Singly Linked Lists

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IIIT, Delhi

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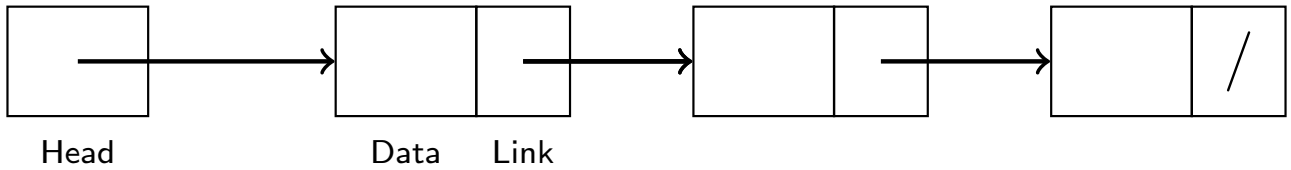
Linked List

Linked List (Recap)



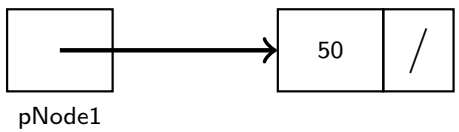
- A linked list is a series of connected nodes.
- Each node contains at least
  - A piece of data (any type)
  - Link to the next node in the list
- Head: points to the first node
- Links are generated by system.
- The last node points to **nil**.

Defining a Node in C (Recap)

```
typedef struct Node {
   int nData;
   struct Node *pNext;
} Node;

int main() {
   Node Node1, *pNode1;
   .
   .
   .
```

Creating Two Nodes

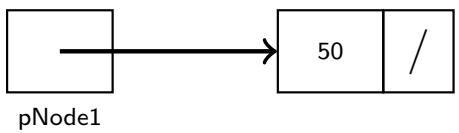
- Creating a node with value 50:



Creating Two Nodes

- Creating a node with value 50:

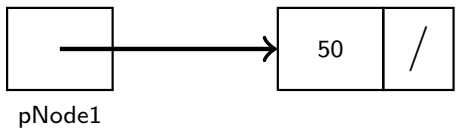
```
Node *pNode1 = NULL;

pNode1 = (Node *)malloc(sizeof(Node));
pNode1->nData = 50;

pNode1->pNext = NULL;
```



Creating Two Nodes

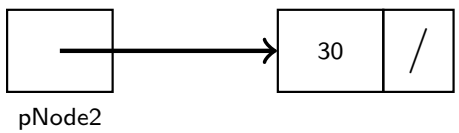
- Creating a node with value 50:

```
Node *pNode1 = NULL;

pNode1 = (Node *)malloc(sizeof(Node));
pNode1->nData = 50;

pNode1->pNext = NULL;
```

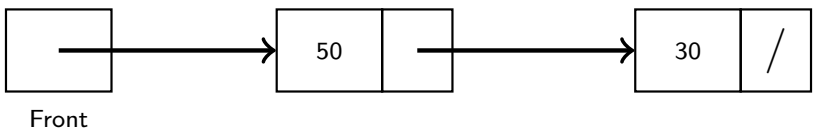


- Similarly creating a node with value 30:

```
Node *pNode2 = NULL;

pNode2 = (Node *)malloc(sizeof(Node));
pNode2->nData = 30;

pNode2->pNext = NULL;
```

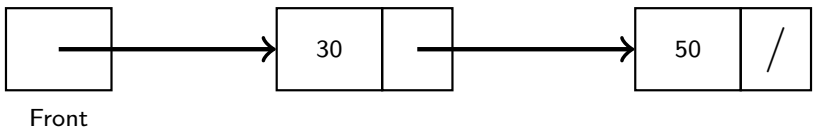


Linked List With First Node Followed By Second Node

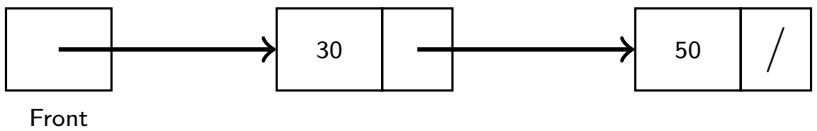



```
Node *pFront = NULL;

pFront = pNode1;
pFront->pNext = pNode2;
```

Linked List With Second Node Followed By First Node



Linked List With Second Node Followed By First Node



Node *pFront = NULL;

pFront = pNode2;

pFront->pNext = pNode1;

Inserting a Node in a Linked List

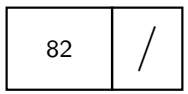
Inserting a Node at the Front of a List

Inserting a node containing value 82 at the front of the linked list.

Inserting a Node at the Front of a List

Inserting a node containing value 82 at the front of the linked list.

