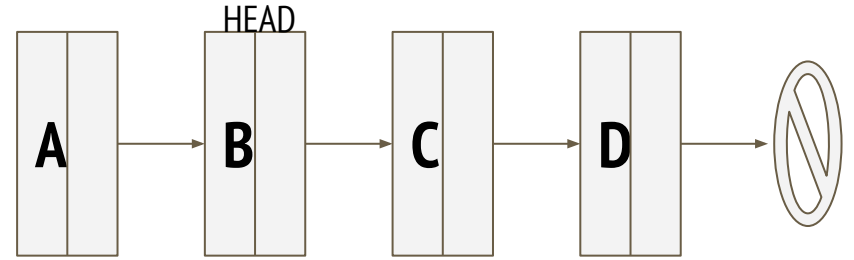
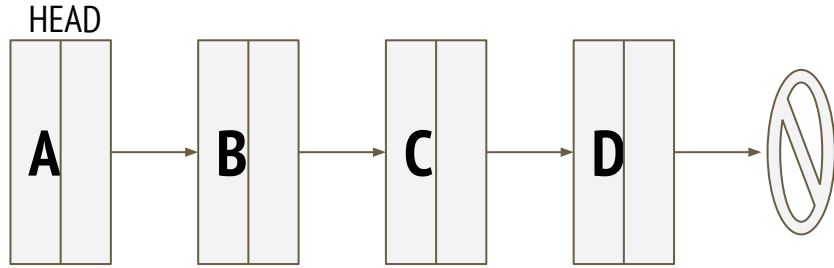
Two cases:

- Node to be deleted is head.
- Node to be deleted is not head.



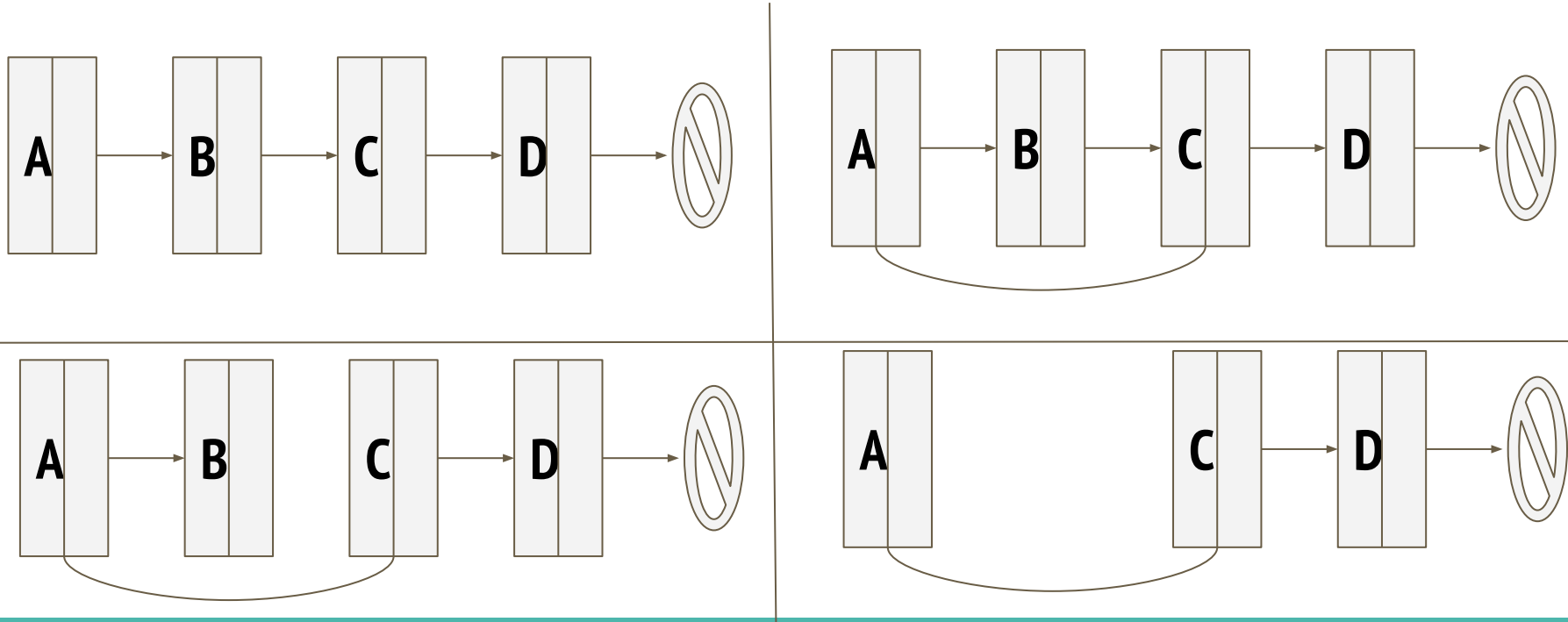
# Singly Linked List: Delete node

Case 1: Node to be deleted is head



# Singly Linked List: Delete node

Case 2: Node to be deleted is not head (say node with “B”)



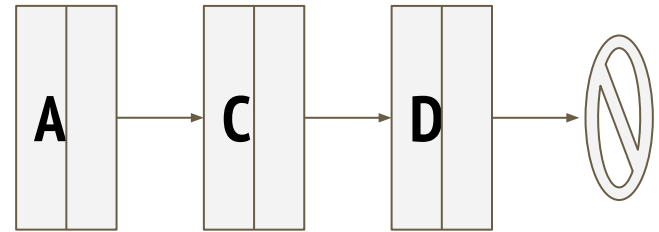
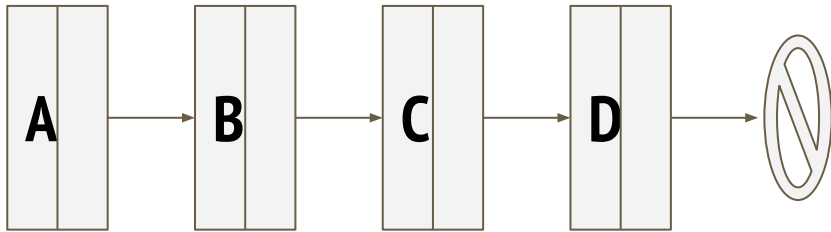


# Singly Linked List: Delete node at position

Given a position, delete node with this position.

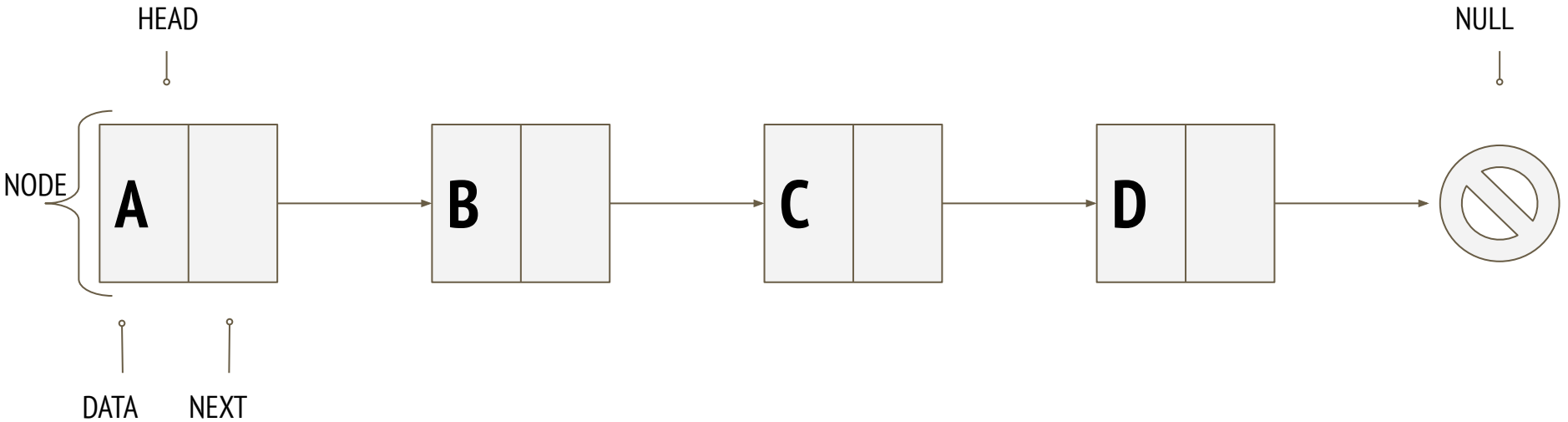
Assume elements in linked list are unique.

Example: Delete node with position 1



# Linked Lists : Calculating Length

# Singly Linked List: Calculating length

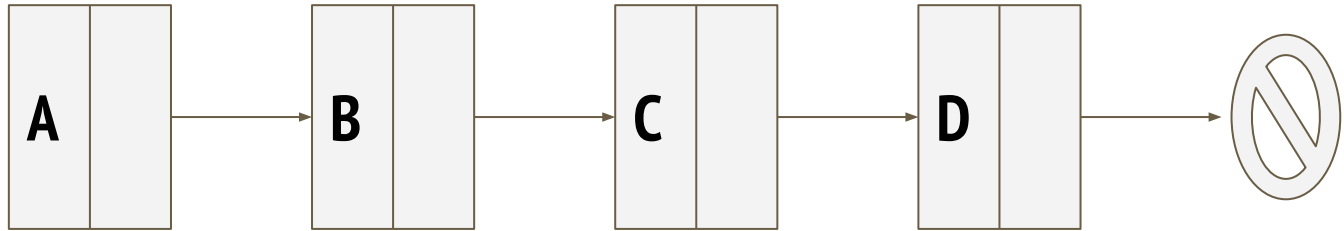


# Linked Lists : Node Swap

# Singly Linked List: Node Swap

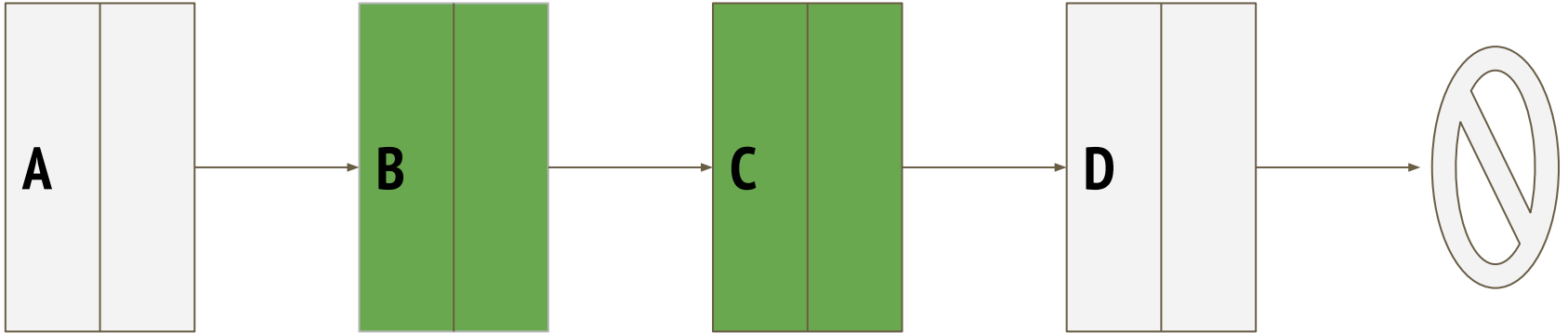
Node swap. Two cases: (Assume data entries are unique).

1. Node\_1 and Node\_2 are not head nodes.
2. Either Node\_1 or Node\_2 are head nodes.



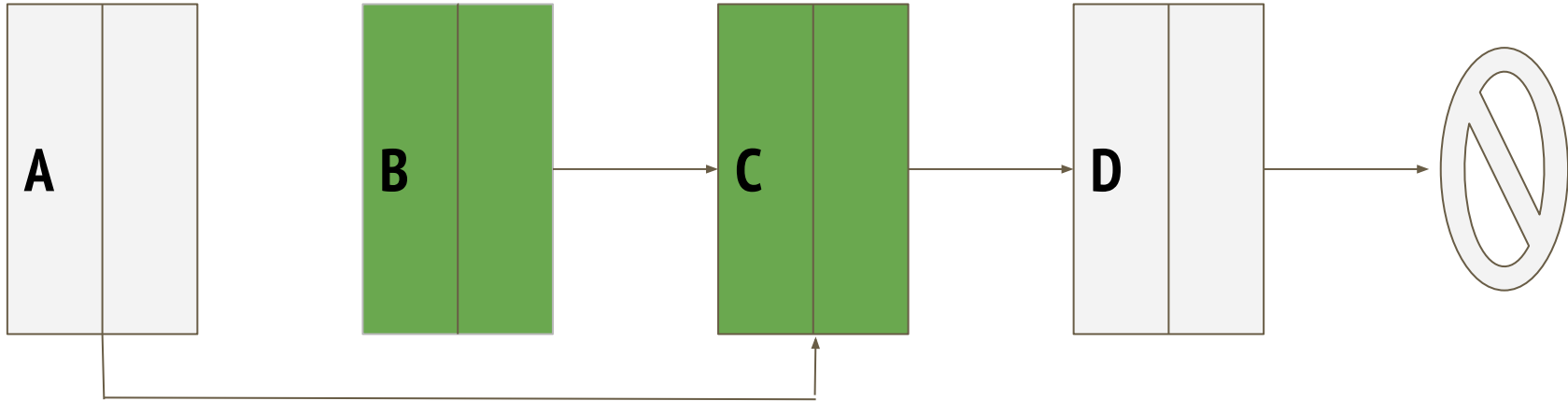
# Singly Linked List: Node Swap - Case 1

Node\_1 and Node\_2 are not head nodes.



# Singly Linked List: Node Swap - Case 1

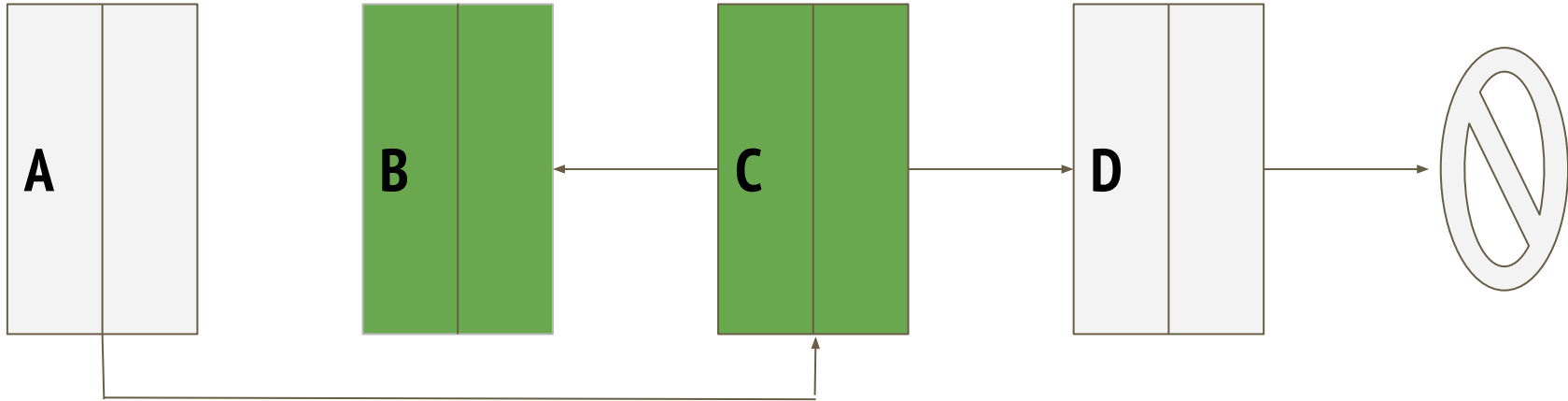
Node\_1 and Node\_2 are not head nodes.



`prev_1.next = curr_2`

# Singly Linked List: Node Swap - Case 1

Node\_1 and Node\_2 are not head nodes.

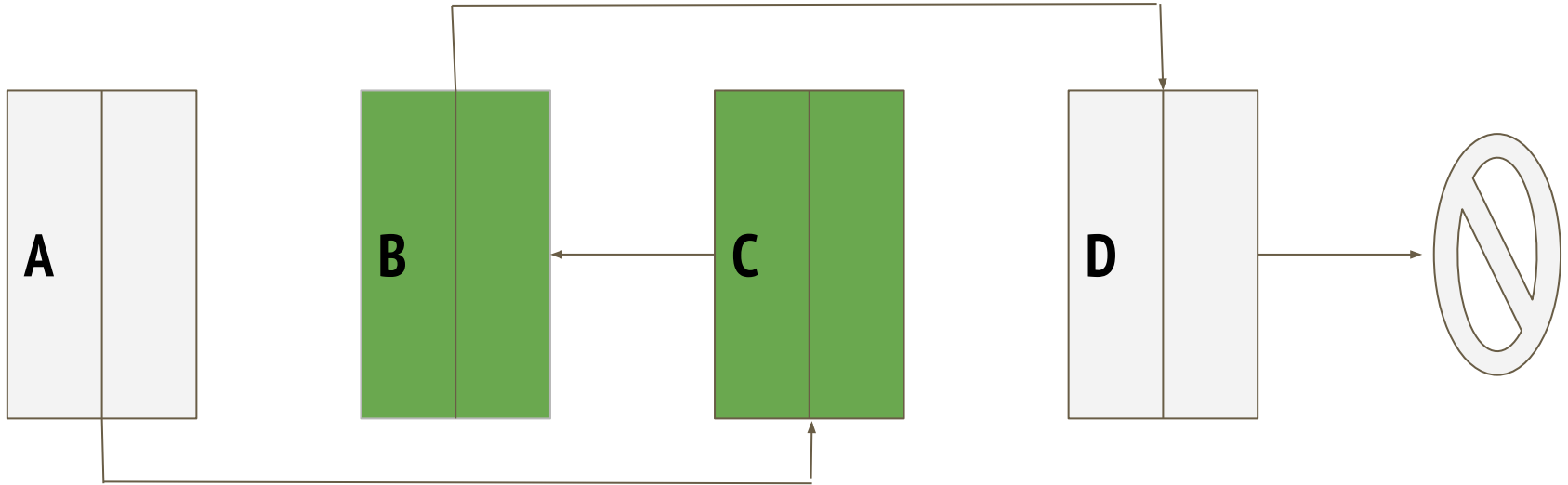


`prev_2.next = curr_1`



# Singly Linked List: Node Swap - Case 1

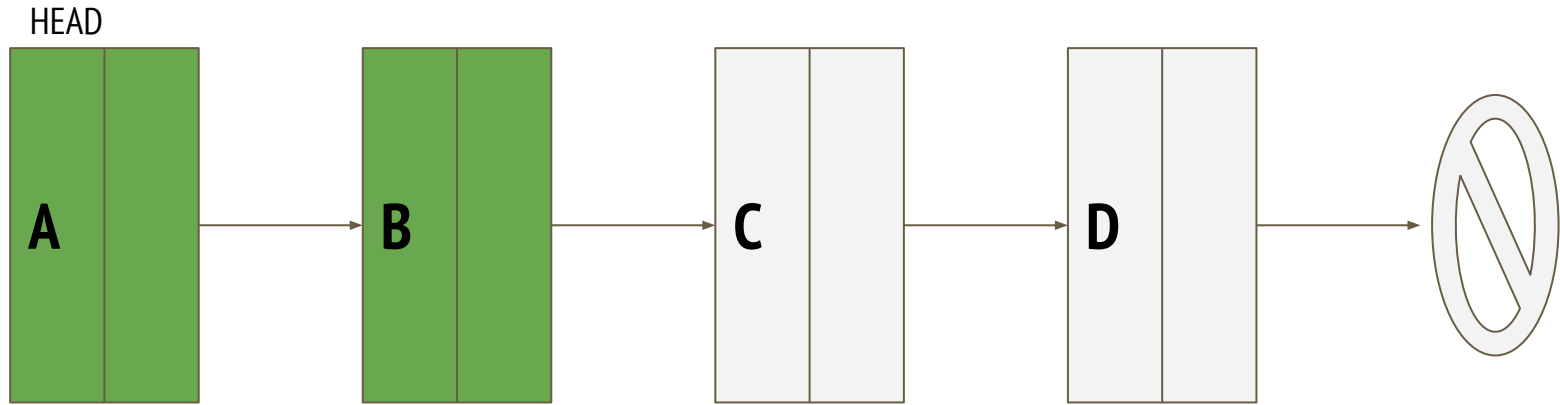
Node\_1 and Node\_2 are not head nodes.



```
curr_1.next, curr_2.next =  
curr_2.next, curr_1.next
```

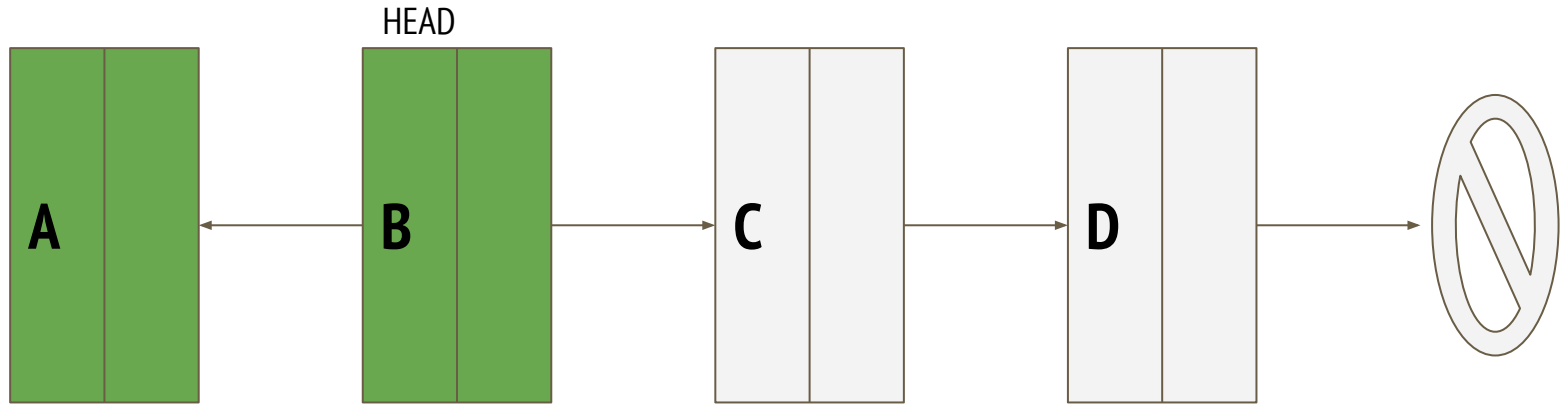
# Singly Linked List: Node Swap - Case 2

Node\_1 is a head node. Node\_2 is not.



