Classes & Methods

Overview

Record Types allow us to create and manipulate real or imaginary world entities

- Records are immutable
- Records are defined by the *properties they store*, not by the *behaviors they exhibit*.

In this module, we will learn how to create and manipulate real or imaginary world entities as **objects**, which have both *properties* AND *behaviors*.

Learning Objectives

- To be able to write and use a class
- To be able to write a class constructor
- To be able to write comments
- To be able to understand and write accessor and mutator methods
- To be able to write methods
- To be able to use static variables and methods
- To be able to understand variable scope
- To be able to understand and use the `this` keyword

Introduction

A **CLASS** is a template for creating objects

- (like a **RECORD TYPE** defines what **RECORDS** of that type look like)

A class defines a new **data type**

- (like record types do.)

A class defines the object's *attributes / properties* and *behaviors*

- Object's properties are implemented as **INSTANCE VARIABLES**
- Object's behavior are implemented as **METHODS**

Objects are instances of a class, the way that records belong to a record type.

Class Design

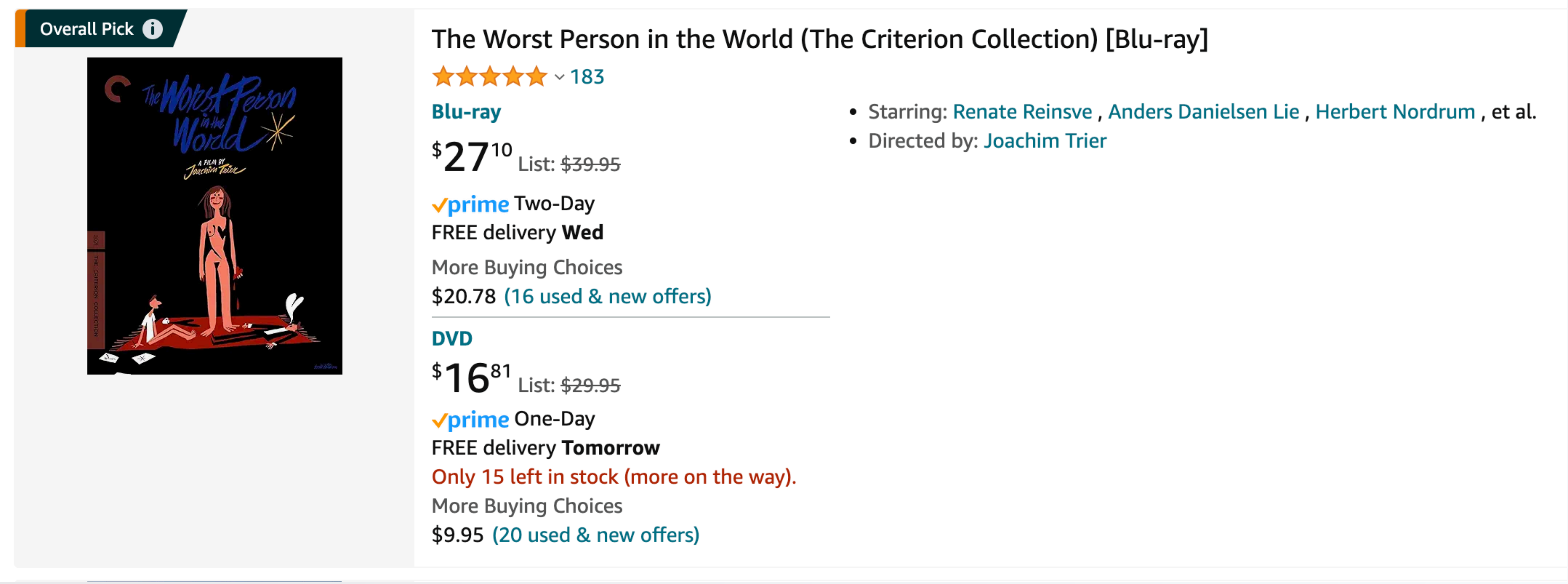
Abstraction: set of information properties relevant to a stakeholder about an entity

Information Property (or just "property"): a named, objective and quantifiable aspect of an entity

Stakeholder: a real or imagined person (or a class of people) who is seen as the audience for, or user of the abstraction being defined

Class Design Exercise

Entity: Movie from the point of view of someone shopping for a movie on an online storefront



The Worst Person in the World (The Criterion Collection) [Blu-ray]

★★★★★ 183

Blu-ray

$\$27^{10}$ List: ~~$39.95~~

✓prime Two-Day

FREE delivery **Wed**

More Buying Choices

$20.78 (16 used & new offers)

DVD

$\$16^{81}$ List: ~~$29.95~~

✓prime One-Day

FREE delivery **Tomorrow**

Only 15 left in stock (more on the way).

