Ordered Array

	Advantages	Disadvantages
Unordered array list	Insertion - O(1)	Search – O(n) Deletion – O(n) Fixed array size
Ordered array list	search –$O(\log_2 n)$	Insertion - O(n) Deletion - O(n) Fixed array size

Better performed when searches are more than insert

Disadvantage of using arrays to store data

- Disadvantages
  - arrays are static structures and therefore cannot be easily extended or reduced to fit the data set.
  - arrays are also expensive to maintain new insertions and deletions.
- In this presentation we consider another data structure called Linked Lists that addresses some of the limitations of arrays.

Linked Lists

- A linked list is a linear data structure where each element is a separate object.

- Each element (we will call it a **node**) of a list is comprising of two items
  - the **data** and a **reference** to the next node

LINKED REPRESENTATION

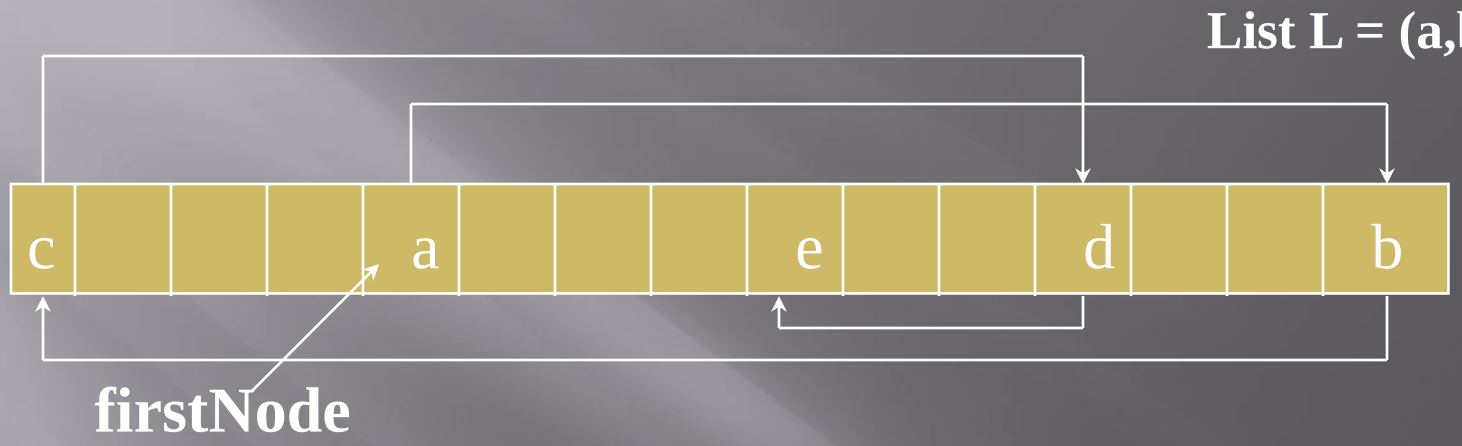
- list elements are stored, in memory, in an arbitrary order
- explicit information (**called a link)** is used to go from one element to the next

MEMORY LAYOUT

Layout of L = (a,b,c,d,e) using an array representation.

A linked representation uses an arbitrary layout.