# Singly Linked List: Node Swap - Case 2

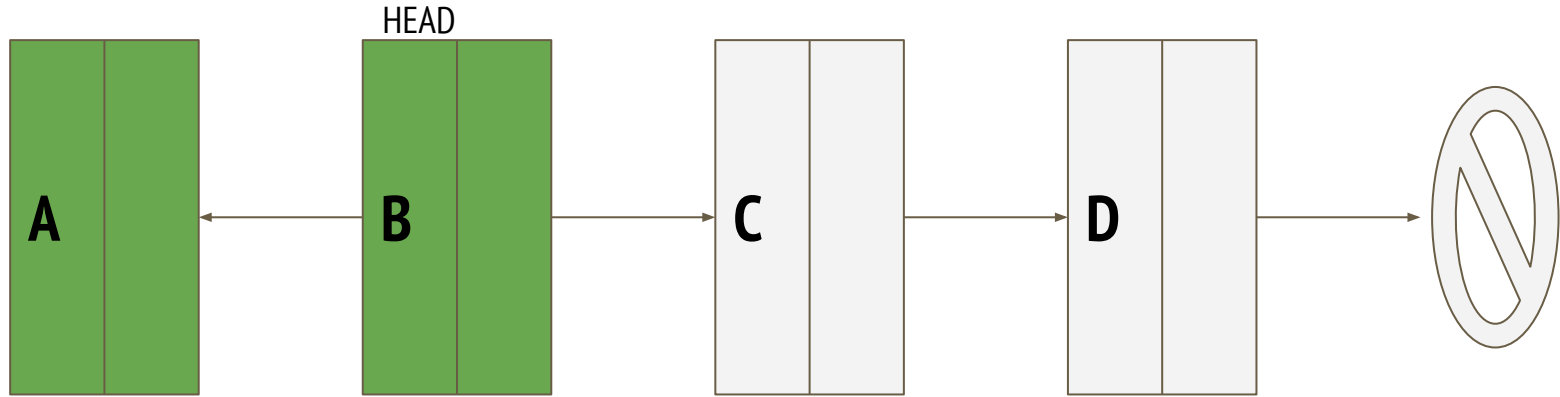
Node\_1 is a head node. Node\_2 is not.



```
self.head = curr_2
```

# Singly Linked List: Node Swap - Case 2

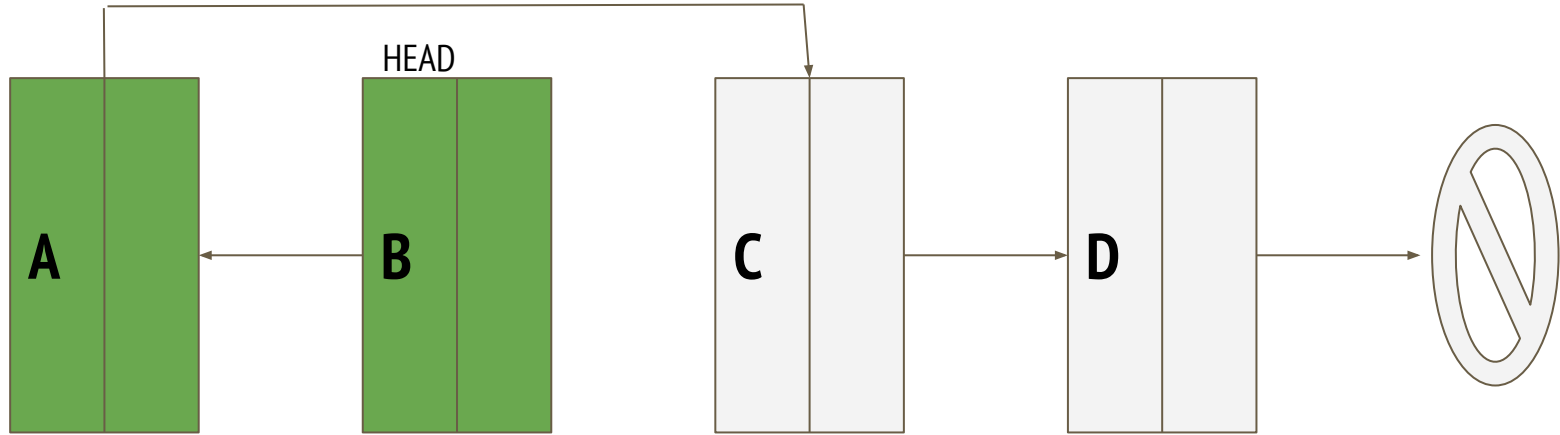
Node\_1 is a head node. Node\_2 is not.



```
prev_2.next = curr_1
```

# Singly Linked List: Node Swap - Case 2

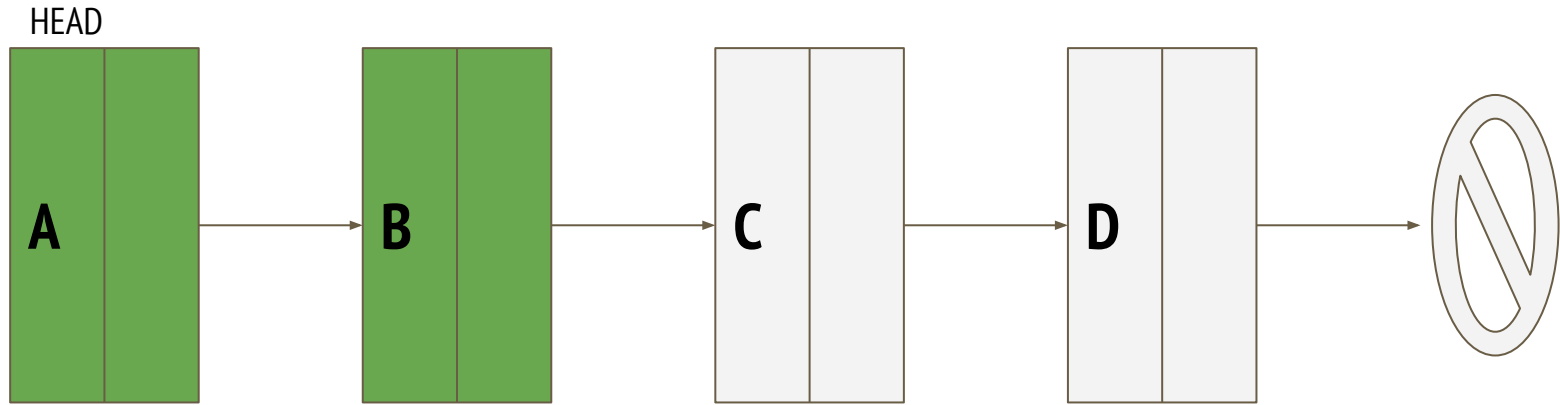
Node\_1 is a head node. Node\_2 is not.



```
curr_1.next, curr_2.next =  
curr_2.next, curr_1.next
```

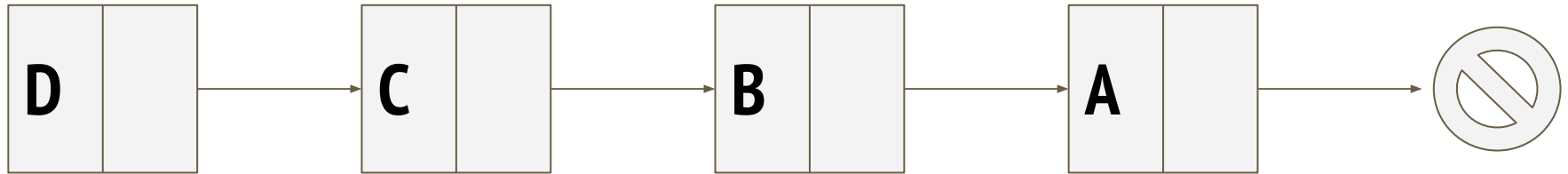
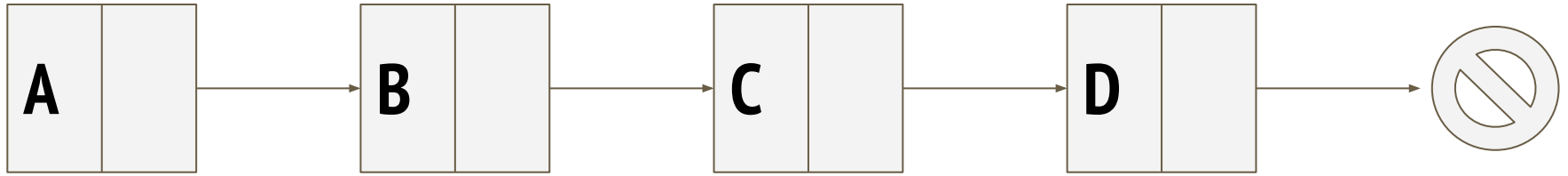
# Singly Linked List: Node Swap - Case 3

Node\_2 is a head node. Node\_1 is not. (almost identical to case 2)



# Linked Lists : Reverse List

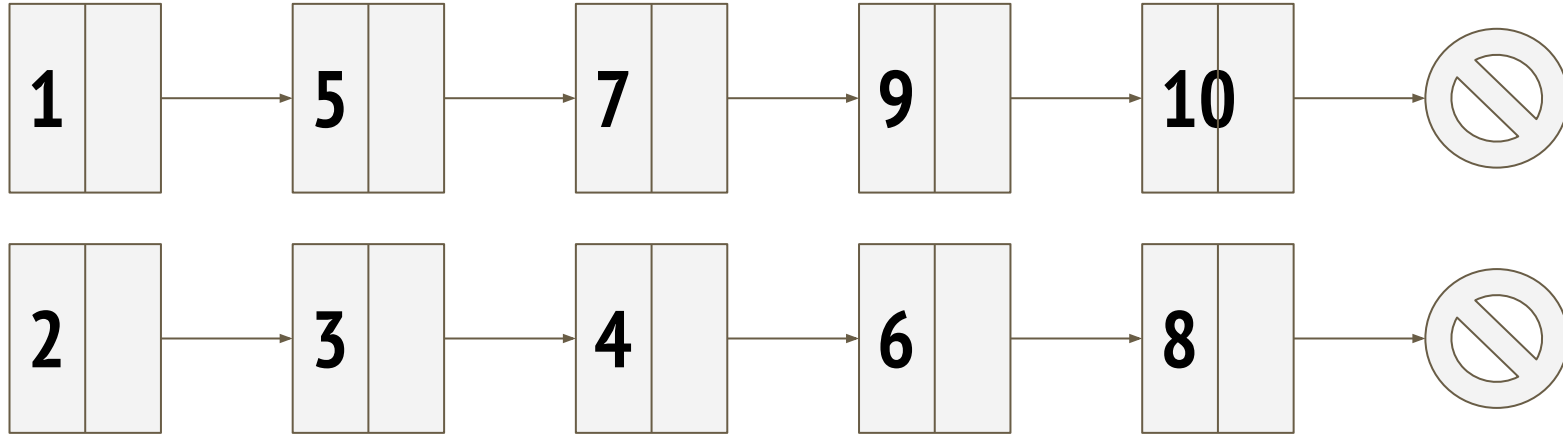
# Singly Linked List: Reverse List



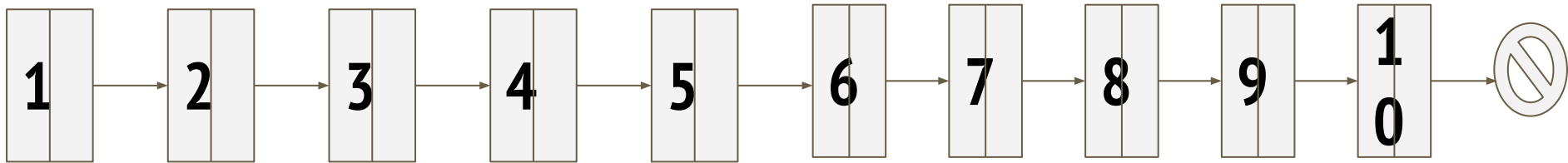
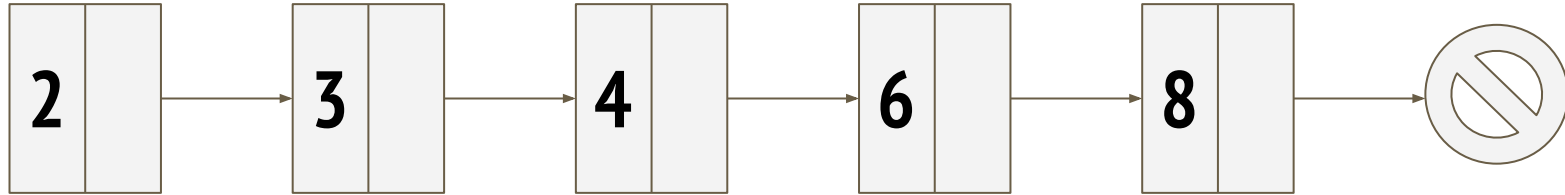
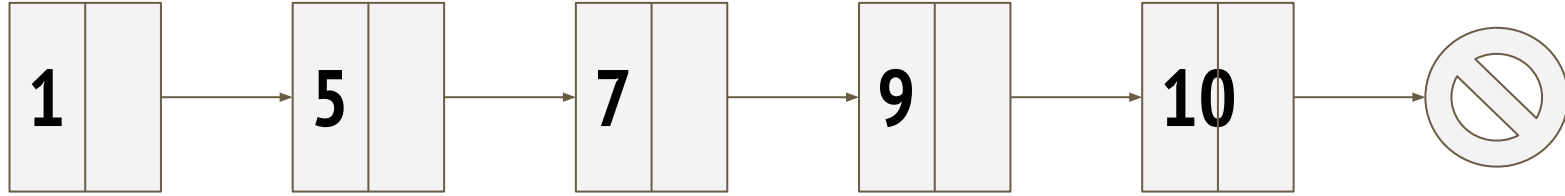


# Linked Lists : Merge Two Sorted Linked Lists

# Singly Linked List: Merge Two Sorted Linked Lists

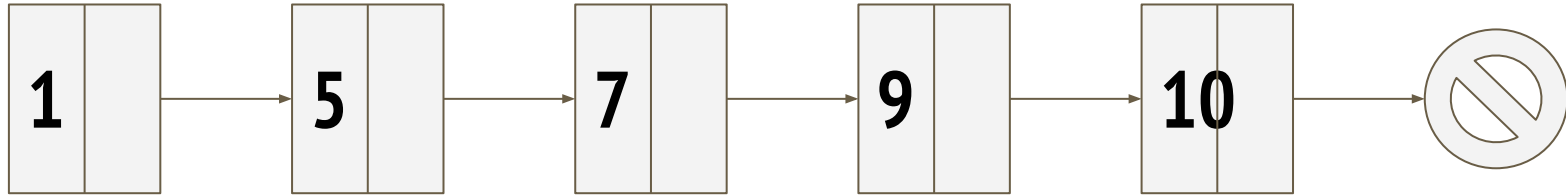


# Singly Linked List: Merge Two Sorted Linked Lists



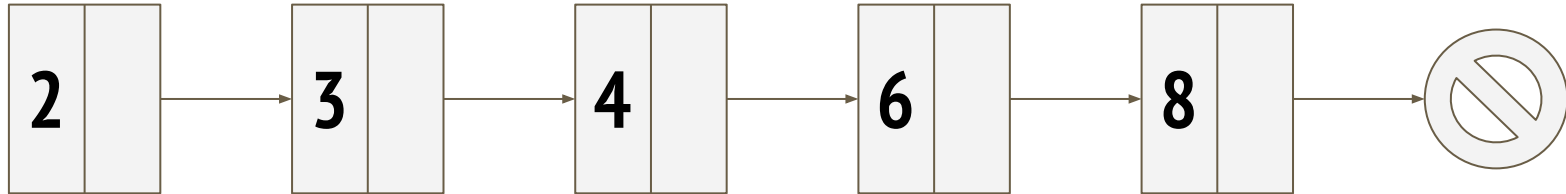
# Singly Linked List: Merge Two Sorted Linked Lists