- First form a new node with value 82 and pointing to null.

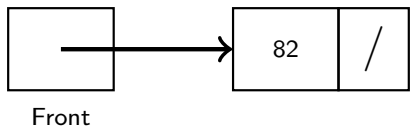



```
Node *pTemp = NULL;

pTemp = (Node *)malloc(sizeof(Node));
pTemp->nData = 82;

pTemp->pNext = Null;
```

Inserting a Node at the Front of a List

Inserting a node containing value 82 at the front of the linked list.

- First form a new node with value 82 and pointing to null.
- **Empty List:** The new node becomes the Front node.

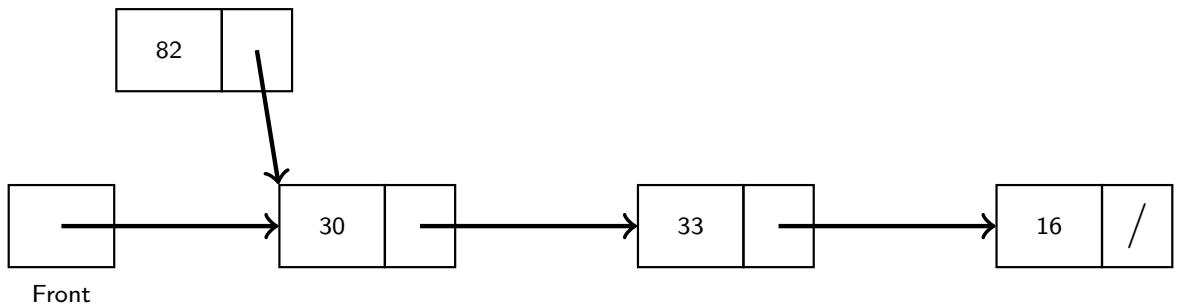



```
if (ppFront == NULL)
  pFront = pTemp;
```

Inserting a Node at the Front of a List

Inserting a node containing value 82 at the front of the linked list.

- First form a new node with value 82 and pointing to null.
- **Otherwise:**
  - Link node 82 to Front (node containing 50).

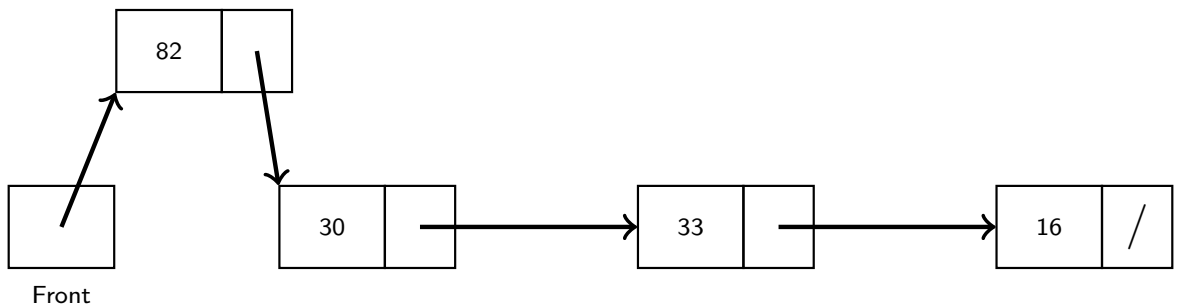



```
if (ppFront == NULL)
  pFront = pTemp;
else
  pTemp->pNext = pFront;
```

Inserting a Node at the Front of a List

Inserting a node containing value 82 at the front of the linked list.

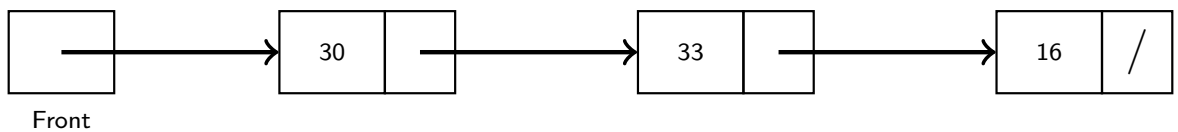
- First form a new node with value 82 and pointing to null.
- **Otherwise:**
  - Link node 82 to Front (node containing 50).
  - Finally, we declare node 82 to be the new Front node.




```
if (ppFront == NULL)
  pFront = pTemp;
else
  pTemp->pNext = pFront;

  pFront = pTemp;
```

Inserting a Node at Rear of a List

Insert a node containing the value 82 at the rear of the linked list.