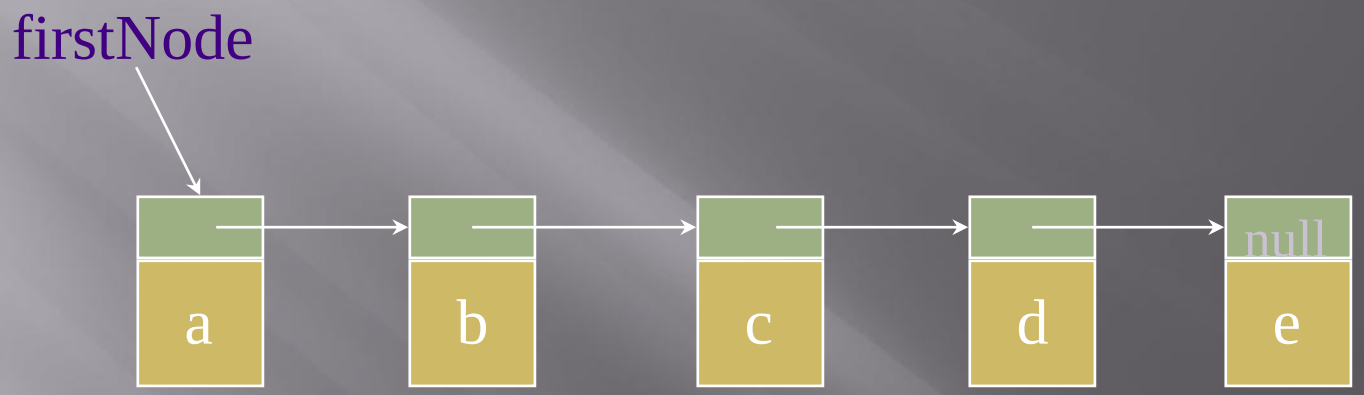
LINKED REPRESENTATION



pointer (or link) in **e** is **null**

use a variable **firstNode** to get to the first element a

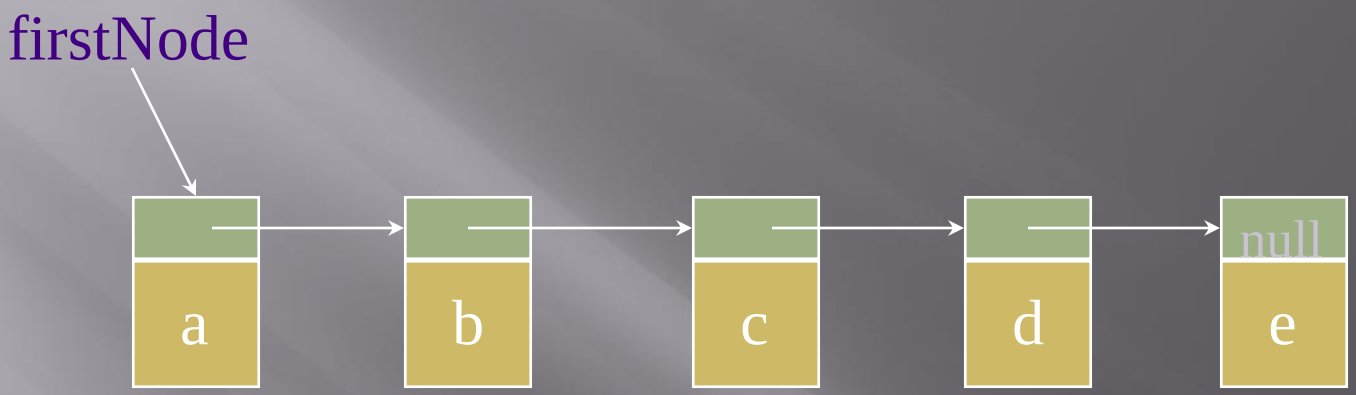
NORMAL WAY TO DRAW A LINKED LIST



link or pointer field of node

data field of node

LINKED LIST



- In a linked list each node represents one element.
- There is a link or pointer from one element to the next.
- The last node has a **null** pointer.

NODE REPRESENTATION

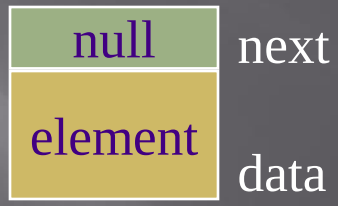
```
class Node
{
   // data members
   Object data;  // data field
   Node next;  // link field

   // constructors come here
}
```

CONSTRUCTORS OF LINKEDLIST NODE

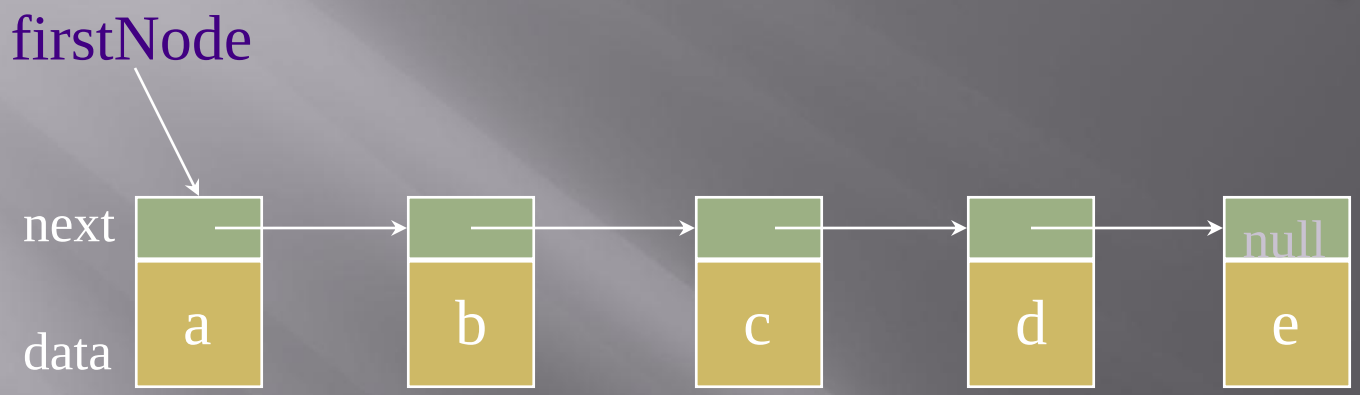
```
Node() {}
```


```
Node(Object element)
    {this.data= element;}
```