P

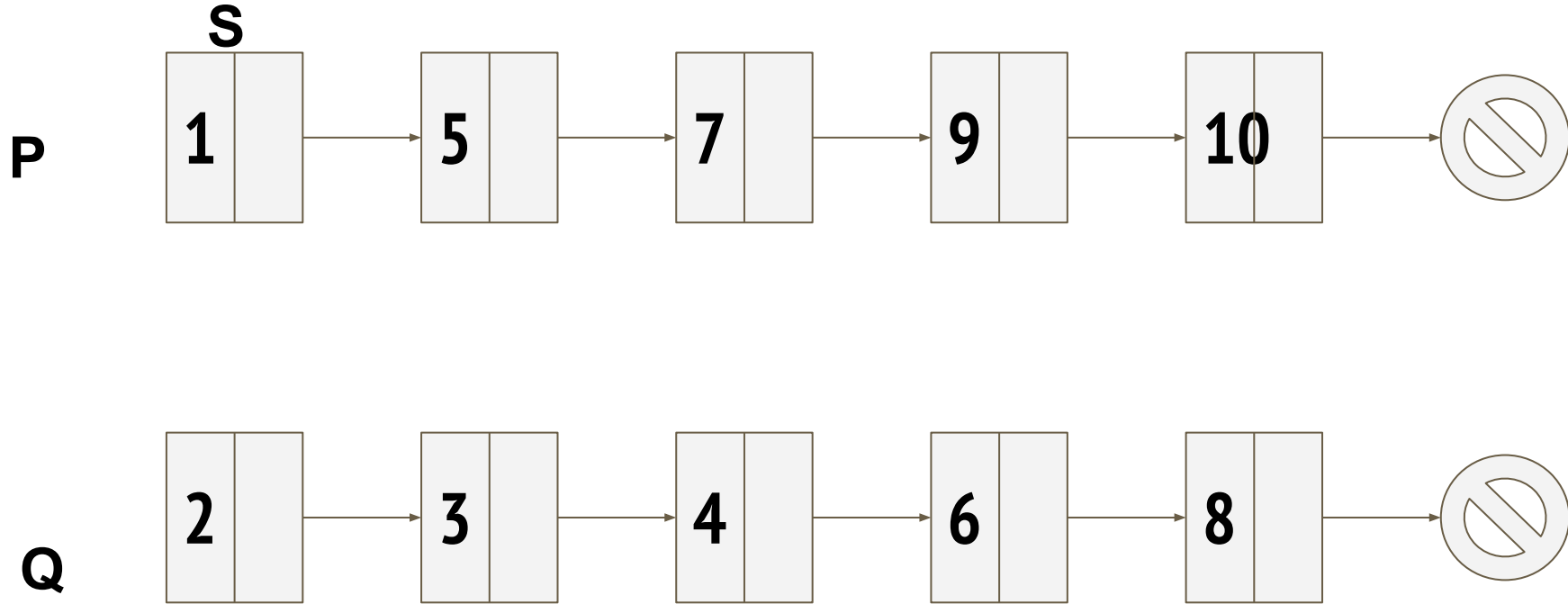


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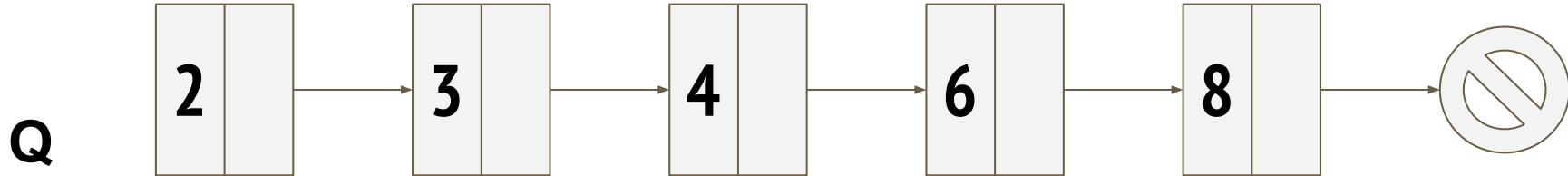
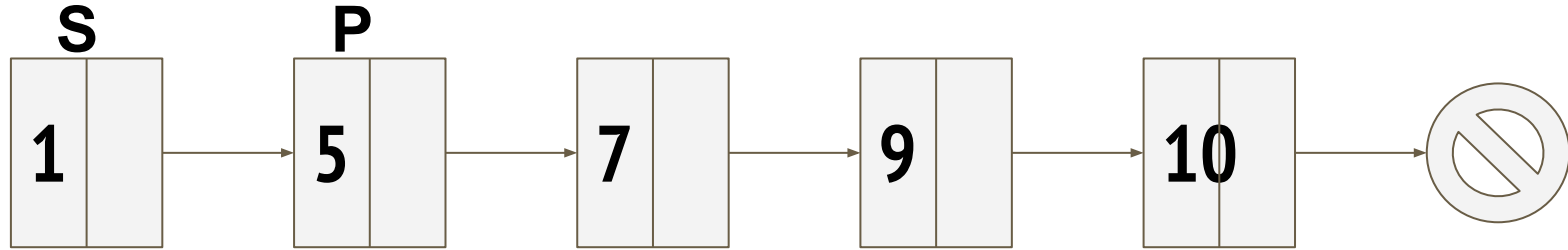
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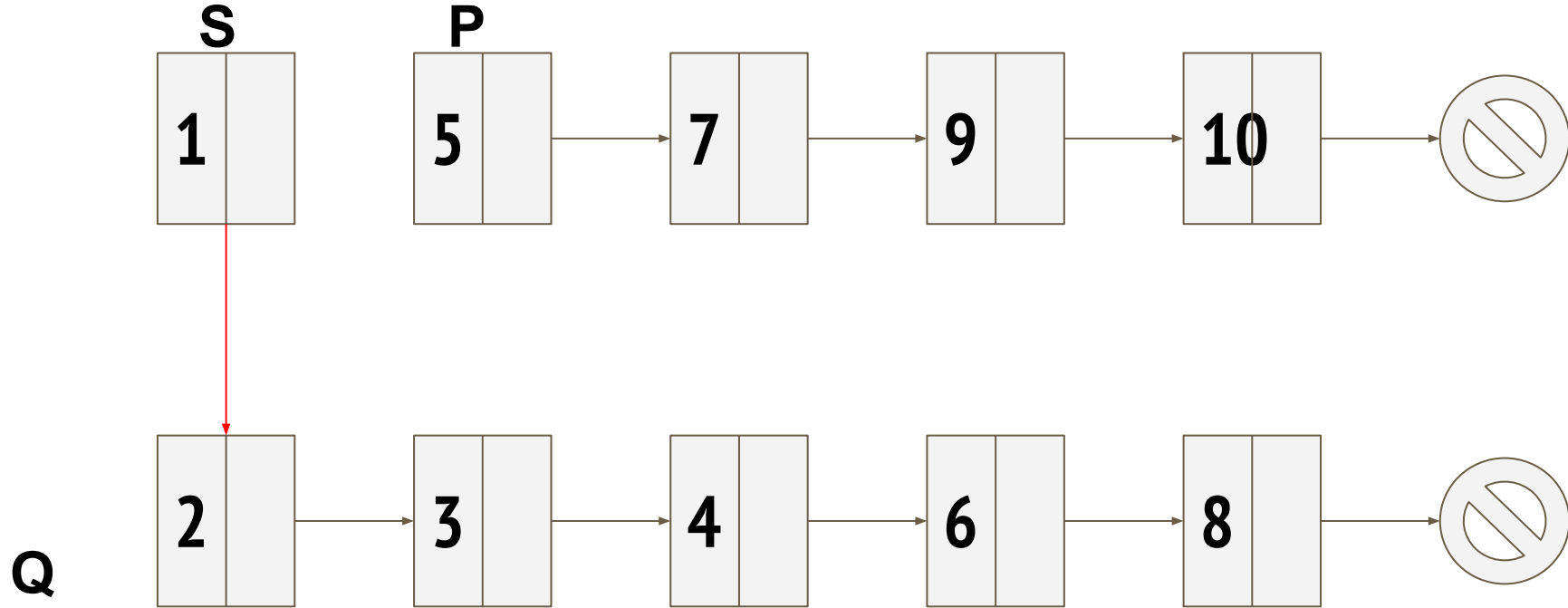
# Singly Linked List: Merge Two Sorted Linked Lists



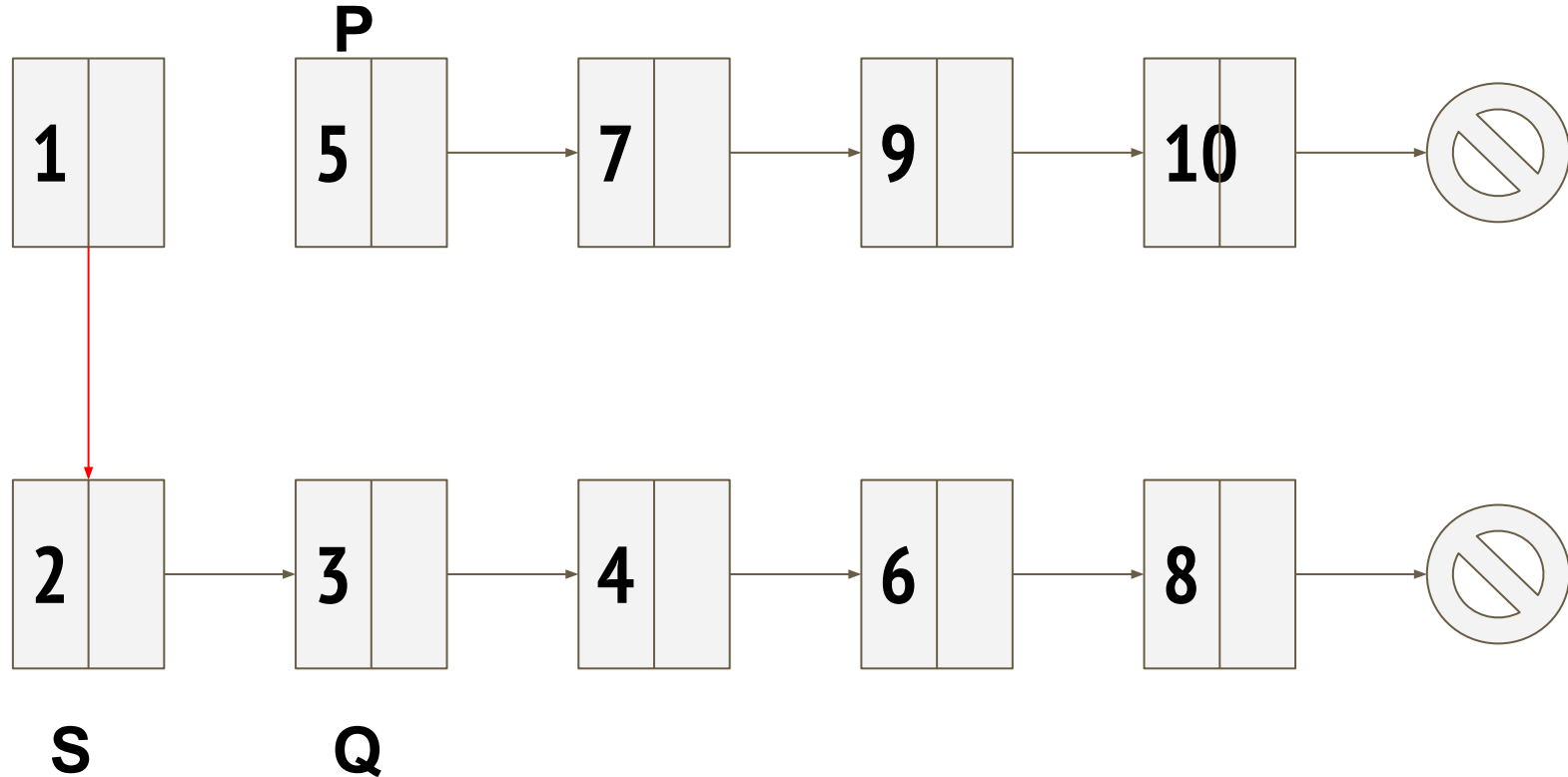
# Singly Linked List: Merge Two Sorted Linked Lists



# Singly Linked List: Merge Two Sorted Linked Lists

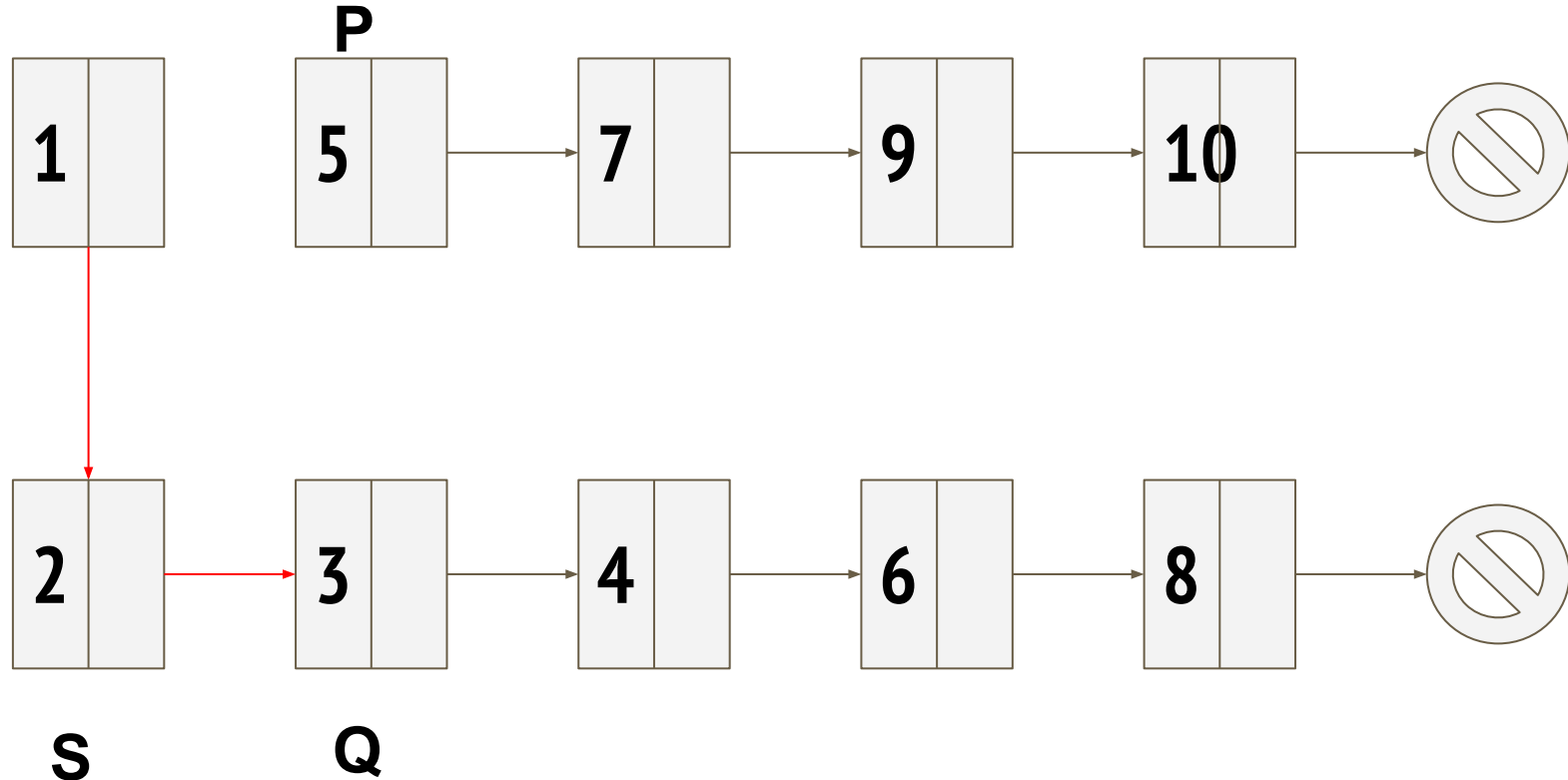


# Singly Linked List: Merge Two Sorted Linked Lists

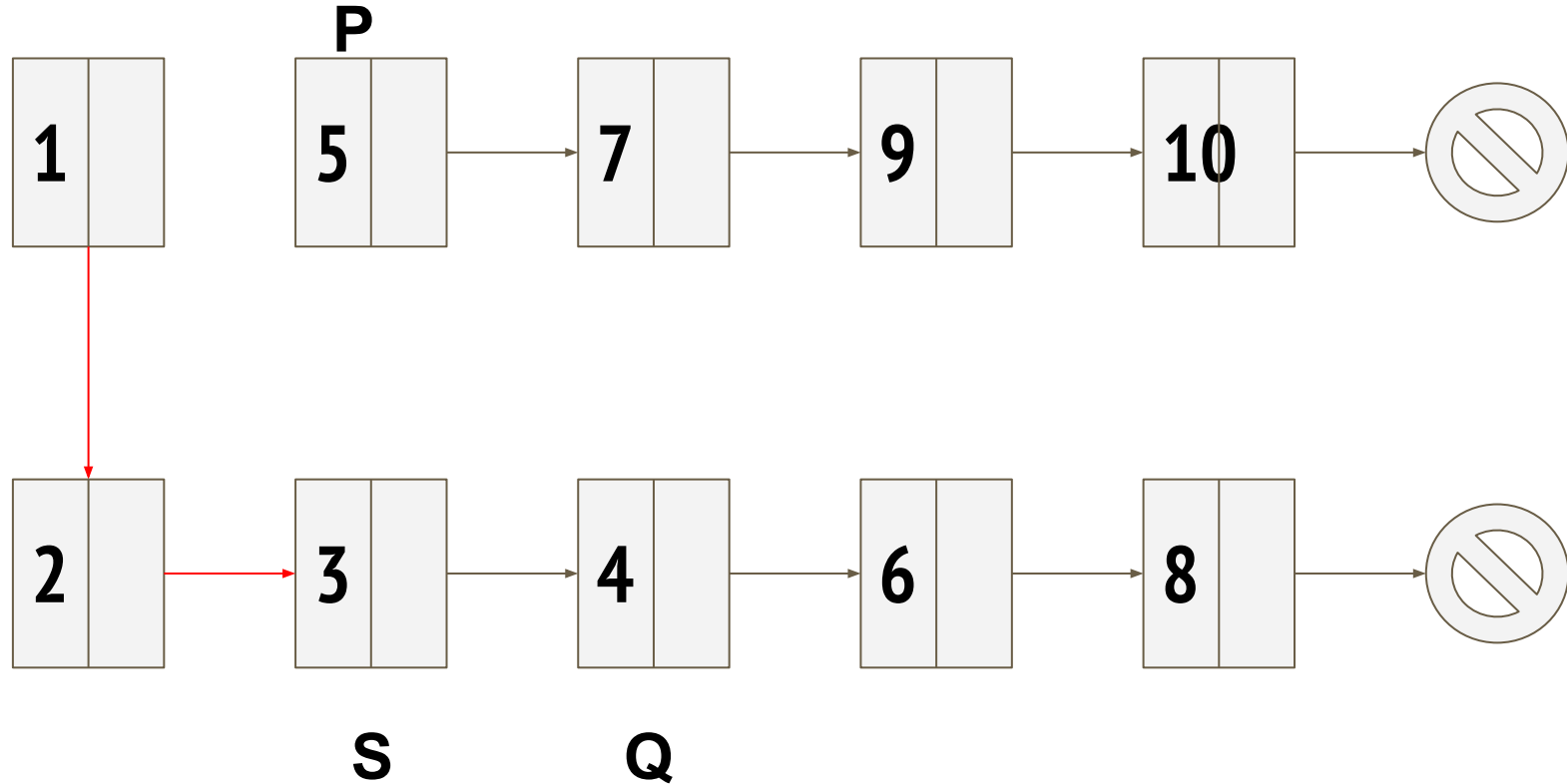




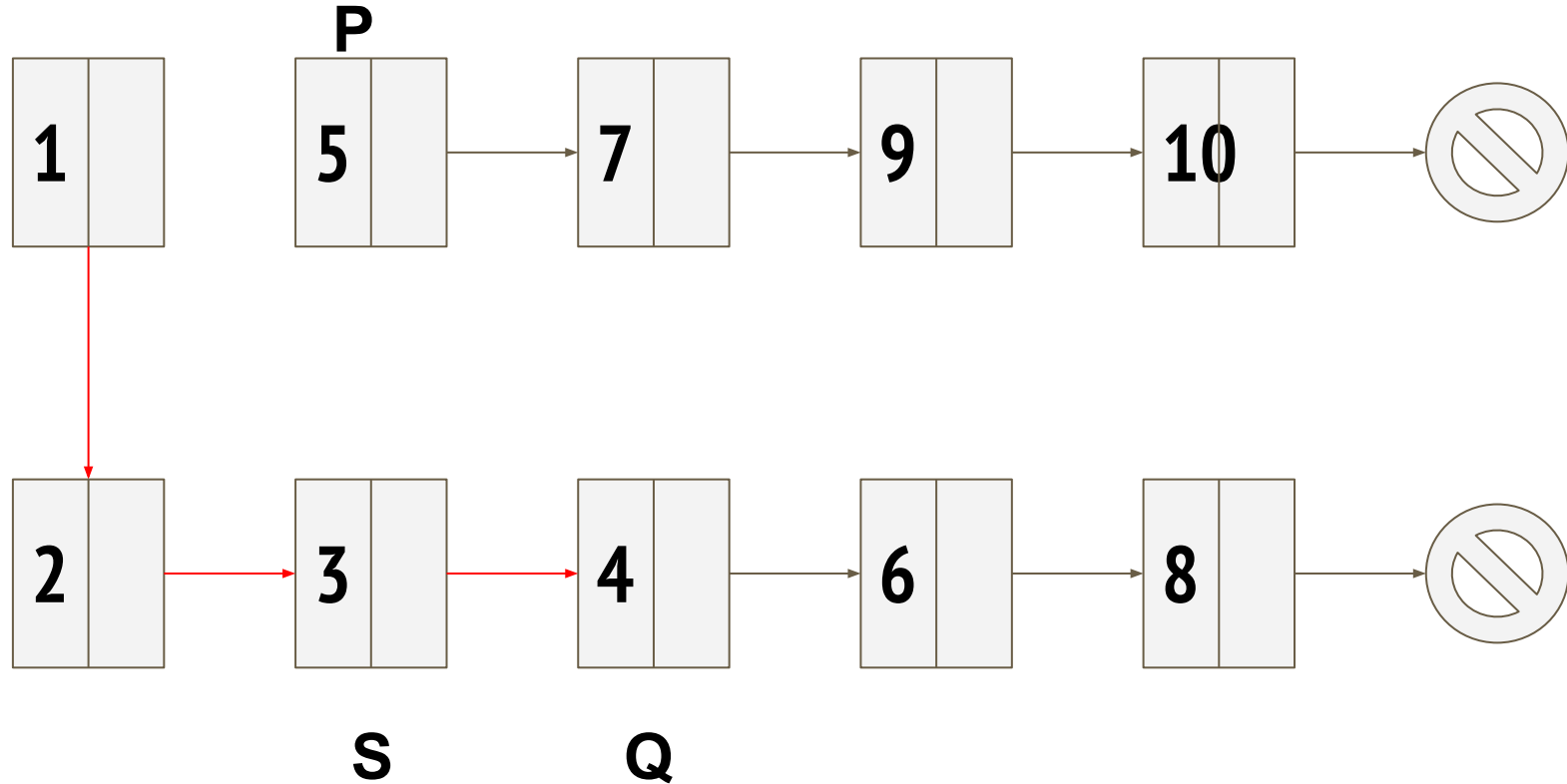
# Singly Linked List: Merge Two Sorted Linked Lists