More Buying Choices

$9.95 (20 used & new offers)

- Starring: Renate Reinsve , Anders Danielsen Lie , Herbert Nordrum , et al.
- Directed by: Joachim Trier

Class Design

Entity: Movie

Properties:

- Title
- Year
- Length
- Genre
- Format
- Price

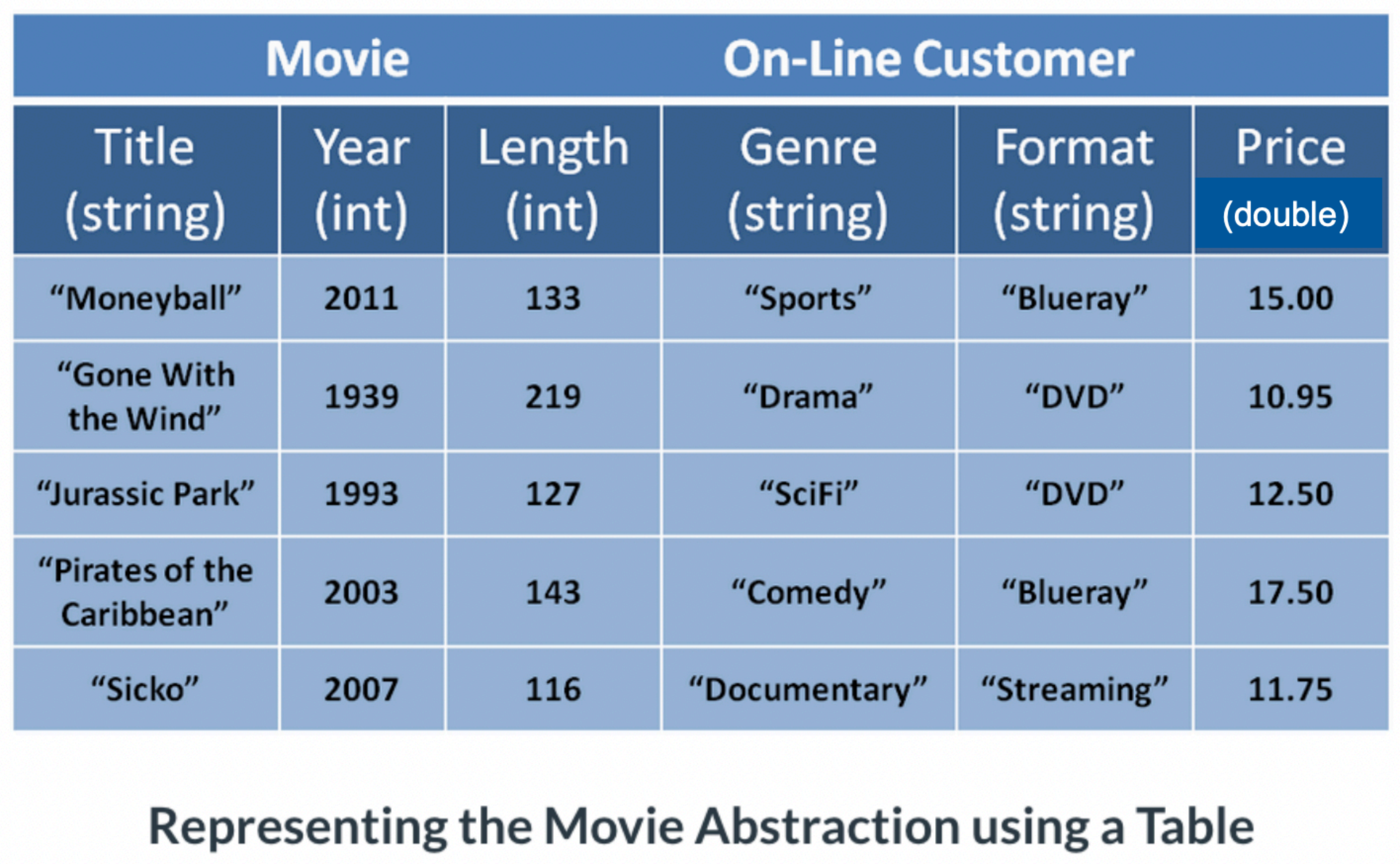
Class Design

Entity: Movie

Properties:

- Title (`String`)
- Year (`int`)
- Length (`int`)
- Genre (`String`)
- Format (`String`)
- Price (`double`)

Instances of the Movie Class



Movie			On-Line Customer		
Title (string)	Year (int)	Length (int)	Genre (string)	Format (string)	Price (double)
"Moneyball"	2011	133	"Sports"	"Blueray"	15.00
"Gone With the Wind"	1939	219	"Drama"	"DVD"	10.95
"Jurassic Park"	1993	127	"SciFi"	"DVD"	12.50
"Pirates of the Caribbean"	2003	143	"Comedy"	"Blueray"	17.50
"Sicko"	2007	116	"Documentary"	"Streaming"	11.75

Representing the Movie Abstraction using a Table

Content of a Class

A class contains

- Instance variables representing the properties of the abstraction
- One or more **constructor(s)** to initialize the objects’ instance variables
- Methods to implement the objects’ behaviors

Anatomy of a Class

```java
public class Person {
  // instance variables
  private String name;
  private String email;
  private String phoneNumber;

  // constructor
  public Person(String newName, String newEmail, String newNumber) {
    // implementation withheld for now
  }

  // methods!
  public void print() {
    // implementation withheld
  }
  public void updateEmail(String newEmail) {
    // implementation withheld
  }
}
```

Instance Variables

- Listed at the top of the class definition
- To declare an instance variable, you write

```
private DataType variableName;
```

e.g. `private String name;` or `private double price;`

- `private` means that only this class has access to this instance variable
    - important for class design! let each class only know about what it needs to.
    - opposite of `public`, which is more appropriate for functions/methods.

Instance Variables

Recalling the properties we decided on for Movies...

```
public class Movie {

  private String title;
  private int year;
  private int length;
  private String genre;
  private String format;
  private double price;
  ...
}
```

