Classes, Objects, and UML

Notes

- Lab 1: grading this week
- Lab 2: available soon
- Catme: should have email invitation
  - Use for group formation

- Next Week: lab 3 and project 1

Notes

- Advancing to the Data Structures course (CS 2413) requires an A or B in at least one of 1323 and 2334 (and at least a C in both)
- Programming team

Lab 1 Lessons

Lab 1 Lessons

- Should now have the essential tools running: Java, Eclipse, Web-Cat
- Web-Cat gives important feedback – use it
- Learn to read the documentation
- Learn to read the specification in detail
  - Requirements are very precise
- Start early

Java Objects

Class: a means of creating new types

- Group data elements that describe some abstract concept
- These data elements can be primitive data or other objects
- Provide methods that operate on these data elements

This is an important way to organize your data – and hence your coding!

Java Objects

An object is one instance of a class

- Occupies a block of memory in the *heap* that contains the values of the data elements
- Each instance has its own memory
- The set of values stored in this memory block is called the *state* of the object
- In code, we refer to object instances using a *reference* to the memory block

Instance Methods

Some specific types of instance methods

- Accessors: Methods used to report the state of objects
- Mutators: Methods used to change the state of objects

Syntax: `reference.method(parameters)`

Examples

- What is the state of a StringBuffer object?
- How can the state of the StringBuffer object be changed?

(StringBuffer API)

Examples

What is the state for a Date object?

Instance Methods: Special Cases

Some specific types of instance methods

- Getters: Accessor methods used to report the low-level state of objects
- Setters: Mutator methods used to change the low-level state of objects

Instance Methods: Special Cases

Mutator methods:

- If there are no methods that change the state of an object. These are called *immutable classes* (e.g. String, Integer, Float classes)
- There may be many methods that change the object's state (e.g. StringBuffer class). We call these classes *mutable*

Examples

Find examples of accessors and mutators in StringBuffer

- And String

A Class is a Contract

The set of instance methods define the legal ways that an object may be accessed/changed

- All operations on an object: must **always** leave the object in a consistent state
  - Enforce through variable visibility and through proper method definition

- Best practice:
  - On entry to a method: assume that the object is in a consistent state
  - On exit, ensure that it is still consistent

Examples

What would an inconsistent state be for a Triangle object?

- Properties: height, base width, area

A Class as an “Encapsulater”

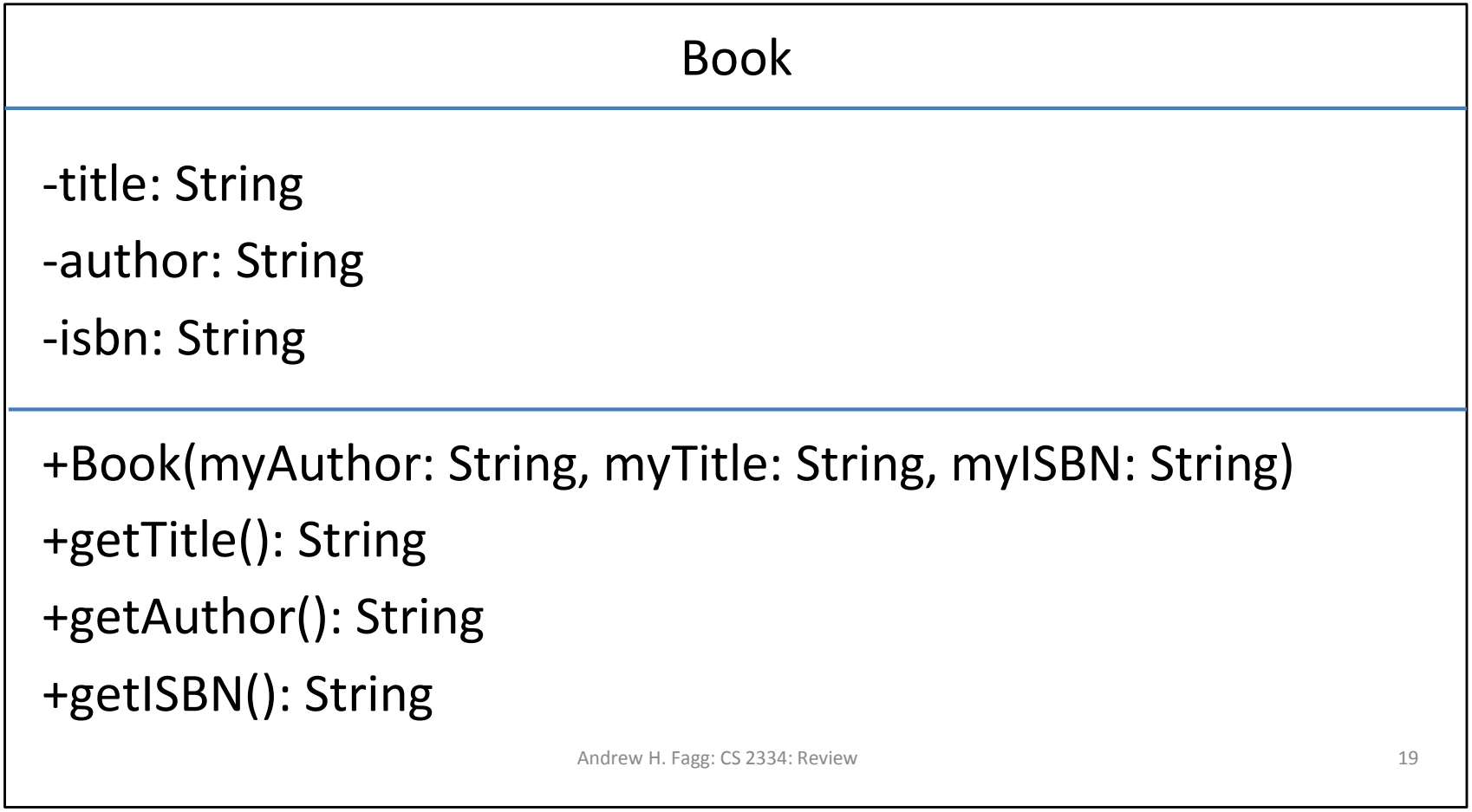
- A class hides many details from the outside world
- The user of a class only has to worry about the class’ public interface
  - Easier to understand how to use the class
  - The implementation of the underlying class can change without the user knowing

