Intro to Data Structures

CS151

Fall 2021

Course Goals

1. Become a better computer scientist
2. Learn about common data structures
    1. Implementation
    2. How and when to use each
3. Understand Object Oriented program design and its implementation in Java
4. Become a better Java programmer
5. Develop an understanding of UNIX

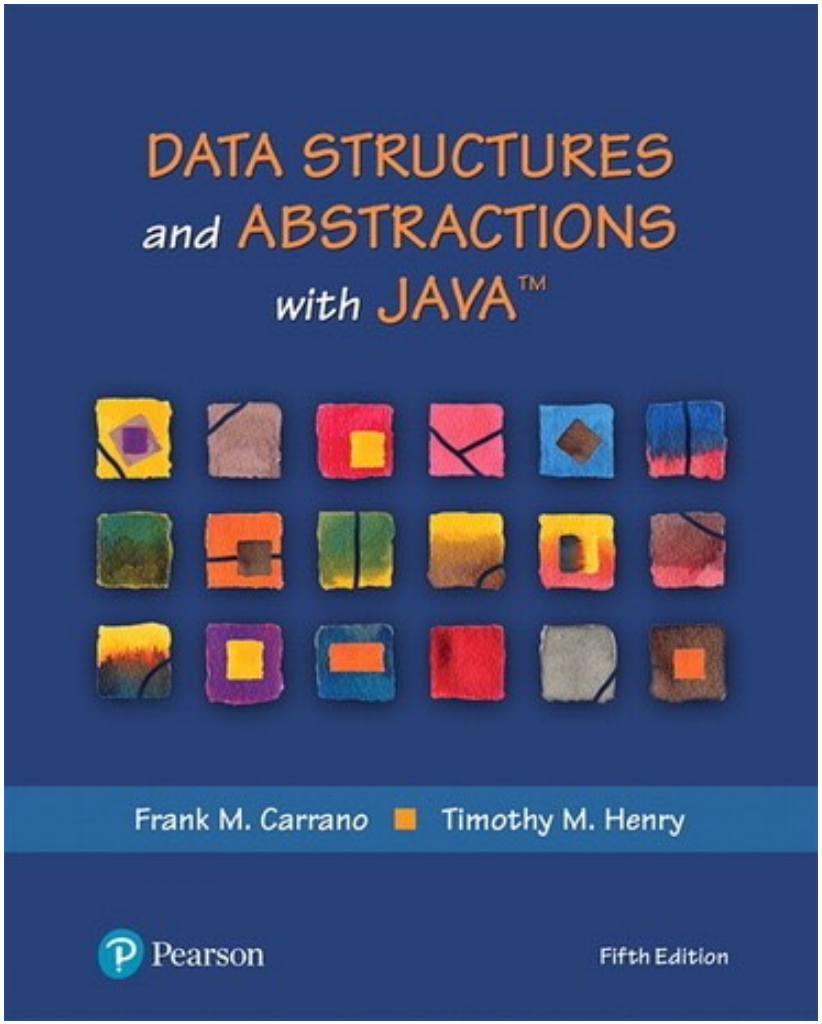
Things to Know

- Course website
  - www.cs.brynmawr.edu/cs151
    - usually updated before and after each class
      - lecture notes and code sample will be posted before class
      - updates after class with revisions, etc
- Syllabus
  - www.cs.brynmawr.edu/cs151/syllabus.html
    - usually updated on weekend for next week's material
- Homeworks
  - posted on class web site
  - Approximately weekly, assigned Thursday.
  - Typically due on Wednesday before midnight
  - Help in lab (Park 231) Sunday-Thursday evening
    - starting next week
  - Homeworks should trail lectures so you should be able to start immediately.

More Things to Know

- CS account
  - You should have gotten email from ddiaz1@brynmawr.edu
- Lab:
  - Park 230
  - Tu 2:25 - 3:45
  - Lab work may be done in groups!
    - I encourage you to do so.
- Software: Java, Visual Studio Code, Unix

Textbook


DATA STRUCTURES
and ABSTRACTIONS
with JAVA™
Frank M. Carrano
Timothy M. Henry
Pearson
Fifth Edition

Data Structure?

