# 자료구조

## L04 Lists

2022년 1학기

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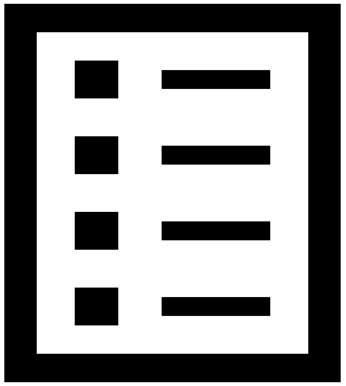
# Summary

- **리스트 (Lists)**
- 배열(Array) 기반 리스트 구현
- 연결(Link) 기반 리스트 구현
- Freelist

# 리스트 (Lists)

- **유한**하고 **순서**가 있는 데이터의 **나열**
- **중요한 개념**: 리스트 속의 데이터들은 **위치**Position가 있음
- 표기법: $\langle a_0, a_1, \cdots, a_{n-1} \rangle$
- 어떤 **연산**Operation이 필요할까?



# 리스트에 필요한 연산, 리스트 ADT

- **특정 위치**에 아이템을 **넣을(insert, append)** 수 있다.
- **특정 위치**의 아이템을 **읽고(getValue), 변경(update)**할 수 있다.
- **특정 위치**의 아이템을 **삭제(remove)**할 수 있다.
- 리스트 내의 **아이템 개수(length)**를 알 수 있다.
- 리스트를 **비울(clear)** 수 있다.

```
public interface List<E> {
    public void clear();
    public void insert(int pos, E item);
    public void append(E item);
    public void update(int pos, E item);
    public E getValue(int pos);
    public E remove(int pos);
    public int length();
}
```

# 리스트 ADT 예제

- **`List L`** = ⟨12, 32, 15⟩
- **`L.insert(1, 99)`** ⇒ ⟨12, **99**, 32, 15⟩
- **`L.remove(3)`** ⇒ ⟨12, 99, 32⟩
- **`L.update(0, 61)`** ⇒ ⟨**61**, 99, 32⟩
- **`L.length()`** ⇒ 3
- **`L.clear()`** ⇒ ⟨⟩

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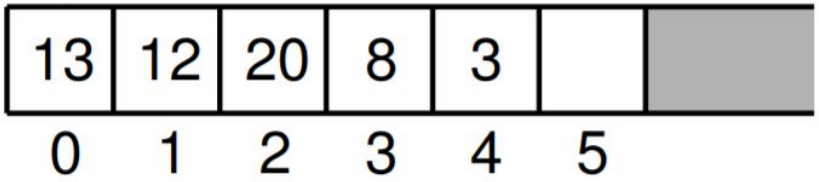
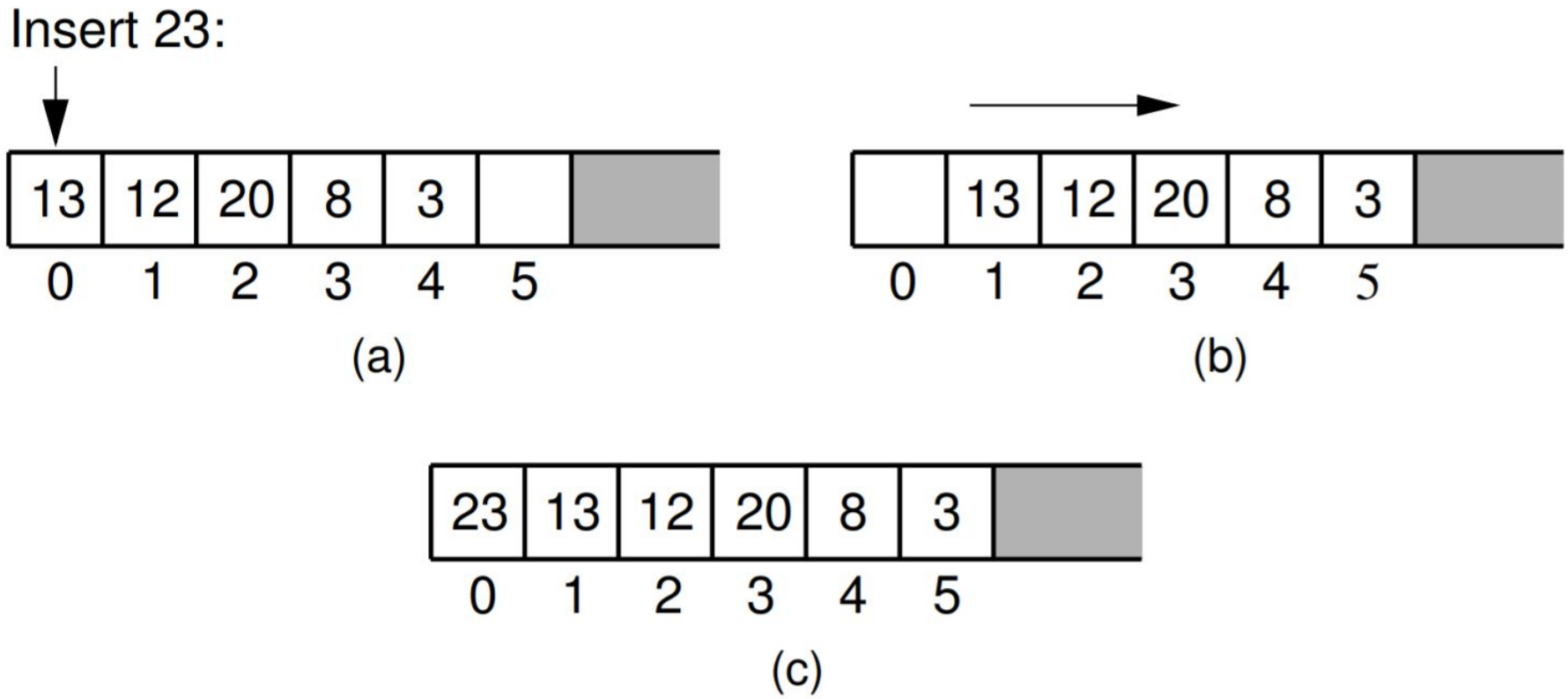
# 배열(Array) 기반 리스트, 넣기

