# CSE 331

## Introduction;
## Review of Java and OOP

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based on materials by M. Ernst, S. Reges, D. Notkin, R. Mercer, Wikipedia

http://www.cs.washington.edu/331/

# What is this course about?

- specification and documentation
- object-oriented design
  - taking a problem and turning it into a set of well-designed classes
- testing, debugging, and correctness
- learning to use existing software libraries and APIs
- using software tools and development environments (IDEs)
- working in small groups to solve programming projects

- things that are "sort of" course topics:
  - Java language features
  - graphical user interfaces (GUIs)

# Building Good Software is Hard

- large software systems are enormously complex
  - millions of "moving parts"
- people expect software to be malleable
  - software mitigates the deficiencies of other components
- we are always trying to do new things with software
  - relevant experience is often missing
- software engineering is about:
  - managing complexity and change
  - coping with potential defects
    - customers, developers, environment, software

# Managing Complexity

- abstraction and specification
  - procedural, data, control flow
  - why they are useful and how to use them
- writing, understanding, and reasoning about code
  - the examples are in Java, but the issues are more general
- program design and documentation
  - the process of design;  design tools
- pragmatic considerations
  - testing
  - debugging and defensive programming

# Prerequisite knowledge

To do well in this course, you should know (or quickly review):

- basic **Java syntax** (loops, if/else, variables, arrays, parameters/return)
- **primitive vs. object** types;  value vs. **reference semantics**
- creating **classes** of objects   (syntax and semantics)
  - fields, encapsulation, public/private, instance methods, constructors
  - client (external) vs. implementation (internal) views of an object
  - **static** vs. non-static
- **inheritance** and **interfaces**   (basic syntax and semantics)
- Java **Collections** Framework (List, Set, Map, Stack, Queue, PriorityQueue)
  - using **generics**;  primitive "wrapper" classes
- **exceptions**   (throwing and catching)
- **recursion**

*see Review slides on course web site, or Core Java Ch. 1-6, for review material*

# OOP and OOD

- **object-oriented programming**: A programming paradigm where a software system is represented as a collection of objects that interact with each other to solve the overall task.

  - most CSE 142 assignments are not object-oriented  (why not?)
  - many CSE 143 assignments are object-oriented
    - but not all are well-*designed*  (seen later)
  - most software you will write after CSE 143 is object-oriented
    - exceptions: functional code;  systems programming;  web programming

# Major OO concepts

- Object-oriented programming is founded on these ideas:
  - **object/class**: An object is an entity that combines data with behavior that acts on that data. A class is a type or category of objects.
  - **information hiding (encapsulation)**: The ability to protect some components of the object from external entities ("private").
  - **inheritance**: The ability for a class ("subclass") to extend or override functionality of another class ("superclass").
  - **polymorphism**: The ability to replace an object with its sub-objects to achieve different behavior from the same piece of code.
  - **interface**: A specification of method signatures without supplying implementations, as a mechanism for enabling polymorphism.

# Object-oriented design

- **object-oriented design**: The process of planning a system of interacting objects and classes to solve a software problem.
  - (looking at a problem and deducing what classes will help to solve it)
  - one of several styles of software design

- What are the benefits of OO design?
  - How do classes and objects help improve the style of a program?
  - What benefits have you received by using objects created by others?

# Inputs to OO design

- OO design is not the start of the software development process. First the dev team may create some or all of the following:
  - **requirements specification**: Documents that describe the desired implementation-independent functionality of the system as a whole.
  - **conceptual model**: Implementation-independent diagram that captures concepts in the problem domain.
  - **use cases**: Descriptions of sequences of events that, taken together, lead to a system doing something useful to achieve a specific goal.
  - **user interface prototype**: Shows and describes the look and feel of the product's user interface.
  - **data model**: An abstract description of how data is represented and used in the system (databases, files, network connections, etc.).

# Classic OO design exercise

- A classic type of object-oriented design question is as follows:
  - Look at a description of a particular problem domain or software system and its necessary features in high-level general terms.
  - From the description, try to identify items that might be good to represent as classes if the system were to be implemented.
  - Hints:
    - Classes and objects often correspond to **nouns** in the problem description.
      - Some nouns are too trivial to represent as entire classes; maybe they are simply data (fields) within other classes or objects.
    - Behaviors of objects are often **verbs** in the problem description.
    - Look for related classes that might make candidates for **inheritance**.

# OO design exercise

What classes are in this Texas Hold 'Em poker system?

- 2 to 8 human or computer players
- Computer players with skill setting: easy, medium, hard
- Each player has a name and stack of chips
- Summary of each hand:
  - Dealer collects ante from appropriate players, shuffles the deck, and deals each player a hand of 2 cards from the deck.
  - A betting round occurs, followed by dealing 3 shared cards from the deck.
  - As shared cards are dealt, more betting rounds occur, where each player can fold, check, or raise.
  - At the end of a round, if more than one player is remaining, players' hands are compared, and the best hand wins the pot of all chips bet.