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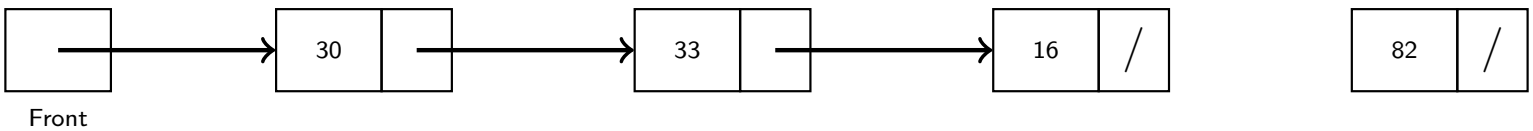
- First form a new node with value 82 and pointing to null.

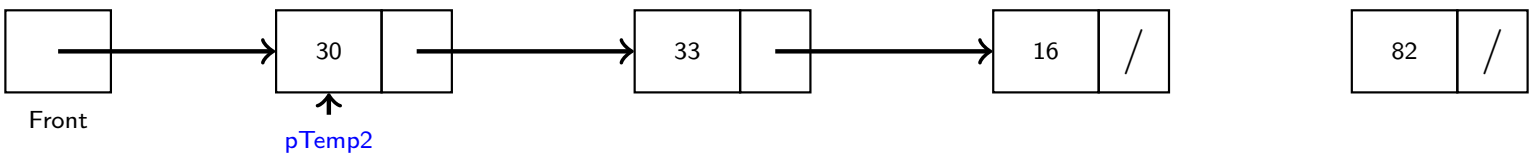



```
Node *pTemp1 = NULL, *pTemp2 = NULL;

pTemp1 = (Node *)malloc(sizeof(Node));
pTemp1->nData = 82;

pTemp1->pNext = Null;
```

Inserting a Node at Rear of a List

Insert a node containing the value 82 at the rear of the linked list.

- First form a new node with value 82 and pointing to null.
- **Empty List:** The new node becomes the Front node.
- Traverse through the list to reach the last node.




```
if (pFront == NULL)
  pFront = pTemp1;
else {
  pTemp2 = pFront;
```

Inserting a Node at Rear of a List

Insert a node containing the value 82 at the rear of the linked list.

- First form a new node with value 82 and pointing to null.
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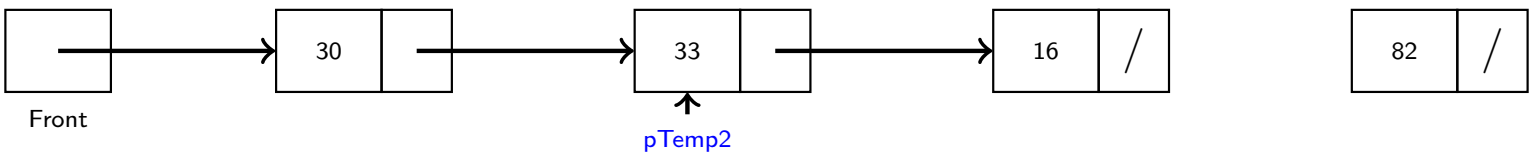


```
if (pFront == NULL)
  pFront = pTemp1;
else {
  pTemp2 = pFront;

  while (pTemp2->pNext != NULL)
    pTemp2 = pTemp2->pNext;
```

Inserting a Node at Rear of a List

Insert a node containing the value 82 at the rear of the linked list.

- First form a new node with value 82 and pointing to null.
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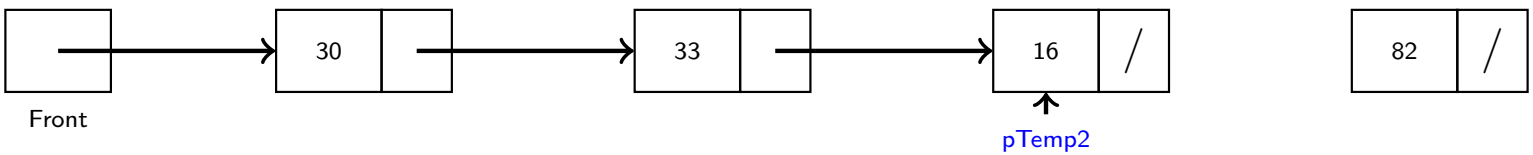
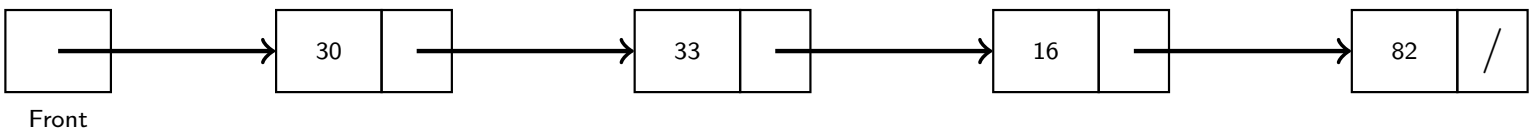



```
if (pFront == NULL)
  pFront = pTemp1;
else {
  pTemp2 = pFront;

  while (pTemp2->pNext != NULL)
    pTemp2 = pTemp2->pNext;
```

Inserting a Node at Rear of a List

Insert a node containing the value 82 at the rear of the linked list.