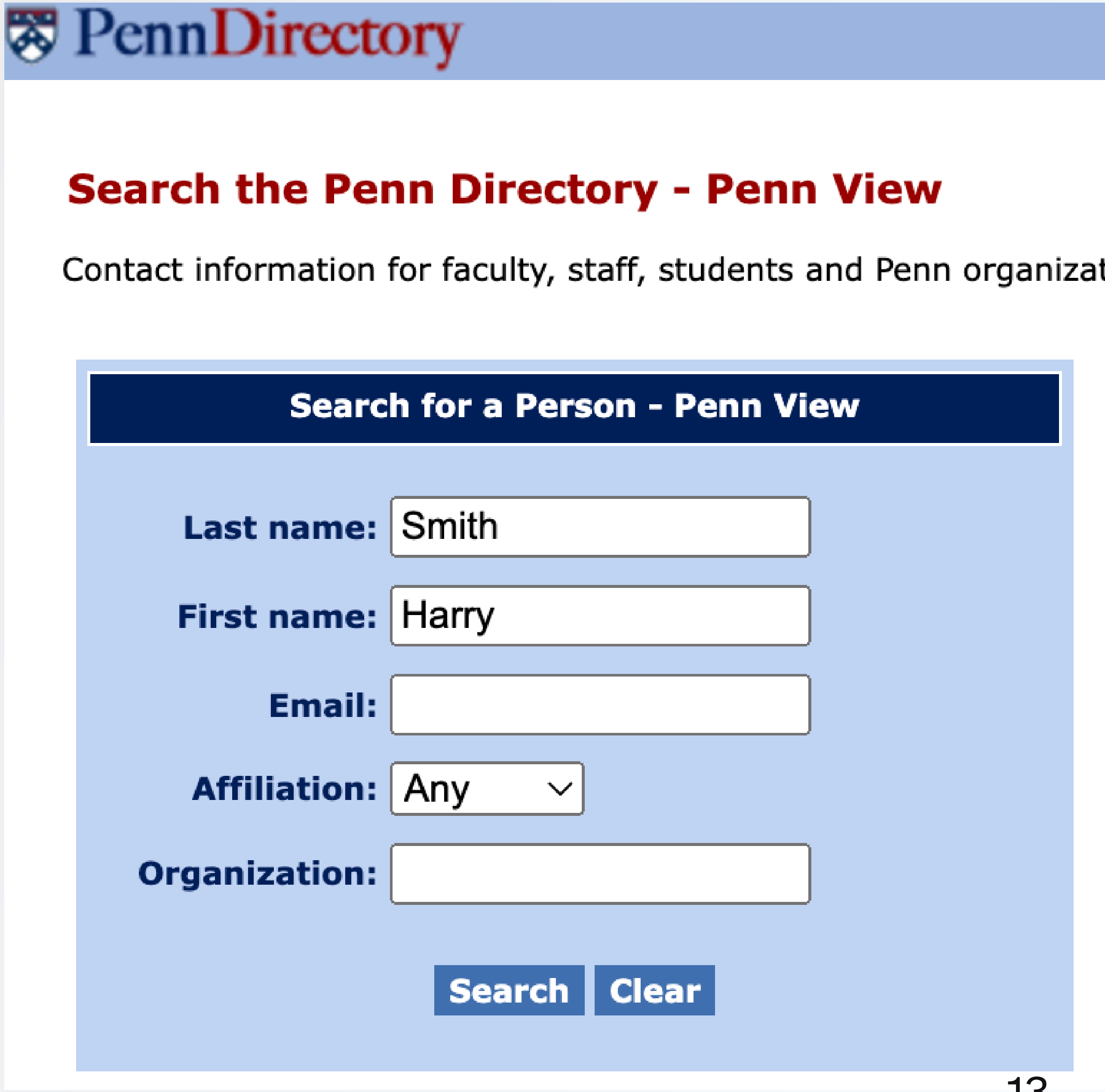
Instance Variables

Another example, for a `Person` class:

```
public class Person {

   private String name;
   private String email;
   private String phoneNumber;
   ...
}
```

From the point of view of a University Directory entry.



PennDirectory

Search the Penn Directory - Penn View

Contact information for faculty, staff, students and Penn organizat

Search for a Person - Penn View

Last name: Smith

First name: Harry

Email:

Affiliation: Any

Organization:

Instance Variables

- Instance variables are the properties of the object
- They are in scope throughout the entire class!
  - Can be used in other functions of the class
- Usually they are not declared with an initial value
  - The initial value is usually assigned in the constructor
  - Different objects of this class will have different values for these variables!

Constructors

- Set the initial values for the object’s instance variables
- Constructors must have the same name as the class
- Constructors have no return type!
- To define a constructor, you write:

```
public ClassName(DataType1 parameter1, DataType2 parameter2, …){

    /* instance variable initialization */

}
```

(the parameter list can also just be empty!)

No-argument constructor

Default constructor (provided by Java) initializes instance variables to default values

- Not often very useful
- `String` and array instance variables set to `null`—dangerous!
- Primitives set to `0`/`false`

equivalent to the following:

```java
public Person() {
  name = null;
  email = null;
  phoneNumber = null;
} // ¯\_(ツ)_/¯ (not very useful!)
```

Argument constructor

A constructor can take in arguments to initialize the instance variables.

```java
public Person(String initName, String initEmail, String initPhone) {
  name = initName;
  email = initEmail;
  phoneNumber = initPhone;
}
```

This constructor says: "*I will create a new `Person` for you with these initial values for `name`, `email`, and `phoneNumber`.*"

Argument constructor

A constructor doesn't have to take one input per instance variable

```java
public Person(String initName, String initEmail) {
  name = initName;
  email = initEmail;
  if (email.indexOf("upenn.edu") != -1) {
    phoneNumber = "215-898-5000";
  } else {
    phoneNumber = "";
  }
}
```

What does this constructor do?

Argument constructor

A constructor doesn't have to take one input per instance variable

```java
public Person(String initName, String initEmail) {
  name = initName;
  email = initEmail;
  if (email.indexOf("upenn.edu") != -1) {
    phoneNumber = "215-898-5000";
  } else {
    phoneNumber = "";
  }
}
```

This constructor says: "*I will create a new* `Person` *for you with these initial values for* `name`, `email`*. If they have a Penn email, I'll give them a default Penn phone number. Otherwise, I'll leave the field blank with an empty String.*"

Methods

Methods are functions that belong to objects of a class. They define how an object behaves based on its properties.

- Every object from a class has the same methods and the same instance variables.
- The values of the instance variables differ between the objects.
- $\Rightarrow$ Since methods behave differently based on the values of the instance variables, they can behave differently for different objects.

