Object Oriented Programming
CS F213

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Generics (J2SE 5)

Generics

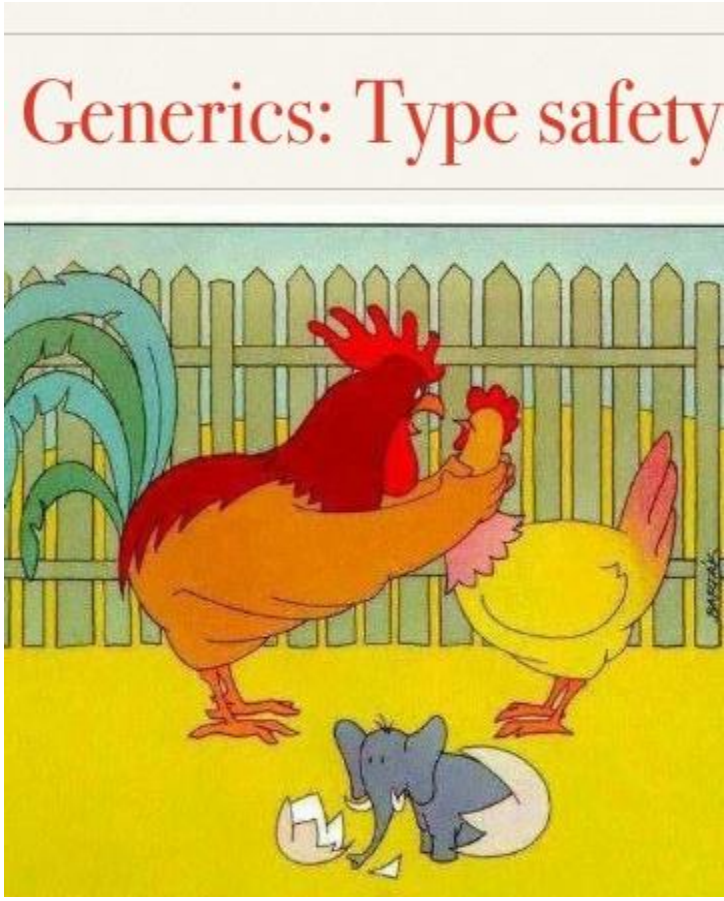
- Similar to templates in C++.
- Allows type to be a parameter to methods, classes and interfaces
- <> is used to specify the parameter types
- To create objects use the following syntax

  BaseType <Type> obj = new BaseType <Type>()

Note: In Parameter type we can not use primitives like 'int','char' or 'double'.

Advantages

- **Type-safety :** We can hold only a single type of objects in generics. It doesn't allow to store other objects.
- **Type casting is not required:** There is no need to typecast the object.
- **Compile-Time Checking:** It is checked at compile time so problem will not occur at runtime.



Generic Class - Example

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```
class Identity<T>{
    T obj;
    Identity(T obj) {  this.obj = obj;  }
    public T getObject()  { return this.obj; }
}

class Test {
    public static void main (String[] args)     {

        Identity <Long> number = new Identity<Long>(9999955555L);
        System.out.println(number.getObject());

        Identity <String> name = new Identity<String>("Ankit");
        System.out.println(name.getObject());
    }
}
```

- Generics in Java was added to provide type-checking at compile time and it has no use at run time
- Java compiler uses **type erasure** feature to remove all the generics type checking code in byte code and insert type-casting if necessary.
- Type erasure ensures that no extra classes are created
- Generics incur no runtime overhead.

Multiple Type Parameters

```
class Identity<T,U> {
    T obj1; U obj2;
    Identity(T obj1,U obj2 ) {  this.obj1 = obj1;this.obj2 = obj2;  }
    public void printObject()  {
     System.out.print(this.obj1+"\t");System.out.println(this.obj2); }
}

class Test {
    public static void main (String[] args)     {
    Identity <String, Integer> I1 = new Identity<String,
     Integer>("Ankit",20171007);
    Identity <Integer,String> I2 = new
     Identity<Integer,String>(20171007,"Ankit");
    I1.printObject();
    I2.printObject();
    }}
```

Generic Functions

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```
class Identity {
    public <T> void printObject(T obj)  {System.out.println(obj); }
}

class Test {
    public static void main (String[] args)     {
    Identity I1, I2;
    I1 = new Identity();
    I2 = new Identity();
    I1.printObject(20071007);
    I2.printObject("Ankit");
    }
}
```