- First form a new node with value 82 and pointing to null.
- **Empty List:** The new node becomes the Front node.
- Traverse through the list to reach the last node.
- Point the last node to the newly formed node with value 82.

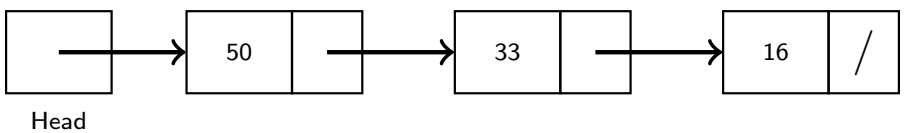



```
if (pFront == NULL)
  pFront = pTemp1;
else {
  pTemp2 = pFront;

  while (pTemp2->pNext != NULL)
    pTemp2 = pTemp2->pNext;


  pTemp2->pNext = pTemp1; }
```

Inserting a Node at a Specific Position

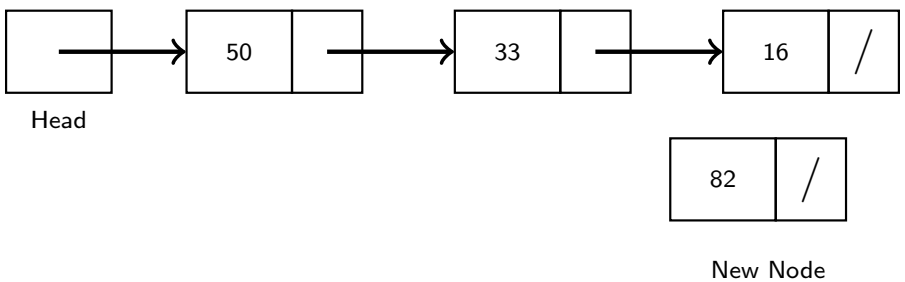
- Insert a node containing value 82 at position 3 after 33.

- Involves breaking the list and setting two links.



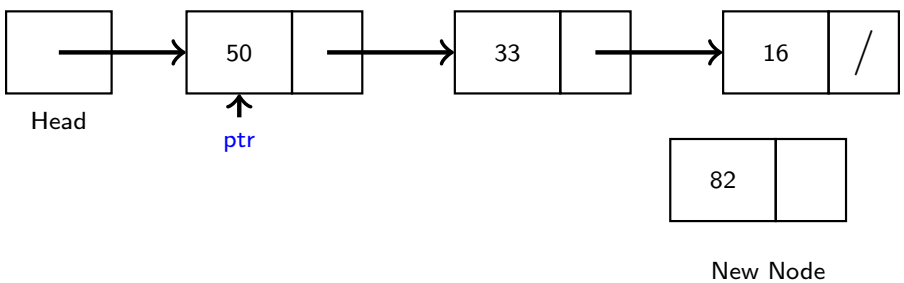
Inserting a Node at a Specific Position

- Insert a node containing value 82 at position 3 after 33.
- Involves breaking the list and setting two links.
- First form a new node with value 82 (and pointing to null).



Inserting a Node at a Specific Position

- Insert a node containing value 82 at position 3 after 33.
- Involves breaking the list and setting two links.
- First form a new node with value 82 (and pointing to null).
- Find the node you want to insert after.



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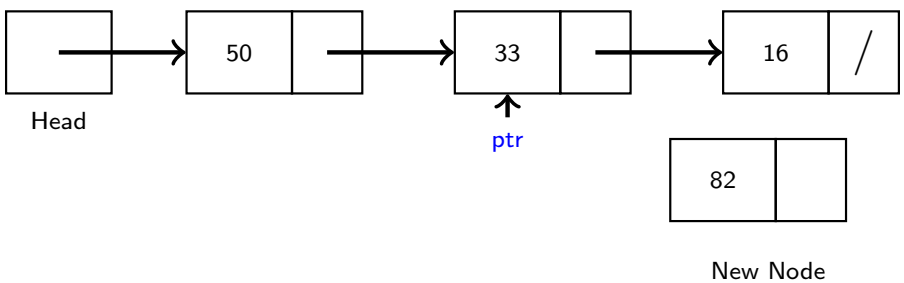
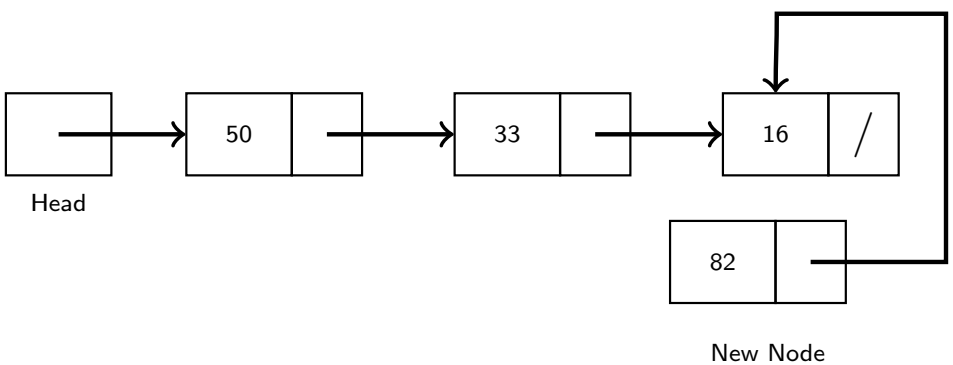