- **`List L`** = ⟨13, 12, 20, 8, 3⟩
- **`L.insert(0, 23)`** ⇒ ⟨**23**, 13, 12, 20, 8, 3⟩
- 배열로 리스트를 어떻게 표현할까?




- 23을 배열의 맨 앞에 넣으려면…?

# 배열(Array) 기반 리스트, 넣기



# 배열(Array) 기반 리스트 구현

- ArrayList의 **자료구조** 및 **생성자**

```
public class ArrayList<E> implements List<E> {

    private static final int defaultSize = 10;
    private int listSize;
    private E[] data;

    public ArrayList() {
        this(defaultSize);
    }

    public ArrayList(int size) {
        listSize = 0;
        data = (E[]) new Object[size];
    }
```

# 배열(Array) 기반 리스트 구현

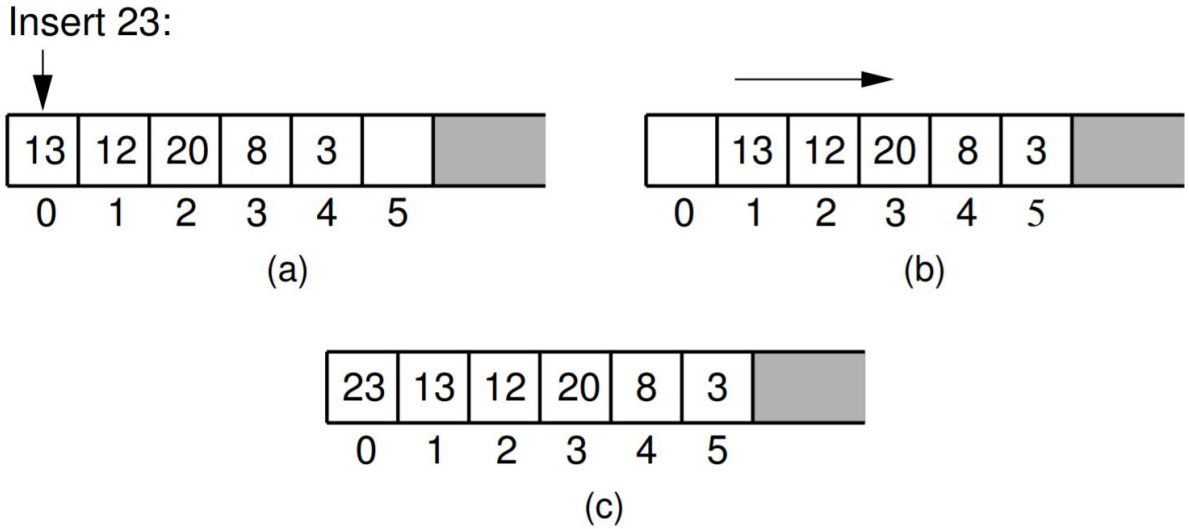
- ArrayList의 **clear**, **update**, **getValue**, **length**, **append**

```
public void clear() { listSize = 0; }

public void update(int pos, E item) { data[pos] = item; }

public E getValue(int pos) { return data[pos]; }

public int length() { return listSize; }

public void append(E item) { data[listSize++] = item; }
```