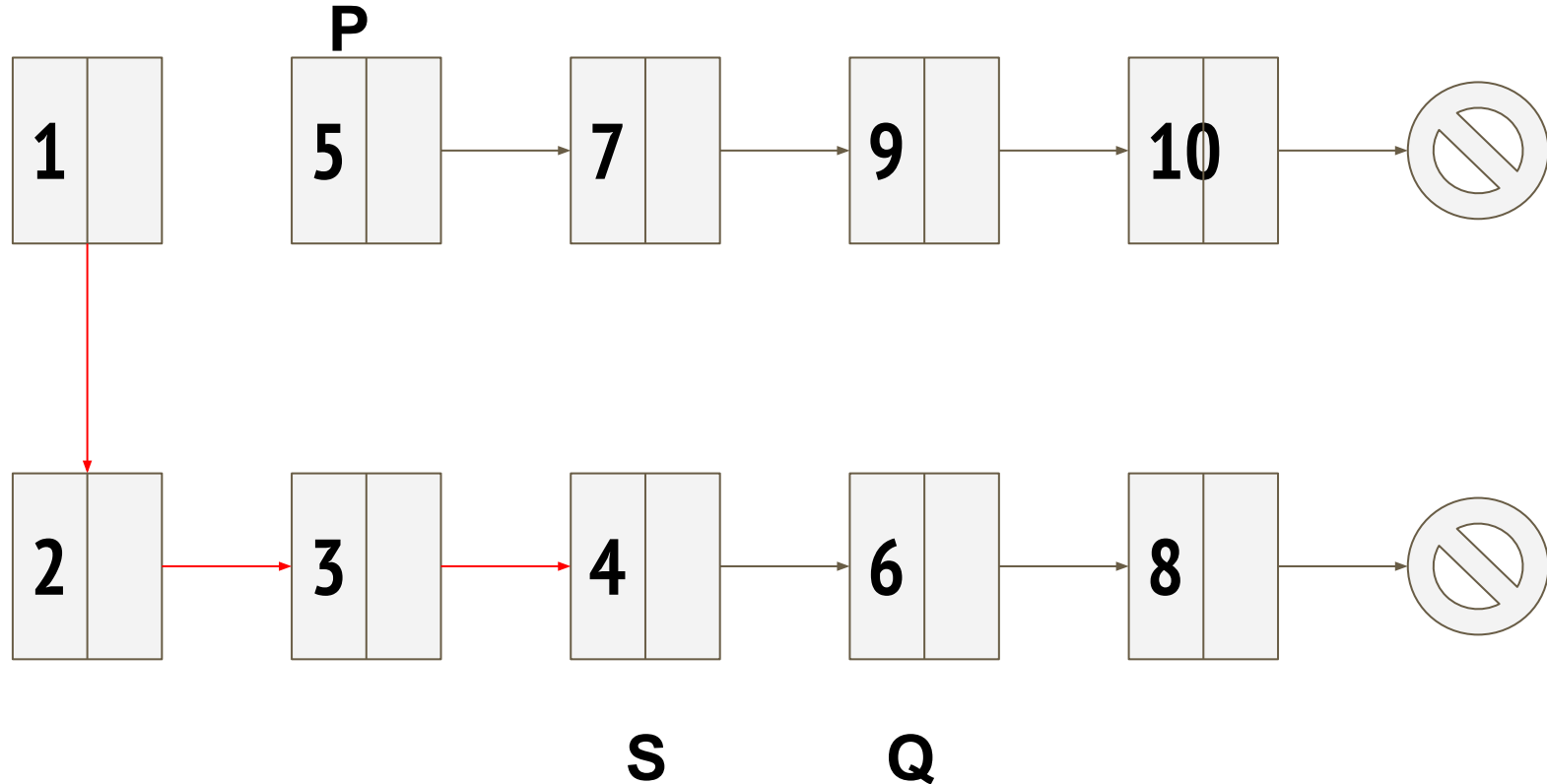
# Singly Linked List: Merge Two Sorted Linked Lists



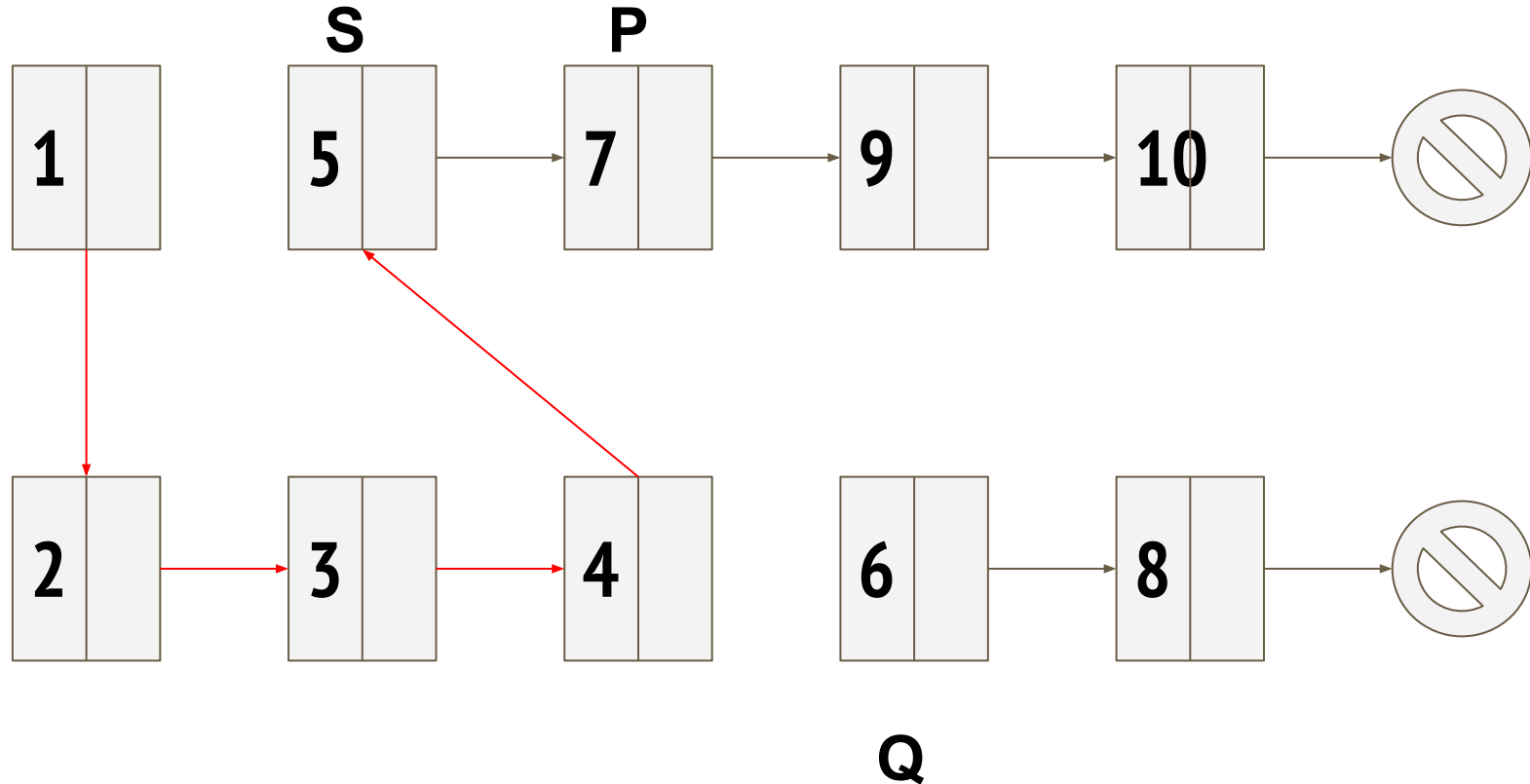
# Singly Linked List: Merge Two Sorted Linked Lists



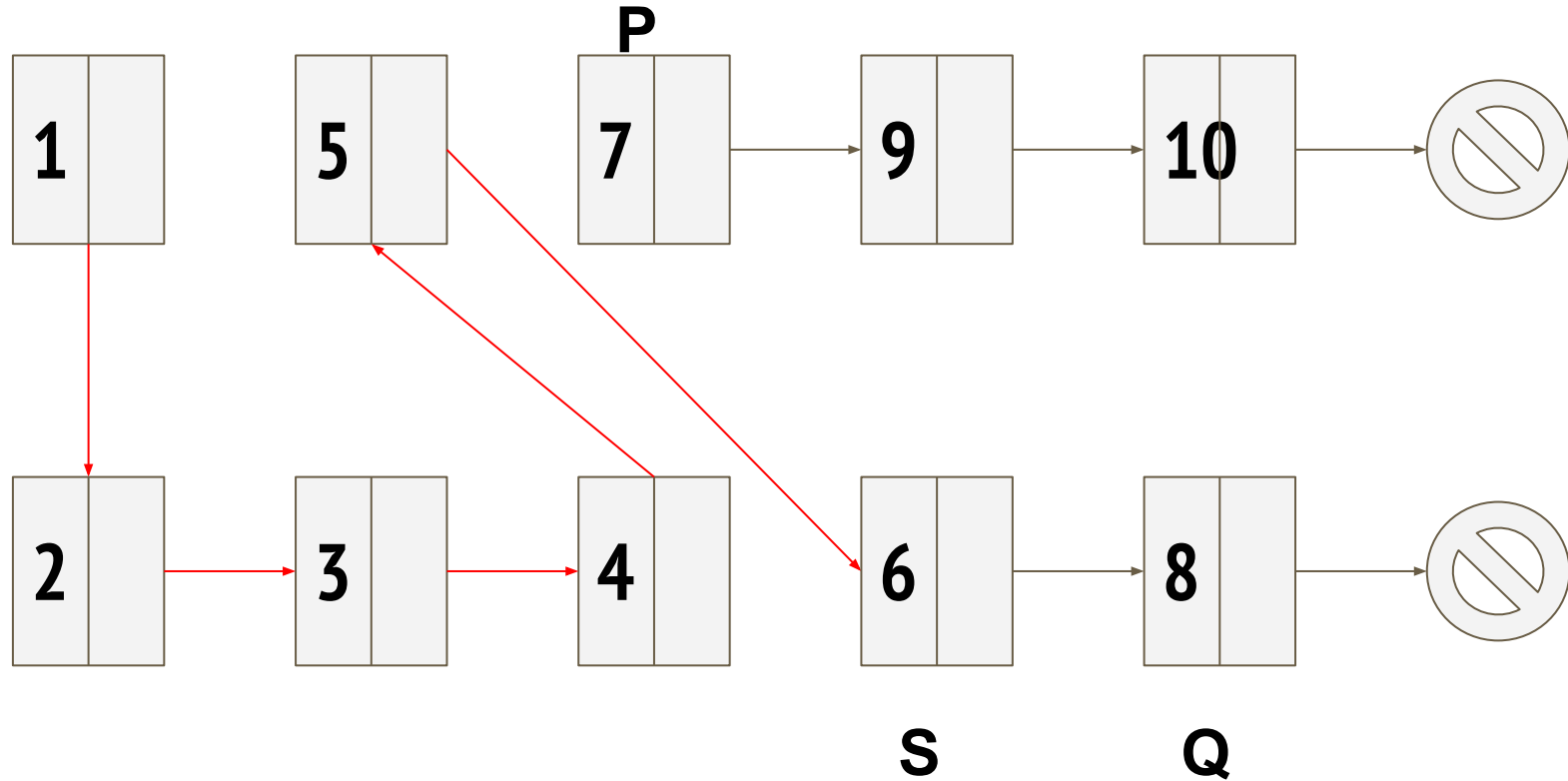
# Singly Linked List: Merge Two Sorted Linked Lists



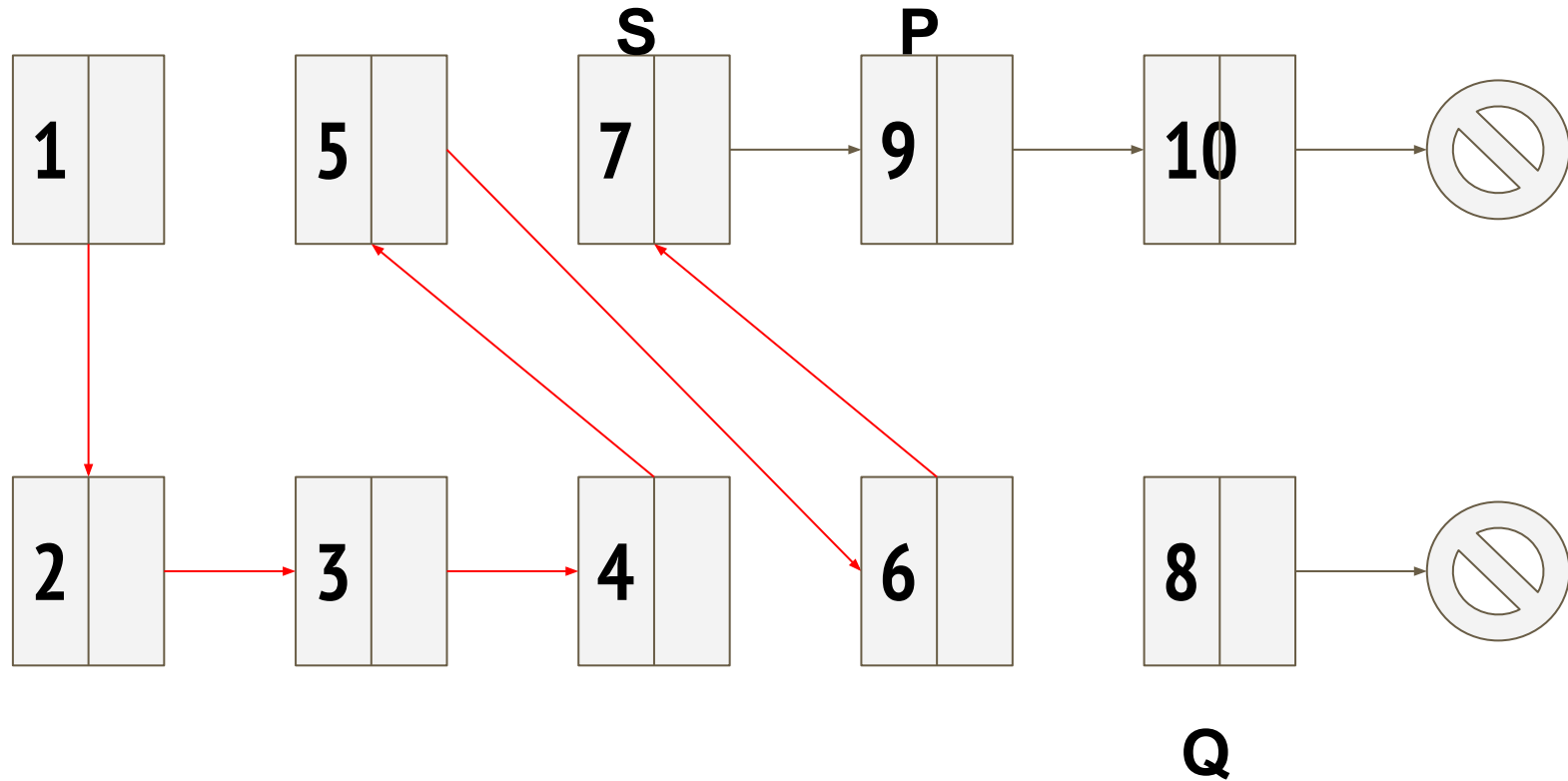
# Singly Linked List: Merge Two Sorted Linked Lists



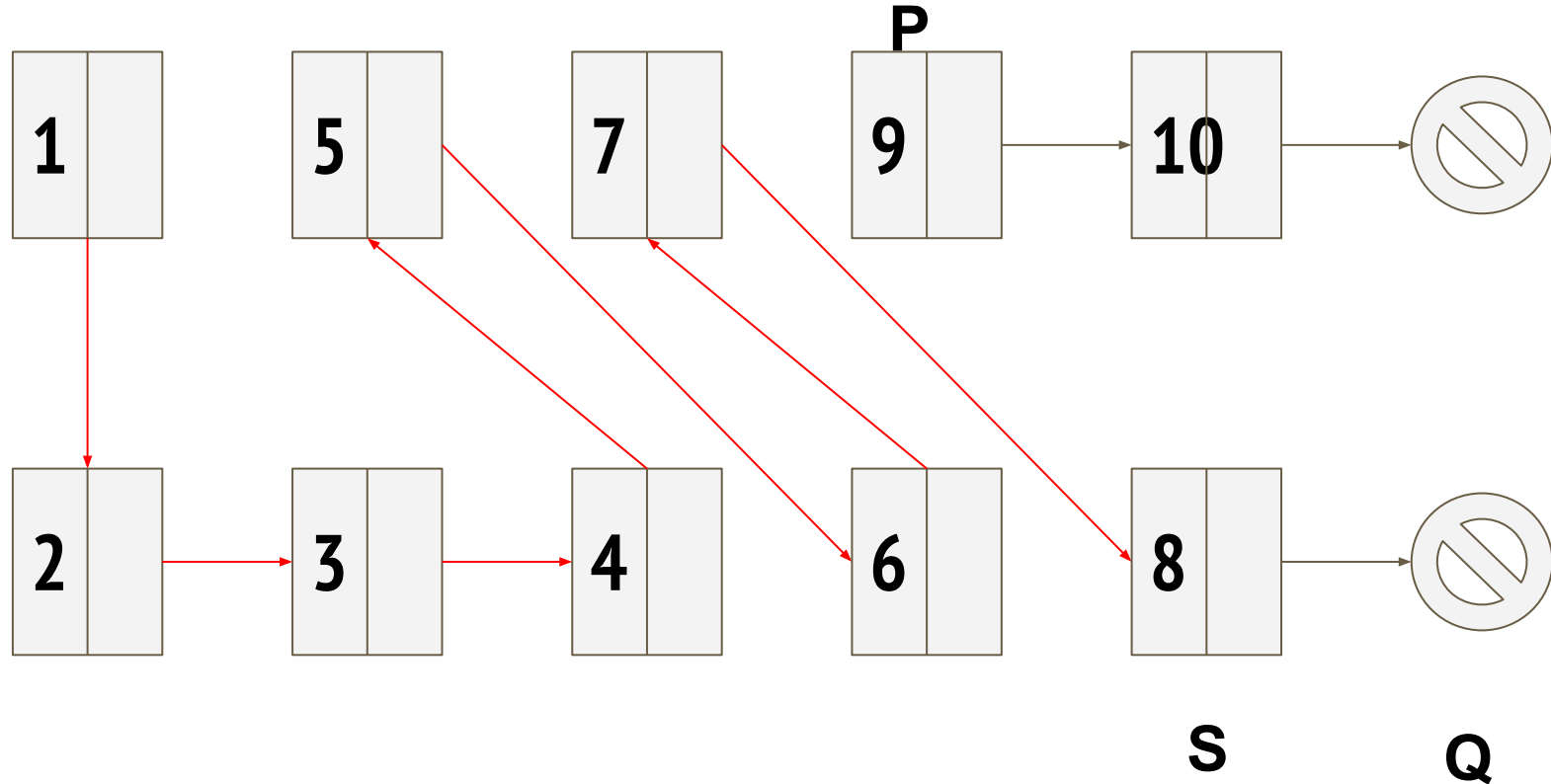
# Singly Linked List: Merge Two Sorted Linked Lists