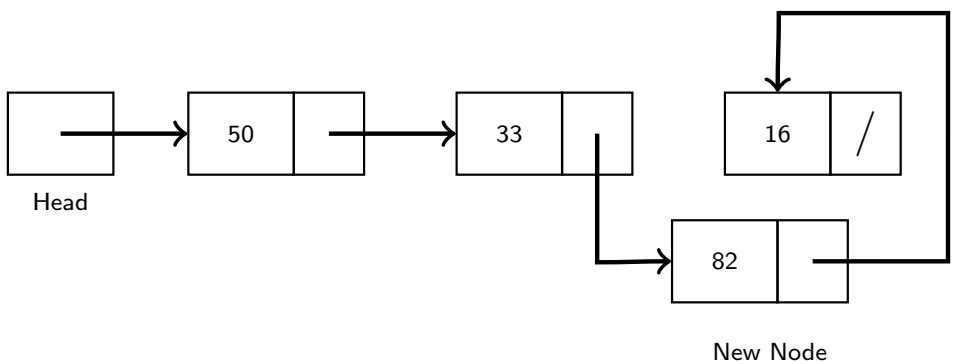
Inserting a Node at a Specific Position

- Insert a node containing value 82 at position 3 after 33.
- Involves breaking the list and setting two links.
- First form a new node with value 82 (and pointing to null).
- Find the node you want to insert after.
- Copy the link from the node that's already in the list.



Inserting a Node at a Specific Position

- Insert a node containing value 82 at position 3 after 33.
- Involves breaking the list and setting two links.
- First form a new node with value 82 (and pointing to null).
- Find the node you want to insert after.
- Copy the link from the node that's already in the list.
- Change the link in the node that's already in the list.

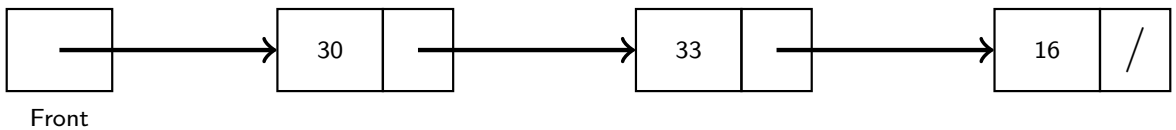


Inserting a Node at a Specific Position in the List: C

```
void insertAtPos(int val , int pos, Node *pFront) {
   Node *pTemp = NULL;
   int nIter = 1;    // Position of first node is assumed 1.

   pTemp = (Node *)malloc(sizeof(Node));
   pTemp->nData = val;
   pTemp->pNext = NULL;

   while (pFront != NULL) {
      if (nIter == pos) {
         if (pFront->pNext == NULL) {
            pFront->pNext = pTemp;
            break;
         }
         else {
            pTemp->pNext = pFront->pNext;
            pFront->pNext = pTemp;
            break;
         }
      }
      pFront = pFront->pNext;
      nIter++;
   }

}
```

