# Inf1B

## Collections

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# Rigidity of arrays

- Length of array is fixed at creation time.
- Can't be expanded.
- Can't be shrunk.
- Arrays are part of Java language — uses special syntax.
- E.g., `myArray[i]` for accessing the ith element.

# Rigidity of arrays

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- Arrays are part of Java language — uses special syntax.
- E.g., `myArray[i]` for accessing the ith element.

Arrays are not always optimal for handling data.

# ArrayList

- Can grow and shrink as needed;
- provides methods for inserting and removing elements.

# ArrayList

## Declaration

```
ArrayList<String> cheers = new ArrayList<String>();
```

- This is an array list of strings; counterpart to `String[]`.
- Angle brackets indicate that `String` is a type parameter.
- Can replace `String` with e.g. `HotelRoom` to get different array list type.
- In general: use `ArrayList<E>` to collect objects of type `E`; but `E` cannot be a primitive type.

# ArrayList

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- Can replace `String` with e.g. `HotelRoom` to get different array list type.
- In general: use `ArrayList<E>` to collect objects of type `E`; but `E` cannot be a primitive type.

**NB**:

```
ArrayList<String> cheers = new ArrayList<>();
```

Since Java 8 the compiler can infer the type of the list in the constructor call.

# ArrayList: Methods

- A newly constructed `ArrayList` has size `0`.
- `ArrayList` has various methods, which allow us to:
  - keep on adding new elements;
  - remove elements.
- The size changes after each addition / removal.

# ArrayList: Adding

## Adding Elements

```
ArrayList<String> cheers = new ArrayList<String>();
cheers.add("hip");
cheers.add("hip");
cheers.add("hooray");
int n = cheers.size(); // n gets value 3
```

- `add()` appends each element to the end of the list.

# ArrayList: Printing

## Printing an ArrayList

```
System.out.println(cheers);
```

**Output**

```
[hip, hip, hooray]
```

The compiler implicitly calls the `.toString()` method of the `cheers` object which in turn calls the `.toString()` method of each of its list elements.

# ArrayList: More methods

## Index of first occurrence

```
int ind = cheers.indexOf("hip");  // ind gets value 0
```

## Adding element at an index

```
cheers.add(1, "hop"); // 2nd "hip" gets shunted along
```

Elements of `cheers`: `["hip", "hop", "hip", "hooray"]`

# ArrayList: More methods

## contains()

```
boolean isHip = cheers.contains("hip");  // isHip is true
```

## remove()

```
cheers.remove("hip");  // removes first occurrence of "hip"
```

Elements of `cheers`: `"hop"`, `"hip"`, `"hooray"`

## get(int index)

```
cheers.get(0);  // get the first element
                // returns "hop"
```

# ArrayList and Loops

Looping over `ArrayList`:

## Standard `for` loop

```
for (int i = 0; i < cheers.size(); i++) {
     System.out.println(cheers.get(i));
}
```

# ArrayList and Loops

Looping over `ArrayList`:

## Standard `for` loop

```
for (int i = 0; i < cheers.size(); i++) {
     System.out.println(cheers.get(i));
}
```

## Enhanced `for` again

```
for (String s : cheers) {
     System.out.println(s);
}
```

# ArrayList and Loops

## Enhanced `for` again

```
for (String s : cheers) {
     System.out.print(s + "\thas index: ");
     System.out.println(cheers.indexOf(s));
}
```

## Output

```
hop     has index: 0
hip     has index: 1
hooray  has index: 2
```

# Wrapper Classes

Wrapper Classes:

- The type variable `E` in a generic type like `ArrayList<E>` must resolve to a reference type.
- So `ArrayList<int>` will not compile.
- All the primitive types can be turned into objects by using wrapper classes:

| *Primitive Type* | *Wrapper Class* |
|---|---|
| `boolean` | `Boolean` |
| `char` | `Character` |
| `double` | `Double` |
| `int` | `Integer` |
| `long` | `Long` |

NB Wrapper class names are always capitalized, always complete words.