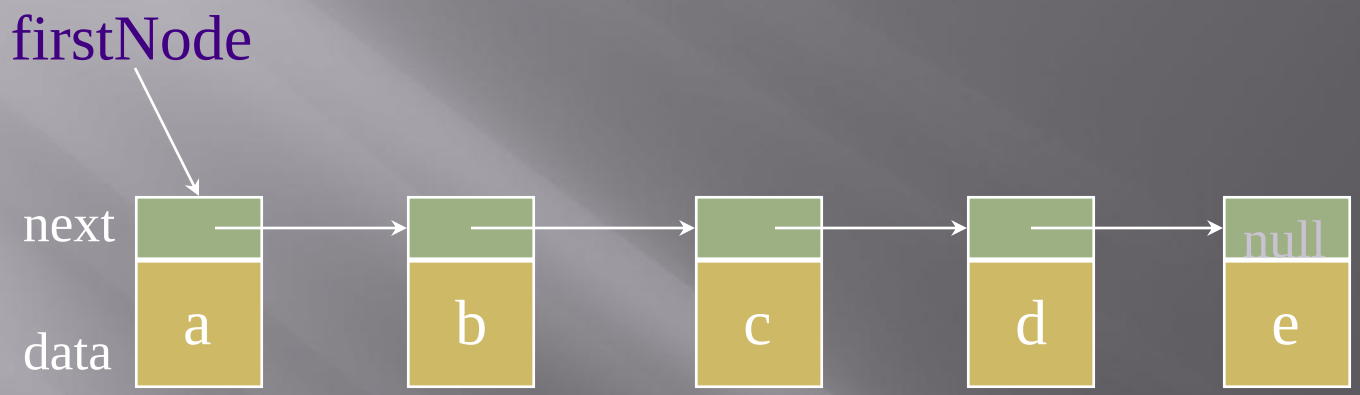

```
Node(Object element, Node addr)
{this.data = element;
 this.next = addr;}
```

GET FIRST ELEMENT: GET(0)



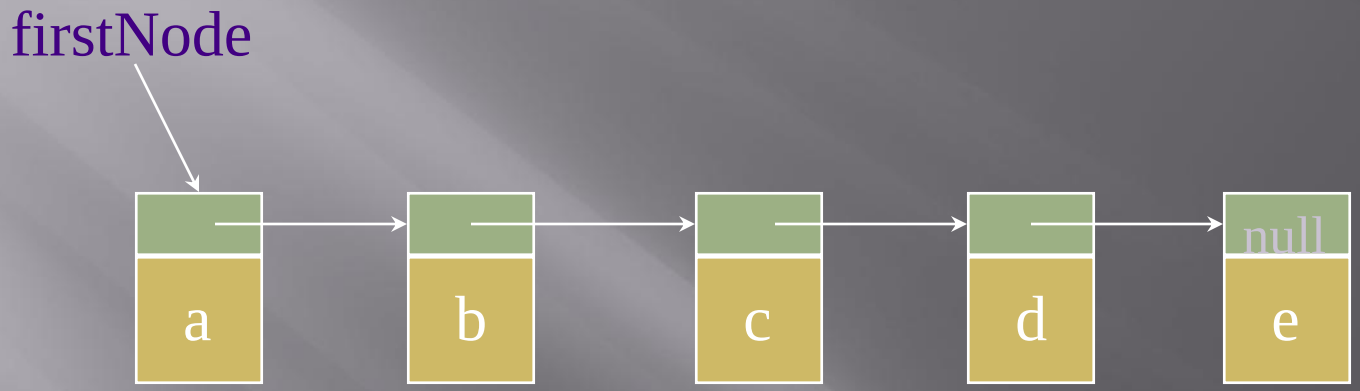

```
checkIndex(0);
return firstNode.data; // gets you to first node
        OR
checkIndex(0);
desiredNode = firstNode;
return desiredNode.data;
```

GET SECOND ELEMENT: GET(1)



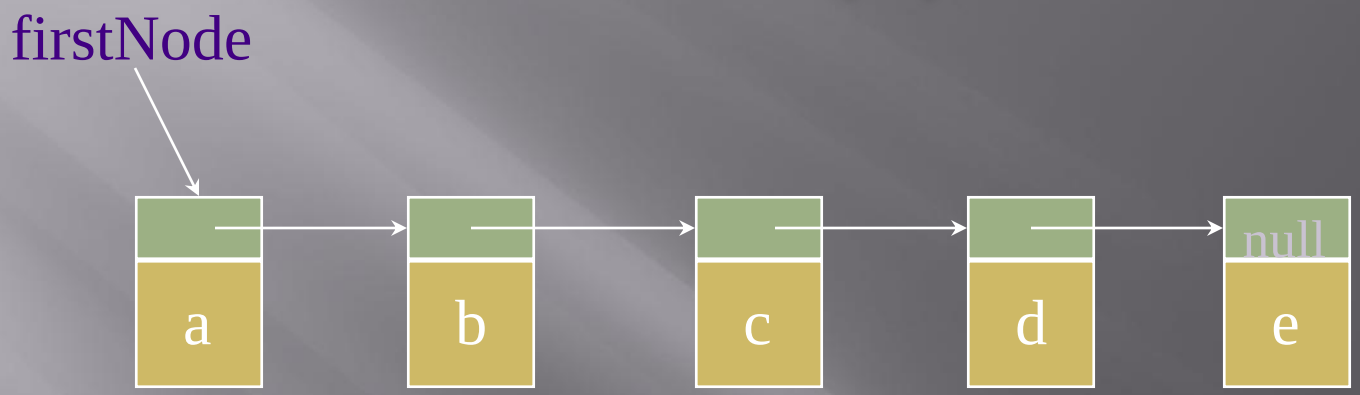

```
checkIndex(1);
desiredNode = firstNode.next; // gets you to second node
return desiredNode.data;
```