Special methods

- **Accessor methods**: to retrieve and return the value of the instance variables
  - Records gave you these for free!
- **Mutator methods**: to change (update) the value of the instance variables
  - These are not possible with Records
- **Main method**: used to test your class (execute your code). There can be only one main method inside a class

Accessor Methods

- AKA "getter" methods
- Used to return the value of an instance variable
- Usually take no input, have the return type of the instance variable they're getting

```
// general structure
public VariableType getVariableName(){
    return variableName
}
```

e.g.

```
public String getName(){
    return name;
}
```

Mutator Methods

- AKA "setter" methods
- Used to change the value of an instance variable
- Usually take an input matching type of the variable being set, have no return type

```
// general structure
public void setVariable(VariableType v){
  instanceVariable = v;
}
```

e.g. in the Person class:

```
public void setName(String newName){
  name = newName;
}
```

Methods, in General

Define the objects’ behavior

- Can only be called on an object that was created using the constructor
- Can return a value or not
- To call a method, you write

```
objectName.methodName(/* parameters or not*/);
```

Example:

```
Person p = new Person();
p.setName(“Mariah”);
```

Methods, in General

A method is just a function, so it has:

- A signature
- A body

```
public returnType methodName(/* parameters */){
    // method’s body
}
```

For example:

```
public String toString() { // signature
  return "my name is: " + name; // body, uses instance variable
}
```

Some Common Methods

- `public String toString()`
  - A method that lets you print out a human-readable String representation of the object
  - Java doesn't do this for you, sadly!
- `public boolean equals(Object other)`
  - A method that lets you decide if this object is the same as some other object
  - `==` is usable, but like with Strings, it doesn't do what you expect! 🚨🚨🚨

Methods with Parameters (Inputs)

When calling a method with parameters, you must provide actual values for each of the **formal parameters** (inputs).

- Within `Point.java`, we might write:

```java
public void move(double dx, double dy) {
  x = x + dx;
  y = y + dy;
}
```

- This could be called by writing, for example:

```java
myPoint.move(-0.5, 1);
```

Methods & Primitive Inputs

When calling a method with a *primitive type input*, any changes to the value of the variable will not be reflected outside of the method call.

```java
public void setXWithinLimit(double newX) {
  if (newX > 1) {
    newX = 1;
  }
  x = newX;
}
```

```java
public static void main(String[] args) {
  Point p = new Point(0.4, 0.3);
  double newX = 34;
  p.setXWithinLimit(newX);
  System.out.println(p.getX()); // 1
  System.out.println(newX);     // 34
}
```

Methods & Object Inputs

When calling a method with an *object type input,* (any array, Point, etc.):

- An **alias**, or copy of the reference, is stored in the parameter variable
- Changes to the object inside of the method will be visible outside of the method!

