"First things first, but not necessarily in that order"

-Dr. Who

Iterators

- ArrayList is part of the Java Collections Framework
- Collection is an interface that specifies the basic operations every collection (data structure) shall have
- Some Collections don’t have a definite order
  - Sets, Maps, Graphs
- How to access all the items in a Collection with no specified order?

Iterator Interface

- An iterator object is a "one shot" object
  - it is designed to go through all the elements of a Collection once
  - if you want to go through the elements of a Collection again you have to get another iterator object
- Iterators are obtained by calling a method from the Collection

Iterator Interface Methods

- The Iterator interface 3 methods we will use:
  boolean hasNext()
  //returns true if this iteration has more elements
  E next()
  //returns the next element in this iteration
  //pre: hasNext()
  void remove()
  /**<Removes from the underlying collection the last element returned by the iterator.
   *pre: This method can be called only once per call to next. After calling, must call next again before calling remove again.
   */
Which of the following produces a syntax error?

```java
ArrayList<String> list = new ArrayList<>();
Iterator<String> it1 = new Iterator(); // I
Iterator<String> it2 = new Iterator(list); // II
Iterator<String> it3 = list.iterator(); // III
```

A. I  
B. II  
C. III  
D. I and II  
E. II and III

---

Imagine a fence made up of fence posts and rail sections

```
ArrayList<String> names = new ArrayList<>();
names.add("Jan");
names.add("Levi");
names.add("Tom");
names.add("Jose");
Iterator<String> it = names.iterator();
int i = 0;
```

---

The iterator lives on the fence posts  
The data in the collection are the rails  
Iterator created at the far left post  
As long as a rail exists to the right of the iterator, hasNext() is true
Fence Analogy

```java
while(it.hasNext()) {
    i++;
    System.out.println(it.next());
}
// when i == 1, prints out Jan
first call to next moves iterator to next post and returns "Jan"

Jan  Levi  Tom  Jose

// when i == 2, prints out Levi

Jan  Levi  Tom  Jose

// when i == 3, prints out Tom

Jan  Levi  Tom  Jose

// when i == 4, prints out Jose

Jan  Levi  Tom  Jose
```
Fence Analogy

```java
while(it.hasNext()) {
    i++;
    System.out.println(it.next());
}
// call to hasNext returns false
// while loop stops
```

Typical Iterator Pattern

```java
public void printAll(Collection<String> col) {
    Iterator<String> it = col.iterator();
    while (it.hasNext()) {
        String temp = it.next();
        System.out.println(temp);
    }
    // OR......
    for (String temp : col) {
        System.out.println(temp);
    }
}
```

Clicker Question 2

✈ What is output by the following code?

```java
ArrayList<Integer> list = new ArrayList<>();
list.add(3);
list.add(3);
list.add(5);
Iterator<Integer> it = list.iterator();
System.out.print(it.next() + " ");
System.out.print(it.next() + " ");
System.out.print(it.next());
```

A. 3 3 5  B. 3 3  C. 3 3 5  D. 3 3  E. 3 3 then a runtime error

remove method

✈ An Iterator can be used to remove things from the Collection
✈ Can only be called once per call to next()
**Clicker 3**

```java
public void printTarget(ArrayList<String> names, int len) {
    Iterator<String> it = names.iterator();
    while (it.hasNext())
        if (it.next().length() == len)
            System.out.println(it.next());
}
```

Given names = ["Jan", "Ivan", "Tom", "George"] and len = 3 what is output by the printTarget method?

- A. Jan Ivan Tom George
- B. Jan Tom
- C. Ivan George
- D. No output due to syntax error
- E. No output due to runtime error

---

**The Iterable Interface**

- A related interface is `Iterable`
- The method of interest to us in the interface:
  ```java
  public Iterator<T> iterator()
  ```
- Why?
- Anything that implements the `Iterable` interface can be used in the for each loop.

```java
ArrayList<Integer> list;
// code to create and fill list
int total = 0;
for (int x : list) {
    total += x;
}
```

---

**Iterable**

- If you simply want to go through all the elements of a Collection (or Iterable thing) use the for each loop
  - hides creation of the Iterator

```java
public void printAllOfLength(ArrayList<String> names, int len) {
    // pre: names != null, names only contains Strings
    // post: print out all elements of names equal in length to len
    for (String s : names)
        if (s.length() == len)
            System.out.println(s);
}
```

---

**Implementing an Iterator**

- Implement an Iterator for our GenericList class
  - Nested Classes
  - Inner Classes
  - Example of encapsulation
  - checking precondition on remove
- does our GenericList need an Iterator?
Comodification

- If a Collection (ArrayList) is changed while an iteration via an iterator is in progress an Exception will be thrown the next time the next() or remove() methods are called via the iterator.

```java
ArrayList<String> names = new ArrayList<>();
names.add("Jan");
Iterator<String> it = names.iterator();
names.add("Andy");
it.next(); // exception occurs here
```