# Singly Linked List: Merge Two Sorted Linked Lists

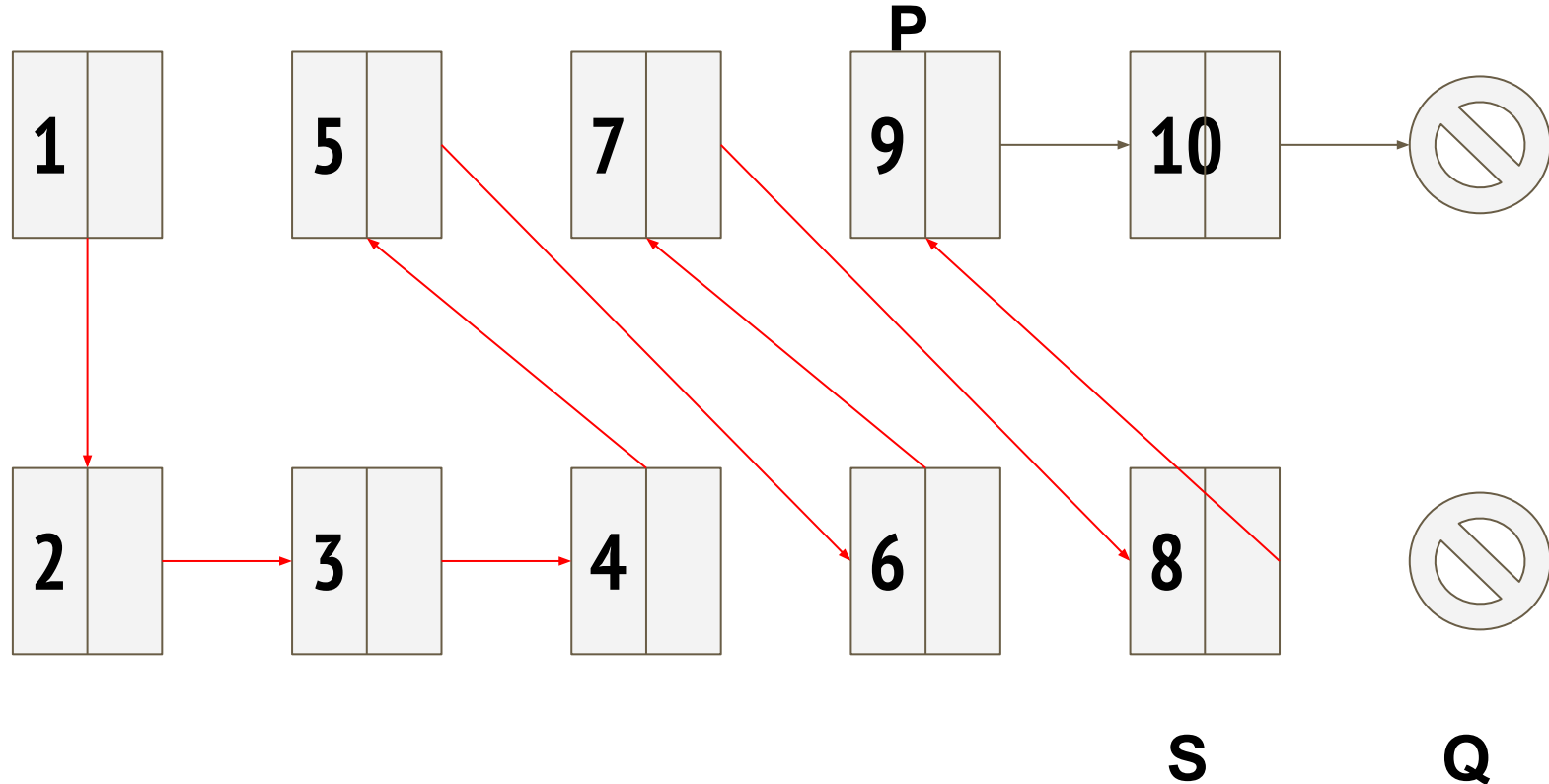


# Singly Linked List: Merge Two Sorted Linked Lists

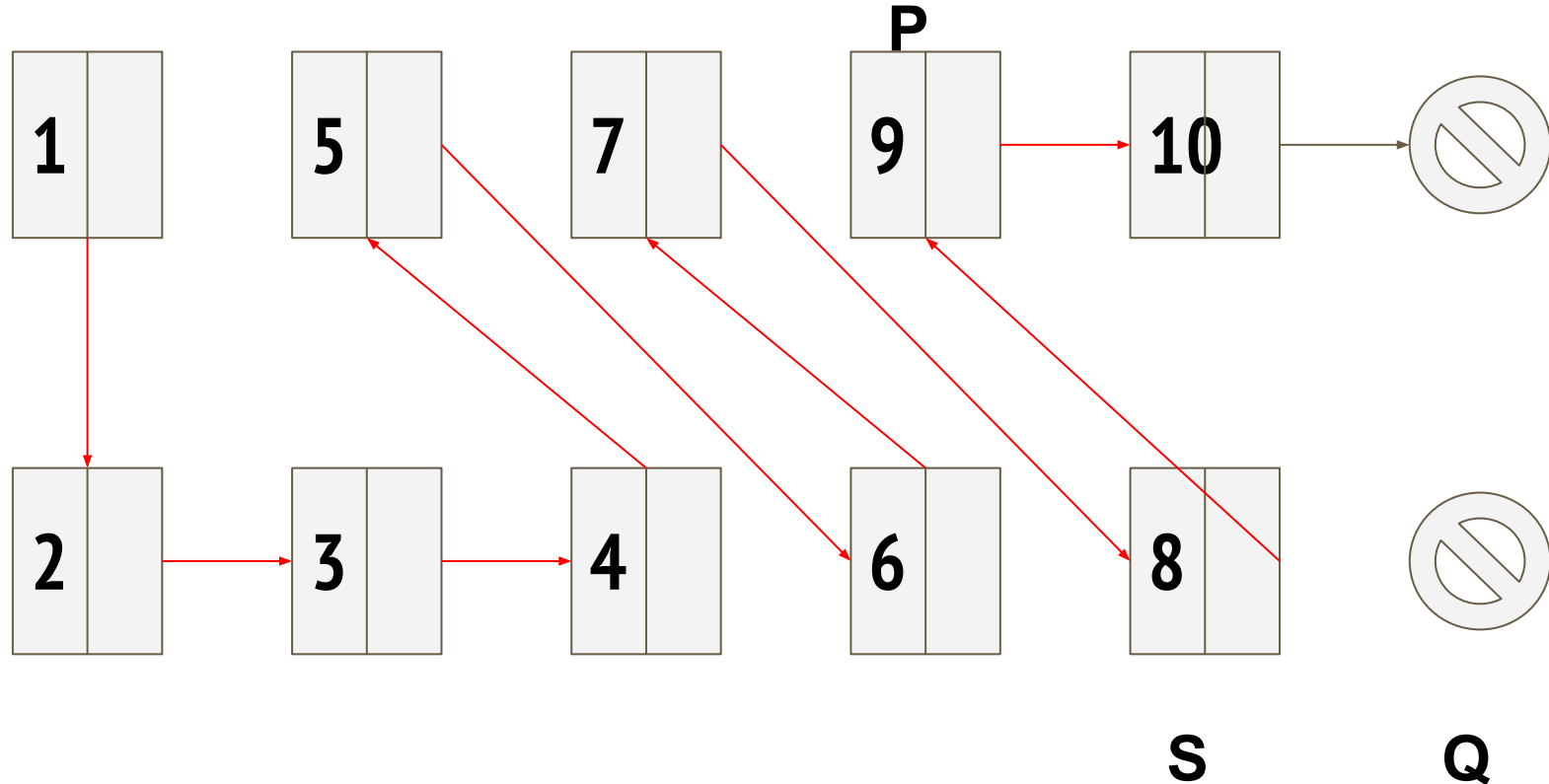




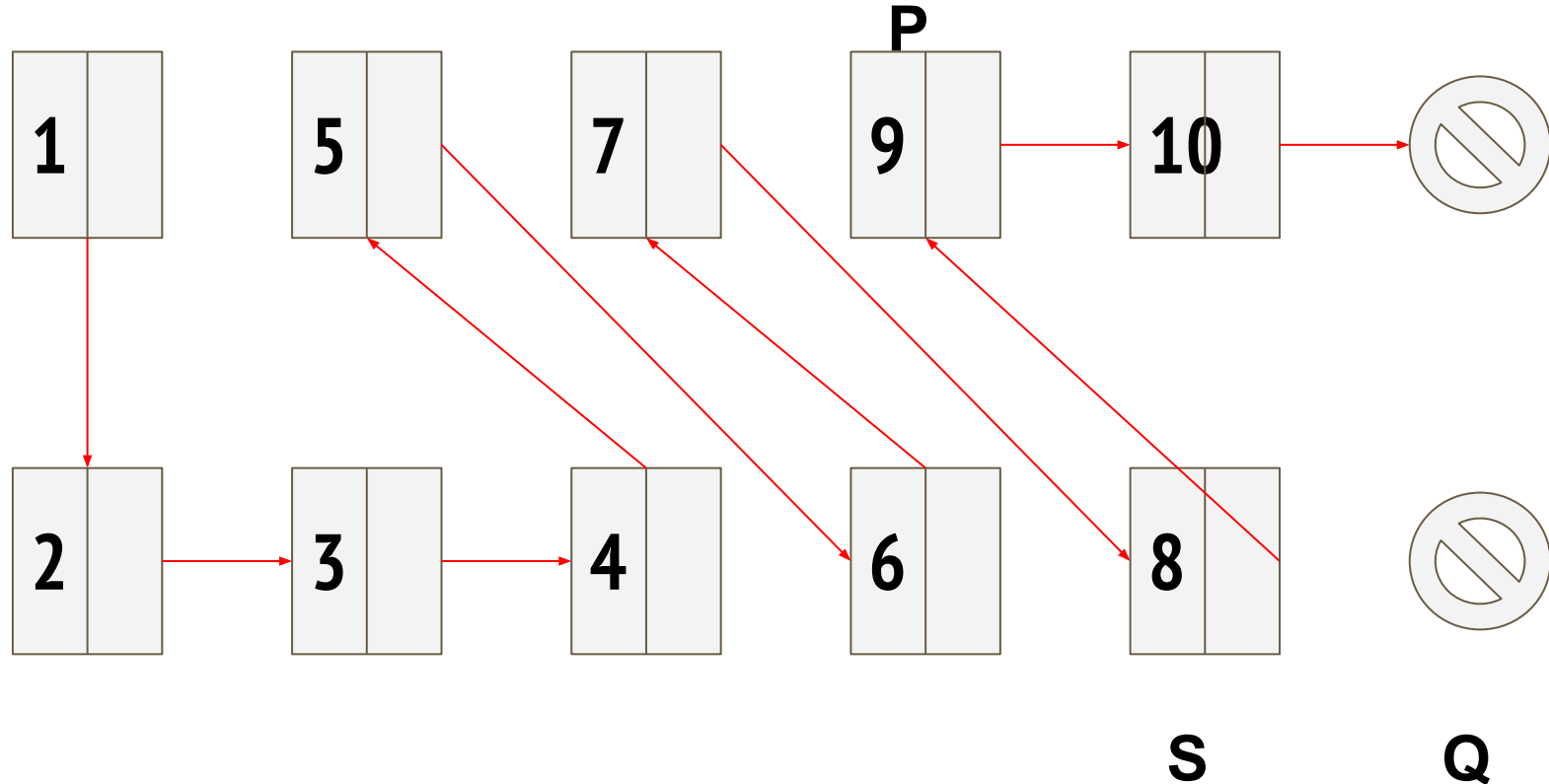
# Singly Linked List: Merge Two Sorted Linked Lists



# Singly Linked List: Merge Two Sorted Linked Lists

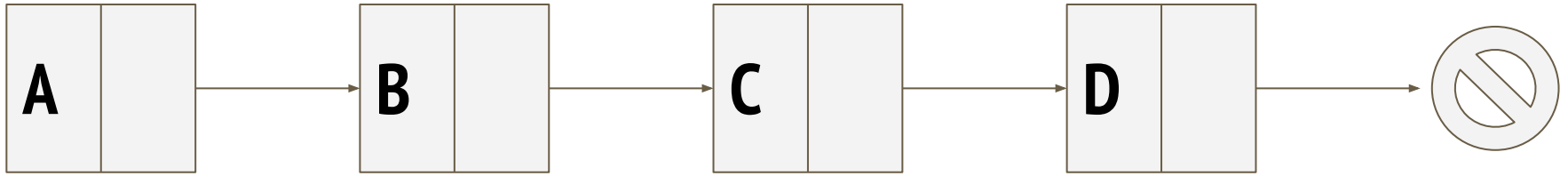


# Singly Linked List: Merge Two Sorted Linked Lists

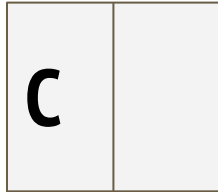


# Linked Lists : Find Nth-to-last Node

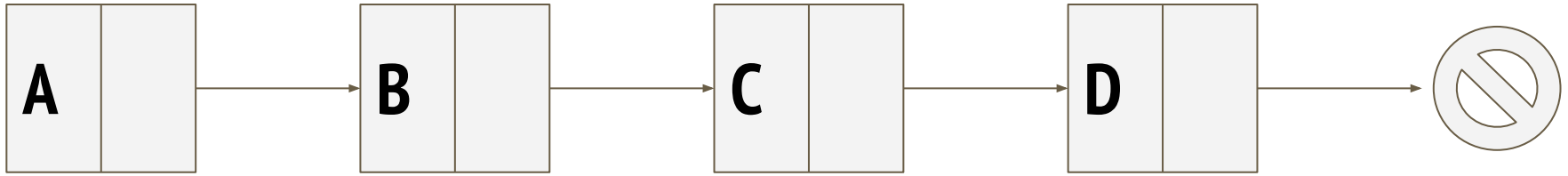
# Singly Linked List: Nth-to-last Node



Second to last node: ( $n = 2$ )

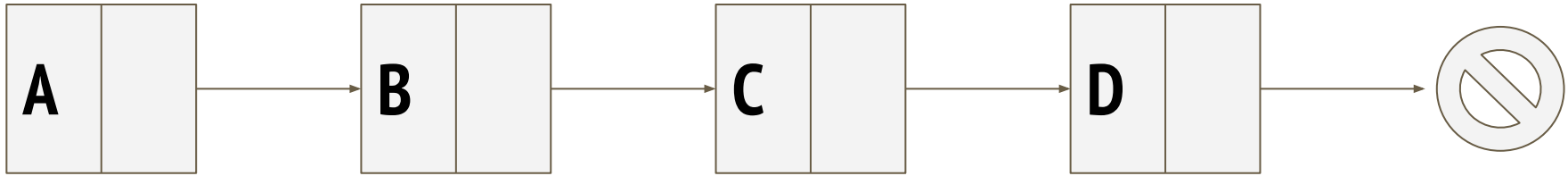


# Singly Linked List: Nth-to-last Node -- Method 1



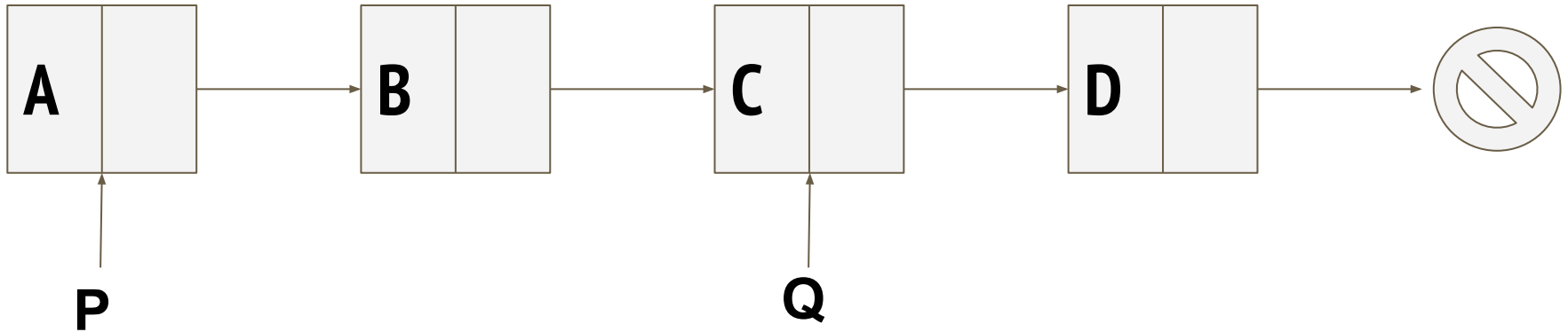
1. Calculate length of linked list.
2. Count down from the total length until "n" is reached.

# Singly Linked List: Nth-to-last Node -- Method 2



1. Two pointers:
  - a. P: head node
  - b. Q: n nodes beyond head node

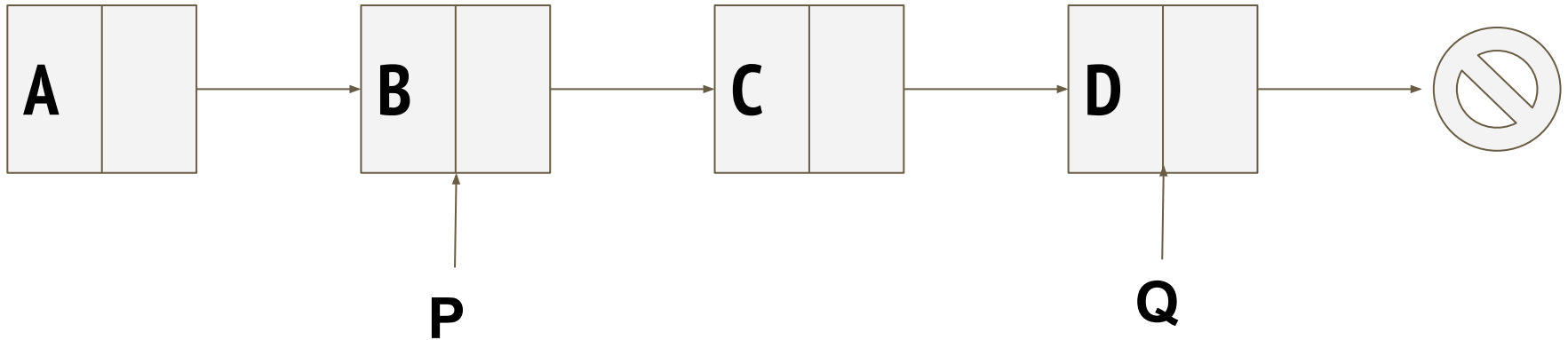
# Singly Linked List: Nth-to-last Node -- Method 2



Example:  $n = 2$

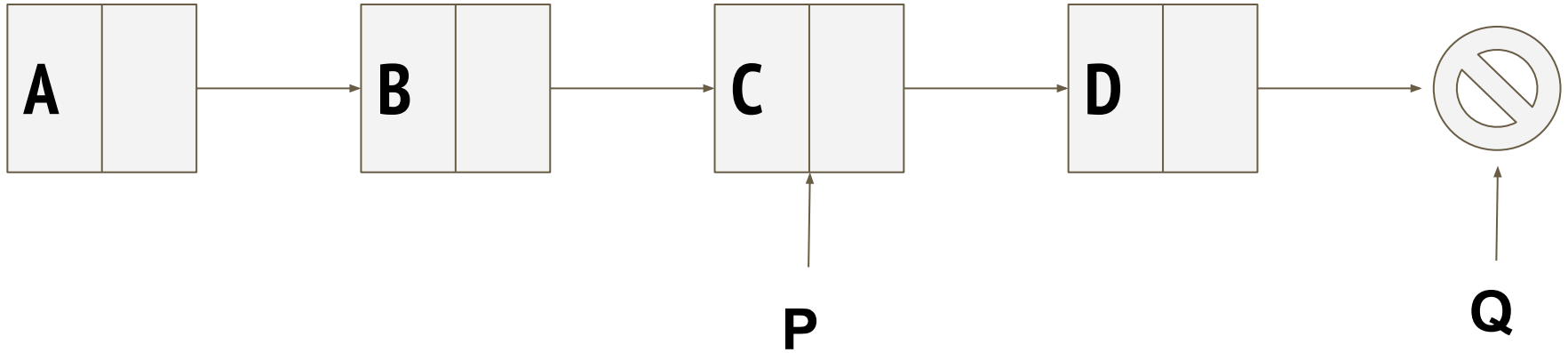


# Singly Linked List: Nth-to-last Node -- Method 2



Example:  $n = 2$

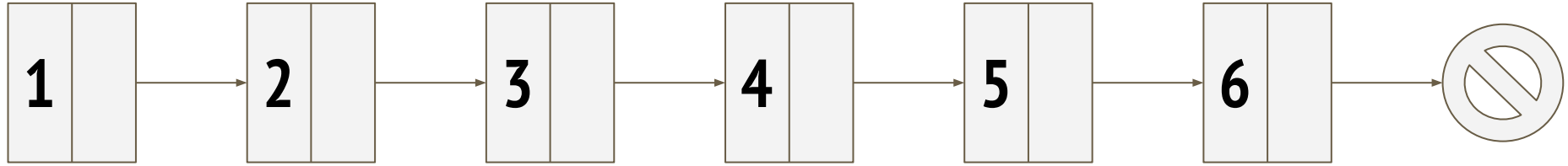
# Singly Linked List: Nth-to-last Node -- Method 2