Unified Modeling Language (UML)

UML is a spatial representation that describes:

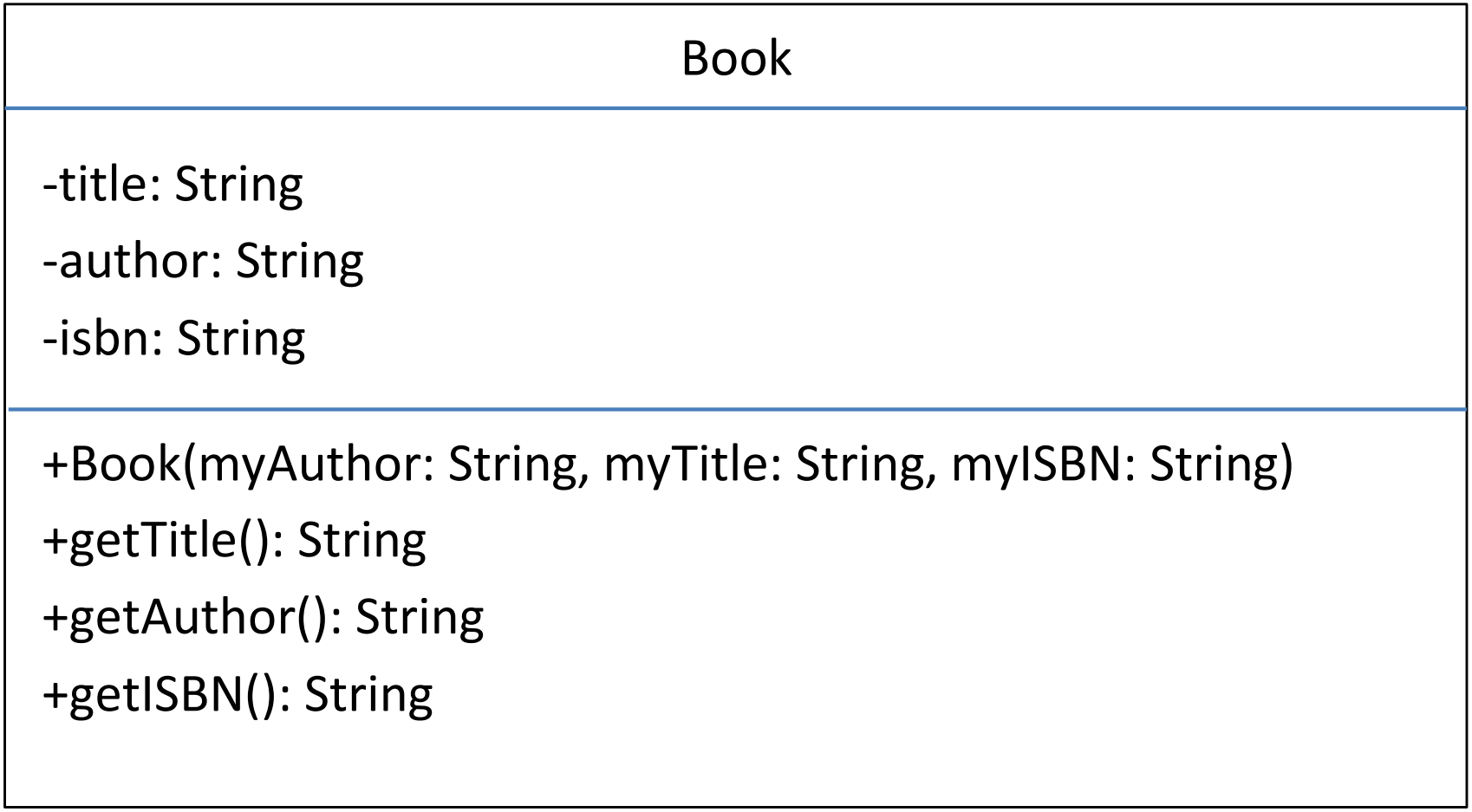
- The definition of a class
- How the different classes relate to on-another