# 배열(Array) 기반 리스트 구현

- ArrayList의 **insert**

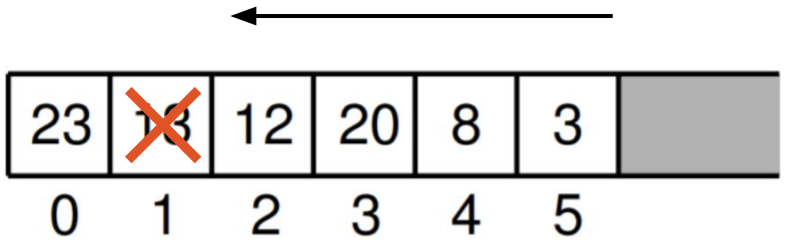
```
public void insert(int pos, E item) {
    for (int i=listSize; i > pos; i--)
        data[i] = data[i-1];

    data[pos] = item;
    listSize++;
}
```



# 배열(Array) 기반 리스트 구현

- ArrayList의 **remove**

```
public E remove(int pos) {
        E ret = data[pos];

        for(int i=pos; i<listSize-1; i++)
            data[i] = data[i+1];

        listSize--;

        return ret;
    }
```



# 배열(Array) 기반 리스트, 장단점

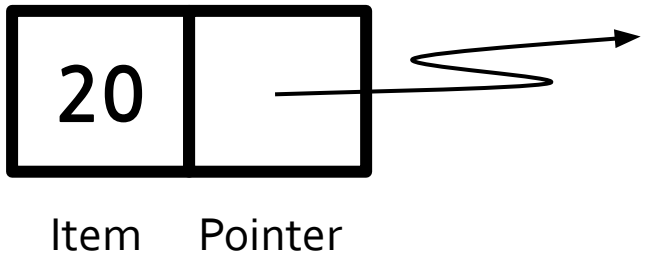
- **장점**
  - 특정 위치의 데이터 **조회가 빠르다**
- **단점**
  - 데이터의 **추가, 삭제의 비용**이 **크다**
  - **크기가 고정**되어 있다
    - 넣으려는 데이터가 더 많으면… Error
    - 넣으려는 데이터가 너무 적으면… 메모리 낭비
    - 해결법?

# Summary

- 리스트 (Lists)
- 배열(Array) 기반 리스트 구현
- **연결(Link) 기반 리스트 구현**
- Freelist

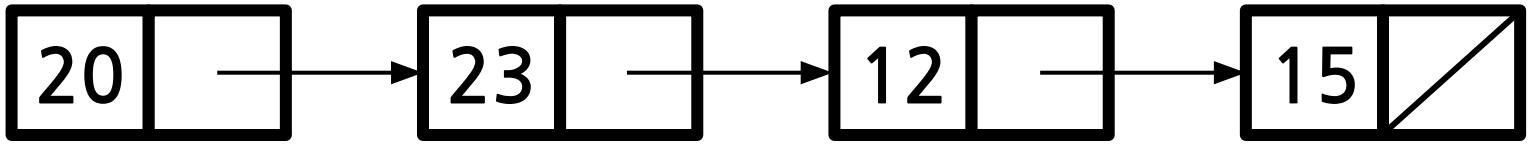
# 연결(Link)과 연결리스트(Linked List)

- **연결**은 **데이터**Item와 **포인터**Pointer로 구성된다.




- 리스트를 **연결을 이용해 표현**하는 방법은?

