Arrays

- Aggregate data type
- Deal with items of same type
  - Lists of words
  - Numbers
- Analogies
  - Mailboxes in post office
  - CD racks with slots
- Simplifies naming
  - What if you needed to come up with unique name for each data item?
- Allows use of loops
- Required for many mathematical and statistical problems
- Multiple *elements* or *cells*
Using arrays

- Use subscript or index to access an element
  ```java
  int x[5] = 20;
  System.out.println("Result is " + x[5]);
  ```
- First element is element 0, not 1!!!
- Often used in loops
  ```java
  int k = 0, sum = 0;
  while (k < 10)
  {
    sum = sum + measurements[k];
    k = k + 1;
  }
  ```
- Note that subscript is an int variable, k
Creating Arrays

- **Declaration**
  
  double weights[];

- **Definition**
  
  weights = new double[50];

- **Combine declaration and definition**
  
  double weights[] = new double[50];

  ```
  int num[] = new int[6];
  ```

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Arrays & Loops

```java
num[0] = 0;
int k = 2;
while (k < num.length) {
    num[k] = k * k;
    k = k + 1;
}
```

- **Subscript range errors!!**
  - Java checks (many languages do not)
  - Costs & tradeoffs
Array Examples

- Sum up elements in a list (4 ways to do same thing)
  ```c
  int k = 0, sum = 0;
  while (k < 10) {
    sum = sum + data[k];
    k = k + 1;
  }
  int k = 1, sum = 0;
  while (k <= 10) {
    sum = sum + data[k - 1];
    k = k + 1;
  }
  int k = 9, sum = 0;
  while (k >= 0) {
    sum = sum + data[k];
    k = k - 1;
  }
  int k = 10, sum = 0;
  while (k > 0) {
    sum = sum + data[k];
    k = k - 1;
  }
  ```

- Count occurrences of something
- Search for something
- Information retrieval
Array Example (another)

Example: method to count number of A grades

```java
public static int getAs(int[] grades) {
    int aCount = 0;
    for (int k = 0; k < grades.length; k++){
        if (grades[k] >= 90)
            aCount++;
    }
    return aCount;
}
```

Understand each line …
Java Basics – Arrays

- **Array Bounds**
  - Index must in range
    - $0 \leq k < \text{grades.length}$
  - Else get `ArrayIndexOutOfBoundsException`

- **Short Circuit Evaluation**
  - Allows expression of the form
    ```java
    if (k>=0 && k<grades.length && grades[k] >= 90) {
      aCount++;
    }
    ```
  - Safe from exception
  - Order important!
  - Holds for any chain of ANDed terms
  - Similar rules for chain of ORed terms
Java Basics – Arrays

- **Creating Arrays (by example)**
  ```java
  int[] counts = new int[101];
  String[] colors = new String[3];
  Counter[] tallies = new Counter[10];
  int[] codes;
  codes = new int[17];
  ```

- **Using Initializer Lists**
  ```java
  String[] colors = {"red", "green", "blue"};
  double[] shims = {1.0, 1.1, 1.3, 1.6, 1.9, 2.5};
  ```

- **Initializing Object Arrays**
  - For most object arrays, need to create objects in the array
  ```java
  for (int k = 0; k < tallies.length; k++) {
    tallies[k] = new Counter();
  }
  ```
Java Basics – Arrays

- **Arrays are Objects**
  - Behavior of arrays similar to other objects
  - Thus `grades.length` works

- **Assignments (Warning!)**
  - Since array identifiers are just *references*
    - Array assignment doesn’t create new array!
  - Use `newArrayname = arrayname.clone();`
    - This works well for arrays of primitives
  - What happens for arrays of objects?
ArrayList

- Better to use than an array (very often)
- ArrayList
  - Can grow and shrink
  - Has methods for common tasks (see API)
  - Only holds objects
- Can’t have an ArrayList of int or double
  - There is a special Integer (an int that is an object) and Double (note the capital letters!) class
ArrayList (cont)

- Create an ArrayList
  ```java
  ArrayList<Integer> idlist = new ArrayList<Integer>();
  ```
- Add an element to the ArrayList
  ```java
  idlist.add(8);
  ```
- Modify kth element in an ArrayList
  ```java
  idlist.set(k, 9);
  ```
- Sum the elements in the ArrayList
  ```java
  // sum up integers in the ArrayList
  int sum = 0;
  for (Integer current : idlist) {
    sum += current;
  }
  ```
Convenient to use ArrayList, not array

- If you are given an array as a parameter
  - Copy values to an ArrayList
  - Then can work with the ArrayList

- If you need to return an array
  - Copy values from ArrayList to an array

- For Example, you’ll need to do both of these for APTs that use arrays.
Example: singleNumbers

- Given an integer array that could have duplicates, return an array that has only unique numbers from the original array.
- For example if the parameter array is:
  - 8 5 5 8 5
- Then the array to return should be:
  - 8 5
First convert array to ArrayList

```java
public int[] singleNumbers(int[] ids) {
    // convert the array ids into an ArrayList idlist
    ArrayList<Integer> idlist = new ArrayList<Integer>()
    for (int k = 0; k < ids.length; k++) {
        idlist.add(ids[k]);
    }

    // Alternatively, loop can be written as
    for (int id : ids) {
        idlist.add(id);
    }
}
```
Second, find unique numbers

// create an ArrayList that will hold unique numbers
ArrayList<Integer> singles = new ArrayList<Integer>();
singles.add(idlist.get(0)); // first number is unique
for (Integer current : idlist) {
    boolean isIn = false;
    for (Integer currentSingle : singles) {
        if (current.equals(currentSingle))
            isIn = true;
    }
    if (!isIn)
        singles.add(current);
}
Third, convert ArrayList to Array

```java
// convert ArrayList to array
int[] answer = new int[singles.size()];
int position = 0;
for (Integer currentSingle : singles) {
    answer[position] = currentSingle;
    position++;
}
return answer;
```