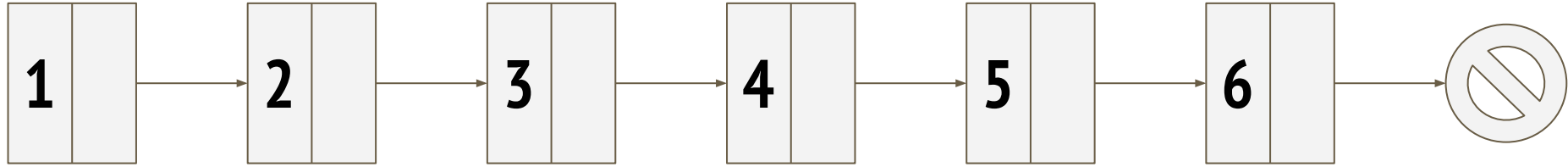
Example:  $n = 2$

# Linked Lists : Rotate List

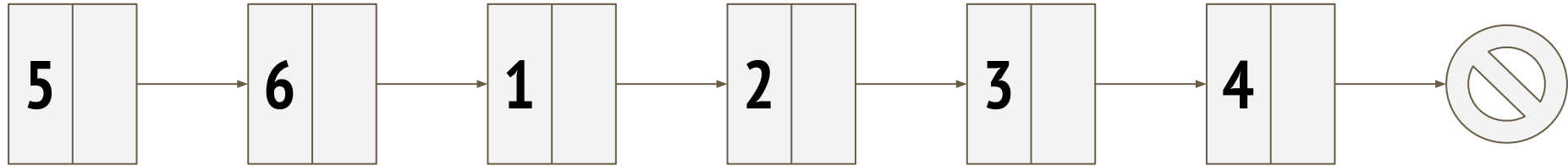
# Singly Linked List: Rotate



# Singly Linked List: Rotate

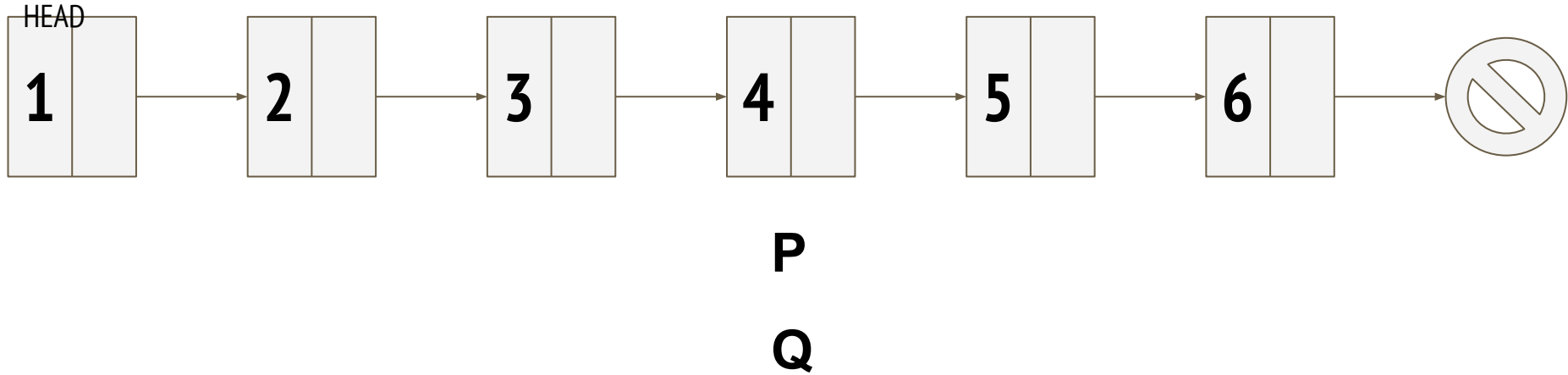


Example:  $k = 4$



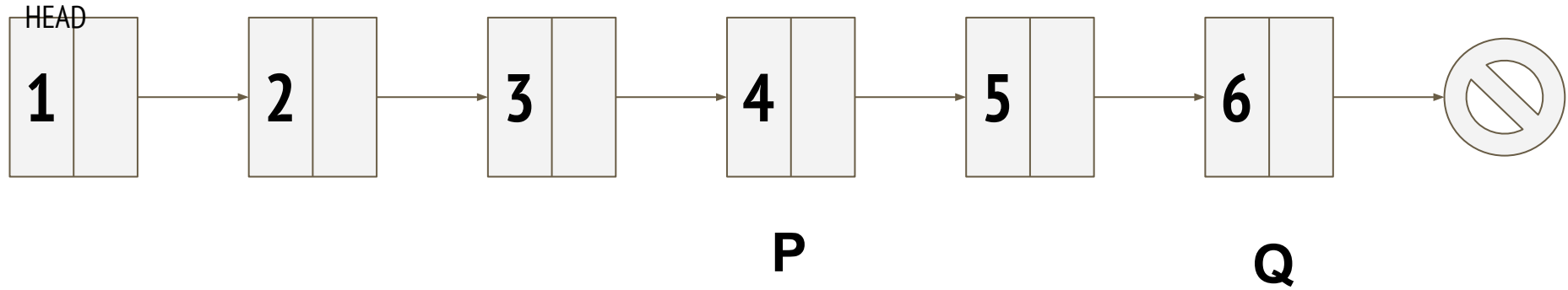
# Singly Linked List: Rotate

Example --  $k = 4$



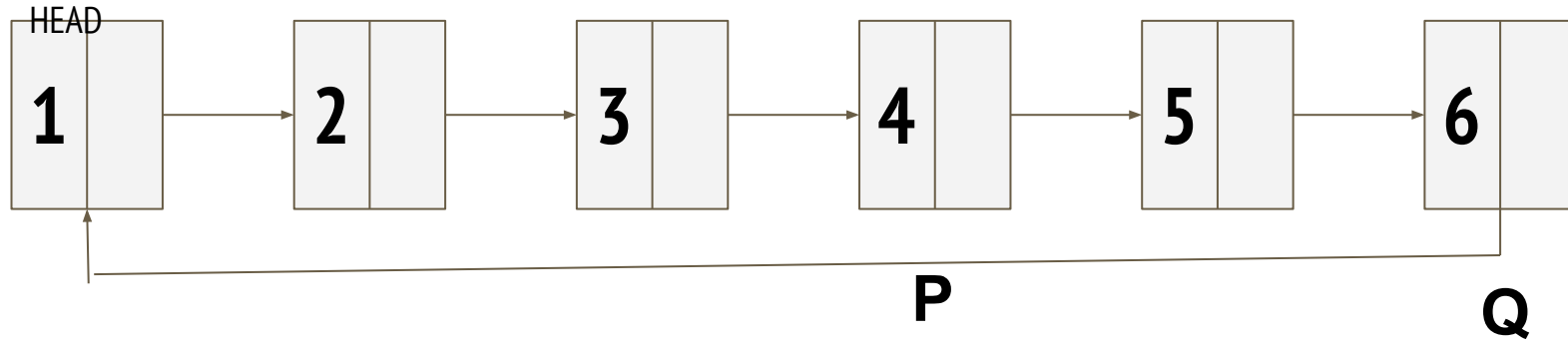
# Singly Linked List: Rotate

Example --  $k = 4$



# Singly Linked List: Rotate

Example --  $k = 4$





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# Circular Linked Lists

## Introduction

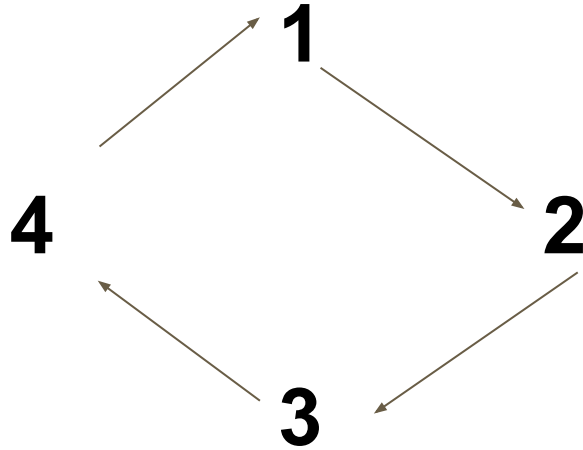
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# Circular Linked Lists: Josephus Problem

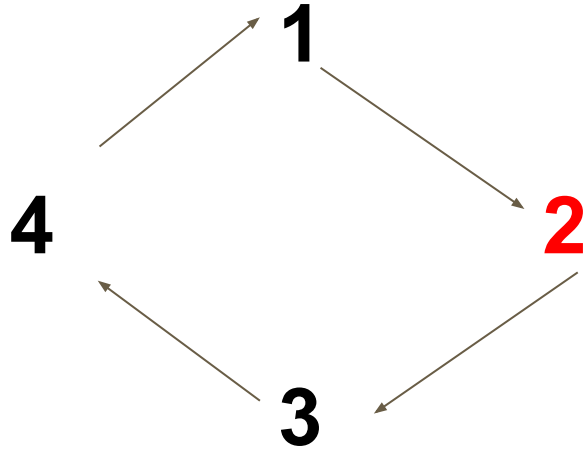
# Circular Linked List: Josephus Problem

Step size = 2



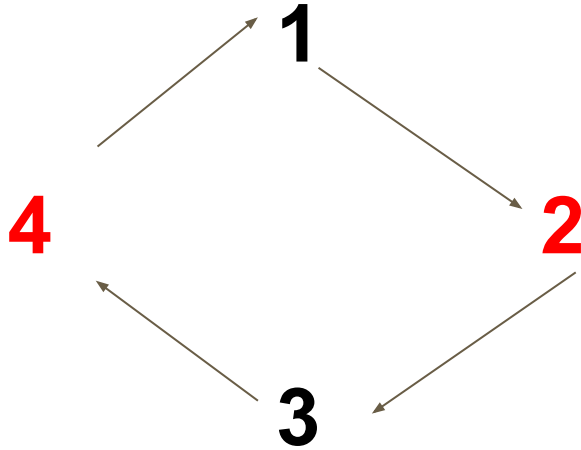
# Circular Linked List: Josephus Problem

Step size = 2



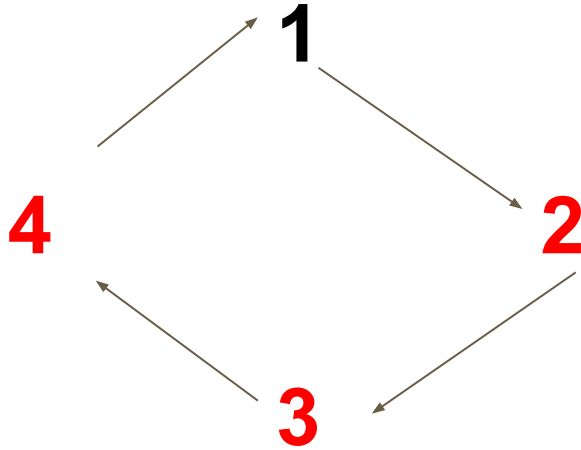
# Circular Linked List: Josephus Problem

Step size = 2



# Circular Linked List: Josephus Problem

Step size = 2



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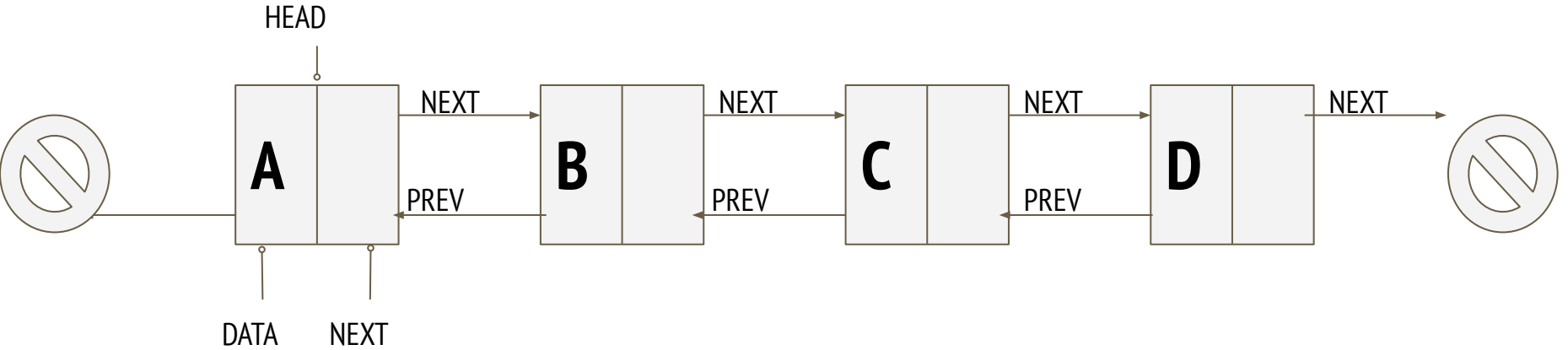
# Doubly Linked Lists

## Introduction

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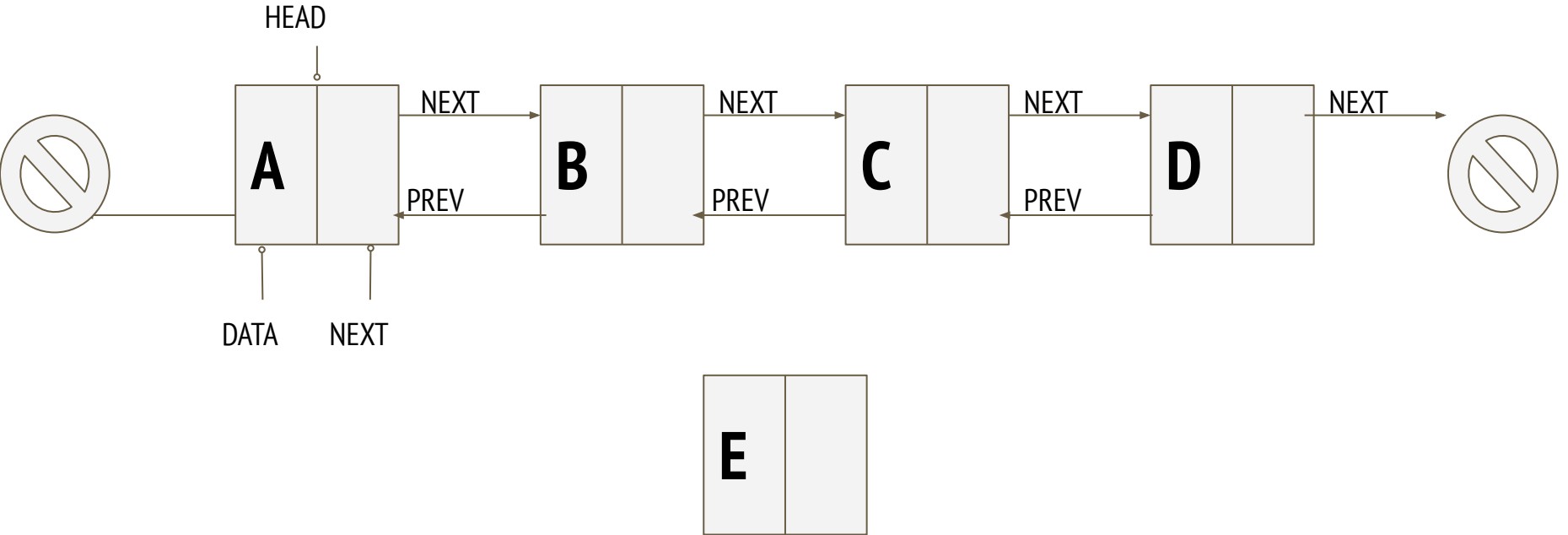
# Doubly Linked List





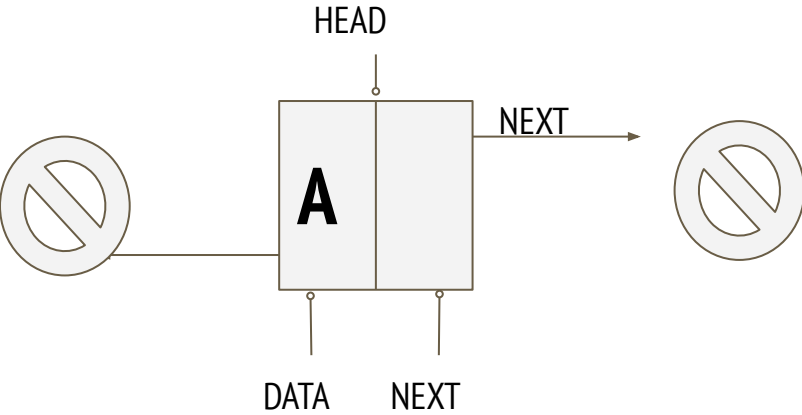
# Doubly Linked Lists: Add after node

# Doubly Linked List



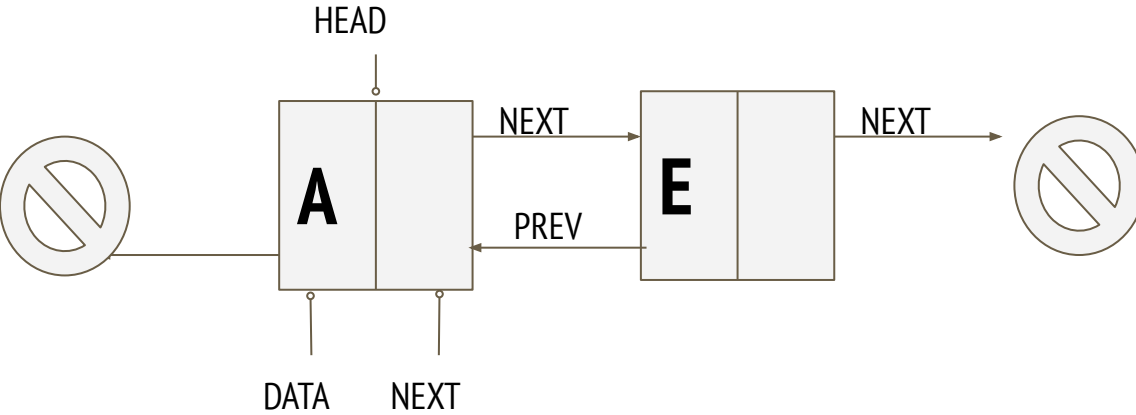
# Doubly Linked List

Add after node with data "A"



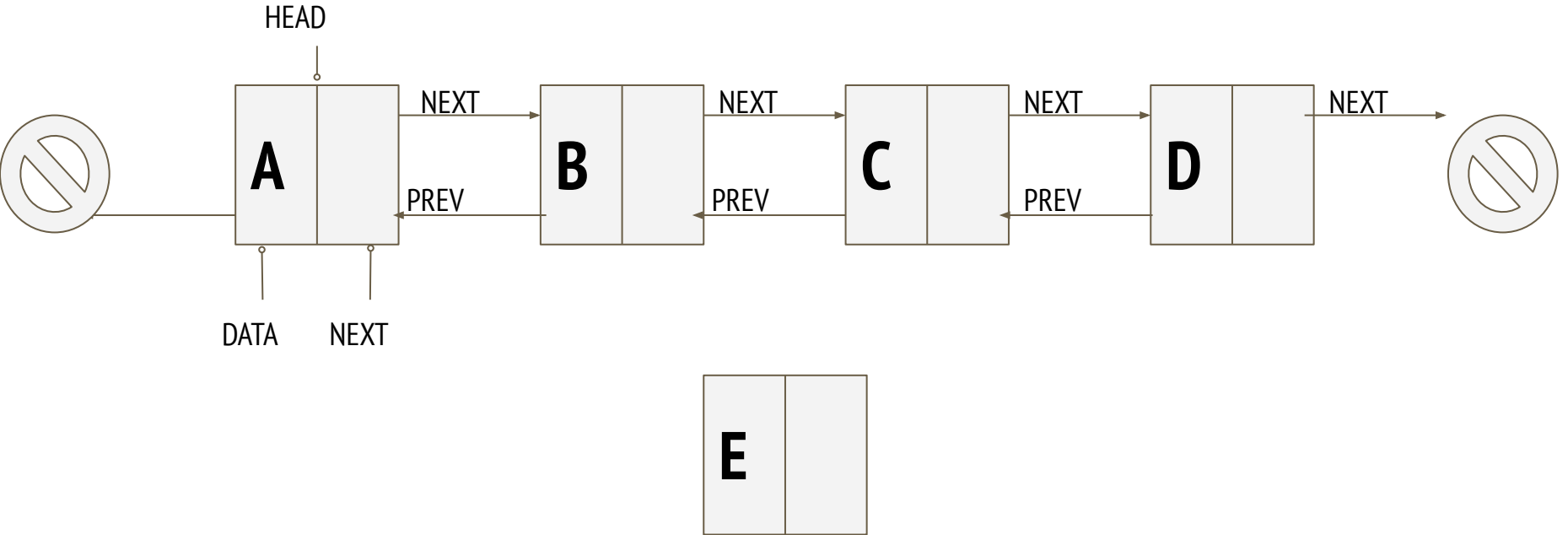
# Doubly Linked List

Add after node with data "A"  
Call to "append" function.



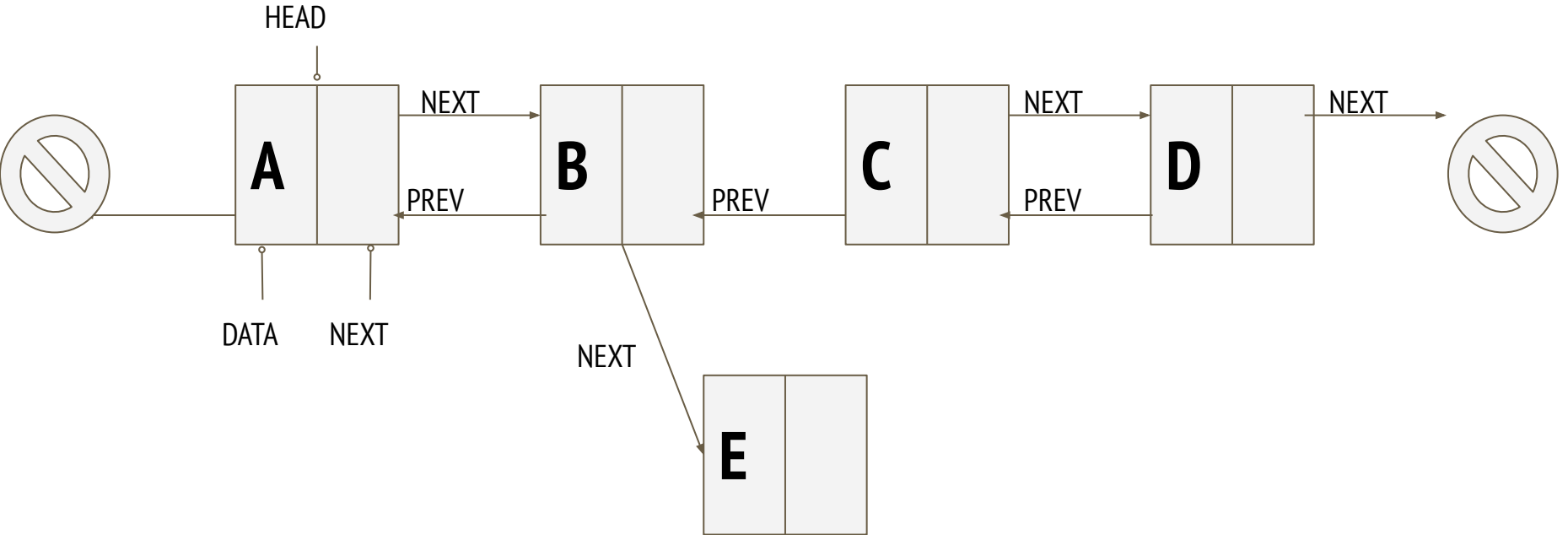
# Doubly Linked List

Add after node with data "B"



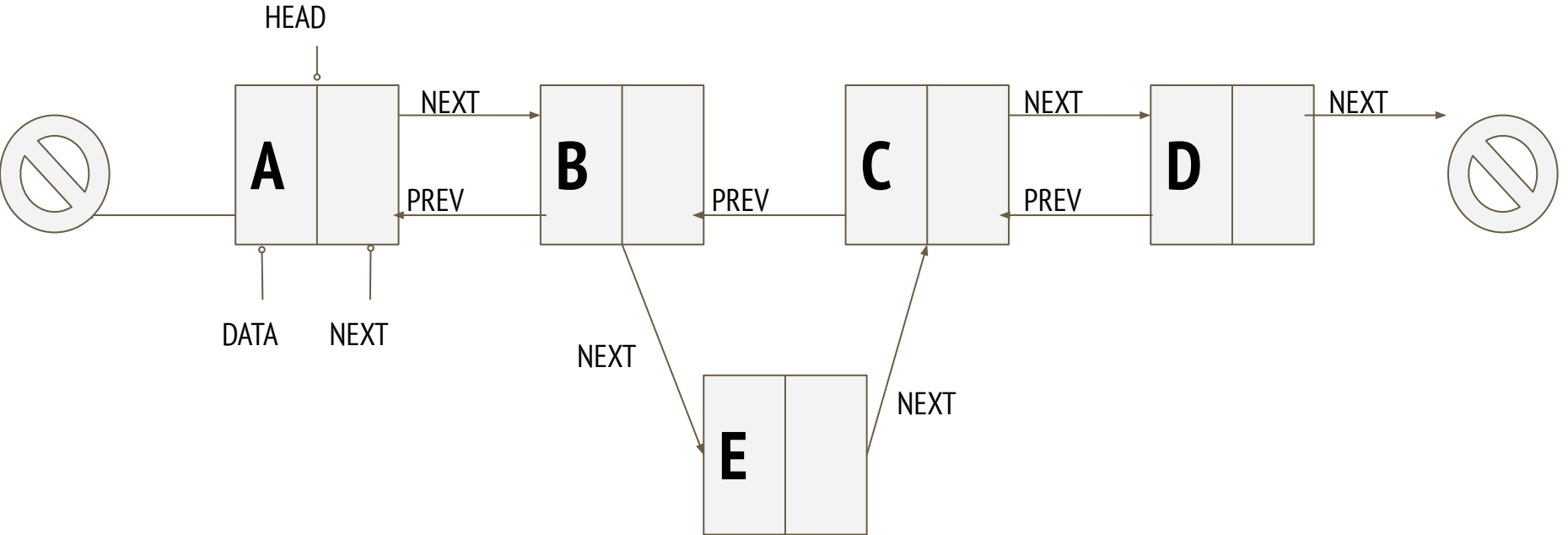
# Doubly Linked List

Add after node with data "B"