GET THIRD ELEMENT: GET(2)



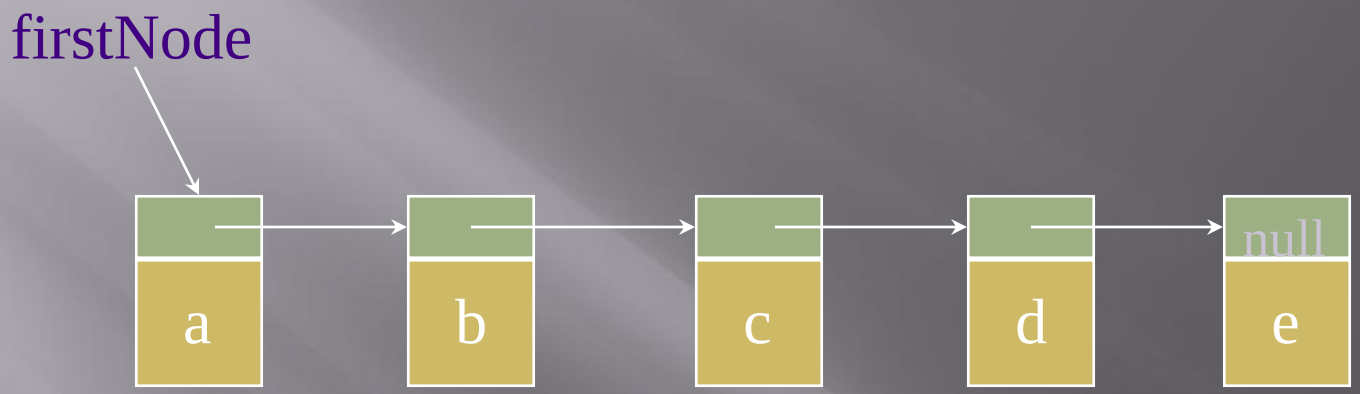

```
checkIndex(2);
desiredNode = firstNode.next.next; // gets you to third
    node
return desiredNode.data;
```

GET(5)



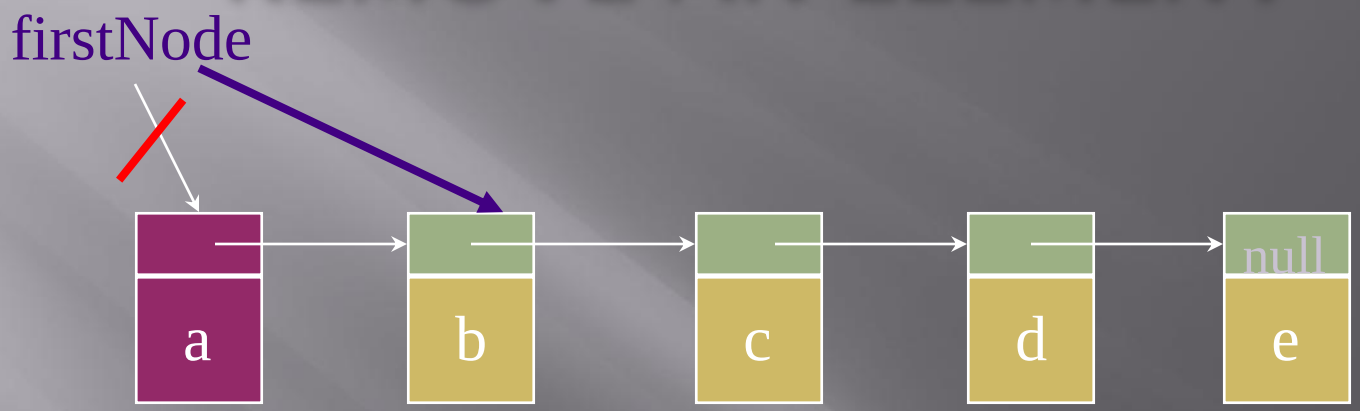

```
checkIndex(5);              // throws exception
desiredNode = firstNode.next.next.next.next.next;
                            // desiredNode = null
return desiredNode.data;    // null.data
```

NULL POINTER EXCEPTION




```
desiredNode =
    firstNode.next.next.next.next.next.next;
      // gets the computer mad
      // you get a NullPointerException
```

