This recitation

- An interesting point about A3: Using previous methods to avoid work in programming and debugging. How much time did *you* spend writing and debugging prepend?
- Enums (enumerations)
- Generics and Java's Collection interfaces and classes

How to use previous methods in A2

The A2 handout contained this:

Further guidelines and instructions!
"Note that some methods that you have to write …. Also, in writing methods 4..7, writing them in terms of calls on previously written methods may save you time."

Did you read that? Think about it? Attempt it?

A lesson in:
1. Reading carefully, wisely.
2. Thinking about what methods do, visualizing what they do.

About enums (enumerations)

An enum: a class that lets you create mnemonic names for entities instead of having to use constants like 1, 2, 3, 4

The declaration below declares a class Suit.
After that, in any method, use Suit.Clubs, Suit.Diamonds, etc. as constants.

public enum Suit {Clubs, Diamonds, Hearts, Spades}

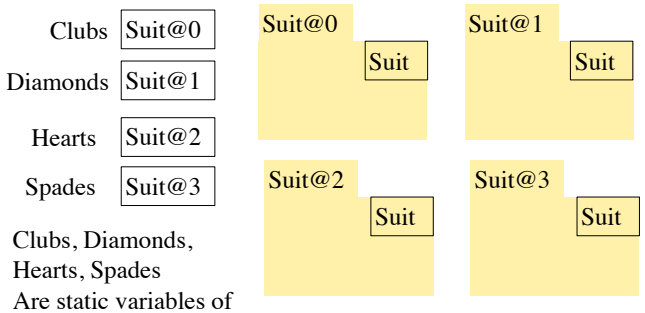
could be private, or any access modifier

new keyword

The constants of the class are Clubs, Diamonds, Hearts, Spades

Four static final variables that contain pointers to objects

public enum Suit {Clubs, Diamonds, Hearts, Spades}



Clubs, Diamonds, Hearts, Spades
Are static variables of class enum

Testing for an enum constant

public enum Suit {Clubs, Diamonds, Hearts, Spades}

Suit s= Suit.Clubs;
Then
s == Suit.Clubs is true s == Suit.Hearts is false

```
switch(s) {
   case Clubs:
   case Spades:
      color= "black"; break;
   case Diamonds:
   case Hearts:
      color= "red"; break;
}
```

Can use a switch statement

Type of s is Suit.

Inside the switch, you cannot write Suit.Hearts instead of Hearts

Miscellaneous points about enums

public enum Suit {Clubs, Diamonds, Hearts, Spades}

This declaration is shorthand for a class that has a constructor, four constants (public static final variables), a static method, and some other components. Here are some points:

1. Suit is a subclass of Enum (in package java.lang)

2. It is not possible to create instances of class Suit, because its constructor is private!

3. It's as if Clubs (as well as the other three names) is declared within class Suit as

public static final Suit Clubs= **new** Suit(some values);

You don't care what values

Miscellaneous points about enums

public enum Suit {Clubs, Diamonds, Hearts, Spades}

4. Static function values() returns a Suit[] containing the four constants. You can, for example, use it to print all of them:

```
for (Suit s : Suit.values())
    System.out.println(s);
```

toString in object Clubs returns the string "Clubs"

Output:
Clubs
Diamonds
Hearts
Spades

Can save this array in a static variable and use it over and over:

```
private static Suit[] mine= Suit.values();
```


Miscellaneous points about enums

public enum Suit {Clubs, Diamonds, Hearts, Spades}

5. Static function valueOf(String name) returns the enum constant with that name:

```
Suit c= Suit.valueOf("Hearts");
```

After the assignment, c contains (the name of) object Hearts

c Suit@2

This is the object for Hearts:

Suit@2

Suit

Miscellaneous points about enums

public enum Suit {Clubs, Diamonds, Hearts, Spades}

This declaration is shorthand for a class that has a constructor, four constants (public static final variables), a static method, and some other components. Here are some points:

6. Object Clubs (and the other three) has a function ordinal() that returns it position in the list

Suit.Clubs.ordinal() is 0
Suit.Diamonds.ordinal() is 1

We have only touched the surface of enums. E.g. in an enum declaration, you can write a private constructor, and instead of Clubs you can put a more elaborate structure. All this is outside the scope of CS2110.

Package java.util has a bunch of classes called the Collection Classes that make it easy to maintain sets of values, list of values, queues, and so on. You should spend some time looking at their API specifications and getting familiar with them.

Remember:
A set is a bunch of distinct (different) values. No ordering is implied
A list is an ordered bunch of values. It may have duplicates.

Interface Collection: abstract methods for dealing with a group of objects (e.g. sets, lists)

Abstract class AbstractCollection: overrides some abstract methods with methods to make it easier to fully implement Collection

AbstractList, AbstractQueue, AbstractSet, AbstractDeque overrides some abstract methods of AbstractCollection with real methods to make it easier to fully implement lists, queues, set, and deques

Next slide contains classes that you should become familiar with and use. Spend time looking at their specifications. There are also other useful Collection classes

Class ArrayList extends AbstractList: An object is a growable/shrinkable list of values implemented in an array

Class HashSet extends AbstractSet: An object maintains a growable/shrinkable set of values using a technique called *hashing*. We will learn about hashing later.

Class LinkedList extends AbstractSequentialList: An object maintains a list as a doubly linked list

Class ArrayList extends AbstractList: An object is a growable/shrinkable list of values implemented in an array. An old class from early Java

Class Stack extends ArrayList: An object maintains LIFO (last-in-first-out) stack of objects

Class Arrays: Has lots of static methods for dealing with arrays —searching, sorting, copying, etc.