Methods & Object Inputs

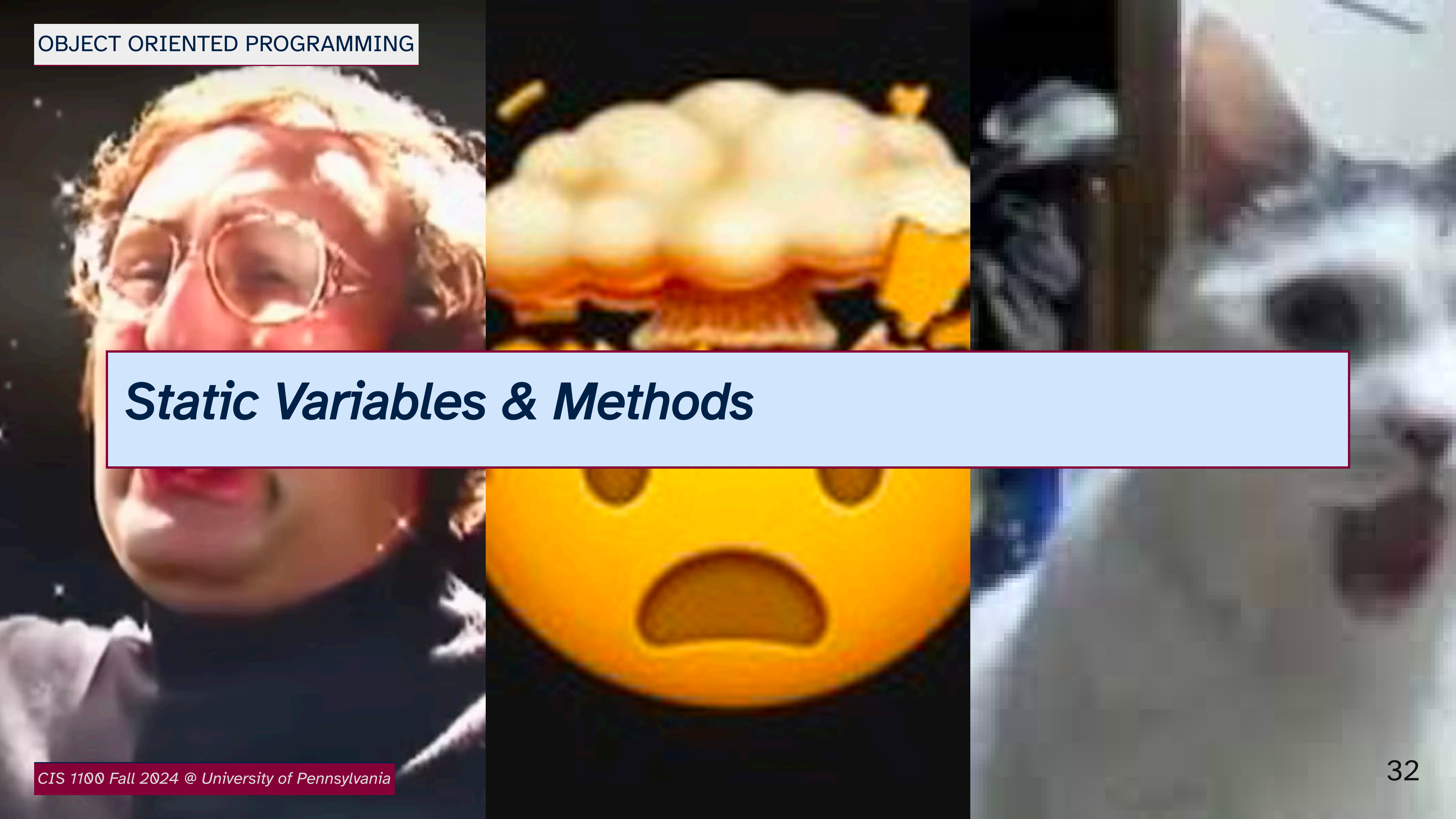
`copyXToOtherPoint` takes a `Point` as input and modifies its `x` value.

```java
public void copyXToOtherPoint(Point other) {
  other.setX(x);
}
```

```java
public static void main(String[] args) {
  Point a = new Point(0.4, 0.3);
  Point b = new Point(0, 0);
  System.out.println(b.getX()); // 0
  a.copyXToOtherPoint(b);
  System.out.println(b.getX()); // 0.4
}
```

The modification made to `other` inside the body of `copyXToOtherPoint` is reflected in whatever object was passed in as input—`b` in this case.

Static Variables & Methods



Static Variables & Methods

Static Variables & Methods

- Instance variables and non-static methods define the properties and behaviors of the objects of a class.
  - These variables and methods are referenced using the name of a particular object instance
  - `p.getX()`, `p.toString()` where `p` is a particular `Point` that's been initialized
- **Static** variables and methods belong to the *entire class* and do not vary among objects of the class.
  - These are referenced using the name of the class itself, e.g. `PennDraw.clear()` or `Math.random()` or `Math.PI`

Static Variables & Methods

- To tag a method or variable as static, write `static` after the public/private modifier

```java
public class Point {
  private double x;
  private double y;
  private static int numPointsCreated = 0; // all Points share this value

  public Point(double newX, double newY) {
    x = newX;
    y = newY;
    numPointsCreated++; // all Points see a new value for this var.
  }
  // other methods omitted...
  public static int getNumPoints() {
    return numPointsCreated;
  }
}
```