# Auto-boxing

- Conversion between primitive types and corresponding wrapper classes is automatic.
- Process of conversion is called auto-boxing

## Auto-box example

```
Double batteryCharge = 2.75;
double x = batteryCharge;
```

## Auto-box example

```
ArrayList<Double> data = new ArrayList<Double>();
data.add(29.95);
double x = data.get(0);
```

# Custom Types in ArrayLists

You can also put your own data types into an `ArrayList`:

## Circle List

```
ArrayList<Circle> data = new ArrayList<Circle>();
Circle c = new Circle(10);
data.add(c);
data.get(0).enlarge(2);
```

# Custom Types in ArrayLists

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ArrayList<Circle> data = new ArrayList<Circle>();
Circle c = new Circle(10);
data.add(c);
data.get(0).enlarge(2);
```

Some functionality will, however, not work properly unless you implement the necessary **Interfaces** (I will tell you more later).

## Comparing Elements

```
Collections.sort(data);
Collections.reverse(data);
```

# Nested ArrayLists

Since I can use any object type as type parameter, I can also create ArrayLists of ArrayLists.

## Daily Temperature Lists

```
ArrayList<ArrayList<Double>> dailyTemp =
        new ArrayList<ArrayList<Double>>();
dailyTemp.add(new ArrayList<Double>());
dailyTemp.get(0).add(1.2);
dailyTemp.get(0).add(1.4);
dailyTemp.add(new ArrayList<Double>());
dailyTemp.get(1).add(2.0);
dailyTemp.get(1).add(1.9);
```

**Output**

```
[[1.0, 1.4], [2.0, 1.9]]
```

# Lists of Lists

This is where type inference comes in handy.

## Nested Lists

```
ArrayList<ArrayList<Double>> dailyTemp = new ArrayList<>();
dailyTemp.add(new ArrayList<>());
dailyTemp.get(0).add(1.0);
dailyTemp.get(0).add(1.4);
dailyTemp.add(new ArrayList<>());
dailyTemp.get(1).add(2.0);
dailyTemp.get(1).add(1.9);
```

**Output**

```
[[1.0, 1.4], [2.0, 1.9]]
```

# Import

Importing:

- To get full access to Java API, we need to import classes.
- Not necessary if class is in same folder, or part of `java.lang` (e.g., `Math` library).
- To use `ArrayList`, add the appropriate `import` statement at top of your file:

## Import example

```
import java.util.ArrayList;
```

# Import

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## Import example

```
import java.util.ArrayList;
```

## Import example — Wrong!

```
import java.util.ArrayList<String>; // Don't use parameter
```

# Java API

Look at sample Javadoc web page.
https://docs.oracle.com/en/java/javase/11/docs/api/index.html

# Another word about removing elements

Let's assume you want to remove elements from a list of `Strings`.

```
ArrayList<String> names = new ArrayList<String>();
names.add("Charles");
names.add("Marry");
names.add("Peter");
```

# Another word about removing elements

Let's assume you want to remove elements from a list of `Strings`.

```
ArrayList<String> names = new ArrayList<String>();
names.add("Charles");
names.add("Marry");
names.add("Peter");

names.remove("Peter");
```

# Another word about removing elements

Let's assume you want to remove elements from a list of `Strings`.

```
ArrayList<String> names = new ArrayList<String>();
names.add("Charles");
names.add("Marry");
names.add("Peter");

names.remove("Peter");
```

This works if I know exactly which object to remove. But what if I want to remove every `String` that contains the substring "ar"?

# Collection Iterators

Demo

# Collection Iterators

Iterators are objects which allow you to iterate through each element of a collection.

- Declare by parameterising it with the collections content type.

```
Iterator<String> nameIter;
```

- Initialise by asking the collection for an instance.

```
nameIter = names.iterator();
```

- Iterate the collection using a while loop and hasNext().

```
while (nameIter.hasNext())
```

- Access individual elements of the collection using getNext().

```
String element = nameIter.getNext();
```

- Remove elements while iterating using remove().