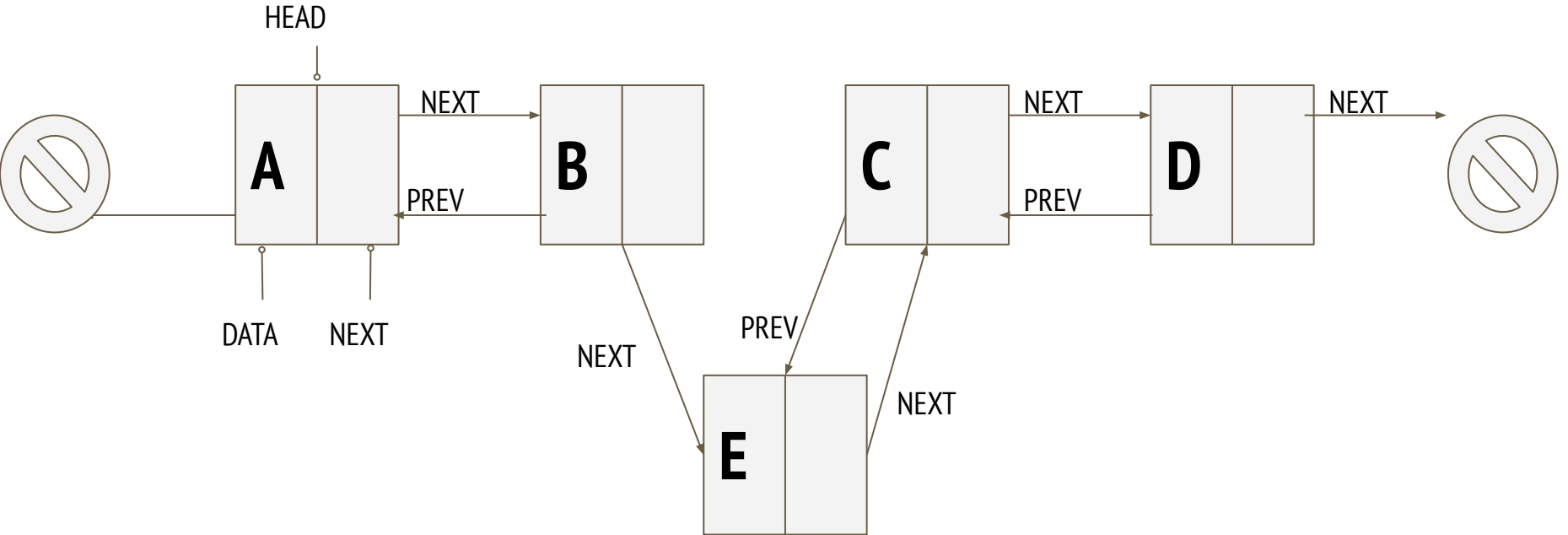
# Doubly Linked List

Add after node with data "B"



# Doubly Linked List

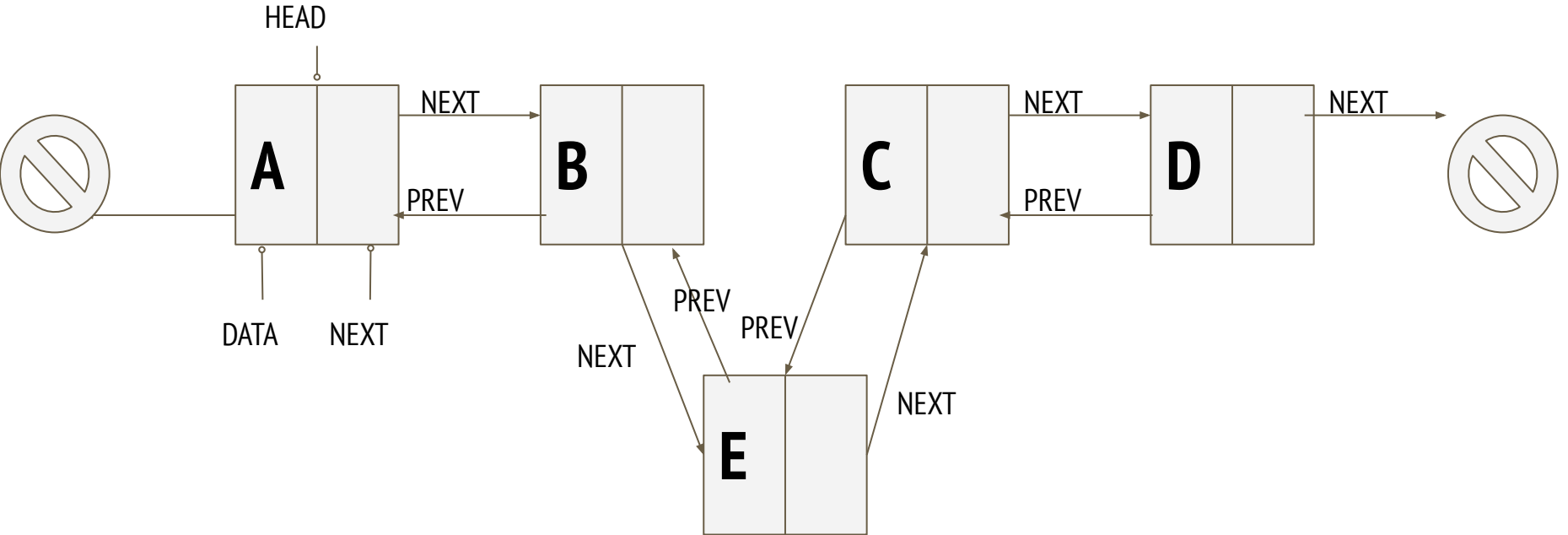
Add after node with data "B"





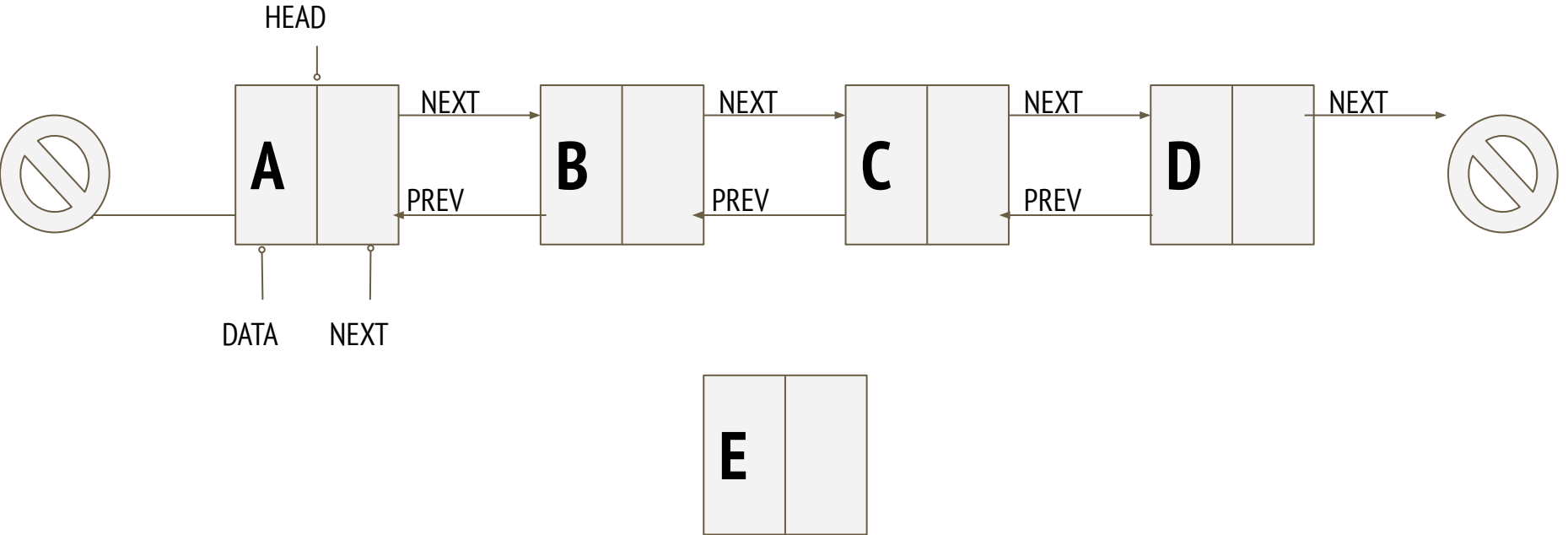
# Doubly Linked List

Add after node with data "B"



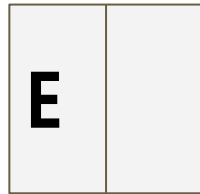
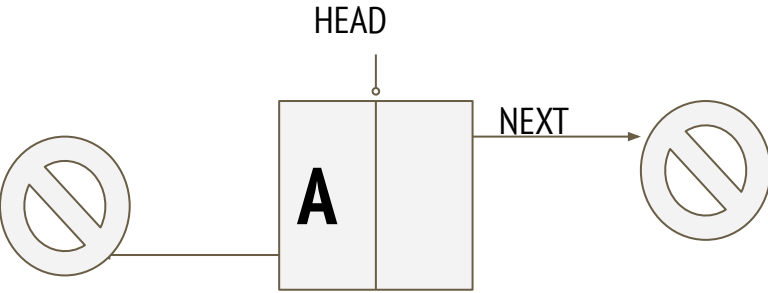
# **Doubly Linked Lists: Add before node**

# Doubly Linked List



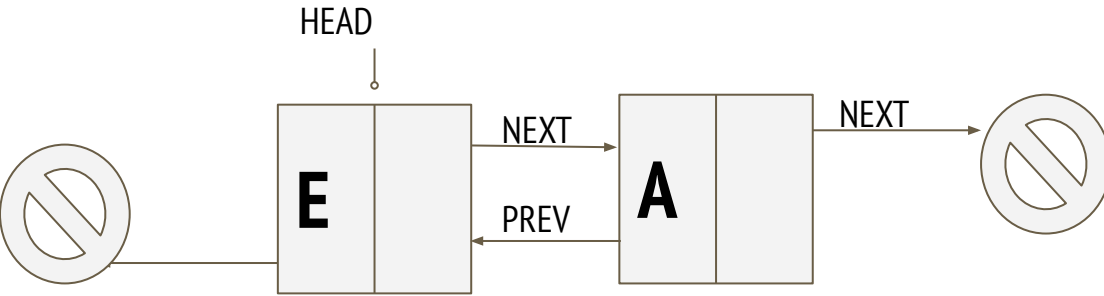
# Doubly Linked List

Add before node with data "A"



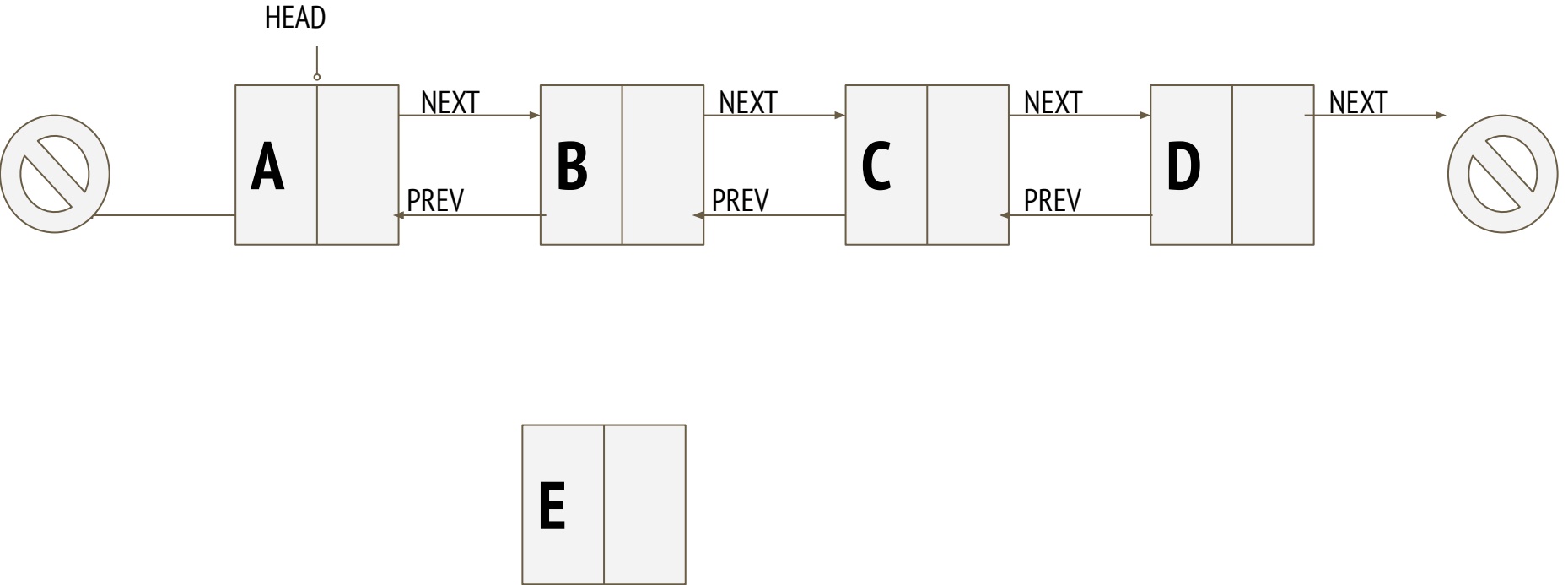
# Doubly Linked List

Add before node with data "A"  
Call to "prepend" function.



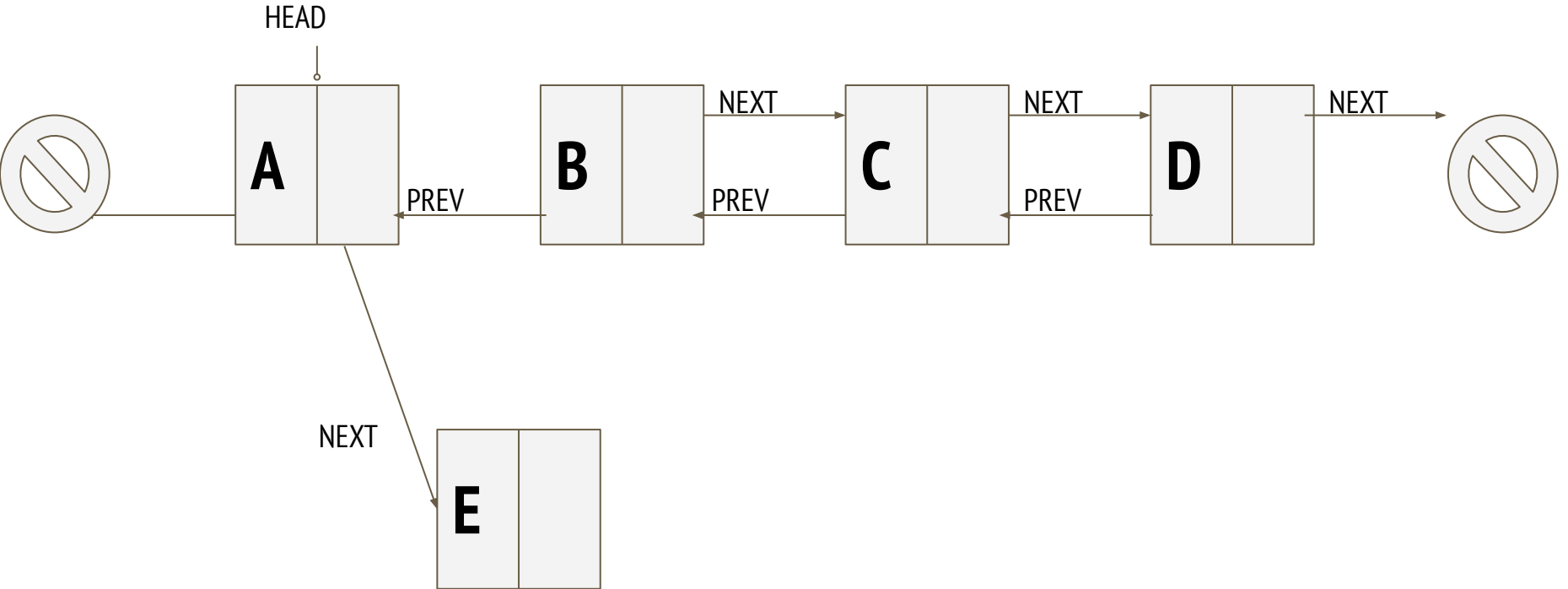
# Doubly Linked List

Add before node with data "B"



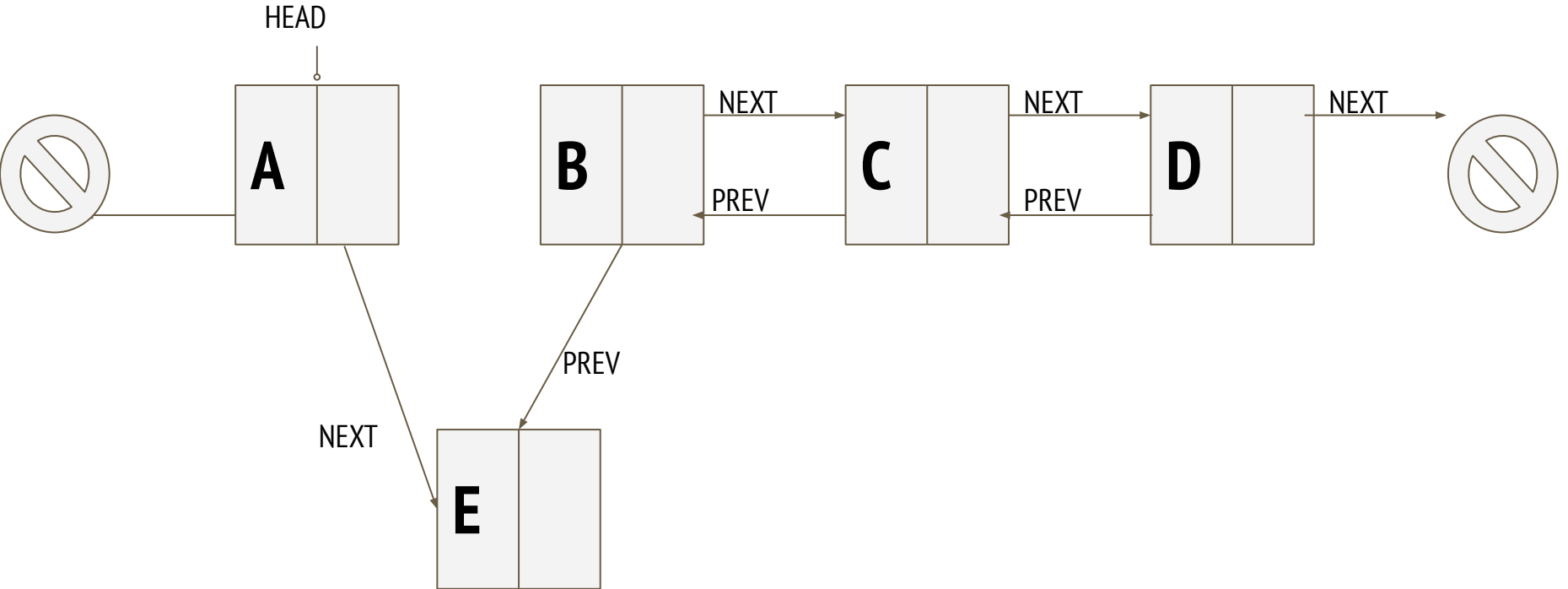
# Doubly Linked List

Add before node with data "B"