- Wikipedia: a **data structure** is a **data** organization, management, and storage format that enables efficient access and modification
- We will talk about approximately 8 data structures
  - How to use
  - Why to choose this one
  - How to implement

Data Structures

- Array
- ArrayList
  - it grows and shrinks
- Maps / Hashtables
  - going beyond numeric indexes
- Stacks and Queues
- Linked Lists
- Trees
- Graphs

Programming techniques and concepts

- Object oriented programming
  - inheritance, generics, …
- Searching
- Sorting
- Recursion
- Asymptotic Analysis

Java

- "Object Oriented" Language
- Data Types
  - Base
    - fixed set
    - Initial lower case letter (e.g. int)
  - Objects (Classes)
    - User extensible
    - Initial capital letter (by convention)

Base/Primitive Types

- Primitive types define memory used to store the data

Extant definitions of primitives subject to change

boolean	a boolean value: true or false
char	16-bit Unicode character
byte	8-bit signed two's complement integer
short	16-bit signed two's complement integer
int	32-bit signed two's complement integer
long	64-bit signed two's complement integer
float	32-bit floating-point number (IEEE 754-1985)
double	64-bit floating-point number (IEEE 754-1985)

```
boolean flag = true;
boolean verbose, debug;
char grade = 'A';
byte b = 12;
short s = 24;
int i, j, k = 257;
long l = 890L;
float pi = 3.1416F;
double e = 2.71828, a = 6.022e23;
```

Testing max Integer

```
public class BoundTest {
    public static void main(String[] args) {
        System.out.println("MAX:" + Integer.MAX_VALUE + "    MIN:" +
Integer.MIN_VALUE);
        BoundTest bt = new BoundTest();
        bt.testInt(1);
    }
    public void testInt(int startingValue) {
        int intV = startingValue;
        for (int jj = 1; jj < 100 && intV > 0; jj++) {
            intV *= 2;
            System.out.println("Pow " + jj + " " + intV);
        }
        for (int jj = 0; jj < 10; jj++) {
            System.out.println("minus " + jj + " " + (intV - jj));
        }
    }
}
```

How integers are stored

- Everything is bits
  - 0 or 1
- the int type uses 32 bits with number in base 2
- To show +/- the leftmost bit
  - "sign bit"
  - 0—positive
  - 1—negative
  - "two's complement"

Suppose you have 4 bits for a number

base 10	in bits
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
-8	1000
-7	1001

Classes and Variables

- A class is a description of what an object stores (its data) and how it functions
  - instance variables
  - methods
- Every variable is either a base type or a reference to an object
- Every object is an instance of a class
    - Object names — initial capital
    - instances — initial lower case
        - camel case thereafter, camelCaseThereAfter

Creating and Using Objects

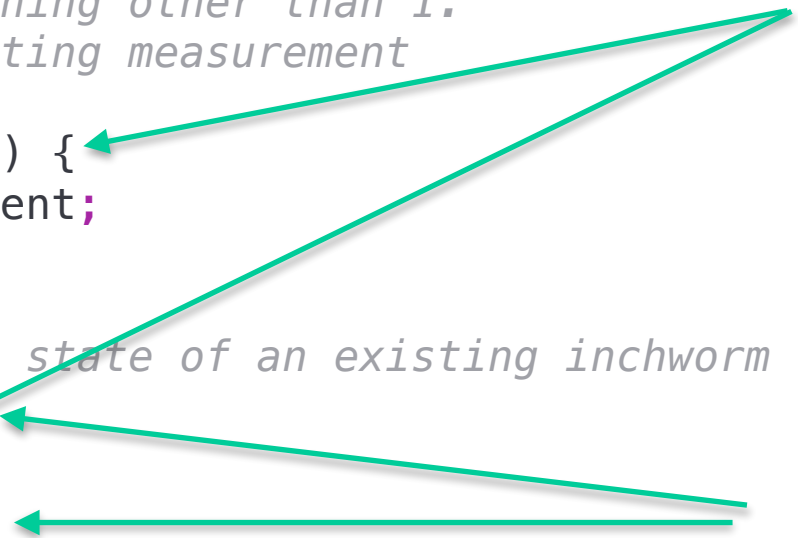
- In Java, a new object is created by using the `new` operator followed by a call to a constructor for the desired class.
- A constructor is a special method that shares the same name of its class. The new operator returns a reference to the newly created instance.
  - every method other than a construction must give the type of information it returns
- **Almost everything in Java is a class**
  - More properly, almost all variables in Java store references to instances of a class

Defining Objects

```
/**
 * A simple class from a simple song
 * Created: Sep 2020
  * @author gtowell
 */
public class Inchworm
{
     //instance variable comment
    private int measurement;
    /**
     * Create a default inchworm.  It starts measuring at 1.
     */
    public Inchworm() {
        this.measurement=1;
    }
```