```
nameIter.remove();
```

# Maps / Associative Arrays

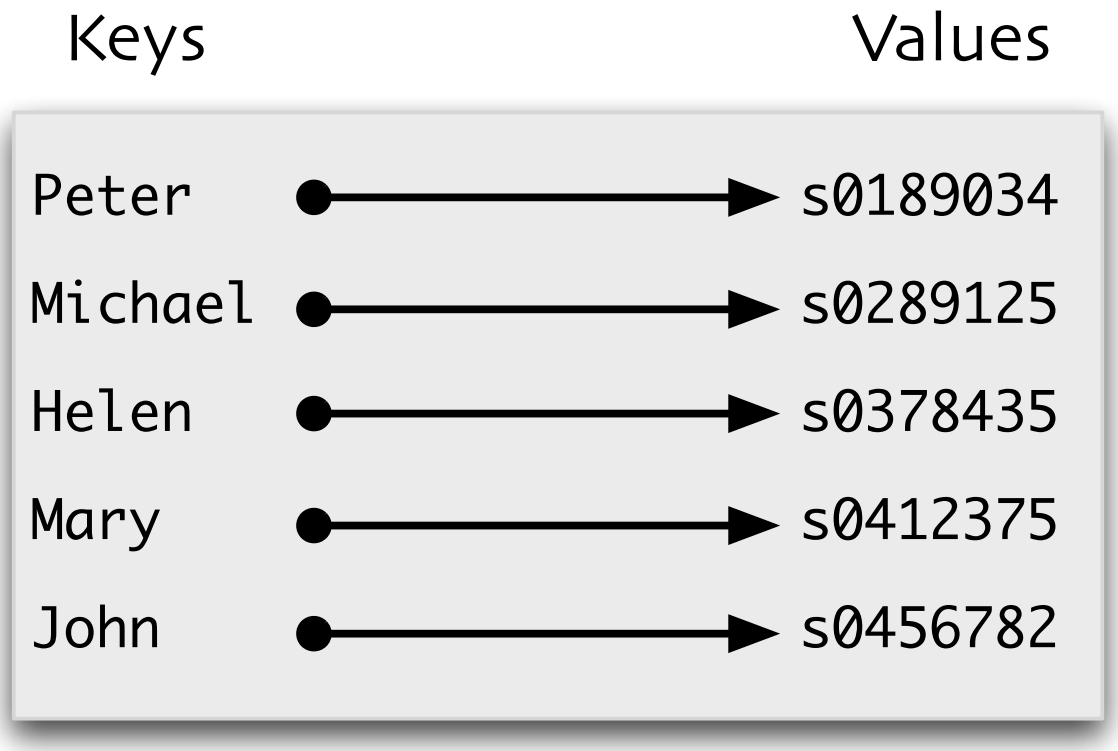
# Associative Arrays

Associative array:

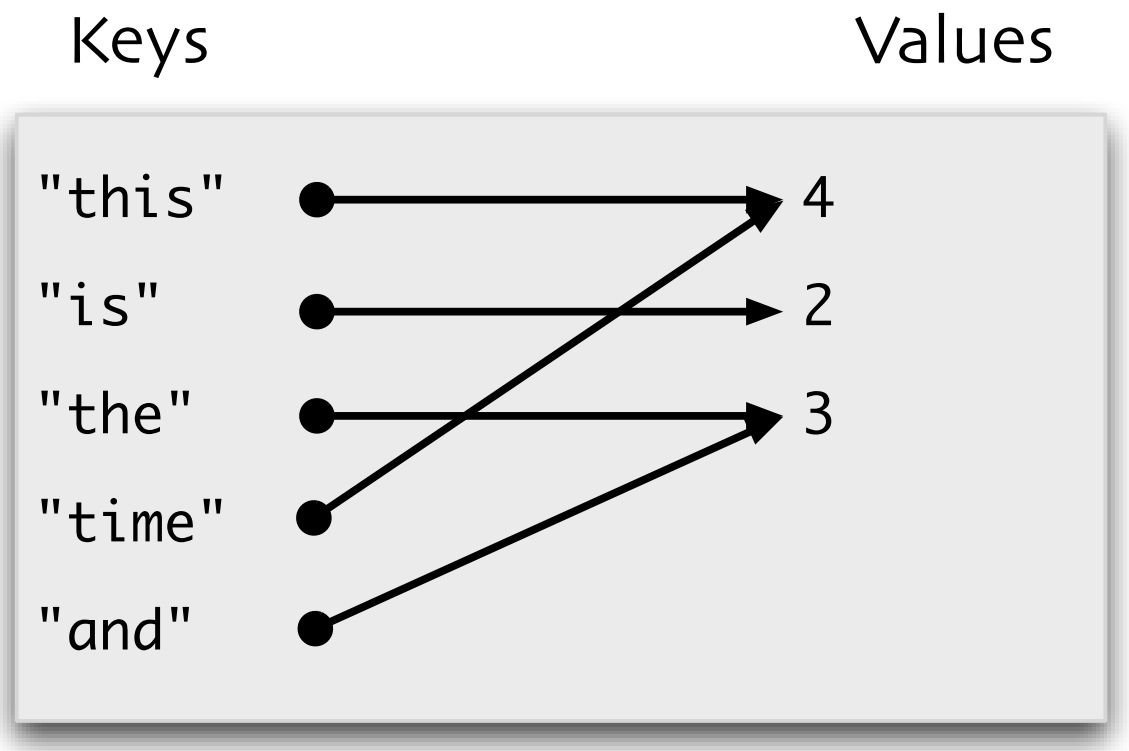
- Associates a collection of unique keys with values.
- Ordinary arrays: keys can only be integers.
- Associative arrays allow keys of many types, most notably strings.
- Examples:
  1. Given a person's name, look up a telephone number.
  2. Given an internet domain, look up its IP address.
  3. Given a geo-location, look up its GPS coordinates.
  4. Given a word, look up its frequency in a text.
- Relationship between key and value: mapping.

Java: associative arrays are implemented by type `HashMap`.

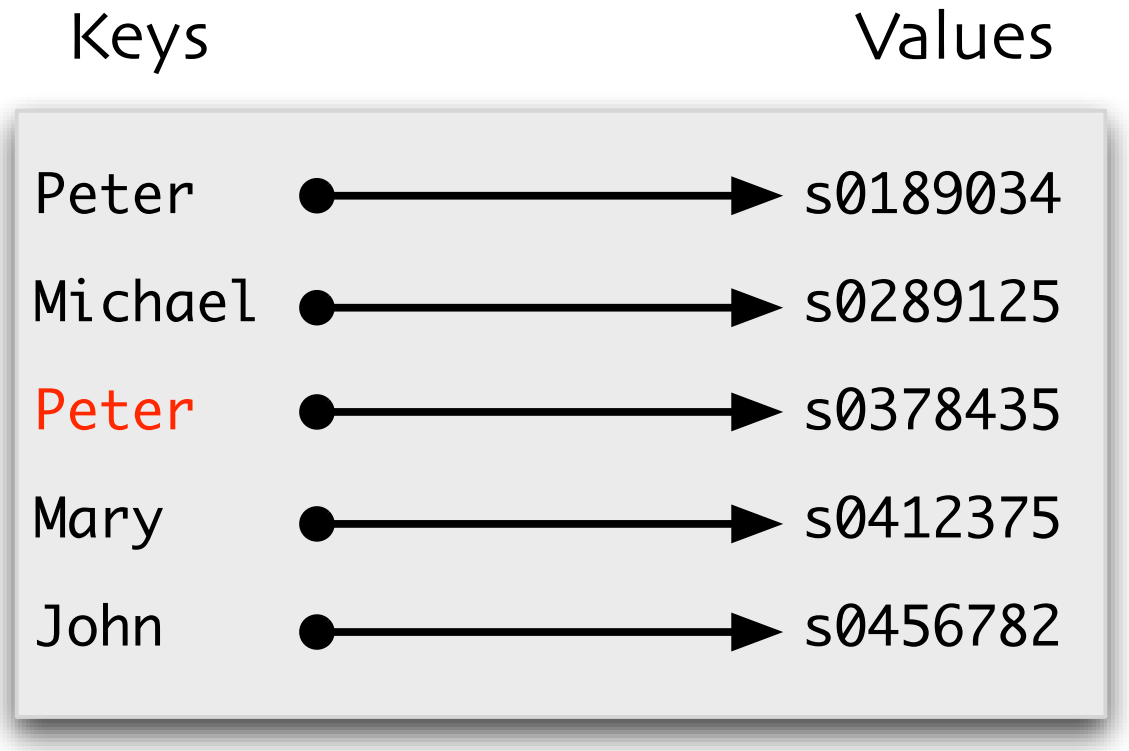