# OO design exercise

What classes are in this video store kiosk system?

- The software is for a video kiosk that replaces human clerks.
- A customer with an account can use their membership and credit card at the kiosk to check out a video.
- The software can look up movies and actors by keywords.
- A customer can check out up to 3 movies, for 5 days each.
- Late fees can be paid at the time of return or at next checkout.

# Java's object-oriented features (overview)

# Fields

- **field**: A variable inside an object that is part of its state.
  - Each object has *its own copy* of each field.

- Declaration syntax:

```
private type name;
```

  - Example:

```
public class Point {
    private int x;
    private int y;

    ...
}
```

# Instance methods

- **instance method** (or **object method**): Exists inside each object of a class and gives behavior to each object.

```
public type name(parameters) {
      statements;
}
```

  - same syntax as static methods, but without `static` keyword

Example:

```
public void tranlate(int dx, int dy) {
      x += dx;
      y += dy;
}
```

# Categories of methods

- **accessor**: A method that lets clients examine object state.
  - Examples: `distance`, `distanceFromOrigin`
  - often has a non-`void` return type

- **mutator**: A method that modifies an object's state.
  - Examples: `setLocation`, `translate`

- **helper**: Assists some other method in performing its task.
  - often declared as private so outside clients cannot call it

# The `toString` method

*tells Java how to convert an object into a* `String` *for printing*

```
public String toString() {
    code that returns a String representing this object;
}
```

- Method name, return, and parameters must match *exactly*.
- Example:

```
// Returns a String representing this Point.
public String toString() {
    return "(" + x + ", " + y + ")";
}
```

# Constructors

- **constructor**: Initializes the state of new objects.

```
public type(parameters) {
    statements;
}
```

  – runs when the client uses the `new` keyword
  – no return type is specified; implicitly "returns" the new object

```
public class Point {
    private int x;
    private int y;

    public Point(int initialX, int initialY) {
        x = initialX;
        y = initialY;
    }
```

# The keyword `this`

- **`this`** : Refers to the implicit parameter inside your class.

  *(a variable that stores the object on which a method is called)*

  - Refer to a field: `this.`**field**
  - Call a method: `this.`**method**`(`**parameters**`);`
  - One constructor can call another: `this(`**parameters**`);`

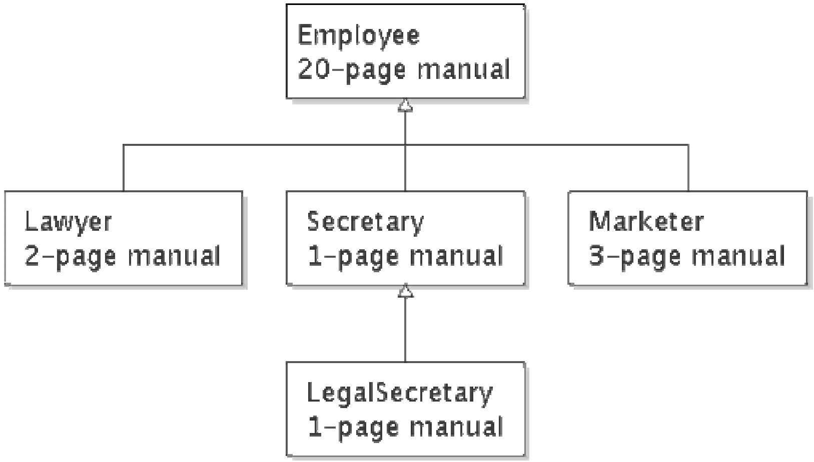
# Calling another constructor

```
public class Point {
    private int x;
    private int y;

    public Point() {
        this(0, 0);
    }

    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }
    ...
}
```

- Avoids redundancy between constructors
- Only a constructor (not a method) can call another constructor

# Inheritance

- **inheritance**: Forming new classes based on existing ones.
  - a way to share/**reuse code** between two or more classes
  - **superclass**: Parent class being extended.
  - **subclass**: Child class that inherits behavior from superclass.
    - gets a copy of every field and method from superclass
  - **is-a relationship**: Each object of the subclass also "is a(n)" object of the superclass and can be treated as one.



# Inheritance syntax

```
public class name extends superclass {
```

- Example:

```
public class Lawyer extends Employee {
    ...
}
```

- By extending `Employee`, each `Lawyer` object now:
  - receives a copy of each method from `Employee` automatically
  - can be treated as an `Employee` by client code
- Lawyer can also replace ("override") behavior from Employee.