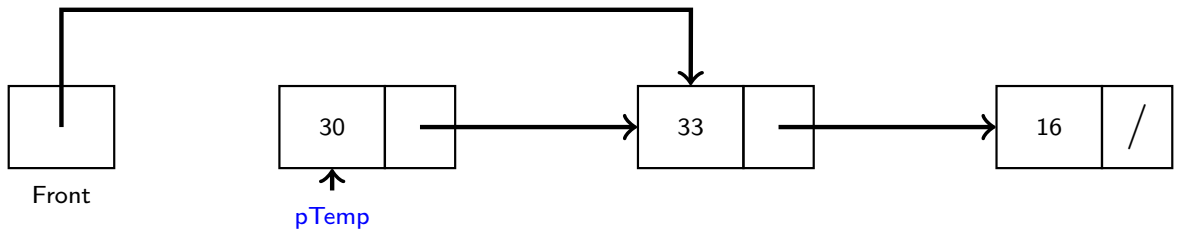
Deletion in Singly Linked Lists

Deleting the First Node



Deleting the First Node

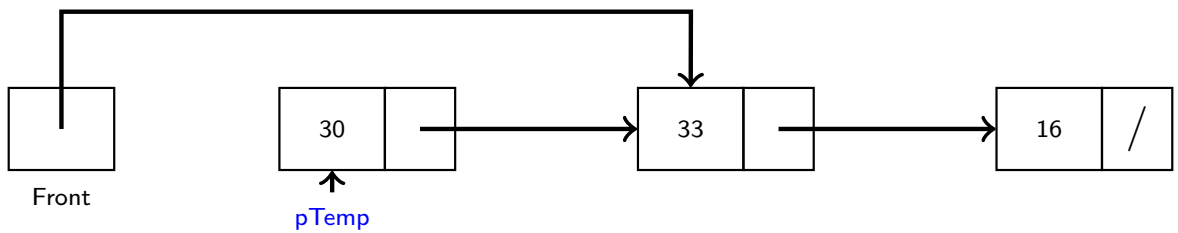
- To delete the first element, change the link in the header.




```
Node *pTemp = NULL;

if (pFront == NULL)
   return 0;
else {
   pTemp = pFront;
   pFront = pFront->pNext;
```

Deleting the First Node

- To delete the first element, change the link in the header.

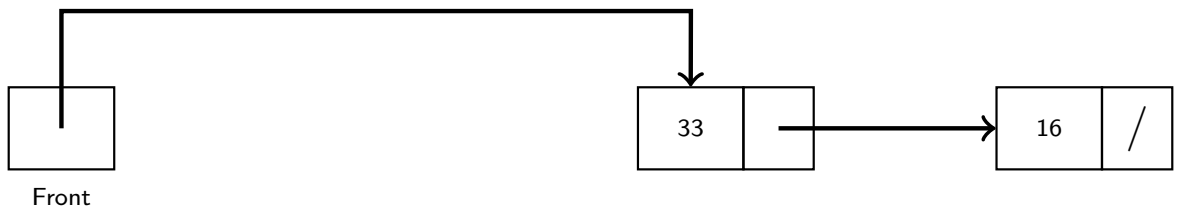



```
Node *pTemp = NULL;

if (pFront == NULL)
   return 0;
else {
   pTemp = pFront;

   pFront = pFront->pNext;
```

What about node 30?

Deleting the First Node

- To delete the first element, change the link in the header.




```
Node *pTemp = NULL;

if (pFront == NULL)
   return 0;
else {
   pTemp = pFront;
   pFront = pFront->pNext;

   free(pTemp);
}
```

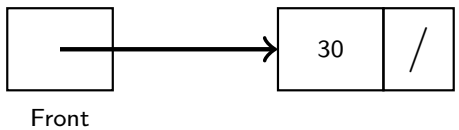
Deleting the Last Node

- **Empty List:** Nothing to do!

```
if (pFront == NULL)
   return 0;
```

Deleting the Last Node

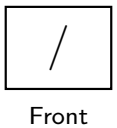
- **Empty List:** Nothing to do!
- **List of size 1:**




```
if (pFront == NULL)
   return 0;
if (pFront->pNext == NULL) {
```

Deleting the Last Node

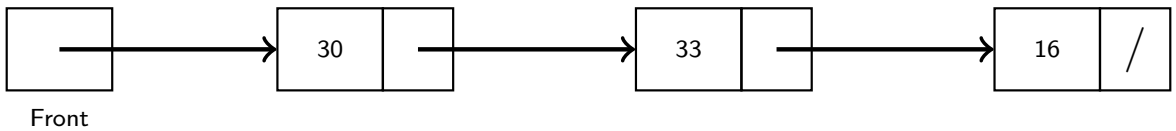
- **Empty List:** Nothing to do!
- **List of size 1:** Set Front = null.




```
if (pFront == NULL)
   return 0;
if (pFront->pNext == NULL) {
   pTemp = pFront;
   pFront = NULL;
   free(pTemp);

   return 0;
}
```

Deleting the Last Node

- Set pointer pPrev to first and pCur to second node of the list.



