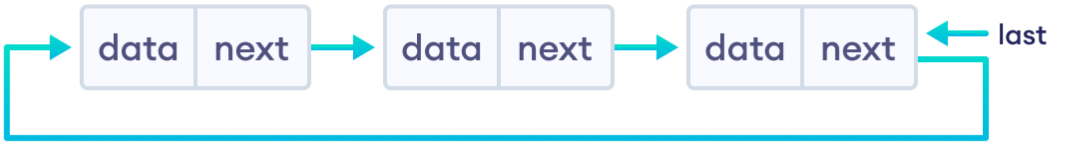
Circular Linked List

A circular linked list is a type of [linked list](#) in which the first and the last nodes are also connected to each other to form a circle.

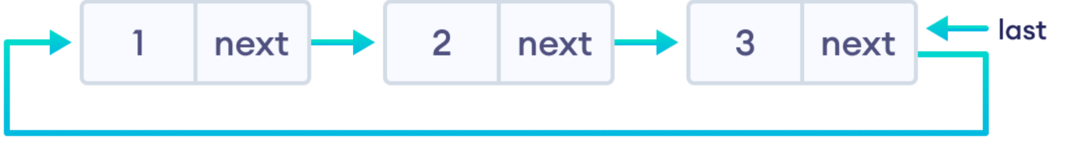
There are basically two types of circular linked list:

1. Circular Singly Linked List



2. Circular Doubly Linked List

Representation of Circular Linked List



```
struct Node {
    int data;
    struct Node * next;
};
```

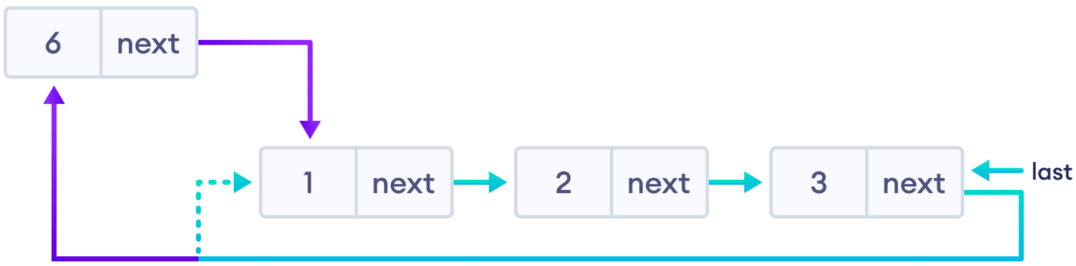
Insertion on a Circular Linked List

We can insert elements at 3 different positions of a circular linked list:

1. **Insertion at the beginning**
2. **Insertion in-between nodes**
3. **Insertion at the end**

1. Insertion at the Beginning

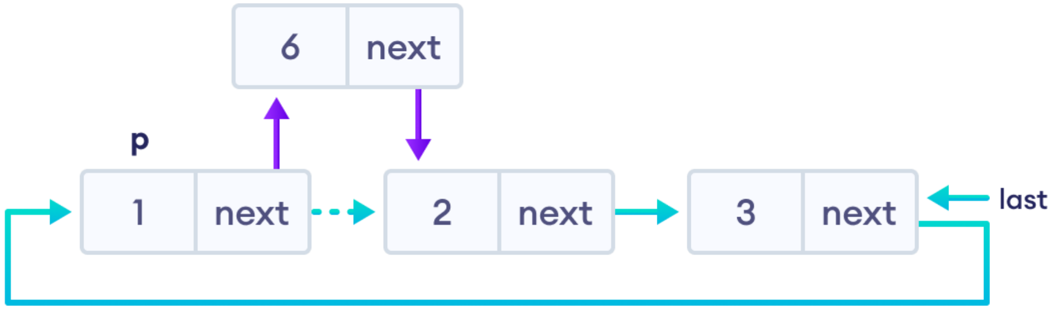
- store the address of the current first node in the `newNode` (i.e. pointing the `newNode` to the current first node)
- point the last node to `newNode` (i.e making `newNode` as head)