Generic Functions with generic return type


```
class Identity {
    public <T> T printObject(T obj)  {return obj; }
}

class Test {
    public static void main (String[] args)     {
    Identity I1, I2;
    I1 = new Identity();
    I2 = new Identity();
    System.out.println(I1.printObject(20071007));
    System.out.println(I2.printObject("Ankit"));
    }
}
```

Generics in Interfaces

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```
//Generic interface definition
interface DemoInterface<T1, T2> {
   T2 doSomeOperation(T1 t);
   T1 doReverseOperation(T2 t);    }

//A class implementing generic interface
class DemoClass implements DemoInterface<String, Integer>
{
   public Integer doSomeOperation(String t)
   {
      //some code
   }
   public String doReverseOperation(Integer t)
   {
      //some code
   }
}
```

Generic Arrays

- Array in any language have same meaning i.e. an array is a collection of similar type of elements.

- In java, pushing any incompatible type in an array on runtime will throw ArrayStoreException.
    - It means array preserve their type information in runtime, and generics use type erasure or remove any type information in runtime.
    - Due to above conflict, instantiating a generic array in java is not permitted.

Bound Type with Generics

- Used to restrict the types that can be used as arguments in a parameterized type.
  - Eg: Method operating on numbers should accept the instances of the Number class or its subclasses.

- Declare a bounded type parameter
  - List the type parameter's name.
  - Along by the extends keyword
  - And by its upper bound.

Bound Type - Example

```
class Identity<T extends Number> {
    T obj;
    Identity(T obj) {  this.obj = obj;  }
    public T getObject()  { return this.obj; }}
class Test {
    public static void main (String[] args)     {
        Identity <Integer> iObj = new Identity<Integer>(20071007);
        System.out.println(iObj.getObject());
        Identity <Double> dObj = new Identity<Double>(2007.00);
        System.out.println(dObj.getObject());
        Identity <String> sObj = new Identity<String>("Ankit");
        System.out.println(sObj.getObject());
    }}
```

Note: Bound Mismatch: type argument String is not within bounds of type-variable T

Type name in Generics

The type name can be named according to programmer's convenience. But the common convention is

T - Type

E - Element

K - Key

N - Number

V – Value

Note: Let there be an interface T;

class Identity<T extends T> cannot be done.

Generics and Inheritance

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```
class MyClass<T>{}
class Main {
    public static void main(String[] args) {
        String str = "abc";
        Object obj = new Object();
        obj = str;
       // works because String is-a Object (inheritance)
        }
}
```

Generics and Inheritance


```
class MyClass<T>{}
class Main {
    public static void main(String[] args) {

        MyClass<String> myClass1 = new MyClass<String>();
        MyClass<Object> myClass2 = new MyClass<Object>();
        myClass2 = myClass1;

// compilation error since MyClass<String> is not a MyClass<Object>
        }
}
```

Generics and Inheritance

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```
class MyClass<T>{}
class Main {
    public static void main(String[] args) {
        String str = "abc";
        Object obj = new Object();

        MyClass<String> myClass1 = new MyClass<String>();
        MyClass<Object> myClass2 = new MyClass<Object>();

        obj = myClass1;
        // MyClass<T> parent is Object
    }
```

What are not allowed with Generics?

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```
public class GenericsExample<T>
{
   private static T member; //This is not allowed
}
```

```
public class GenericsExample<T>
{
   public GenericsExample(){
      new T();
   }
}
```

What are not allowed with Generics?