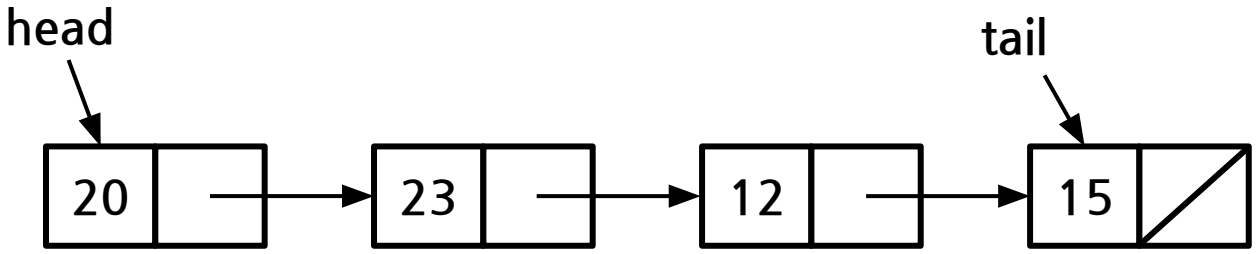
〈20, 23, 12, 15〉



# 연결 Class

```
class Link<E> {
    private E item;
    private Link<E> next;

    public Link(E item, Link<E> next) {
        this.item = item;
        this.next = nextval;
    }

    Link<E> next() { return next; }

    Link<E> setNext(Link<E> next) { return this.next = next; }

    E item() { return item; }

    E setItem(E item) { return this.item = item; }
}
```

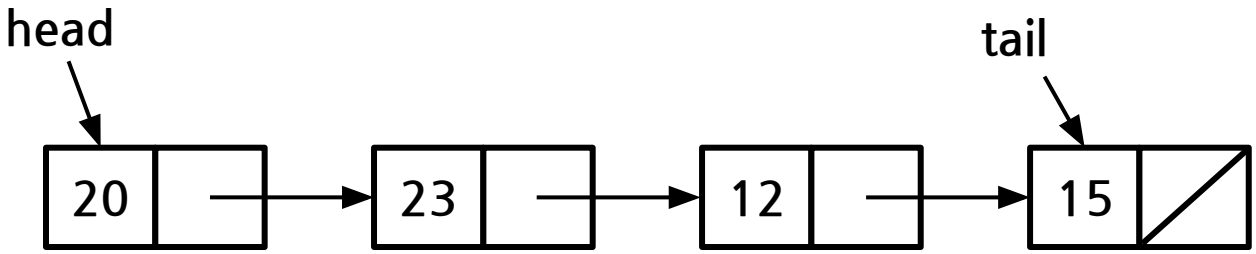
# 연결 in Java




```
Link<Integer> l15 = new Link<>(15, null);
Link<Integer> l12 = new Link<>(12, l15);
Link<Integer> l23 = new Link<>(23, l12);
Link<Integer> l20 = new Link<>(20, l23);
Link<Integer> head = l20;
Link<Integer> tail = l15;

System.out.println(head.next().next().item());
```

# 연결리스트 구현 이슈

- head를 따로 둘까? 말까?

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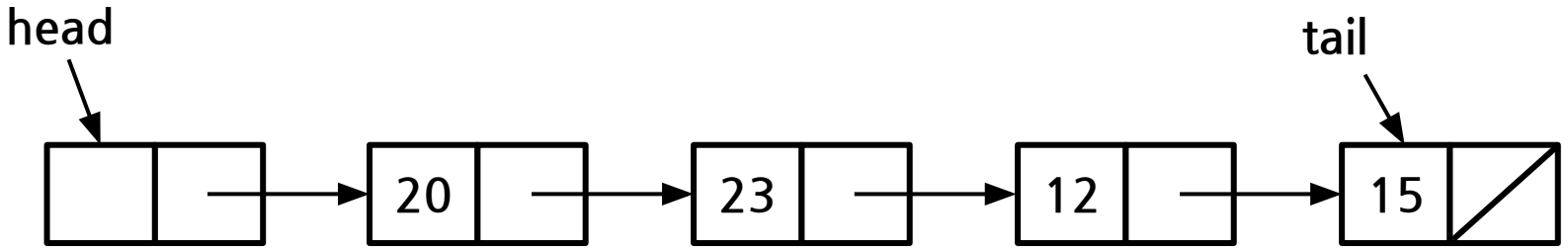
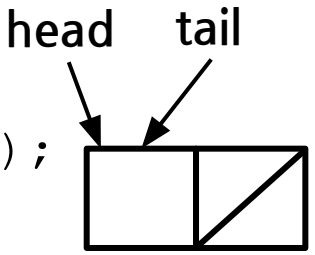