Deleting the Last Node

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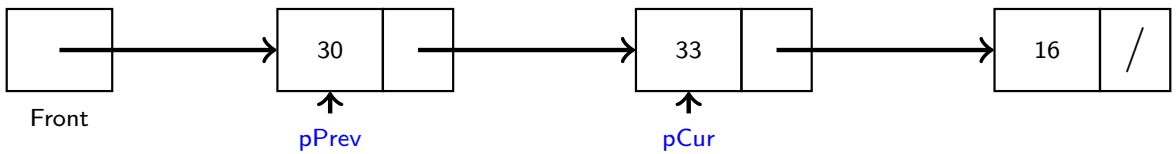
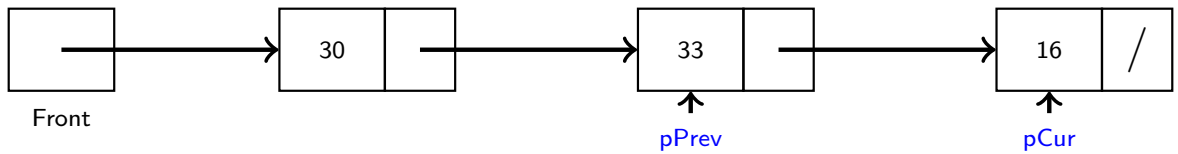



```
Node *pPrev = NULL, *pCur = NULL;

pPrev = pFront;
pCur = pFront->pNext;
```

Deleting the Last Node

- Set pointer pPrev to first and pCur to second node of the list.
- Traverse till pCur->pNext == NULL.

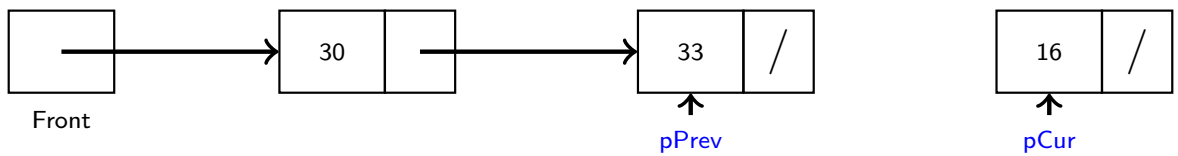



```
Node *pPrev = NULL, *pCur = NULL;

pPrev = pFront;
pCur = pFront->pNext;
while (pCur->pNext != NULL) {
   pPrev = pCur;
   pCur = pCur->pNext; }
```

Deleting the Last Node

- Set pointer pPrev to first and pCur to second node of the list.
- Traverse till pCur->pNext == NULL.
- Set link for pPrev to null, so that last node is not reachable.

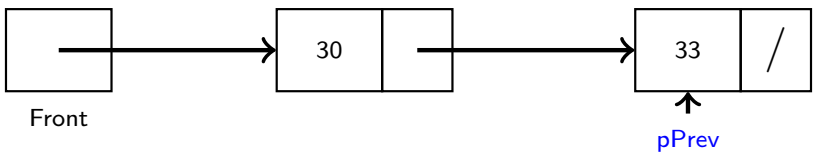



```
Node *pPrev = NULL, *pCur = NULL;

pPrev = pFront;
pCur = pFront->pNext;
while (pCur->pNext != NULL) {
   pPrev = pCur;
   pCur = pCur->pNext; }
pPrev->pNext = NULL;
```

Deleting the Last Node

- Set pointer pPrev to first and pCur to second node of the list.
- Traverse till pCur->pNext == NULL.
- Set link for pPrev to null, so that last node is not reachable.
- **To free memory in C:** free(pCur).



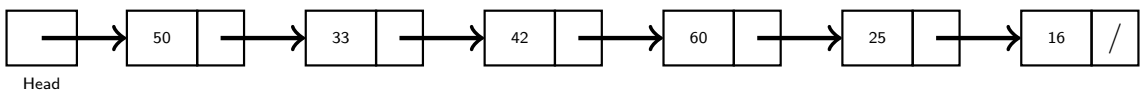

```
Node *pPrev = NULL, *pCur = NULL;

pPrev = pFront;
pCur = pFront->pNext;
while (pCur->pNext != NULL) {
   pPrev = pCur;
   pCur = pCur->pNext; }
pPrev->pNext = NULL;

free(pCur);
```

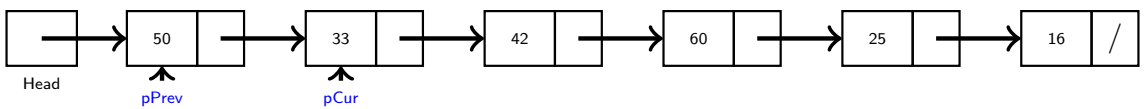
Deleting a Node Containing Data d

- Assume that the list is of length at least 2.
- Let $d = 60$.



Deleting a Node Containing Data d

- Assume that the list is of length at least 2.
- Let $d = 60$.
- Set pointer pPrev to first and pCur to second node of the list.