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```
final List<int> ids = new ArrayList<>();     //Not allowed

final List<Integer> ids = new ArrayList<>(); //Allowed
```

```
// causes compiler error
public class GenericException<T> extends Exception {}
```

Bounded Types – Additional Info

```
class A{
}

class B{

}

interface C{

}

interface D{

}

class E<T extends A & C & D>{

}
```

- Thus, **T** is bounded by a class **A** and interface **C** and **D**.
- Type argument passed to **T** must be a subclass of **A** and have implemented **C** and **D**

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Introduction to Collections

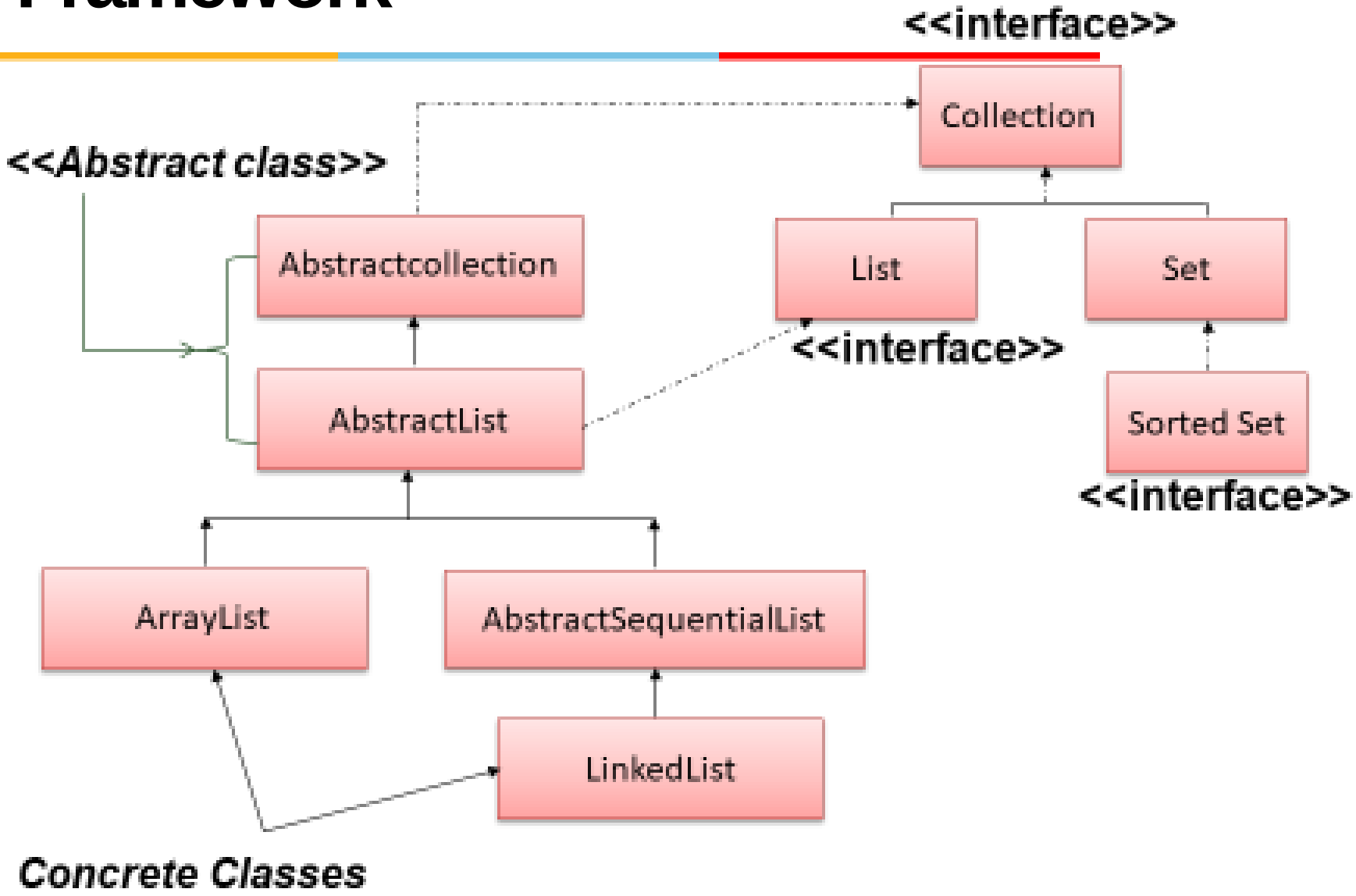
What are Collections

- Group of Objects treated as a single Object.
- Java provides supports for manipulating collections in the form of
  - Collection Interfaces
  - Collection Classes
- Collection interfaces provide basic functionalities whereas collection classes provides their concrete implementation

Collection Classes

- Collection classes are standard classes that implement collection interfaces
- Some Collection Classes are abstract and some classes are concrete and can be used as it is.
- Important Collection Classes:
  - ✓ AbstractCollection
  - ✓ AbstractList
  - ✓ AbstractSequentialList
  - ✓ LinkedList
  - ✓ ArrayList
  - ✓ AbstractSet
  - ✓ HasSet
  - ✓ LinkedHashSet
  - ✓ TreeSet

Partial View of Collection's Framework



ArrayList - Example