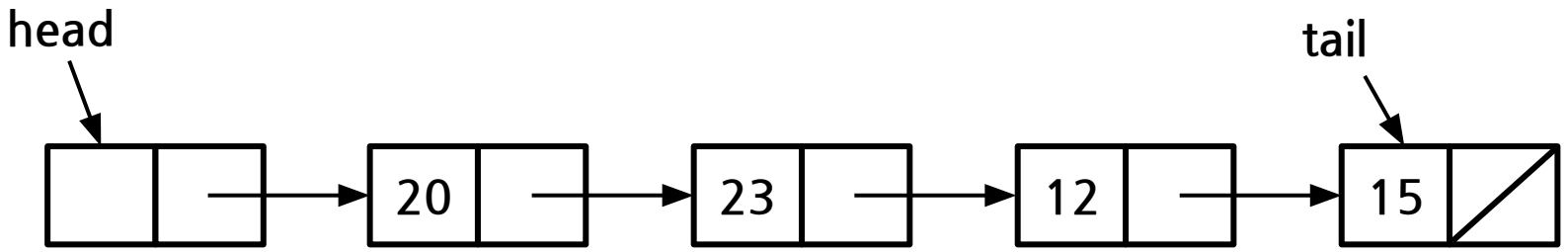
# Linked List Class

```
public class LinkedList<E> implements List<E>{

    private Link<E> head, tail;
    int size;

    public LinkedList() {
        head = tail = new Link<>(null, null);
        size = 0;
    }

    @Override
    public void clear() {
        head.setNext(null);
        size = 0;
    }
```



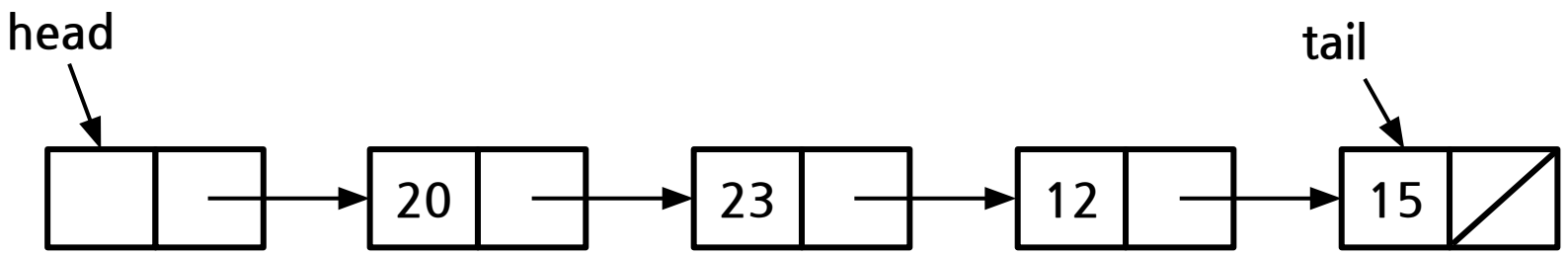
# Linked List Class: update/getValue

```
@Override
public void update(int pos, E item) {
    Link<E> curr = head;
    for(int i=0; i<pos; i++) curr = curr.next();
    curr.next().setItem(item);
}

@Override
public E getValue(int pos) {
    Link<E> curr = head;
    for(int i=0; i<pos; i++) curr = curr.next();
    return curr.next().item();
}
```