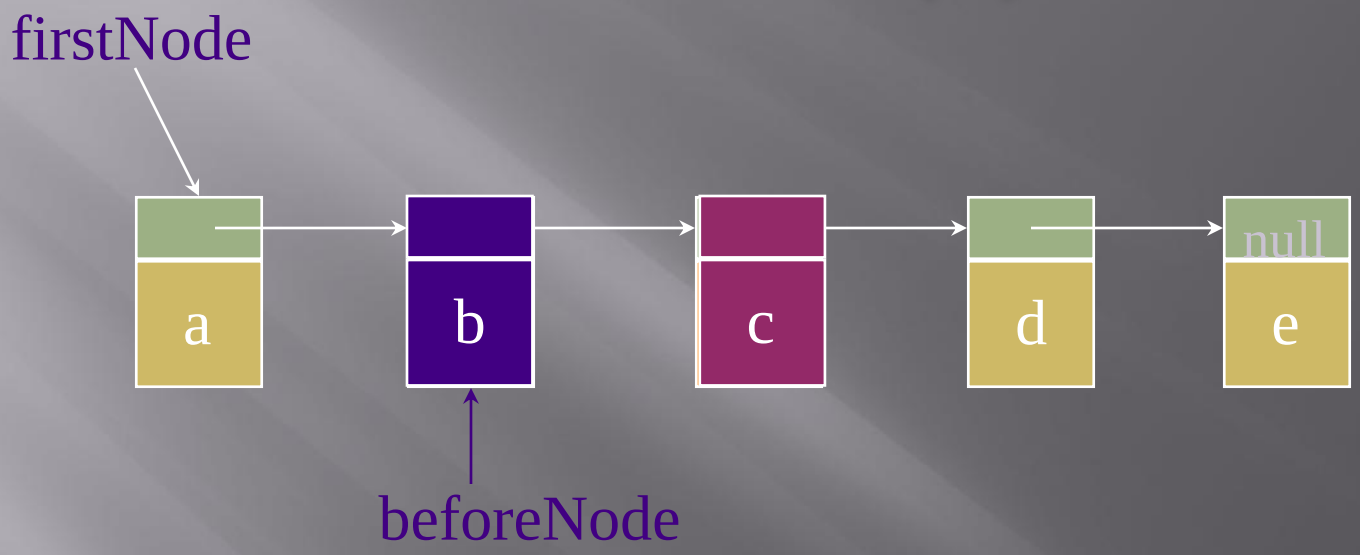
REMOVE AN ELEMENT



remove(0)

firstNode = firstNode.next;

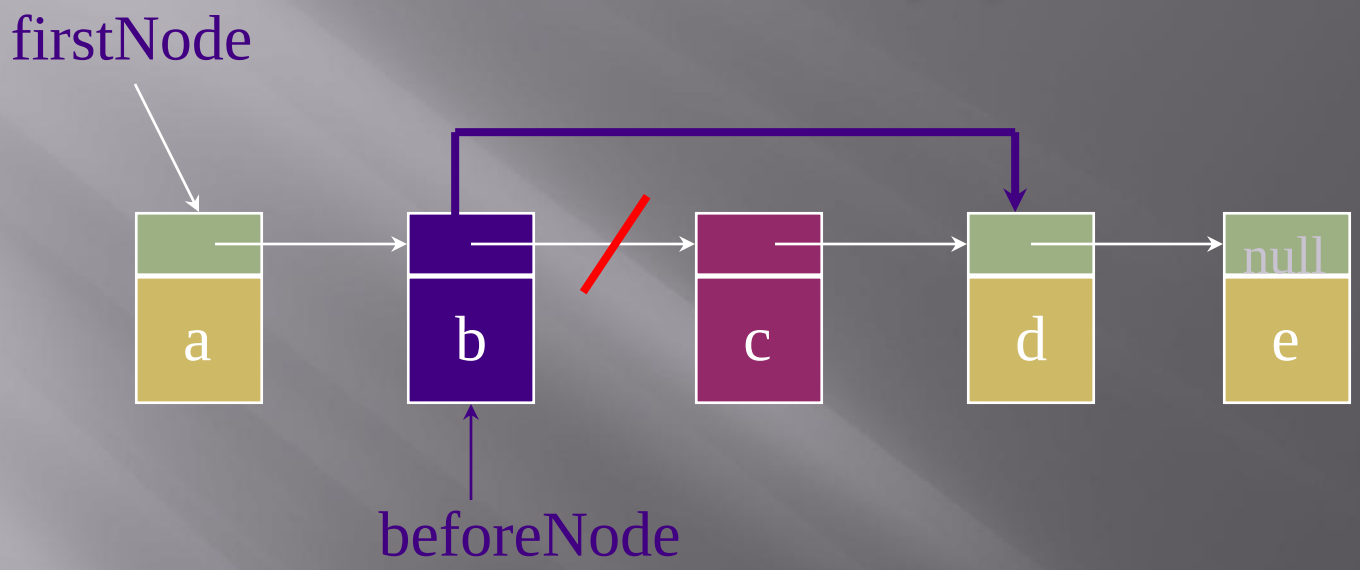
REMOVE(2)



first get to node just before node to be removed

beforeNode = firstNode.next;