# Map People to their Matric Nos.



# Map Words to Length

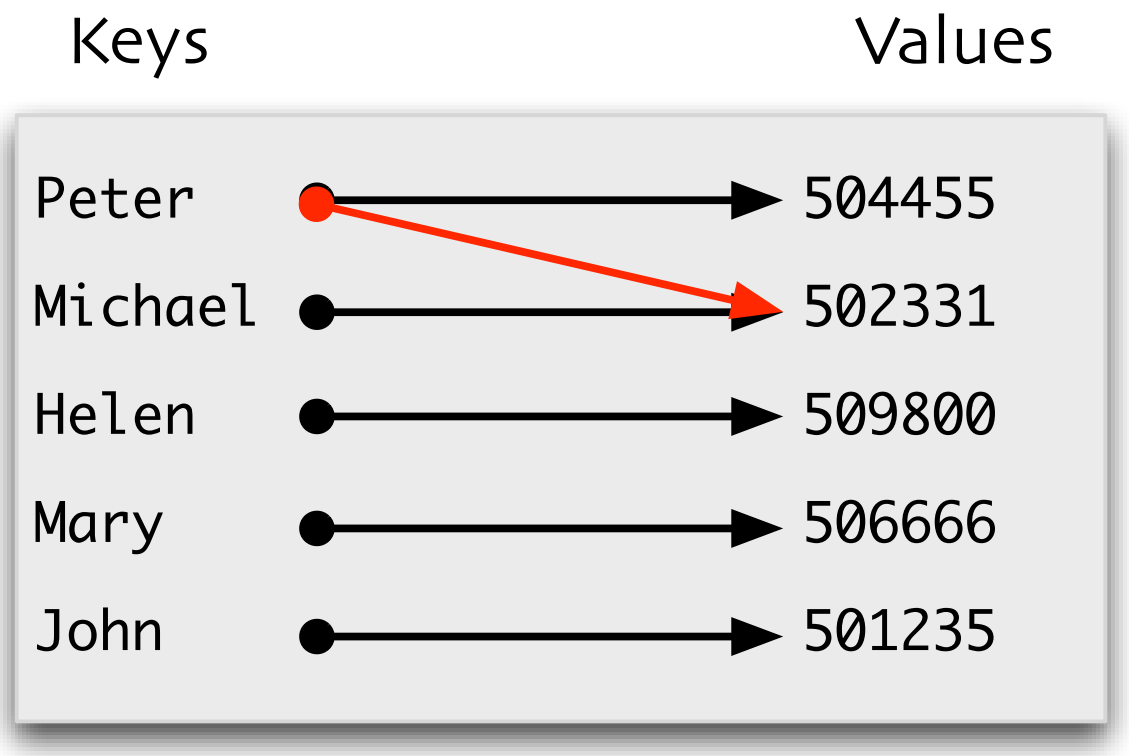


# Map People to their Matric Nos: Wrong!




NB Keys must be unique.

# Map People to their Telephone Nos: Wrong!




- A given key can only be mapped to one value.
- However, type of value can be array, or some other object.

# HashMap

## Import HashMap