```
import java.util.*;
class Test{
public static void main(String args[]){
ArrayList<Integer> al1 = new ArrayList<Integer>();
al1.add(20);
al1.add(9);

ArrayList<Integer> al2 = new ArrayList<Integer>();
al2.add(22);
al2.add(53);

al1.addAll(al2);
Collections.sort(al1);
System.out.println(al1);
System.out.println(al1.get(3));}
}
```

Output:
[9, 20, 22, 53]
53

List Iterator

- List Iterator is used to traverse forward and backward directions

Method	Description
boolean hasNext()	This method return true if the list iterator has more elements when traversing the list in the forward direction.
Object next()	This method return the next element in the list and advances the cursor position.
boolean hasPrevious()	This method return true if this list iterator has more elements when traversing the list in the reverse direction.
Object previous()	This method return the previous element in the list and moves the cursor position backwards.

List Iterator - Example

```
ArrayList<Integer> al = new ArrayList<Integer>();
al.add(20);
al.add(9);
al.add(22);
al.add(53);

ListIterator<Integer> itr=al.listIterator();
System.out.println("Forward Traversal");
while(itr.hasNext()) {
System.out.println(itr.next());
}
System.out.println("Backward Traversal");
while(itr.hasPrevious()) {
System.out.println(itr.previous());
}
```

Output:

```
Forward Traversal
20
9
22
53
Backward Traversal
53
22
9
20
```

Question: What happens if the backward traversal happens before the forward?

Review Question

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```
ArrayList al = new ArrayList();
al.add("Sachin");
al.add("Rahul");
al.add(10);

String s[] = new String[3];
for(int i=0;i<3;i++)
s[i] = (String)al.get(i);

System.out.println(al);

System.out.println(Arrays.toString(s));
```

Find the output

a. Compilation Error
b. Runtime Error
c. [Sachin, Rahul, 10]
   [Sachin, Rahul, 10]

Note:

No compilation error because add(Object o) method in the ArrayList class

Runtime Error because integer object is type case to String

Solution:

Generics

Array List /Generics - Review

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```
ArrayList<String> al = new ArrayList<String>();
al.add("Sachin");
al.add("Rahul");
al.add("10");

String s[] = new String[3];
for(int i=0;i<3;i++)
s[i] =al.get(i);

System.out.println(al);
System.out.println(Arrays.toString(s));
```

Note:
Compilation Error if we try to include al.add(10)

Wildcard in Generics

```
abstract class Shape{
final double pi = 3.14;
double area;
abstract void draw();
 }
class Rectangle extends Shape{
Rectangle(int l,int b){
area = l*b; }
void draw(){System.out.println("Area of Rect:"+area);}
}
class Circle extends Shape{
Circle(int r){
area = pi*r*r; }
void draw(){System.out.println("Area of circle:"+area);}
}
```

Wildcard in Generics