# The `super` keyword

- A subclass can call its parent's method/constructor:

```
super.method(parameters)          // method
super(parameters);                // constructor
```

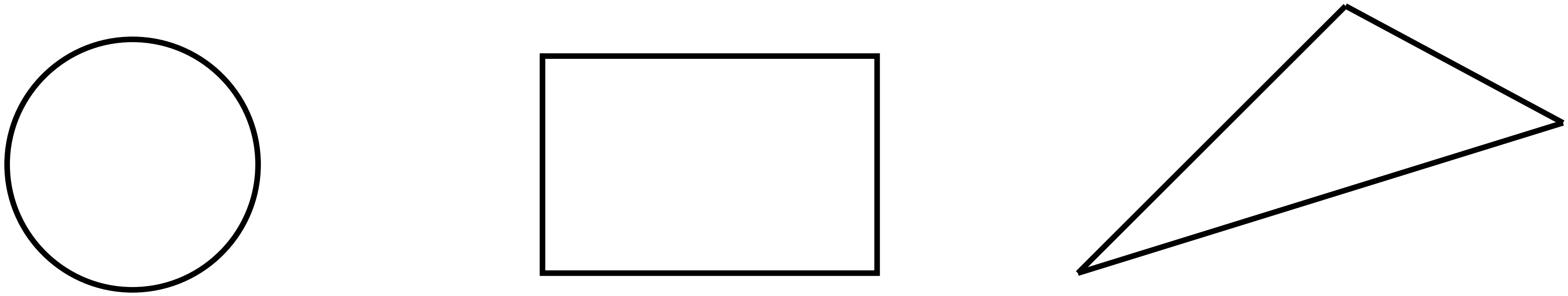
```
public class Lawyer extends Employee {
    public Lawyer(String name) {
        super(name);
    }

    // give Lawyers a $5K raise (better)
    public double getSalary() {
        double baseSalary = super.getSalary();
        return baseSalary + 5000.00;
    }
}
```

# Shapes example

- Consider the task of writing classes to represent 2D shapes such as `Circle`, `Rectangle`, and `Triangle`.

- Certain attributes or operations are common to all shapes:
  - perimeter: distance around the outside of the shape
  - area: amount of 2D space occupied by the shape

  - Every shape has these, but each computes them differently.



# Interfaces

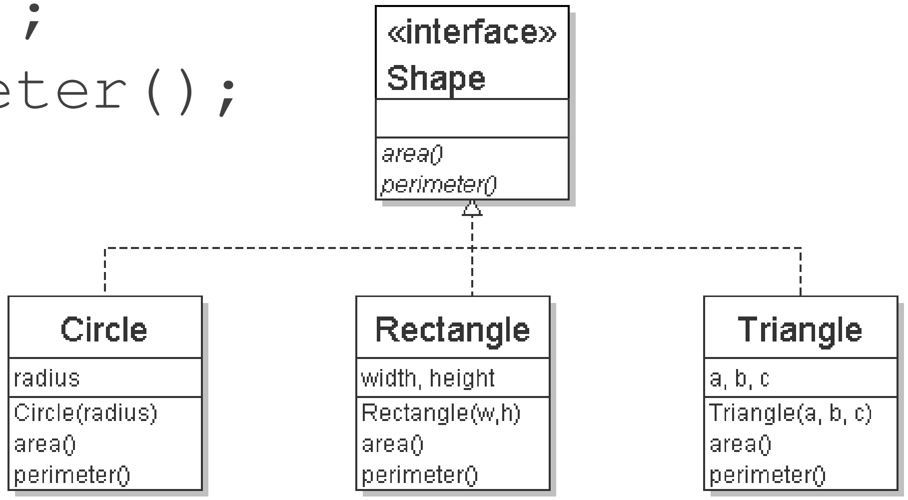
- **interface**: A list of methods that a class can promise to implement.
  - Inheritance gives you an is-a relationship *and* code sharing.
    - A `Lawyer` can be treated as an `Employee` and inherits its code.
  - Interfaces give you an is-a relationship *without* code sharing.
    - A `Rectangle` object can be treated as a `Shape` but inherits no code.
  - Analogous to non-programming idea of roles or certifications:
    - "I'm certified as a CPA accountant.
      This assures you I know how to do taxes, audits, and consulting."
    - "I'm 'certified' as a Shape, because I implement the Shape interface.
      This assures you I know how to compute my area and perimeter."

# Interface syntax

```
public interface name {
    public type name(type name, ..., type name);
    public type name(type name, ..., type name);
    ...
    public type name(type name, ..., type name);
}
```

Example:

```
public interface Shape {
    public double area();
    public double perimeter();
}
```



# Implementing an interface

```
public class name implements interface {
    ...
}
```

- A class can declare that it "implements" an interface.
  - The class promises to contain each method in that interface.
    (Otherwise it will fail to compile.)

  - Example:

```
public class Rectangle implements Shape {
    ...
    public double area() { ... }
    public double perimeter() { ... }
}
```

# Interfaces + polymorphism

- Interfaces benefit the *client code* author the most.
  - they allow **polymorphism**
    (the same code can work with different types of objects)

```
public static void printInfo(Shape s) {
    System.out.println("The shape: " + s);
    System.out.println("area : " + s.area());
    System.out.println("perim: " + s.perimeter());
    System.out.println();
}
...
Circle circ = new Circle(12.0);
Triangle tri = new Triangle(5, 12, 13);
printInfo(circ);
printInfo(tri);
```