```
import java.util.HashMap;
```

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import java.util.HashMap;
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## Declare HashMap

```
HashMap<String, Integer> map
   = new HashMap<String, Integer>();
```

- HashMap takes two type parameters.
- Here, String is type of key, Integer is type of value.

# HashMap

## Import HashMap

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import java.util.HashMap;
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## Declare HashMap

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HashMap<String, Integer> map
   = new HashMap<String, Integer>();
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- HashMap takes two type parameters.
- Here, String is type of key, Integer is type of value.

NB: There is a different type called Hashtable which is the same for our purposes.

# Mapping Words to their Lengths

Goal: Given a string of words, derive an associative array that maps each word to its length.

1. Split the string on whitespace, to yield words.
2. For each word `w`, add it as a key, and associate it with value `w.length()`.
3. When we add the same key again, we overwrite the previous association — wasteful but harmless in this case.

## `split()` method of `String`

```
String sent = "this is the time and this is the record of the ti
String[] words = sent.split(" "); // split on whitespace
```

# HashMap: Add and retrieve mappings

- put(*Key*, *Value*): put *Value* as the value of *Key* in wordLengths.

```
HashMap<String, Integer> wordLengths = new HashMap<String, Integer>();
for (String word : words) {
     wordLengths.put(word, word.length());
    }
```

add a key-value pair to the mapping

- get(*Key*): get the value of *Key* in wordLengths.

```
int wl = wordLengths.get("record"); // value is 6
```

# HashMap: Add and retrieve mappings

`wordLengths.keySet()`: the set of keys in `wordLengths`.

```
[of, record, time, is, the, this, and]
```

# HashMap: Add and retrieve mappings

`wordLengths.keySet()`: the set of keys in `wordLengths`.

```
[of, record, time, is, the, this, and]
```

Q How do we list all key-value pairs in a map?

A Loop over the set of keys.

```
for (String key : wordLengths.keySet()) {
     System.out.printf("%s => %s\n", key, wordLengths.get(key));
     }
```

## Output

```
of => 2
record => 6
time => 4
is => 2
the => 3
this => 4
```

# HashMap: Printing

## Output

```
System.out.println(wordLengths);
```

**Output**

```
{of=2, record=6, time=4, is=2, the=3, this=4, and=3}
```

Format is {*Key1*=*Value1*, *Key2*=*Value2*, ... }

# Custom Types in HashMaps

You can also put your own data types into a HashMap:

## Circle Values

```
HashMap<String, Circle> data = new HashMap<String, Circle>();
data.put("Small", new Circle(2));
data.put("Large", new Circle(200));
```

# Custom Types in HashMaps

You can also put your own data types into a `HashMap`:

## Circle Values

```
HashMap<String, Circle> data = new HashMap<String, Circle>();
data.put("Small", new Circle(2));
data.put("Large", new Circle(200));
```

Using custom types as keys, is more tricky: You will have to make sure they have an `equals` method and produce the same hash code.

# Nested HashMaps

Similar to ArrayLists, you can also write nested HashMaps.

## Circle Organiser

```
HashMap<String, ArrayList<Circle>> data = new HashMap<>();
data.put("Large", new ArrayList<>());
data.put("Small", new ArrayList<>());
data.get("Large").add(new Circle(200));
data.get("Large").add(new Circle(300));
data.get("Small").add(new Circle(5));
data.get("Small").add(new Circle(6));
System.out.println(data);
```

Let's assume Circle implements toString.

**Output**

```
Small=[5, 6], Large=[200, 300]
```

# Summary ArrayList & HashMap

- Use `ArrayList` when you want your arrays to be able to grow, or you want to easily insert and remove items in the middle of an array.
- Use `HashMap` when you want to use keys other than a predetermined list of integers.
- For more on `ArrayList` and `HashMap`, look at the Java API: https://docs.oracle.com/en/java/javase/11/docs/api/index.html
- Iterate collections with ease using an Iterator object.

# Reading

Objects First

Chapter 4 *Grouping Objects* *RECOMMENDED*

Java Tutorial

Chapter 12 *Collections*, stopping at *Algorithms*.