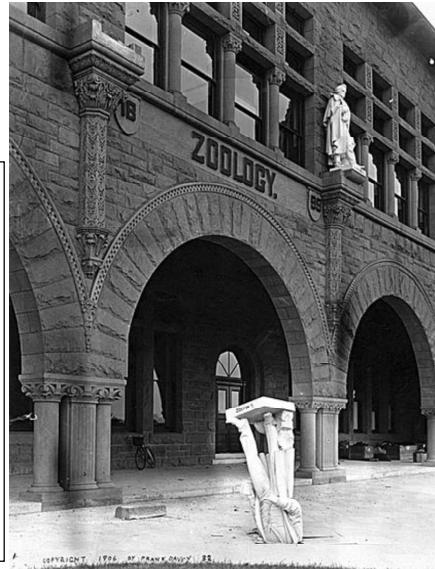


# Topic 9

## Abstract Classes

"I prefer Agassiz in the abstract, rather than in the concrete."

- Statue of Biologist Louis Agassiz that fell from a ledge on the Stanford Quad during the 1906 San Francisco earthquake.



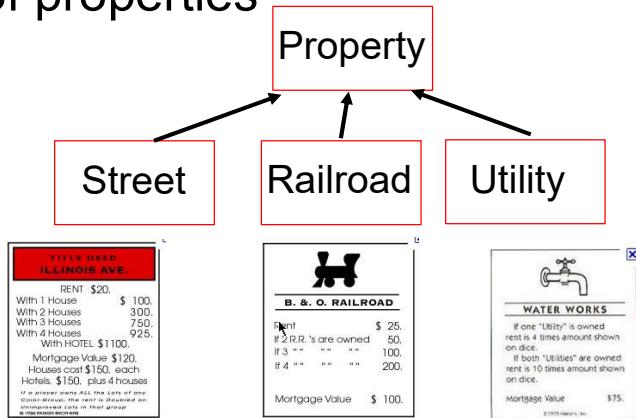
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## A getRent Behavior

- One behavior we want in Property is the getRent method
- problem: How do I get the rent of something that is “just a Property”?

## Back to the Monopoly Property Example

- There are properties on a monopoly board
- Railroads, Utilities, and Streets are kinds of properties



ILLINOIS AVE.

RENT \$20.  
With 1 House \$100.  
With 2 Houses \$300.  
With 3 Houses \$750.  
With 4 Houses \$225.  
Mortgage Value \$1000.  
House cost \$150, each.  
Hotels \$150, plus 4 houses.

B. & O. RAILROAD

RENT  
If 2 R.R.'s are owned \$50.  
If 3 " " " " 100.  
If 4 " " " " 200.  
Mortgage Value \$100.

WATER WORKS

RENT  
If one "Utility" is owned  
rent is 4 times amount shown  
on dice.  
If 2 or 3 "Utilities" are owned  
rent is 10 times amount shown  
on dice.  
Mortgage Value \$175.

## The Property class

```
public class Property {  
    private int cost;  
    private String name;  
  
    public int getRent() {  
        return hmmm??????;  
    }  
}
```

Doesn't seem like we have enough information to get the rent if all we know is it is a Property.

## Potential Solutions

1. Just leave it for the sub classes.
  - ▶ Have each sub class define getRent()
2. Define getRent() in Property and simply return -1.
  - ▶ Sub classes override the method with more meaningful behavior.

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## Leave it to the Sub - Classes

```
// no getRent() in Property
// Railroad and Utility DO have getRent() methods

public void printRents(Property[] props) {
    for (Property p : props)
        System.out.println(p.getRent());
}

Property[] props = new Property[2];
props[0] = new Railroad("NP", 200, 1);
props[1] = new Utility("Electric", 150, false);
printRents(props);
```

**Clicker 1** - What is result of above code?

- A. 200150
- B. different every time
- C. Syntax error
- D. Class Cast Exception
- E. Null Pointer Exception

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## "Fix" by Casting

```
// no getRent() in Property
public void printRents(Property[] props) {
    for (Property p : props) {
        if (p instanceof Railroad)
            System.out.println(((Railroad) p).getRent());
        else if (p instanceof Utility)
            System.out.println(((Utility) p).getRent());
        else if (p instanceof Street)
            System.out.println(((Street) p).getRent())
    } // GACK!!!!
}

Property[] props= new Property[2];
props[0] = new Railroad("NP", 200, 1);
props[1] = new Utility("Electric", 150, false);
printRents( props);
```

What happens as we add more sub classes of Property?

What happens if one of the objects is just a Property?

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## Fix with Placeholder Return

```
// getRent() in Property returns -1

public void printRents(Property[] props) {
    for (Property p : props)
        System.out.println(p.getRent());
}

Property[] props= new Property[2];
props[0] = new Railroad("NP", 200, 1);
props[1] = new Utility("Electric", 150, false);
printRents(props);
```

What happens if sub classes don't override getRent()?

Is that a good answer?