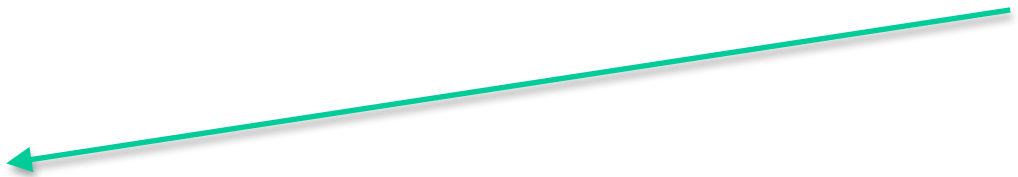
Class Part2

```
/**
 * Create an inchworm starting at something other than 1.
 * @param startingMeasurement  the starting measurement
 */
public Inchworm(int startingMeasurement) {
    this.measurement = startingMeasurement;
}
/**
 * A "copy" constructor.  It copies the state of an existing inchworm
 * @param iw the inchworm to be copied
 */
public Inchworm(Inchworm iw) {
    this.measurement = iw.getMeasurement();
}
/**
 * Get accessor for measurement.  Get accessors need NOT be commented
 * @return the measurement
 */
public int getMeasurement() {
    return this.measurement;
}
```



Class Part3

```
/**
 * Change the measurement by doubling.  It is all inchworms can do.
 */
public void doubleMeasure() {
    this.measurement *= 2;
}
/**
 * The toString function.  Normally this does not need a comment.
 * @Override indicates that function is defined in ancestor
 */
@Override
public String toString() {
    return "The marigold measures " + this.measurement + " inches";
}
/**
 * Put the inchworm back in its base state
 */
public void reset() {
    this.measurement=1;
}
```



Class Part4

```
/**
     * Function to be executed at start.
     * @param args NOT used.
     */
    public static void main(String[] args) {
        Inchworm inchworm = new Inchworm();
        inchworm.doubleM();
        System.out.println(inchworm);
        Inchworm inchworm2 = new Inchworm(inchworm);
        inchworm2.doubleM();
        System.out.println(inchworm2 + " " + inchworm);
    }
```

Access Control Modifiers

- `public` — all classes may access
- `private` — access only within that class.
- `protected` — access only from decendents
- "" (read as package) — access only by classes within the package
  - (I hate significant whitespace)
  - The package is generally the code you are working on.
  - packages very useful in large development projects (>10 people)
  - DO NOT use in this course

Static

- When a variable or method of a class is declared as `static`, it is associated with the class as a whole, rather than with each individual instance of that class.
- **Only acceptable use** (at least for this course):
  - In methods …
    - `public static void main(String[] args)`
  - In variables .. to declare constants
    - `public static final double GOLDEN_MEAN =1.61803398875;`

Casting (of base types)

- Assignment REQUIRES type equality
- Use casting to change type
- Must explicitly cast if there is a possible loss of precision

```
private void trial()
    {
        int x = 5;
        double y = 1.2;
        y = x;
        x = y;

        y = (double) x;
        x = (int) y;
    }
```

`.equals`: Object Equality

- Do not use `==`
  - Use `==` only when comparing base types
- Review your strings and `String` class methods

```
public class StringEqual {
  public static void main(String[] args) {
    String str1 = new String("one");
    String str2 = new String("one");
    System.out.println("str1==str2: "
            + str1 == str2);
    System.out.println("str1==str2: "
            + (str1 == str2));
    System.out.println("str1.equals(str2): "
            + str1.equals(str2));
  }
}
```

Wrapper Types

- Most data structures and algorithms in Java's libraries only work with object types (not base types).
- To get around this obstacle, Java defines a wrapper class for each base type.
- Implicitly converting between base types and their wrapper types is known as automatic boxing and unboxing.

Autoboxing and unboxing

```
public class Wrapper
{
    public void w1(Integer ii) {
        System.out.println(ii);
        int i3 = ii; // auto unboxing
        System.out.println(i3*i3);
        System.out.println(i3*ii); // auto unboxing
    }
    public static void main(String[] args) {
        Wrapper w = new Wrapper();
        w.w1(5); // autoboxing
    }
}
```

What you should know/review

- variables
- expressions
- operators
- methods
  - parameters
  - return value
- conditionals
- `for`/`while` loops
- class design and object construction
  - instance variables
  - constructor
  - getters/setters
  - class methods
  - `new`
- arrays
- arrays of objects
- `String`