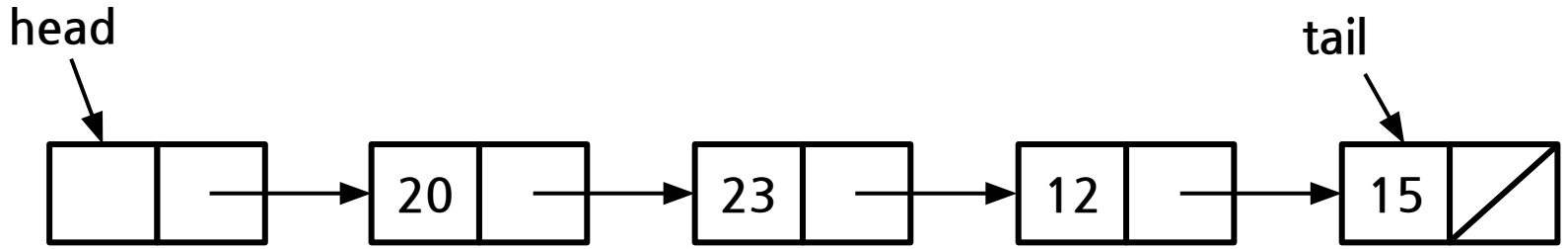
# Linked List Class: length/append

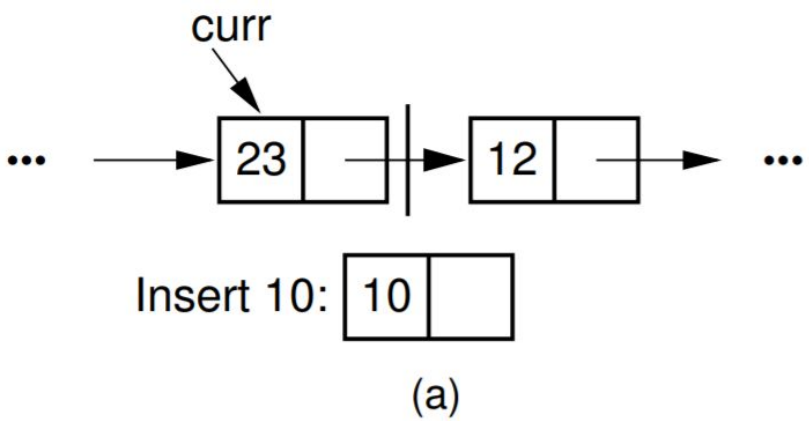
```
@Override
public int length() {
    return size;
}

@Override
public void append(E item) {
    tail = tail.setNext(new Link<>(item, null));
    size++;
}
```