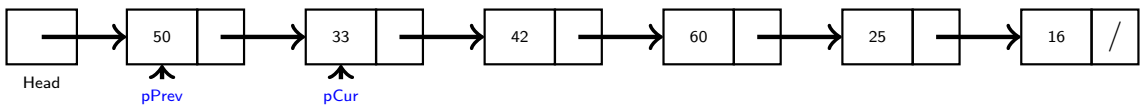


pPrev = pFront;

pCur = pFront->pNext;

Deleting a Node Containing Data *d*

- Assume that the list is of length at least 2.
- Let $d = 60$.
- Set pointer pPrev to first and pCur to second node of the list.
- Traverse until pCur->nData == 60.

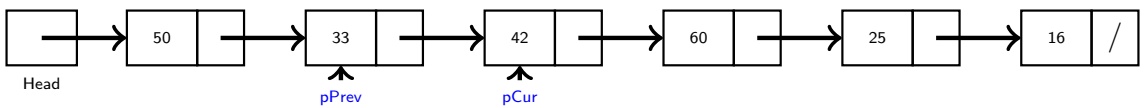



```
pPrev = pFront;
pCur = pFront->pNext;

while ( pCur->nData != d ) {
   pPrev = pCur;
   pCur = pCur->pNext; }
```

Deleting a Node Containing Data *d*

- Assume that the list is of length at least 2.
- Let $d = 60$.
- Set pointer pPrev to first and pCur to second node of the list.
- Traverse until pCur->nData == 60.




```
pPrev = pFront;
pCur = pFront->pNext;

while ( pCur->nData != d ) {
   pPrev = pCur;
   pCur = pCur->pNext; }
```

Deleting a Node Containing Data *d*

- Assume that the list is of length at least 2.
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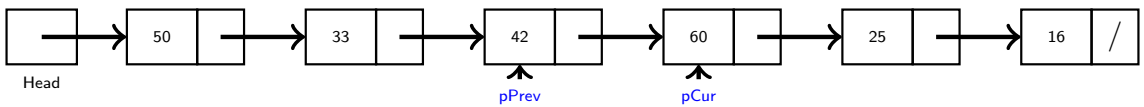
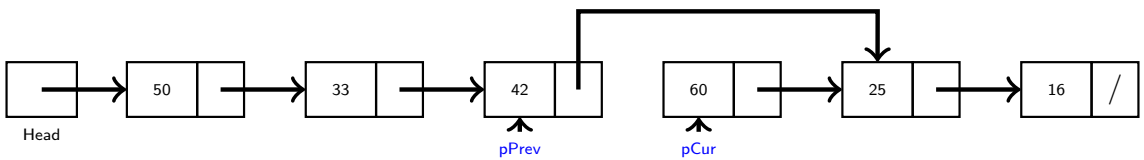



```
pPrev = pFront;
pCur = pFront->pNext;

while ( pCur->nData != d ) {
   pPrev = pCur;
   pCur = pCur->pNext; }
```

Deleting a Node Containing Data *d*

- Assume that the list is of length at least 2.
- Let $d = 60$.
- Set pointer pPrev to first and pCur to second node of the list.
- Traverse until pCur->nData == 60.
- Set link of pPrev to next node of pCur.




```
pPrev = pFront;
pCur = pFront->pNext;

while ( pCur->nData != d ) {
   pPrev = pCur;
   pCur = pCur->pNext; }

pPrev->pNext = pCur->pNext;
```

Deleting a Node Containing Data d

- Assume that the list is of length at least 2.
- Let $d = 60$.
- Set pointer pPrev to first and pCur to second node of the list.
- Traverse until pCur->nData == 60.
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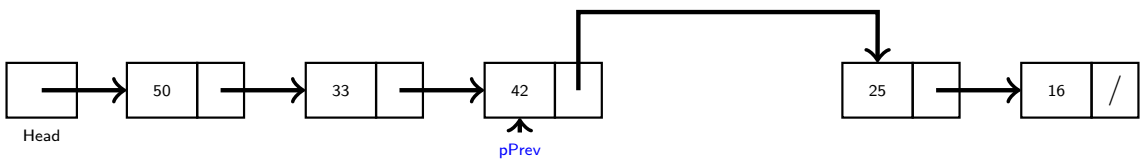


```
pPrev = pFront;
pCur = pFront->pNext;

while ( pCur->nData != d ) {
   pPrev = pCur;
   pCur = pCur->pNext; }
pPrev->pNext = pCur->pNext;

free(pCur);
```

Books Consulted

1. Chapter 10.2 of *Introduction to Algorithms* by Thomas H Cormen, Charles E Leiserson, Ronald L Rivest, Clifford Stein.

Thank You for your kind attention!

Questions!!