Collections
The Plan

- Why use collections?
- What collections are available?
- How are the collections different?
- Examples
- Practice
Why use collections?

Consider the code below. What if you wanted 1000 grades? Why is this code not designed well?

```java
int grade0, grade1, grade2, grade3, ..., grade100;
grade0=Integer.parseInt(field0.getText());
grade1=Integer.parseInt(field1.getText());
...
grade100=Integer.parseInt(field100.getText());
int sum=grade0+grade1+grade2+...+grade100;
average.setText("average is \(\frac{\text{sum}}{100.0}\));
```
Collections & Loops

Recall:

- Loops
  - group repeatedly executed code for uniformity
  - make the number of repetitions easily changeable
  - can be combined with selection to make more complex algorithms
Collections Motivation

Collections help enable
- declaring multiple variables
- naming multiple variables
- grouping similar variables under one name
- grouping similar code that acts on the variables
- changing the number of variables easily
- implementing more complex algorithms
Why use collections?

The code below uses an array to average the 1000 grades. What change would make it do 10 grades?

```java
int[] grade=new int[1000];
int sum=0;
for(int i=0; i<grade.length; i++)
{
    grade[i]=Integer.parseInt(field[i].getText());
    sum+=grade[i];
}
average.setText("average is "+sum/grade.length);
```
What an array looks like

- grade is an array
- grade[i] is an int

Arrays are only one way to collect variables

<table>
<thead>
<tr>
<th>grade</th>
<th>grade[0]</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>grade[1]</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>grade[2]</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>grade[3]</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>grade[5]</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>grade[6]</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>grade[n-2]</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>grade[n-1]</td>
<td>92</td>
</tr>
</tbody>
</table>
What collections are available?

- Arrays
- java.util.Collection
  - HashSet
  - LinkedList
  - LinkedHashSet
  - ArrayList
- java.util.Map
  - HashMap
  - TreeMap
Arrays

- Store primitives or particular Objects
- Size is immutable
- Contain length field
- Is an Object
- Indexed 0 to length-1
- Can generate ArrayIndexOutOfBoundsException
java.util.Collection

- Store Objects directly
- Size is typically dynamic
- Has a size method
- Is an Object
- Indexing varies
- Has `toArray(Object[])` method for converting to an array.
java.util.Map

- Store Object-to-Object mapping
- Size is typically dynamic
- Has a size method
- Is an Object
- Indexing by keys
- Use keySet().toArray(Object[]) method for converting keys to an array.
- Use valueSet().toArray(Object[]) method for converting values to an array.
HashSet

- Fast for
  - insertion
  - removal
  - checking membership

- Uses 1-way function (like used with passwords)

- Not great for
  - ordering
  - iterating over members
  - memory use
LinkedList

- Fast for
  - insertion at ends
  - removal at ends
- Slow for
  - insertion in middle
  - removal from middle
  - checking membership
- Minimal memory waste
- Used for stacks and queues
LinkedHashSet

- Combines good elements of LinkedList and HashSet
- Fast
  - insertion
  - removal
  - check for membership
- Keeps insertion and removal order
- Fast for iteration
- Memory still underutilized
ArrayList

- Fast
  - insertion
  - removal
  - random access
- Slow
  - check for membership
- Great for
  - iterating over members
  - memory use
  - ordering
HashMap

- Like the HashSet except contains key->value mapping.
TreeMap

- Relatively fast
  - insertion
  - removal
  - checking membership

- Best for maintaining order
  - always in sorted order by keys
  - uses the compareTo method
Arrays

- Fastest
  - insertion
  - removal
- Very general purpose
- Immutable size can be a problem
- When full, most memory efficient
- Best for holding primitives
- Best when used in conjunction with Collections and Maps
Examples