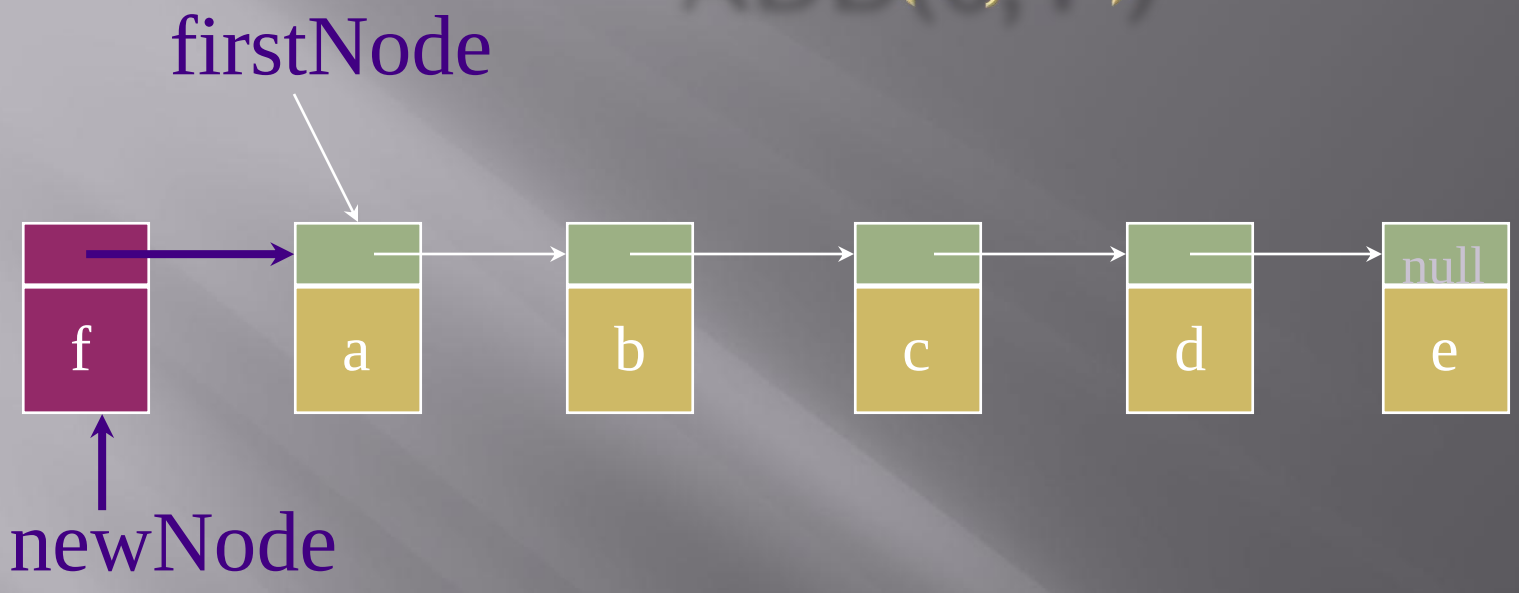
REMOVE(2)



now change pointer in beforeNode

beforeNode.next = beforeNode.next.next;

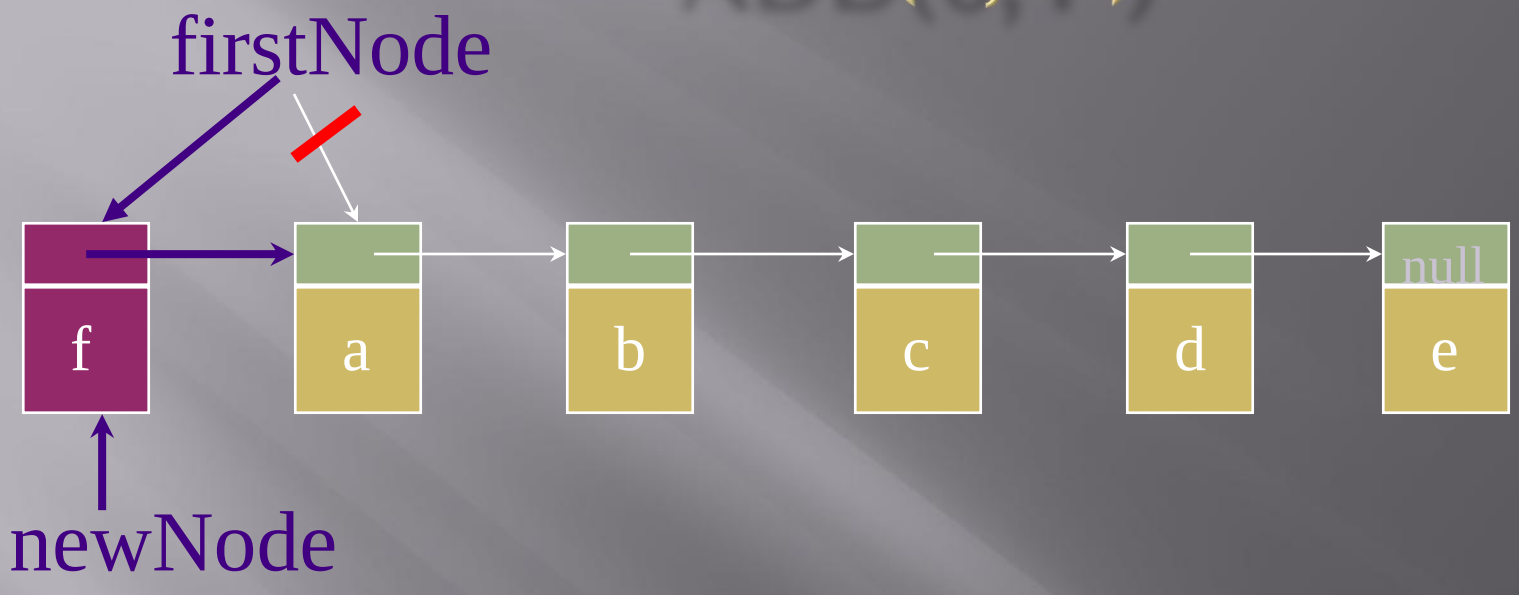
ADD(0,'F')