2. Insertion in between two nodes

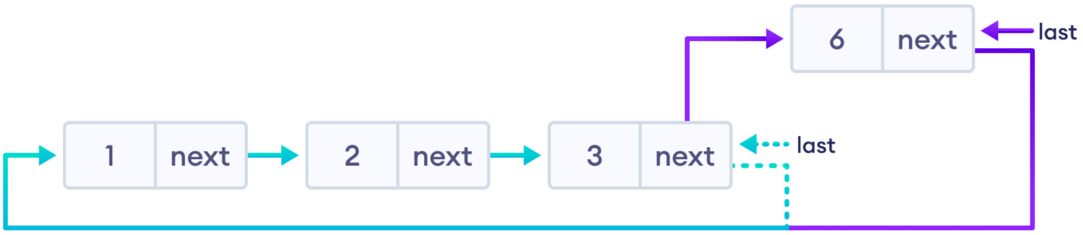
Let's insert newNode after the first node.

- travel to the node given (let this node be `p`)
- point the `next` of `newNode` to the node next to `p`
- store the address of `newNode` at `next` of `p`

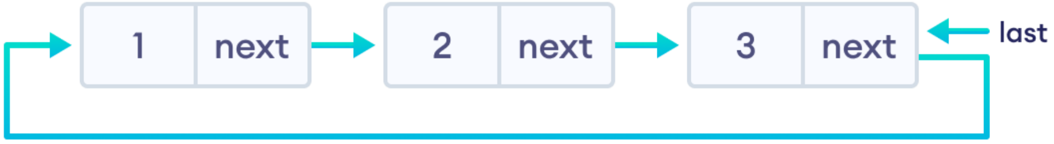


3. Insertion at the end

- store the address of the head node to `next` of newNode (making `newNode` the last node)
- point the current last node to `newNode`
- make `newNode` as the last node



Deletion on a Circular Linked List

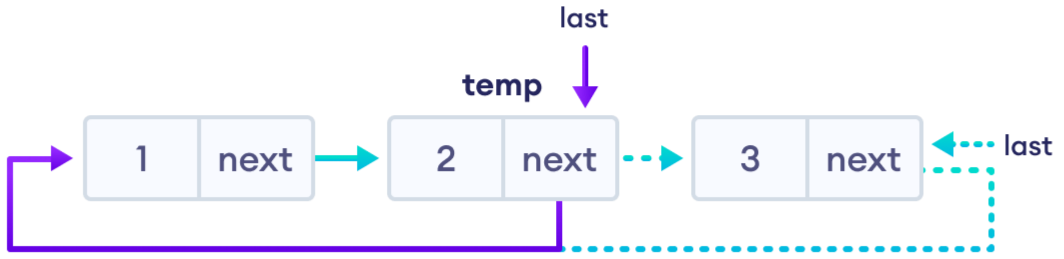


1. If the node to be deleted is the only node

- free the memory occupied by the node
- store NULL in `last`

2. If last node is to be deleted

- find the node before the last node (let it be `temp`)
- store the address of the node next to the last node in `temp`
- free the memory of last
- make `temp` as the last node



3. If any other nodes are to be deleted

- travel to the node to be deleted (here we are deleting node 2)
- let the node before node 2 be `temp`
- store the address of the node next to 2 in `temp`
- free the memory of 2