ArrayList

ArrayList v= **new** ArrayList ();

defined in package java.util

An object of class ArrayList contains a growable/shrinkable list of elements (of class Object). You can get the size of the list, add an object at the end, remove the last element, get element i, etc. More methods exist! Look at them!

v ArrayList@x1

ArrayList@x1

Object

Fields that ArrayList contain a list of objects $(o_0, o_1, \ldots, o_{size()-1})$

ArrayList () add(Object) get(int) size() remove(…) set(int, Object) …

HashSet

HashSet s= **new** HashSet();

Don't ask what "hash" means. Just know that a Hash Set object maintains a set

An object of class HashSet contains a growable/shrinkable set of elements (of class Object). You can get the size of the set, add an object to the set, remove an object, etc. More methods exist! Look at them!

s HashSet@y2

HashSet

HashSet@y2

Object

Fields that Hashset contain a setof objects $\{o_0, o_1, \ldots, o_{size()-1}\}$

HashSet() add(Object) contains(Object) size() remove(Object) …

Iterating over a HashSet or ArrayList

```
HashSet s= new HashSet();
… code to store values in the set …
for (Object e : s) {
    System.out.println(c);
}
```

A loop whose body is executed once with e being each element of the set. Don't know order in which set elements processed

Use same sort of loop to process elements of an ArrayList in the order in which they are in the ArrayList .

HashSet@y2

Object

Fields that HashSet contain a setof objects $\{o_0, o_1, \ldots, o_{size()-1}\}$

HashSet() add(Object) contains(Object) size() remove(Object) …

s HashSet@y2

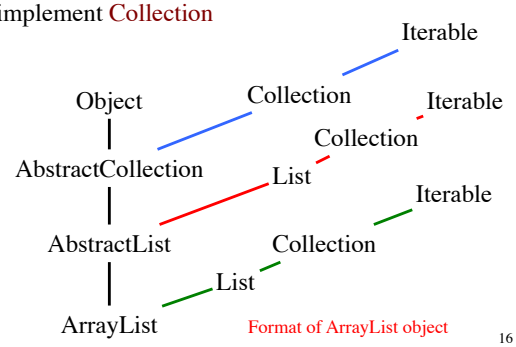
HashSet

Interface Collection: abstract methods for dealing with a group of objects (e.g. sets, lists)

Iterable Not discussed today

Abstract class AbstractCollection: overrides some abstract methods with real methods to make it easier to fully implement Collection

ArrayList implements 3 other interfaces, not shown



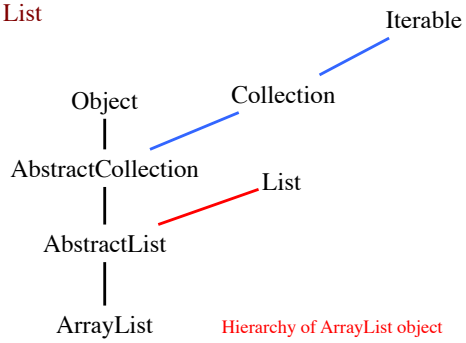
Format of ArrayList object

Interface List: abstract methods for dealing with a list of objects $(o_0, \ldots, o_{n-1})$. Examples: ArrayList, LinkedList

Iterable Not discussed today

Abstract class AbstractList: overrides some abstract methods with real methods to make it easier to fully implement List

Homework: Look at API specifications and build diagram giving format of HashSet



Hierarchy of ArrayList object

Generics and Java's Collection Classes

ge·ner·ic *adjective* \jə'nerik, -rēk\
relating or applied to or descriptive of all members of a genus, species, class, or group: common to or characteristic of a whole group or class: typifying or subsuming: not specific or individual.

From Wikipedia: generic programming: a style of computer programming in which algorithms are written in terms of to-be-specified-later types that are then *instantiated* when needed for specific types provided as parameters.

Read carefully!

In Java: Without generics, every ArrayList object contains a list of elements of class Object. Clumsy

With generics, we can have an ArrayList of Strings, an ArrayList of Integers, an ArrayList of Genes. Simplifies programming, guards against some errors

Generics: say we want an ArrayList of only one class

API specs: ArrayList declared like this:

```
public class ArrayList <E> extends AbstractList<E>
                       implements List<E> … { … }
```

Means:
Can create ArrayList specialized to certain class of objects:

```
ArrayList <String>  vs= new ArrayList <String>();  //only Strings
ArrayList <Integer> vi= new ArrayList <Integer>(); //only Integers
```

```
vs.add(3);
vi.add("abc");
```
These are illegal

```
int n= vs.get(0).size();
```
vs.get(0) has type String
No need to cast

ArrayList to maintain list of Strings is cumbersome

```
ArrayList v= new ArrayList ();
… Store a bunch of Strings in v …
// Get element 0, store its size in n
String ob= ((String) v.get(0)).length();
int n= ob.size();
```
—Only Strings, nothing else

All elements of v are of type Object. So, to get the size of element 0, you first have to cast it to String.

Make mistake, put an Integer in v? May not catch error for some time.

v [ArrayList@x1] ArrayList

ArrayList @x1

Object

Fields that ArrayList contain a list of objects $(o_0, o_1, \ldots, o_{size()-1})$

ArrayList() add(Object)
get(int) size()
remove() set(int, Object)
…

Generics allow us to say we want ArrayList of Strings only

API specs: ArrayList declared like this:

```
public class ArrayList<E> extends AbstractList<E>
                          implements List<E> … { … }
```

Full understanding of generics is not given in this recitation.
E.g. We do not show you how to write a generic class.

Important point: When you want to use a class that is defined like ArrayList above, you can write

```
ArrayList<C> v= new ArrayList<C>(…);
```

to have v contain an ArrayList object whose elements HAVE to be of class C, and when retrieving an element from v, its class is C.