Step 1: get a new node, set its data and link fields

```
Node newNode =
  new Node(new Character('f'), firstNode);
```

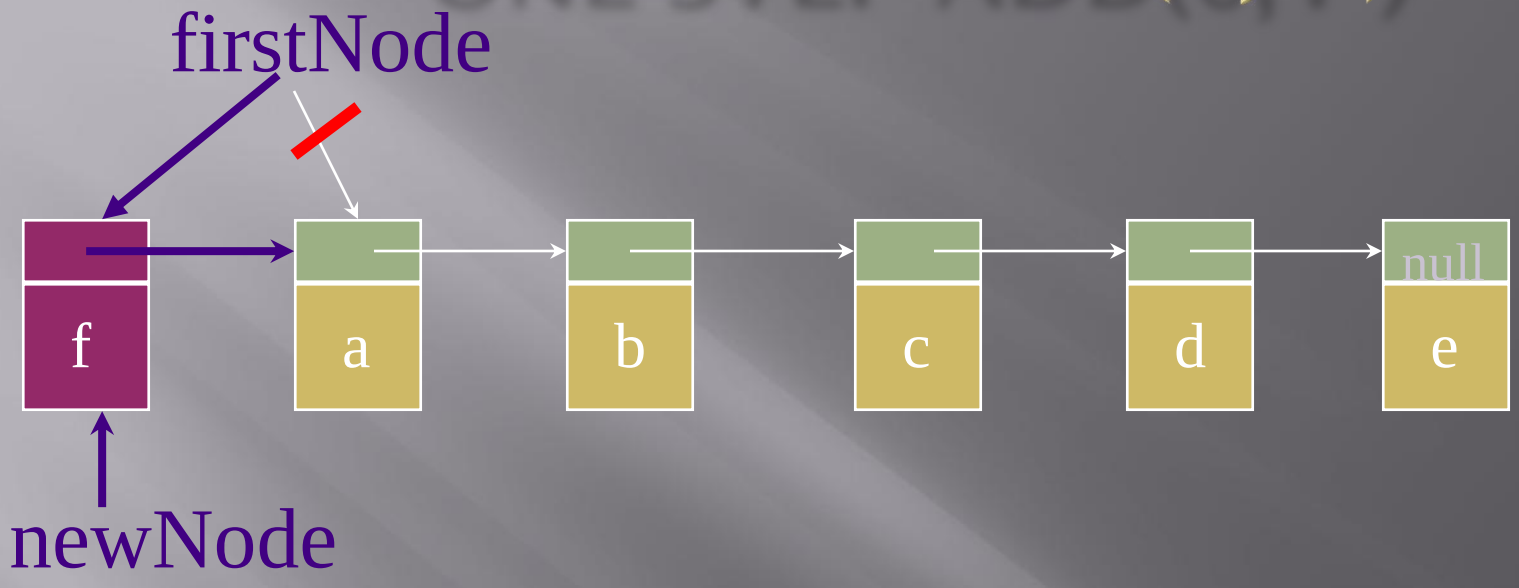
ADD(0,'F')