Static Variables & Methods

Later, in `main`…

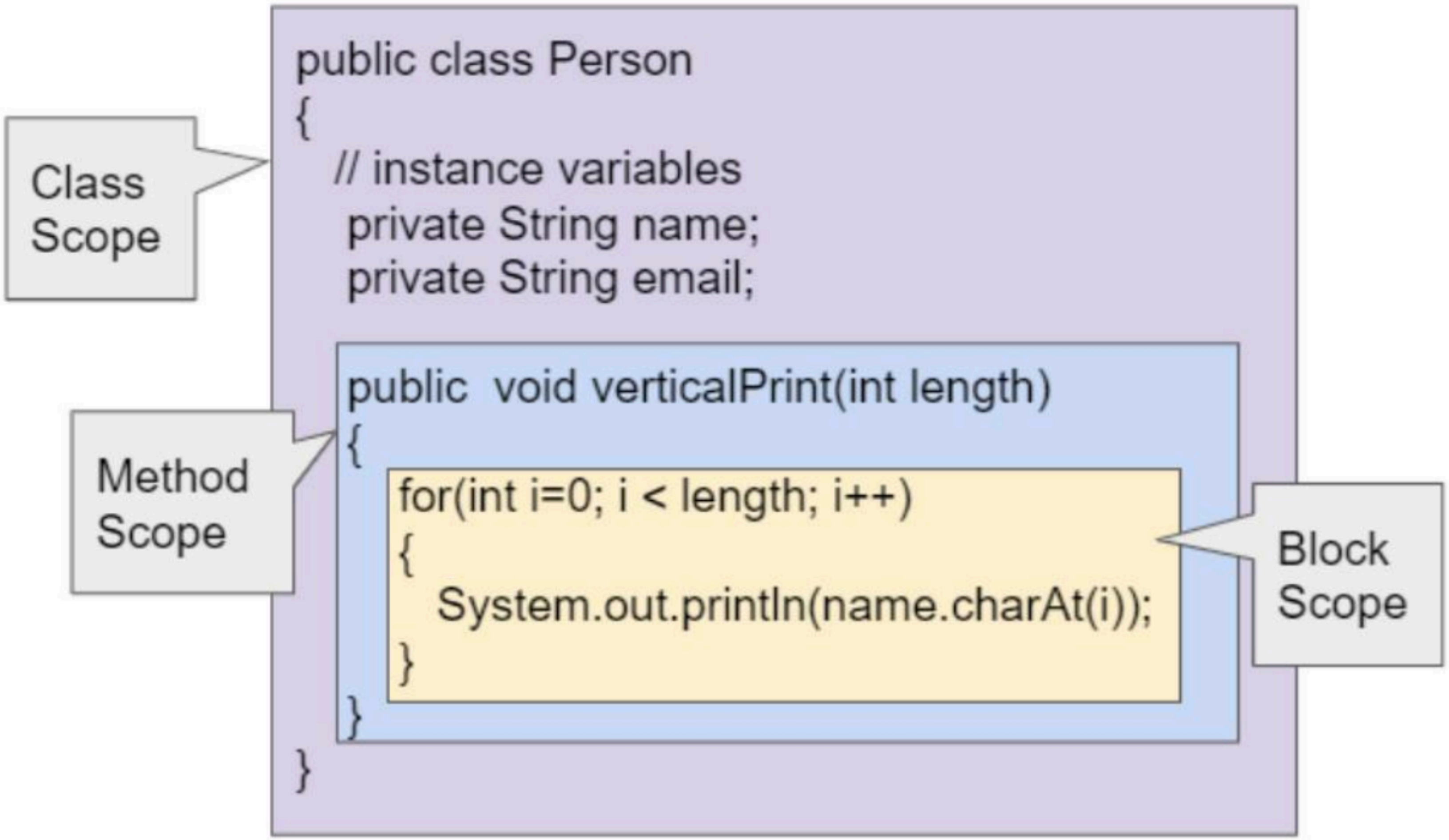
```
public static void main(String[] args) {
  Point first = new Point(0.1, 0.3);
  System.out.println(Point.getNumPoints()); // prints 1
  Point second = new Point(0, 0);
  System.out.println(Point.getNumPoints()); // prints 2

  // technically, you can do this, too:
  System.out.println(first.getNumPoints());   // prints 2
  System.out.println(second.getNumPoints());  // prints 2
}
```

Making Scope Explicit

- The **scope** of a variable is where the variable is accessible by name and depends on where the variable was declared.
- Three main levels of scope when designing classes:
  - **CLASS LEVEL SCOPE**: used for instance variables, these are accessible in the entire class.
  - **METHOD LEVEL SCOPE**: used for "local" variables and method inputs, these are accessible inside of a single method.
  - **BLOCK LEVEL SCOPE**: used for loop control variables, these are accessible only inside the body of a loop or conditional

Scoping out Scope



```
public class Person
{
  // instance variables
   private String name;
   private String email;

   public  void verticalPrint(int length)
   {
     for(int i=0; i < length; i++)
     {
       System.out.println(name.charAt(i));
     }
   }
}
```