- Collection Framework
    - Queue
    - Set
    - Map
- hashCode()

Collection framework

Queue interface

- Represents utility data structures (like Stack, Queue, ...) data structure.
- Implementations: LinkedList, ArrayDeque, PriorityQueue.
- Can be accessed using iterator, but no random access.
- Methods
    - boolean add(E e) - throw IllegalStateException if full.
    - E remove() - throw NoSuchElementException if empty
    - E element() - throw NoSuchElementException if empty
    - boolean offer(E e) - return false if full.
    - E poll() - returns null if empty
    - E peek() - returns null if empty
- In queue, addition and deletion is done from the different ends (rear and front).

Deque interface

- Represents double ended queue data structure i.e. add/delete can be done from both the ends.
- Two sets of methods
    - Throwing exception on failure: addFirst(), addLast(), removeFirst(), removeLast(), getFirst(), getLast().
    - Returning special value on failure: offerFirst(), offerLast(), pollFirst(), pollLast(), peekFirst(), peekLast().
- Can used as Queue as well as Stack.
- Methods
    - boolean offerFirst(E e)
    - E pollFirst()
    - E peekFirst()
    - boolean offerLast(E e)
    - E pollLast()
    - E peekLast()

ArrayDeque class

- Internally ArrayDeque is dynamically growable array.

- Elements are allocated contiguously in memory.

LinkedList class

- Internally LinkedList is doubly linked list.

PriorityQueue class

- Internally PriorityQueue is a "binary heap" data structure.
- Elements with highest priority is deleted first (NOT FIFO).
- Elements should have natural ordering or need to provide comparator.

Set interface

- Collection of unique elements (NO duplicates allowed).
- Implementations: HashSet, LinkedHashSet, TreeSet.
- Elements can be accessed using an Iterator.
- Abstract methods (same as Collection interface)
    - add() returns false if element is duplicate

HashSet class

- Non-ordered set (elements stored in any order)
- Elements must implement equals() and hashCode()
- Fast execution

LinkedHashSet class

- Ordered set (preserves order of insertion)
- Elements must implement equals() and hashCode()
- Slower than HashSet

SortedSet interface

- Use natural ordering or Comparator to keep elemenrs in sorted order
- Methods
    - E first()
    - E last()
    - SortedSet headSet(E toElement)
    - SortedSet subSet(E fromElement, E toElement)
    - SortedSet tailSet(E fromElement)

NavigableSet interface

- Sorted set with additional methods for navigation
- Methods
    - E higher(E e)
    - E lower(E e)

    - E pollFirst()
    - E pollLast()
    - NavigableSet descendingSet()
    - Iterator descendingIterator()

TreeSet class

- Sorted navigable set (stores elements in sorted order)
- Elements must implement Comparable or provide Comparator
- Slower than HashSet and LinkedHashSet
- It is recommended to have consistent implementation for Comparable (Natural ordering) and equals() method i.e. equality and comparison should done on same fields.
- If need to sort on other fields, use Comparator.

```
class Book implememts Comparable<Book> {
    private String isbn;
    private String name;
    // ...
    public int hashCode() {
        return isbn.hashCode();
    }
    public boolean equals(Object obj) {
        if(!(obj instanceof Book))
            return false;
        Book other=(Book)obj;
        if(this.isbn.equals(other.isbn))
            return true;
        return false;
    }
    public int compareTo(Book other) {
        return this.isbn.compareTo(other.isbn);
    }
}
```

```
// Store in sorted order by name
set = new TreeSet<Book>((b1,b2) -> b1.getName().compareTo(b2.getName()));
```

```
// Store in sorted order by isbn (Natural ordering)
set = new TreeSet<Book>();
```

HashTable Data structure

- Hashtable stores data in key-value pairs so that for the given key, value can be searched in fastest possible time.

- Internally hash-table is a table(array), in which each slot(index) has a bucket(collection). Key-value entries are stored in the buckets depending on hash code of the "key".
- Load factor = Number of entries / Number of buckets.
- Examples
    - Key=pincode, Value=city/area
    - Key=Employee, Value=Manager
    - Key=Department, Value=list of Employees

hashCode() method

- Object class has hashCode() method, that returns a unique number for each object (by converting its address into a number).
- To use any hash-based data structure hashCode() and equals() method must be implemented.
- If two distinct objects yield same hashCode(), it is referred as collision. More collisions reduce performance.
- Most common technique is to multiply field values with prime numbers to get uniform distribution and lesser collsions.
- hashCode() overriding rules
    - hash code should be calculated on the fields that decides equality of the object.
    - hashCode() should return same hash code each time unless object state is modified.
    - If two objects are equal (by equals()), then their hash code must be same.
    - If two objects are not equal (by equals()), then their hash code may be same (but reduce performance).

Map interface

- Collection of key-value entries (Duplicate "keys" not allowed).
- Implementations: HashMap, LinkedHashMap, TreeMap, Hashtable, ...
- The data can be accessed as set of keys, collection of values, and/or set of key-value entries.
- Map.Entry<K,V> is nested interface of Map<K,V>.
    - K getKey()
    - V getValue()
    - V setValue(V value)
- Abstract methods

```
* boolean isEmpty()
* int size()
* V put(K key, V value)
* V get(Object key)
* Set<K> keySet()
* Collection<V> values()
* Set<Map.Entry<K,V>> entrySet()
* boolean containsValue(Object value)
* boolean containsKey(Object key)
* V remove(Object key)
* void clear()
* void putAll(Map<? extends K,? extends V> map)
```

- Maps not considered as true collection, because it is not inherited from Collection interface.

HashMap class

- Non-ordered map (entries stored in any order -- as per hash code of key)
- Keys must implement equals() and hashCode()
- Fast execution
- Mostly used Map implementation

LinkedHashMap class

- Ordered map (preserves order of insertion)
- Keys must implement equals() and hashCode()
- Slower than HashSet
- Since Java 1.4

TreeMap class

- Sorted navigable map (stores entries in sorted order of key)
- Keys must implement Comparable or provide Comparator
- Slower than HashMap and LinkedHashMap
- Internally based on Red-Black tree.
- Doesn't allow null key (allows null value though).

Hashtable class

- Similar to HashMap class.
- Legacy collection class (since Java 1.0), modified for collection framework (Map interface).
- Synchronized collection -- Thread safe but slower performance
- Inherited from java.util.Dictionary abstract class (it is Obsolete).