Step 2: update firstNode

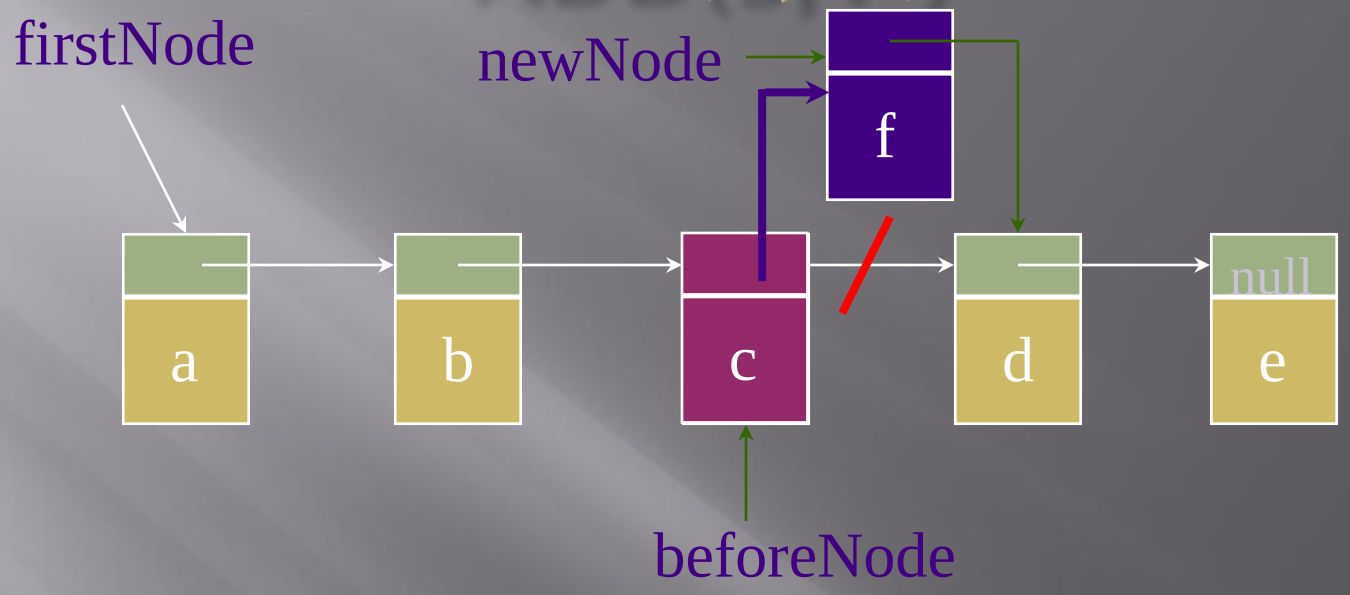
firstNode = newNode;

ONE-STEP ADD(0,'F')



firstNode = new Node(new Character('f'),
firstNode);

ADD(3,'F')



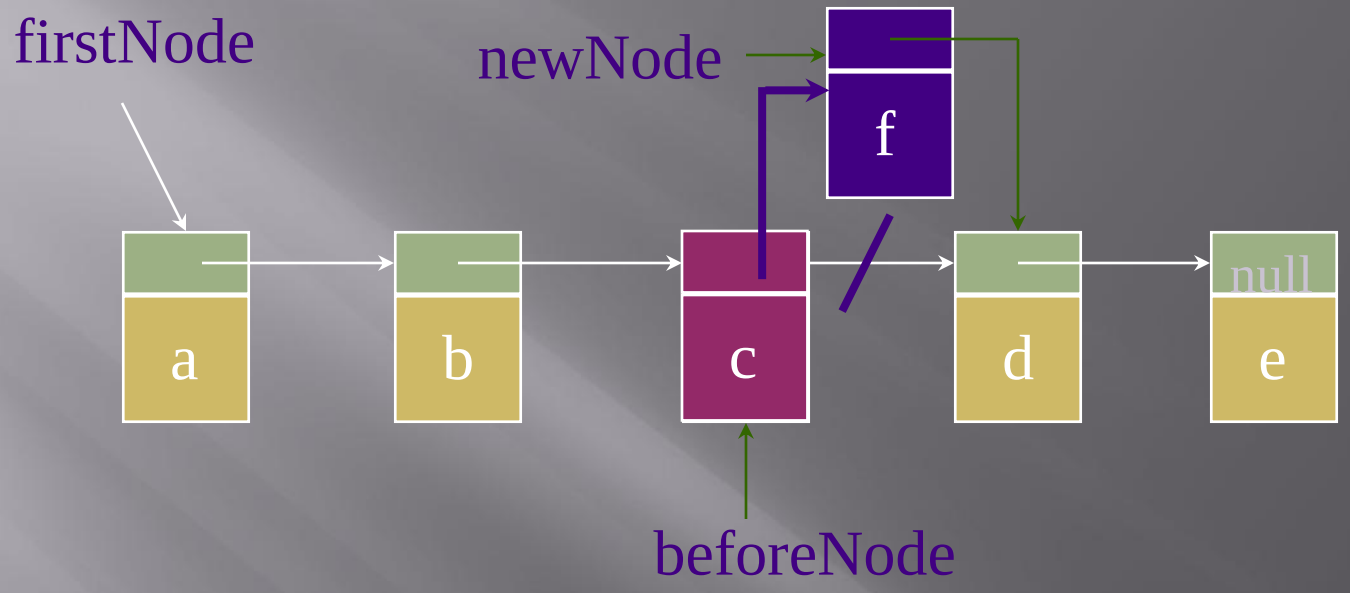
- first find node whose index is 2
- next create a node and set its data and link fields

```
Node newNode = new Node(new Character('f'), beforeNode.next);
```

- finally link beforeNode to newNode

```
beforeNode.next = newNode;
```

TWO-STEP ADD(3,'F')



beforeNode = firstNode.next.next;

beforeNode.next = new Node(new Character('f'),
beforeNode.next);

Remember

- A linked list is a dynamic data structure. The number of nodes in a list is not fixed and can grow and shrink on demand.
- Any application which has to deal with an unknown number of objects will need to use a linked list.
- One disadvantage against an array is that
  - it does not allow direct access to the individual elements. If you want to access a particular item then you have to start at the head and follow the references until you get to that item.