```
class test{
//creating a method that accepts only child class of Shape
public static void drawShapes(List<? extends Shape> lists){
for(Shape s:lists){
s.draw();}
}
public static void main(String args[]){
List<Rectangle> list1=new ArrayList<Rectangle>();
list1.add(new Rectangle(3,5));

List<Circle> list2=new ArrayList<Circle>();
list2.add(new Circle(2));
list2.add(new Circle(5));
drawShapes(list1);
drawShapes(list2);
}}
```

Output:
Area of Rect:15.0
Area of circle:12.56
Area of circle:78.5

Wildcard in Generics

```
class test{
    public static void main(String[] args) {
     List<Integer> list1= Arrays.asList(1,2,3);
     List<Number> list2=Arrays.asList(1.1,2.2,3.3);
     List<Double> list3=Arrays.asList(1.1,2.2,3.3);
      List<String> list4=Arrays.asList("s","j","r");

        printlist(list1);
       printlist(list2);
      printlist(list3);
    printlist(list4);
    }
     private static void printlist(List<Number> list)      {
         System.out.println(list);
    }
}
```

Output:
list1, list3, list4 – compilation error
Type not applicable for the arguements

Wildcard in Generics

```
class test{
    public static void main(String[] args) {
     List<Integer> list1= Arrays.asList(1,2,3);
     List<Number> list2=Arrays.asList(1.1,2.2,3.3);
     List<Double> list3=Arrays.asList(1.1,2.2,3.3);
      List<String> list4=Arrays.asList("s","j","r");

        printlist(list1);
       printlist(list2);
      printlist(list3);
    printlist(list4);
    }
     private static void printlist(List<?> list)      {
         System.out.println(list);
    }
}
```

Output:
[1, 2, 3]
[1.1, 2.2, 3.3]
[1.1, 2.2, 3.3]
[s, j, r]

Upper Bounded Wildcard

```
class test{
    public static void main(String[] args) {
     List<Integer> list1= Arrays.asList(1,2,3);
     List<Number> list2=Arrays.asList(1.1,2.2,3.3);
     List<Double> list3=Arrays.asList(1.1,2.2,3.3);
      List<String> list4=Arrays.asList("s","j","r");

        printlist(list1);
       printlist(list2);
      printlist(list3);
    printlist(list4);
    }
     private static void printlist(List<? extends Number> list)      {
         System.out.println(list);
    }
}
```

Output:
list4 – compilation error
Type not applicable for the arguements

Lower Bounded Wildcard

```
class test{
    public static void main(String[] args) {
     List<Integer> list1= Arrays.asList(1,2,3);
     List<Number> list2=Arrays.asList(1.1,2.2,3.3);
     List<Double> list3=Arrays.asList(1.1,2.2,3.3);
        printlist(list1);
       printlist(list2);
      printlist(list3);
}
    private static void printlist(List<? super Integer> list)     {
        System.out.println(list);
   }
}
```

Output:
list3 – compilation error
Type not applicable for the arguements

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Comparable Interface

Comparable Interface

- It is used to order the objects of user-defined class.
- It is found in java.lang package and contains only one method named compareTo(Object)
- Elements can be sorted based on single data member eg: account number, name or age.
- We can sort the elements of:
  - String objects
  - Wrapper class objects
  - User-defined class objects

Comparable-Example

```
import java.util.*;
class Account implements Comparable<Account>{
        int acc;
        String name;
        float amt;
Account(int acc,String name,float amt){
        this.acc = acc;
        this.name = name;
        this.amt = amt; }
public int compareTo(Account ac){
        if(amt==ac.amt)
        return 0;
        else if(amt>ac.amt)
        return 1;
        else
        return -1;  }
public String toString() {
        return "Acc. No.: "+acc+" Name: "+name+" Amount: "+amt;}
}
```

Comparable-Example

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```
class Test{
public static void main(String[] args) {
List<Account> al = new ArrayList<Account>();

al.add(new Account(111,"Ankit",5000));
al.add(new Account(112,"Ashok",4000));
al.add(new Account(123,“Ryan",5000));

Collections.sort(al);

for(Account a:al)
System.out.println(a);
  }
}
```