Program Implementation

```
// C++ code to perform circular linked list operations

#include <iostream>

using namespace std;

struct Node {
```

```
  int data;
  struct Node* next;
};
struct Node* addToEmpty(struct Node* last, int data) {
  if (last != NULL) return last;
  // allocate memory to the new node
 struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
  // assign data to the new node
 newNode->data = data;
  // assign last to newNode
 last = newNode;
  // create link to iteself
 last->next = last;
  return last;
}
// add node to the front
struct Node* addFront(struct Node* last, int data) {
  // check if the list is empty
  if (last == NULL) return addToEmpty(last, data);
  // allocate memory to the new node
  struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
  // add data to the node
  newNode->data = data;
  // store the address of the current first node in the newNode
  newNode->next = last->next;

  // make newNode as head
  last->next = newNode;
  return last;
}
// add node to the end
struct Node* addEnd(struct Node* last, int data) {
  // check if the node is empty
  if (last == NULL) return addToEmpty(last, data);
```

```
  // allocate memory to the new node
  struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
  // add data to the node
  newNode->data = data;
  // store the address of the head node to next of newNode
  newNode->next = last->next;
  // point the current last node to the newNode
  last->next = newNode;
  // make newNode as the last node
  last = newNode;
  return last;
}
// insert node after a specific node
struct Node* addAfter(struct Node* last, int data, int item) {
  // check if the list is empty
  if (last == NULL) return NULL;
  struct Node *newNode, *p;
  p = last->next;
  do {
  // if the item is found, place newNode after it
  if (p->data == item) {
    // allocate memory to the new node
    newNode = (struct Node*)malloc(sizeof(struct Node));
    // add data to the node
    newNode->data = data;
    // make the next of the current node as the next of newNode
    newNode->next = p->next;
    // put newNode to the next of p
    p->next = newNode;
    // if p is the last node, make newNode as the last node
    if (p == last) last = newNode;
    return last;
  }
```

```
 p = p->next;
  } while (p != last->next);
cout << "\nThe given node is not present in the list" << endl;
  return last;
}
// delete a node
void deleteNode(Node** last, int key) {
  // if linked list is empty
  if (*last == NULL) return;
  // if the list contains only a single node
  if ((*last)->data == key && (*last)->next == *last) {
  free(*last);
  *last = NULL;
  return;
  }
  Node *temp = *last, *d;
  // if last is to be deleted
  if ((*last)->data == key) {
  // find the node before the last node
  while (temp->next != *last) temp = temp->next;
  // point temp node to the next of last i.e. first node
  temp->next = (*last)->next;
  free(*last);
  *last = temp->next;
  }
  // travel to the node to be deleted
  while (temp->next != *last && temp->next->data != key) {
  temp = temp->next;
  }
  // if node to be deleted was found
  if (temp->next->data == key) {
  d = temp->next;
  temp->next = d->next;
  free(d);
```

```
 }
}
void traverse(struct Node* last) {
 struct Node* p;
 if (last == NULL) {
 cout << "The list is empty" << endl;
 return;
 }
 p = last->next;
 do {
 cout << p->data << " ";
 p = p->next;
 } while (p != last->next);
}

int main() {
 struct Node* last = NULL;
 last = addToEmpty(last, 6);
 last = addEnd(last, 8);
 last = addFront(last, 2);
 last = addAfter(last, 10, 2);
 traverse(last);
 deleteNode(&last, 8);
 cout << endl;
 traverse(last);
 return 0;
}
```

Circular Linked List Complexity

Circular Linked List Complexity	**Time Complexity**	**Space Complexity**
Insertion Operation	O(1) or O(n)	O(1)
Deletion Operation	O(1)	O(1)

Complexity of Insertion Operation

- The insertion operations that do not require traversal have the time complexity of `O(1)`.
- And, an insertion that requires traversal has a time complexity of `O(n)`.
- The space complexity is `O(1)`.

2. Complexity of Deletion Operation

- All deletion operations run with a time complexity of `O(1)`.
- And, the space complexity is `O(1)`.

Why Circular Linked List?

1. The NULL assignment is not required because a node always points to another node.
2. The starting point can be set to any node.
3. Traversal from the first node to the last node is quick.

Circular Linked List Applications

- It is used in multiplayer games to give a chance to each player to play the game.
- Multiple running applications can be placed in a circular linked list on an operating system. The os keeps on iterating over these applications.