Unified Modeling Language (UML)



Unified Modeling Language (UML)

Let’s implement this class



UML Class Diagrams

- Name of class at top
- Middle section contains data
  - Name: type
- Bottom section contains methods
  - Name(param1: type, param2: type…): return type
- Plus (+) means public
- Minus (-) means private

Unified Modeling Language (UML)

Umlet tool:

http://www.umlet.com/

Classes & Objects (continued)

Public vs Private Data

Can be a tough decision.

- What are the pros & cons?

Public vs Private Data

- Public Pros:
  - Easy access to all data by other classes
  - Don't have to implement getters and setters
- Public Cons:
  - Can't protect the data from other classes – easy to get into an inconsistent state
  - Therefore, the class cannot make any guarantees about how it behaves

Public vs Private Data

For this class:

- We want our classes to protect themselves
- All instance variables will be declared as private or protected (more on the latter soon)
- All external access to instance variables will be through public methods

Putting it All Together

- TopHat exercise

Instance vs Class Data

- Each object gets its own copy of ***instance data***
- All objects in a class share one copy of ***class data***
  - In UML, class variables are underlined
  - In the class definition, class variables are declared as ***static***

Example

Suppose we were going to design a post-it note application

- What is the state of the Note?
- How might the state be changed?
  - Let's make UML for this…

Example

How are we going to store things like the number of characters that are allowed in a note?

- Why is instance data not appropriate for this?

Class Variables

Only one copy of the variables for all instances in the class

- Declare as static:

```
private static final int maxCharacters = 100;
private static int numNotes = 0;
```

Class Methods

- Class-level methods are labeled ***static*** in Java
- Invocation (execution):

```
Class.methodName(parameters)
```

- Project 1 is live
- Lab 1 grades have been transferred to Canvas
- Lab 2 grading has started
- Lab 3 is live

Class Methods

Examine Math class on Java API

- How is Math different from String?

Class Methods

- Many class methods have no access to instance data
  - There is no object, so there is no instance data
  - Example: examine toString() in Integer class for both instance and class methods
- But: if a static method in a class has access to an object reference, it can access the private instance variables of that object
  - My opinion: this is poor language design. Avoid doing this!

Instance Methods

- Are always called with respect to an object instance
- Can “see” both instance and class variables

Parameter Passing

Primitive data types:

- Value gets copied (pass by value)
- Changes made in method don't affect the calling method
  - Except when a value is explicitly returned
- A reference is a primitive data type

Parameter Passing

Objects:

- References are passed by value
- But: inside and outside the method, the reference refers to the same memory location
- So: changes to data by the called method are visible to the calling method
  - True for both primitive data and objects inside the object

Method Overloading

Overloading: using the same method name, but different parameters

- Common when we want to assume default parameters
- or when different types convey similar types of information

```
public void addValue(int val);
public void addValue(double val);
```

“this"

- The “this” keyword is a reference that refers to the object on which an instance method was called on
- Can also refer to a constructor

“this” Referring to the Called Object

```
class Person{
    private String name;
    private int age;

    public Person(String name, int age){
        this.name = name;
        this.age = age;
    }
}
```

“this” as a Constructor

```
class Person{
	private String name;
	private int age;

	public Person(String name, int age){
		this.name = name;
		this.age = age;
	}

	public Person(String name){
		this(name, 20);
	}

	public Person(){
		this(“Bob”, 42);
	}
}
```

Classes within Classes

- One of the “big wins” with object-oriented programming is that we can define classes hierarchically
- Now that we have a “Person”, we can create new classes that contain Persons

Classes within Classes

```
class Course {
     private int courseNumber;
     private Person instructor;
     private ArrayList<Person> teachingAssistants;
     private ArrayList<Person> students;

     :
     :
}
```

Classes within Classes

Constructor is responsible for initializing underlying classes…

```
class Course {
     private int courseNumber;
     private Person instructor;
     private ArrayList<Person> teachingAssistants;
     private ArrayList<Person> students;

     public Course(){
          teachingAssistants = new ArrayList<Person>();
          students = new ArrayList<Person>();
     }
}
```

Classes within Classes

Constructors can use the default constructor to handle some initialization

```
class Course {
      :
      public Course(){
            teachingAssistants = new ArrayList<Person>();
            students = new ArrayList<Person>();
      }

      public Course(int courseNumber, Person instructor)
      {
            this();
            this.courseNumber = courseNumber;
            this.instructor = instructor;
      }
      :
}
```