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## A Better Fix

- We know we want to be able to get the rent of objects that are instances of `Property`
- The problem is we don't know how to do that if all we know is it a `Property`
- Make `getRent` an abstract method
- Java keyword

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## Making `getRent` Abstract

```
public class Property {  
  
    private int cost;  
    private String name;  
  
    public abstract int getRent();  
    // I know I want it.  
    // Just don't know how, yet...  
}
```

Methods that are declared abstract have no body an undefined behavior.

All non-default methods in a Java interface are abstract.

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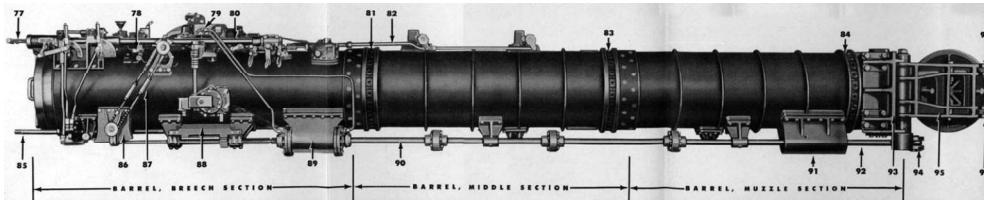
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## Problems with Abstract Methods

Given `getRent()` is now an abstract method what is wrong with the following code?

```
Property p = new Property();  
System.out.println(p.getRent());
```



If things can go wrong with a tool, provide safeguards to prevent that from happening.

## Undefined Behavior = Bad

- Not good to have undefined behaviors
- If a class has 1 or more abstract methods, the class must also be declared abstract.
  - version of `Property` shown would cause a compile error
- Even if a class has zero abstract methods a programmer can still choose to make it abstract
  - if it models some abstract thing
  - is there anything that is just a “Mammal”?

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## Abstract Classes Safety

1. A class with one or more abstract methods must be declared abstract.
  - Syntax error if not done.
  - Can still decide to make class abstract even if no abstract methods.
2. Objects of an abstract type cannot be instantiated.
  - Just like interfaces
  - Can still declare variables of this type
3. A subclass must implement all inherited abstract methods or be abstract itself.

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## Abstract Classes

```
public abstract class Property {  
    private int cost;  
    private String name;  
  
    public abstract double getRent();  
    // I know I want it.  
    // Just don't know how, yet...  
}  
// Other methods not shown
```

if a class is abstract the compiler will not allow constructors of that class to be called

```
Property s = new Property(1, 2);  
//syntax error
```

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## Abstract Classes

- ▶ In other words you can't create instances of objects where the lowest or most specific class type is an abstract class
- ▶ Prevents having an object with an undefined behavior
- ▶ Why would you still want to have constructors in an abstract class?
- ▶ Object variables of classes that are abstract types may still be declared

Property p; //okay

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## Sub Classes of Abstract Classes

- ▶ Classes that extend an abstract class must provide a working version of any and all abstract methods from the parent class
  - or they must be declared to be abstract as well
  - could still decide to keep a class abstract regardless of status of abstract methods

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## Implementing getRent()

```
public class Railroad extends Property {  
  
    private static int[] rents  
        = {25, 50, 100, 200};  
  
    private int numOtherRailroadsOwned;  
  
    public double getRent() {  
        return rents[numOtherRailroadsOwned];  
    }  
  
    // other methods not shown  
}
```

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## A Utility Class

```
public class Utility extends Property {  
  
    private static final int ONE_UTILITY_RENT = 4;  
    private static final int TWO_UTILITY_RENT = 10;  
  
    private boolean ownOtherUtility;  
  
    public Utility(String n, int c, boolean other) {  
        super(n, c);  
    }  
  
    public String toString() {  
        return "Utility. own other utility? " + ownOtherUtility;  
    }  
  
    public int getRent(int roll) {  
        return ownOtherUtility ? roll * TWO_UTILITY_RENT :  
            roll * ONE_UTILITY_RENT;  
    }  
}
```

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## Polymorphism in Action

```
// getRent() in Property is abstract  
  
public void printRents(Property[] props) {  
    for (Property p : props)  
        System.out.println(p.getRent());  
}
```

- Add the Street class. What needs to change in printRents method?
- Inheritance is can be described as new code using old code.
- **Koan of Polymorphism: Polymorphism can be described as old code reusing new code.**

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## Comparable in Property

```
public abstract class Property  
    implements Comparable<Property> {  
  
    private int cost;  
    private String name;  
  
    public abstract int getRent();  
  
    public int compareTo(Property other) {  
        return this.getRent()  
            - otherProperty.getRent();  
    }  
}
```

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## Back to Lists

- We suggested having a list interface

```
public interface IList<E> extends Iterable<E> {  
    public void add(E value);  
    public int size();  
    public E get(int location);  
    public E remove(int location);  
    public boolean contains(E value);  
    public void addAll(IList<E> other);  
    public boolean containsAll(IList<E> other);  
}
```

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## Data Structures

When implementing data structures:

- Specify an interface
- Create an abstract class that is *skeletal implementation* interface
- Create classes that extend the skeletal interface

```
public boolean contains(E val) {  
    for (E e : this)  
        if val.equals(e)  
            return true;  
    return false
```

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