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Comparator Interface

Comparator Interface

- Used to order user defined class
- This interface is found in java.util package and contains 2 methods
  - compare(Object obj1,Object obj2)
  - equals(Object element)
- It provides multiple sorting sequence
  - Elements can be sorted based on any data member

Comparator - Example

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```
import java.util.*;

class Account{
        int acc;
        String name;
        float amt;
Account(int acc,String name,float amt){
        this.acc = acc;
        this.name = name;
        this.amt = amt; }
public String toString() {
        return "Acc. No.: "+acc+" Name: "+name+" Amount: "+amt;}
}
```

Comparator - Example

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```
class AmtCmp implements Comparator<Account>{
public int compare(Account a1,Account a2){
        if(a1.amt==a2.amt)
        return 0;
        else if(a1.amt>a2.amt)
        return 1;
        else
        return -1; }
}
```

Comparator - Example

```
class AccCmp implements Comparator<Account>{
public int compare(Account a1,Account a2){
        if(a1.acc==a2.acc)
        return 0;
        else if(a1.acc>a2.acc)
        return 1;
        else
        return -1; }
}
```

Comparator - Example

```
class test {
public static void main(String[] args) {
List<Account> al = new ArrayList<Account>();

al.add(new Account(123,"Ankit",5000));
al.add(new Account(112,"Ashok",4000));
al.add(new Account(111,"Ryan",5000));

System.out.println("Comparison on Amount");
Collections.sort(al,new AmtCmp());
for(Account a:al)
System.out.println(a);

System.out.println("Comparison on Acc. No.");
Collections.sort(al,new AccCmp());
for(Account a:al)
System.out.println(a);  }
}
```

Overriding Equals method

```
class Account implements Comparator<Account>{
        int acc;
        String name;
        float amt;
Account(int acc,String name,float amt){
        this.acc = acc;
        this.name = name;
        this.amt = amt; }
public boolean equals(Account a1) {
         if (a1 == null)
         return false;
         if(this.acc != a1.acc)
         return false;
         if(this.amt != a1.amt)
         return false;
         if(!(a1.name.equals(this.name)))
         return false;
         return true;}
```

Overriding Equals method

```
public String toString() {
        return "Acc. No.: "+acc+" Name: "+name+" Amount: "+amt;}
public int compare(Account arg0, Account arg1) {
        // TODO Auto-generated method stub
return 0;}
}

class test {
public static void main(String[] args) {
        List<Account> al = new ArrayList<Account>();
        al.add(new Account(111,"Ryan",5000));
        al.add(new Account(112,“Ryan",5000));
        al.add(new Account(111,"Ryan",5000));
        System.out.println(al.get(0).equals(al.get(2)));
        System.out.println(al.get(0).equals(al.get(1))); }
}
```

Bounds in Generics (Comparator)

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```
public class test {
   public static void main(String[] args) {
      System.out.printf("Max of %d, %d and %d is %d\n\n",
         3, 4, 5, maximum( 3, 4, 5 ));
      System.out.printf("Max of %.1f,%.1f and %.1f is %.1f\n\n",
         6.6, 8.8, 7.7, maximum( 6.6, 8.8, 7.7 ));
      System.out.printf("Max of %s,%s and %s is %s\n\n",
          "s", "j", "r", maximum( "s", "j", "r" ));
}
   public static <T extends Comparable<T>> T maximum(T x, T y, T z) {
      T max = x;
      if(y.compareTo(max) > 0) {
         max = y;        }
      if(z.compareTo(max) > 0) {
         max = z;        }
      return max;        }
}
```

Output:
Max of 3, 4 and 5 is 5
Max of 6.6,8.8 and 7.7 is 8.8
Max of s,j and r is s

Multiple Bounds in Generics