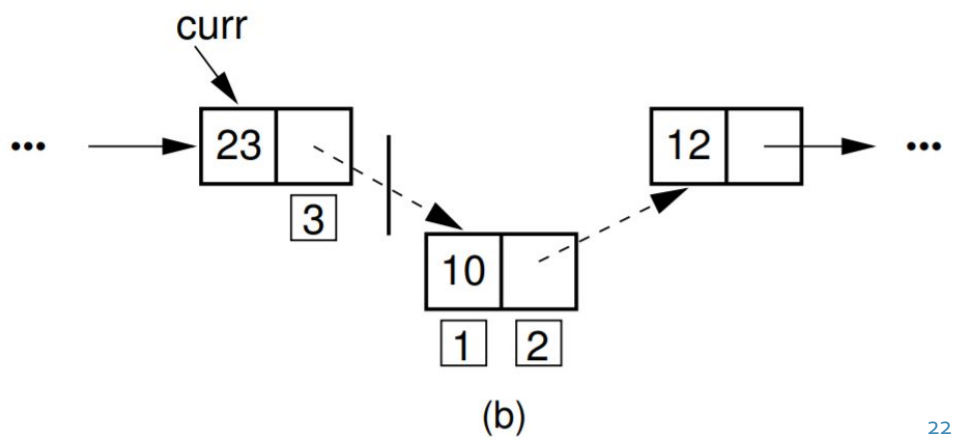


# Linked List Class: insert

- 23과 12 사이에 10 넣기

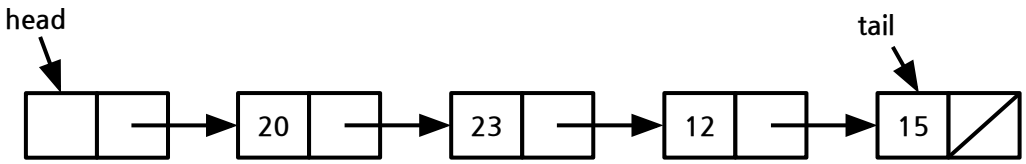


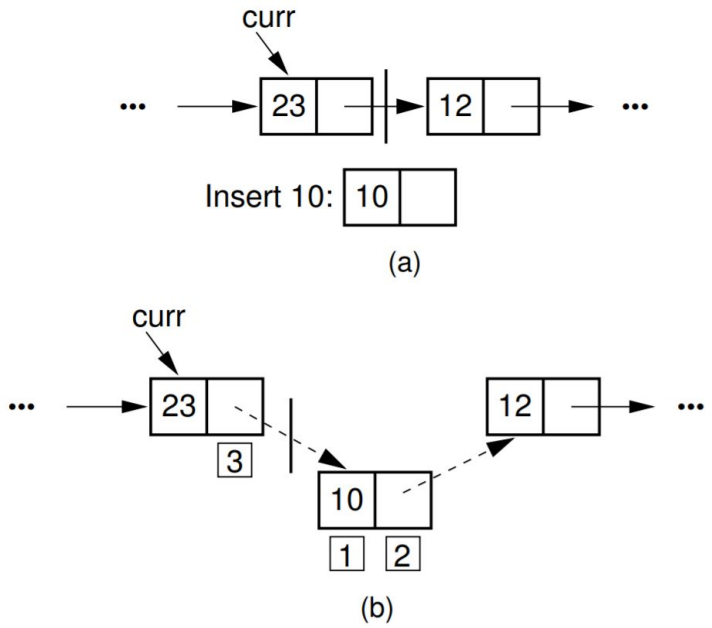



# Linked List Class: insert

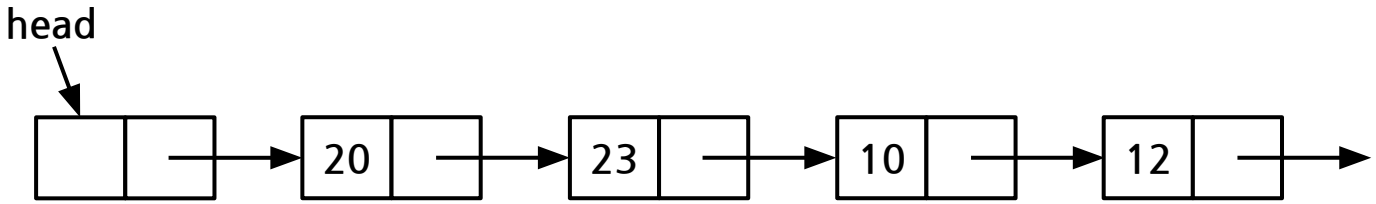
```
public void insert(int pos, E item) {
    Link<E> curr = head;
    for(int i=0; i<pos; i++)
        curr = curr.next();

    curr.setNext(new Link<>(item, curr.next()));

    if(curr == tail)
        tail = curr.next();

    size++;
}
```