- Sprites in AnimationCanvas
  - LinkedHashSet
  - array
- Alarms in FrameAdvancer
  - TreeMap
- Shapes in BlurSprite
  - LinkedList
public class AnimationCanvas
extends JPanel
{
    private LinkedHashSet sprites;
    private Color background=Color.WHITE;
    private Sprite[] array;
    private boolean dirty;
}
public void addSprite(Sprite sprite) {
    sprites.add(sprite);
    dirty = true;
}
Sprites in AnimationCanvas

```java
public boolean containsSprite(Sprite sprite) {
    return sprites.contains(sprite);
}
```
Sprites in AnimationCanvas

public void updateSprites()
{
    if(dirty)
    {
        array=(Sprite[])sprites.toArray(new Sprite[0]);
        dirty=false;
    }
    for(int i=0; i<array.length; i++)
    {
        if(array[i].isDestroyed())
        {
            removeSprite(array[i]);
        }
        array[i].updateInternal();
    }
}
private void paintSprites(Graphics2D brush)
{
    if (dirty)
    {
        array = (Sprite[]) sprites.toArray(new Sprite[0]);
        dirty = false;
    }
    for (int i = 0; i < array.length; i++)
    {
        array[i].paintInternal(brush);
    }
}
Alarms in FrameAdvancer

```java
public class FrameAdvancer implements Runnable {
    protected static AnimationCanvas canvas=new AnimationCanvas();
    ...
    private static TreeMap alarms=new TreeMap();
    private static Thread worker;
```
Alarms in FrameAdvancer

private static void soundAlarms()
{
    if(alarms.isEmpty())
    {
        return;
    }
    double
    timeToAlarm=((Double)alarms.firstKey()).doubleValue();
    while(timeToAlarm<totalTime)
    {
        Alarm alarm=(Alarm)alarms.remove(alarms.firstKey());
        alarm.alarm();
        if(alarms.isEmpty())
        {
            break;
        }
        timeToAlarm=((Double)alarms.firstKey()).doubleValue();
    }
}
Shapes in BlurSprite

public class BlurSprite extends Sprite{
    private LinkedList previous=new LinkedList();
}
Shapes in BlurSprite

```java
public void update()
{
    super.update();
    drawNumber++;  
    int frequency=Math.max(1,
        FrameAdvancer.getUpdatesPerFrame()/numPerFrame);
    if(drawNumber%frequency!=0)
        return;
    boolean bounding=getUseBoundingBox();
    setUseBoundingBox(false);
    previous.addLast(getShape());
    setUseBoundingBox(bounding);
    if(previous.size()>numFrames*numPerFrame)
    {
        previous.removeFirst();
    }
}
```
Practice

Write code on paper to

- Declare an array of integers
- Initialize the array to be able to hold 10 integers
- Set the values in the array to be the first ten squares (i.e. 1, 4, 9, 16, 25 ...)
- Sum the values
- Output the average
- Alter your code to do the first 100 integers instead
Practice

Write code on paper to

● Declare an array of JButtons
● Initialize the array to be able to hold 12 buttons
● Make 12 buttons and put them into the array. The text on the button should be the integers 0-9 and '.' and '-'.
● Write a method to put the buttons into a 4x3 grid on a panel.
Practice

Write code on paper to

● Declare a HashSet variable called bullets

● Initialize the HashSet variable

● Put 10 Sprites of your choice into the bullets hash set

● Write a loop to go through the bullets hash set and print the location of all Sprites.

● Modify the loop above to print only those Sprites which are enabled.
Practice

Complete the following method

//return all Sprites intersecting with target Sprite
public Sprite[] getIntersecting(Sprite target, Sprite[] all)
{
    LinkedList list = new LinkedList();
    for(int i = 0; i < all.length; i++)
    {
        if(all[i] == target)
        {
            list.addLast(all[i]);
        }
    }
    return (Sprite[])list.toArray(new Sprite[0]);
}
Practice

- What purpose could the previous method have?
- Can you think of any use of arrays in your current homework assignment? (Hint: you are welcome, but not required to use arrays in the current homework)
- How could collections be used to enable multiple bullets to be fired in BeatTheBugs? If you were to use multiple bullets, which structure would you use?