# Doubly Linked List

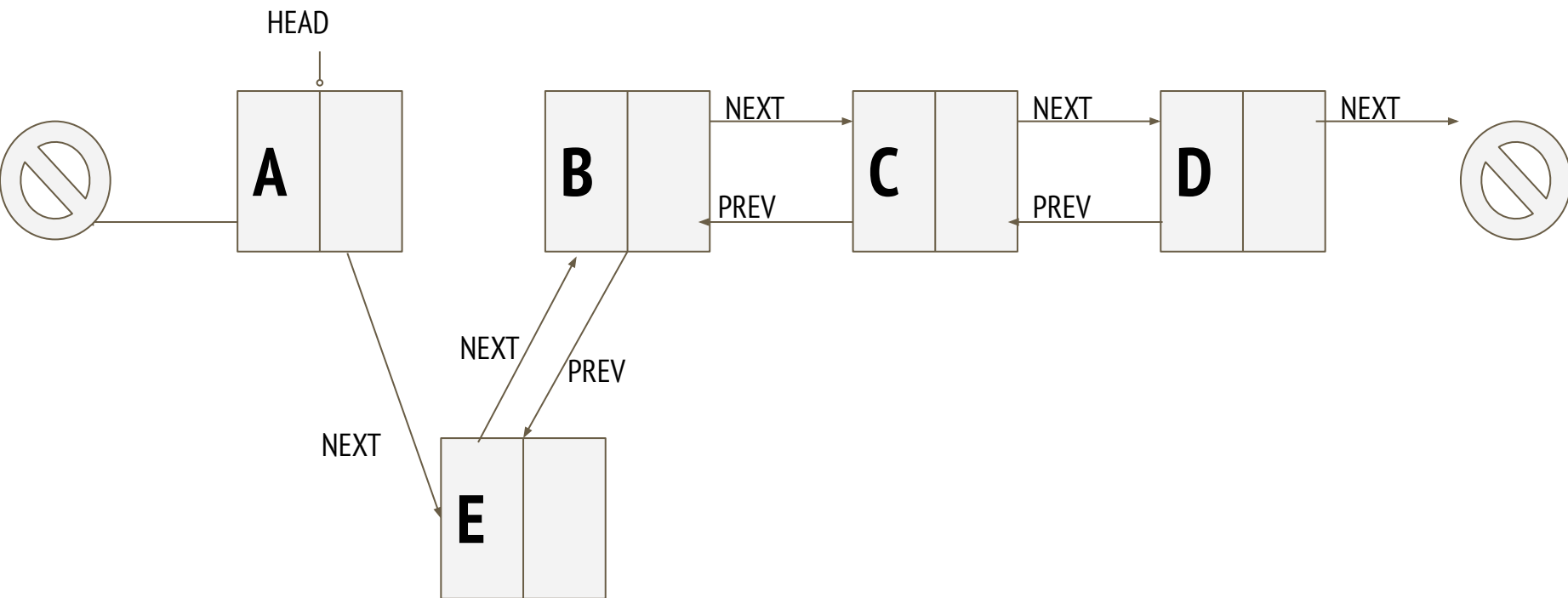
Add before node with data "B"





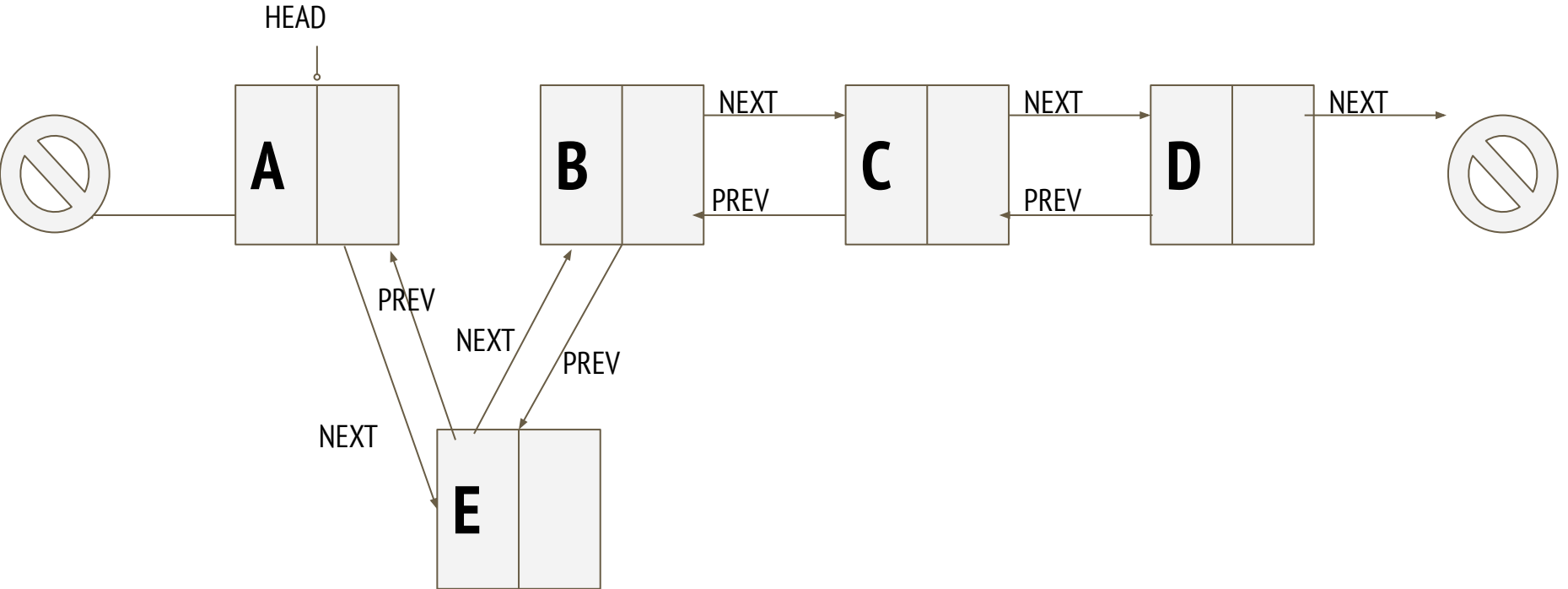
# Doubly Linked List

Add before node with data "B"



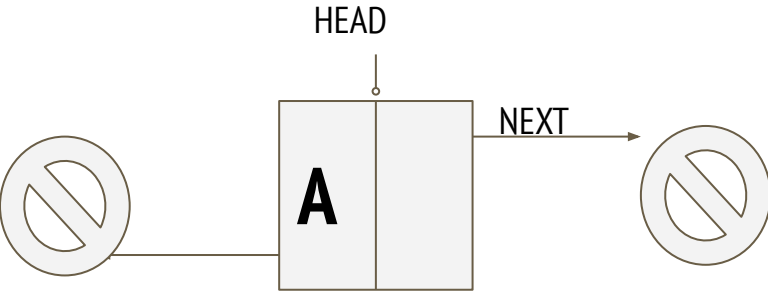
# Doubly Linked List

Add before node with data "B"



# Doubly Linked Lists: Delete node

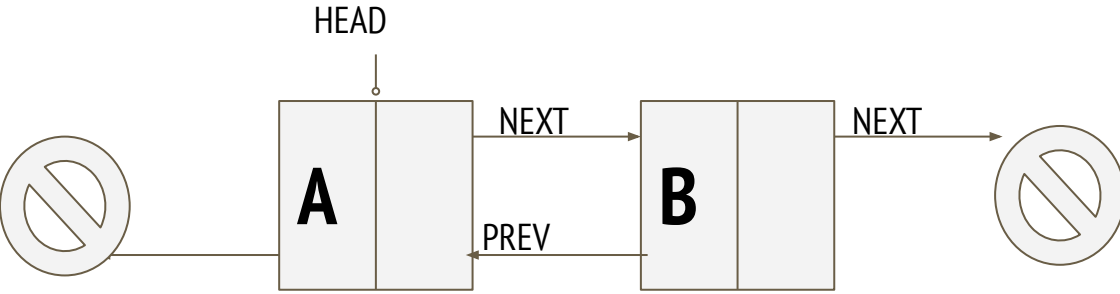
# Doubly Linked List: Delete -- Case 1



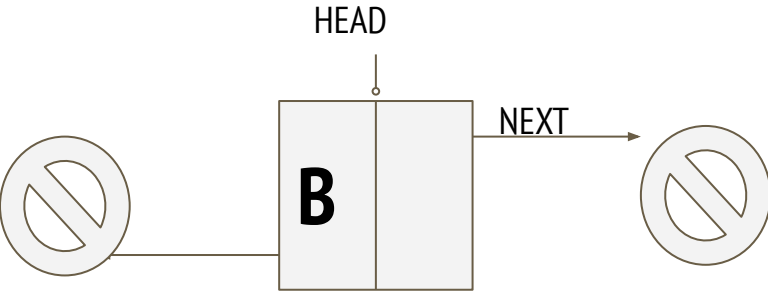
# Doubly Linked List: Delete -- Case 1



# Doubly Linked List: Delete -- Case 2

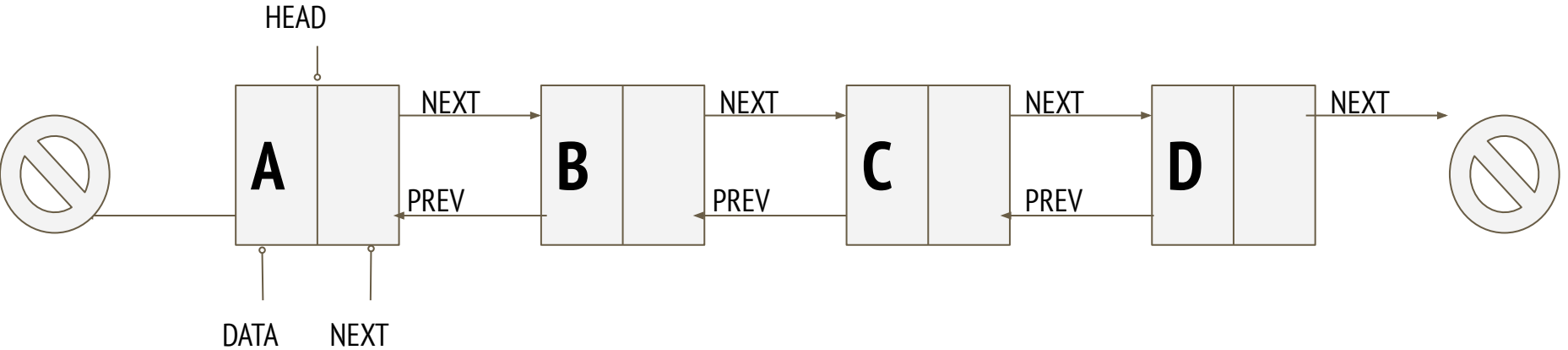


# Doubly Linked List: Delete -- Case 2



# Doubly Linked List: Delete -- Case 3

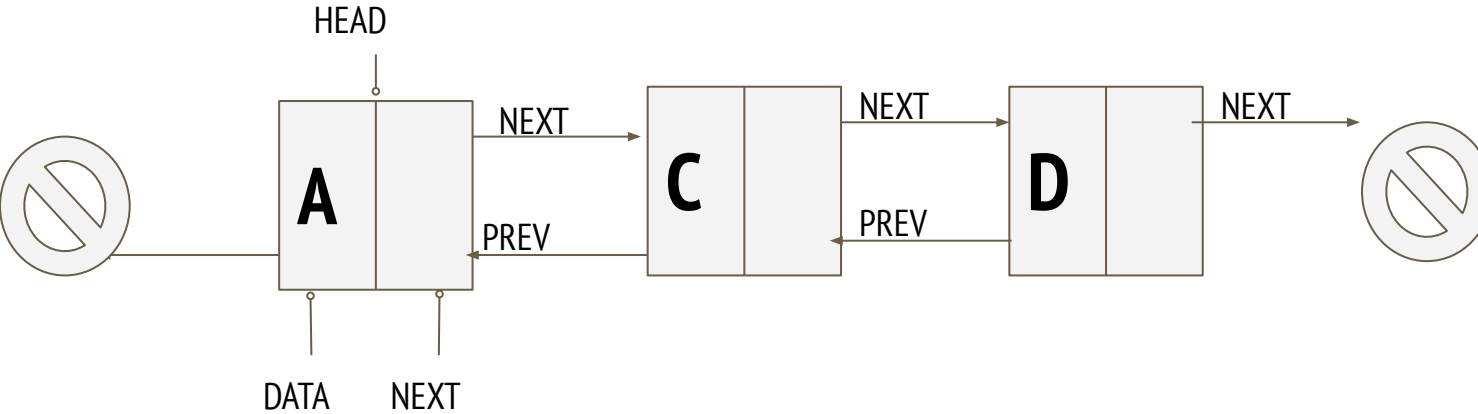
Cur.next is not None



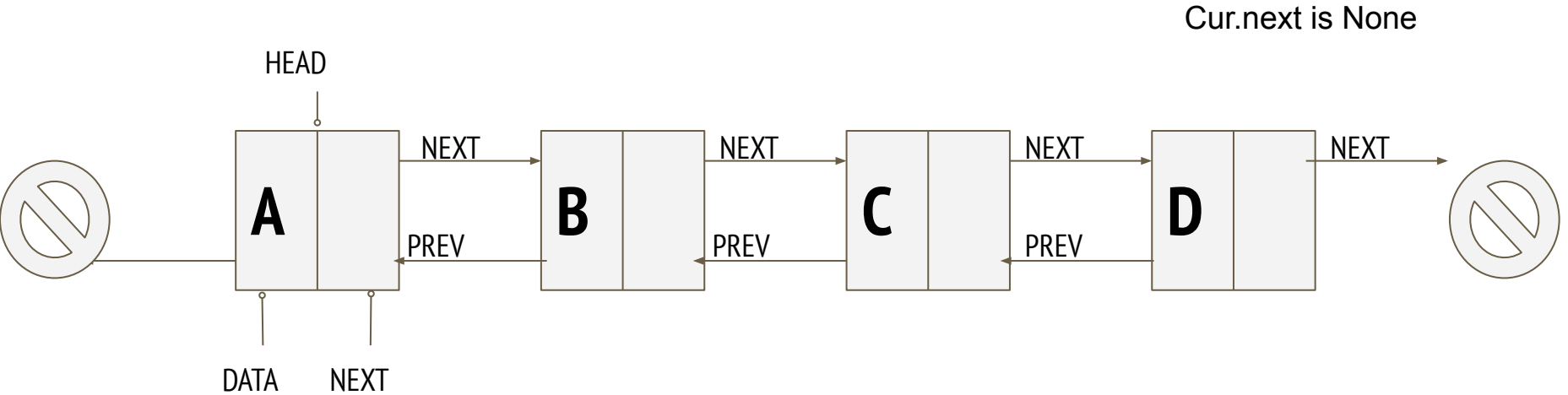


# Doubly Linked List: Delete -- Case 3

Cur.next is not None

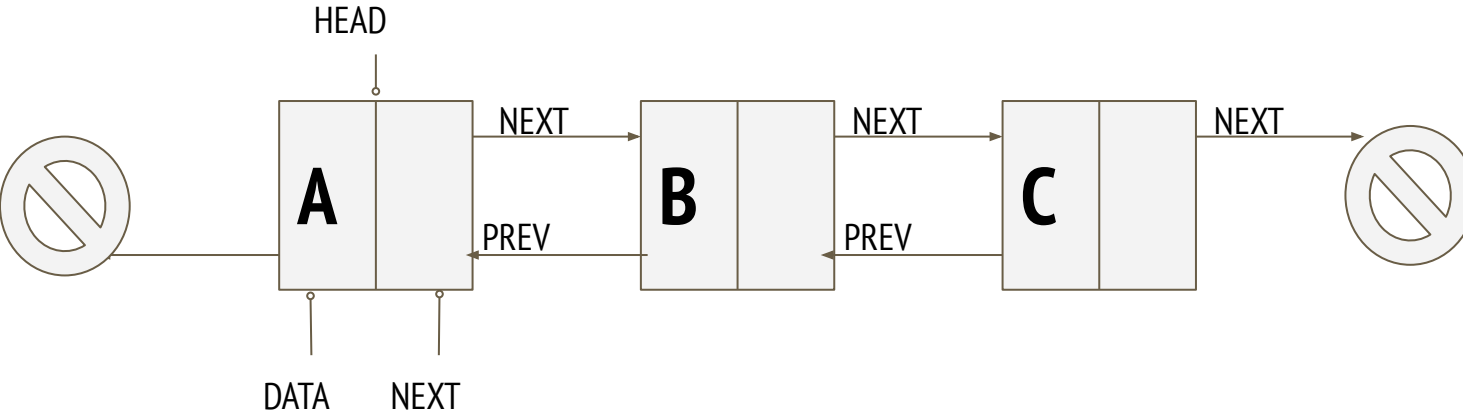


# Doubly Linked List: Delete -- Case 4



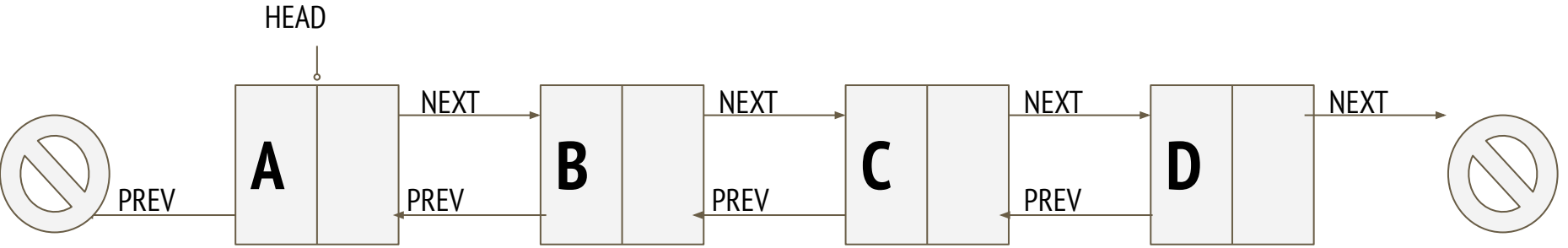
# Doubly Linked List: Delete -- Case 4

Cur.next is None

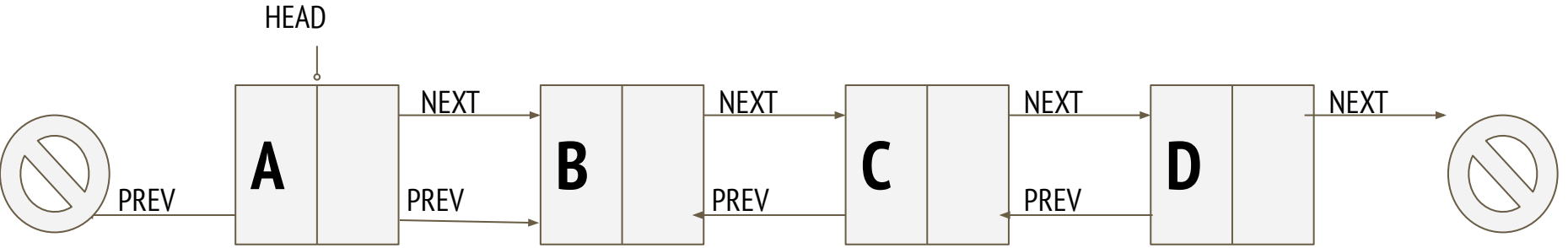


# Doubly Linked Lists: Reverse

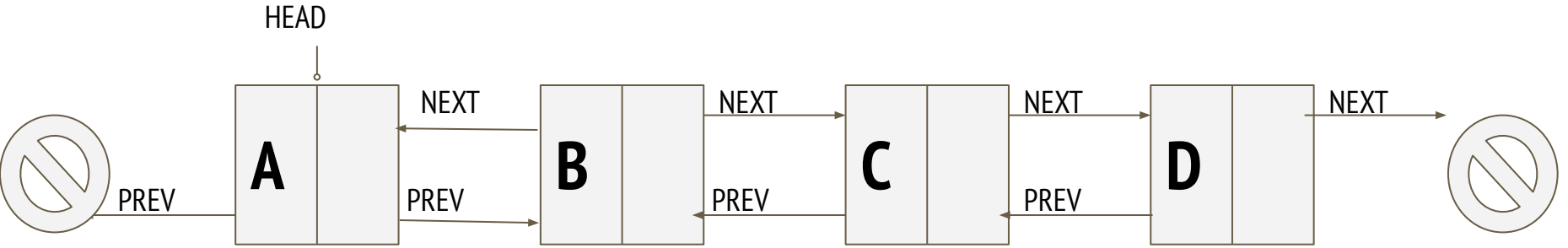
# Doubly Linked List: Reverse



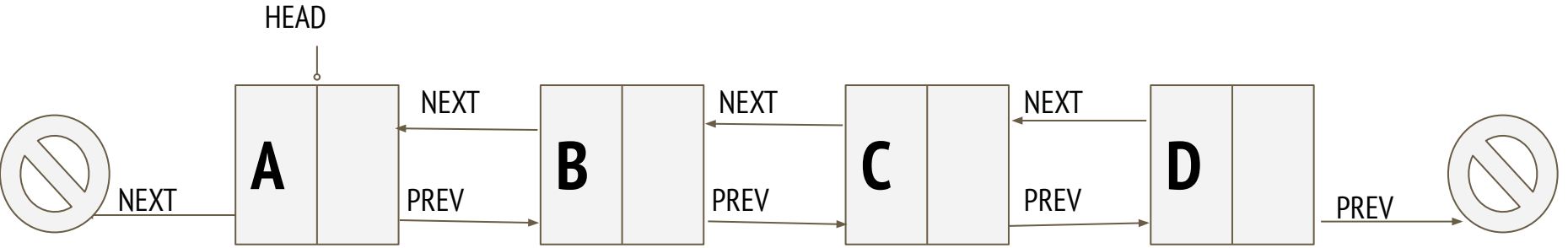
# Doubly Linked List: Reverse



# Doubly Linked List: Reverse



# Doubly Linked List: Reverse





# Doubly Linked List: Reverse