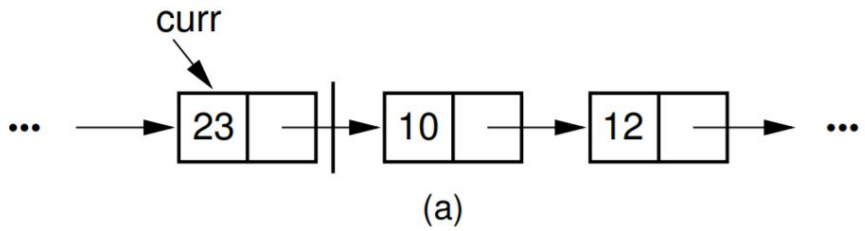


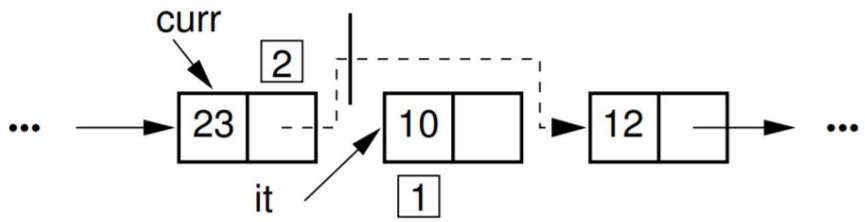
# Linked List Class: remove

- 2번 index에 있는 값 (10) 지우기



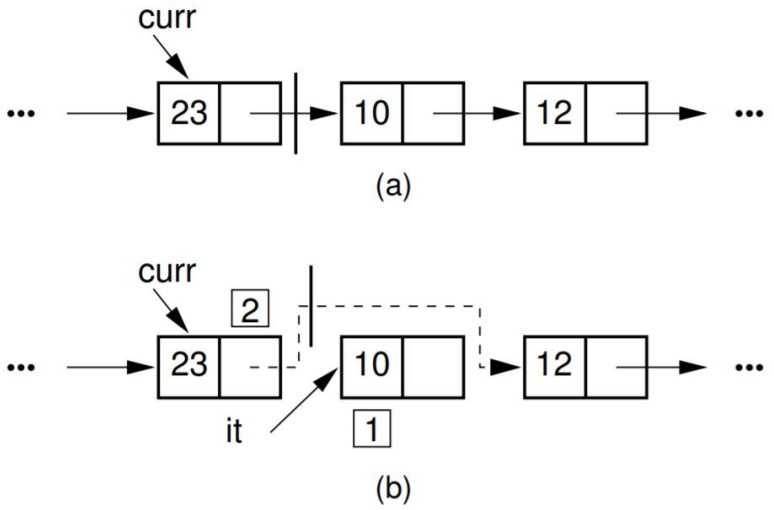

(a)

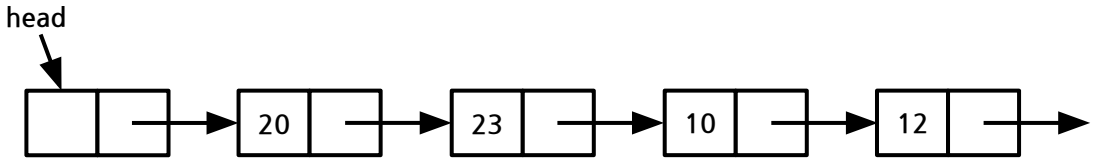



(b)

# Linked List Class: remove

```
public E remove(int pos) {
    Link<E> curr = head;
    for(int i=0; i<pos; i++)
        curr = curr.next();

    E ret = curr.next().item();

    if(curr.next() == tail)
        tail = curr;

    curr.setNext(curr.next().next());

    size--;

    return ret;
}
```



# Comparison of Implementations

| | Array Based List | Linked List |
|---|---|---|
| 넣기/빼기 | | |
| 맨 앞에 넣기/빼기 | | |
| 맨 뒤에 넣기/빼기 | | |
| 메모리 오버헤드<br>Space overhead | | |

When should we use an array based list or a linked list?

# Space Comparison

Break-even point:

$$DE = n(P + E)$$

$$n = \frac{DE}{P + E}$$

D: 최대 데이터 수 (array 크기)

n: 데이터 개수 (linked-list에 있는 데이터 개수)

E: item 하나에 필요한 메모리 양

P: pointer 하나에 필요한 메모리 양

# Outline

- Introduction to Lists
- Array-based List Implementation
- Link-based List Implementation
- **Freelist**

# Freelists

System **new** and garbage collection are slow.

- Add freelist support to the Link class.

# Link Class Extensions

```
static Link<?> freelist = null;

static <E> Link<E> get(E item, Link<E> next){
    if(freelist == null)
        return new Link<>(item, next);

    Link<E> ret = (Link<E>) Link.freelist;
    freelist = freelist.next();

    ret.setItem(item);
    ret.setNext(next);

    return ret;
}

void release() {
    item = null;
    next = (Link<E>) Link.freelist;
    freelist = this;
}
```

# Using Freelist

```
new Link<E>(item, next); → Link.get(item, next);
```

```
public E remove(int pos) {
  Link<E> curr = head;
  for(int i=0; i<pos; i++)
    curr = curr.next();

  E ret = curr.next().item();
  if(curr == tail.next())tail = curr;


  curr.setNext(curr.next().next());


  size--;
  return ret;
}
```

→

```
public E remove(int pos) {
  Link<E> curr = head;
  for(int i=0; i<pos; i++)
    curr = curr.next();

  E ret = curr.next().item();
  if(curr == tail.next())tail = curr;

  Link<E> tmp = curr.next();
  curr.setNext(curr.next().next());
  tmp.release();

  size--;
  return ret;
}
```

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# Questions?