```
public class test {
   public static void main(String[] args) {
      System.out.printf("Max of %d, %d and %d is %d\n\n",
         3, 4, 5, maximum( 3, 4, 5 ));
      System.out.printf("Max of %.1f,%.1f and %.1f is %.1f\n\n",
         6.6, 8.8, 7.7, maximum( 6.6, 8.8, 7.7 ));
      System.out.printf("Max of %s,%s and %s is %s\n\n",
          "s", "j", "r", maximum( "s", "j", "r" ));
}
   public static <T extends Number & Comparable<T>> T maximum(T x, T
     y, T z) {
      T max = x;
      if(y.compareTo(max) > 0) {
         max = y;       }
      if(z.compareTo(max) > 0) {
         max = z;       }
      return max;       }   }
```

Error:
The method maximum(T, T, T) in the type test is not applicable for the arguments (String, String, String)

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Coming back to Collections

ArrayList

- Growable Array implementation of List interface.
- Insertion order is preserved.
- Duplicate elements are allowed.
- Multiple null elements of insertion are allowed.
- Default initial capacity of an ArrayList is 10.
- The capacity grows with the below formula, once ArrayList reaches its max capacity.
- newCapacity= (oldCapacity * 3)/2 + 1
- **When to use?**
  - **If elements are to be retrieved frequently. Because ArrayList implements RandomAccess Interface**
- **When not to use?**
  - **If elements are added/removed at specific positions frequently**

LinkedList

- Linked list is implementation class of List interface.
- Underlying data structure is Double linked list.
- Insertion order is preserved.
- Duplicate elements are allowed.
- Multiple null elements of insertion are allowed.

LinkedList - Methods

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Constructor/Method	Description
List list = new LinkedList();	It creates an empty linked list.
public boolean add(E e);	It adds the specified element at the end of the list.
public void addFirst(E e);	It adds the specified element in the beginni ng of the list.
public void addLast(E e);	It adds the specified element to the end of the list
public E removeFirst();	It removes and returns the first element fr om the list.
public E removeLast();	It removes and returns the last element fro m the list.
public E getFirst();	It returns the first element from the list.
public E getLast();	It returns the last element from the list.

Iterator vs. ListIterator

Iterator	ListIterator
Can do remove operation only on elements	Can remove, add and replace elements
Method is remove()	Methods are remove(), add() and set()
iterator() method returns an object of Itertor	listIterator() method returns an object of ListItertor
iterator() method is available for all collections. That is, Iterator can be used for all collection classes	listIterator() method is available for those collections that implement List interface. That is, descendents of List interface only can use ListIterator

Stack

- Stack is child class of Vector
- Stack class in java represents LIFO (Last in First Out) stack of objects.

Method	Description
public E push(E item);	Pushes the item on top of the stack
public synchronized E pop();	Removes the item at the top of the stack and returns that item
public synchronized E peek();	Returns the item at the top of the stack
public boolean empty();	Checks whether stack is empty or not
public synchronized int search (Object o);	Returns the position of an object in the stack.

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Set Interface

Set Interface

- The set interface is an unordered collection of objects in which duplicate values cannot be stored.
- The Java Set does not provide control over the position of insertion or deletion of elements.
- Basically, Set is implemented by HashSet, LinkedHashSet or TreeSet (sorted representation).

HashSet

- Implements Set Interface.
- Underlying data structure for HashSet is hashtable.
- As it implements the Set Interface, duplicate values are not allowed.
- Objects that you insert in HashSet are not guaranteed to be inserted in same order. Objects are inserted based on their hash code.
- NULL elements are allowed in HashSet.
- Execution time of add(), contains(), remove(), size() is constant even for large sets.

HashSet - Example

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```
HashSet<Integer> set = new HashSet<Integer>();
    set.add(12);
    set.add(63);
    set.add(34);
    set.add(45);
    set.add(12);

    Iterator<Integer> iterator = set.iterator();
    System.out.print("Set data: ");
    while (iterator.hasNext()) {
        System.out.print(iterator.next() + " ");
    }
```

Output:
Set data: 34 12 45 63