

# Generics

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## Lecture 10

# A Simple Component

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- Client-side view: Pencil

```
public interface Pencil {  
    String toString();  
    void setColor(Colors newColor);  
    void sharpen(int remove);  
}
```

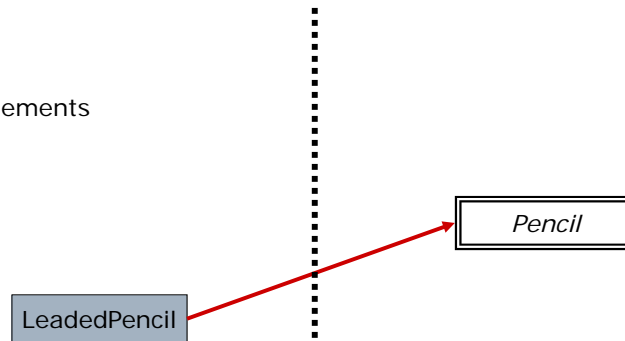
- Implementer's view: LeadedPencil

```
public class LeadedPencil implements Pencil {  
    private static final int STD_LENGTH = 10;  
    private Colors color;  
    private int length;  
    . . . etc . . .  
}
```

- See code listings for full documentation

# Pencils

→ implements



# Background

- Methods are parameterized by the *values* of their formal arguments

```
void enableLaunch (boolean go) { ... }
```

- In a sense, there are 2 enableLaunch()'s:

- one where go begins with value true
- one where go begins with value false

- *Could* define enableLaunchT(), enableLaunchF()

```
boolean isEven (int i) { ... }
```

- In a sense, there are 4,294,967,296 versions of isEven() (half return true, half return false)

- *Could* define isEven0(), isEven1(), isEven2(), ...

```
void println (String s) { ... }
```

- In a sense, there are ?? versions of println()

# Motivation: Using Components

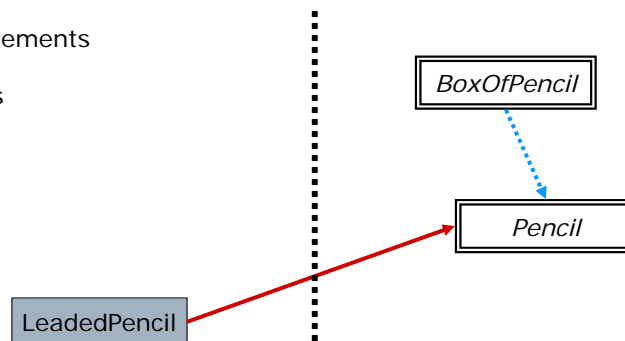
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- Consider a box that holds a pencil
  - See `BoxOfPencil.java`
  - Box contains at most one pencil
  - Methods: `size`, `contains`, `insert`, `removeAny`
- Aside: Notice “coding to the interface”
  - Method signatures contain **interface** types
    - `boolean contains(Pencil target)`
    - `void insert(Pencil item)`
    - `Pencil removeAny()`
  - Specifications also contain this type
- Recall: **Declared** vs **Dynamic** type
  - The **dynamic** type of these arguments and return values will be a reference to an instance of a class that *implements* **Pencil** (eg `LeadedPencil`)

# Box of Pencils

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- implements
- uses



## Using a Different Component

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- Now consider a box that holds a string
  - See BoxOfString.java
- (Aside: Is it coded to the interface?)
- These two class definitions differ *only* in:
  - The argument type of contains()
  - The argument type of insert()
  - The return type of removeAny()
  - The types mentioned in specifications
- All the rest is identical!
- BoxOfPencil and BoxOfString are like two instantiations of a generic class definition
  - Parameterized by *type* (not value)

## Example: Generic Box Interface

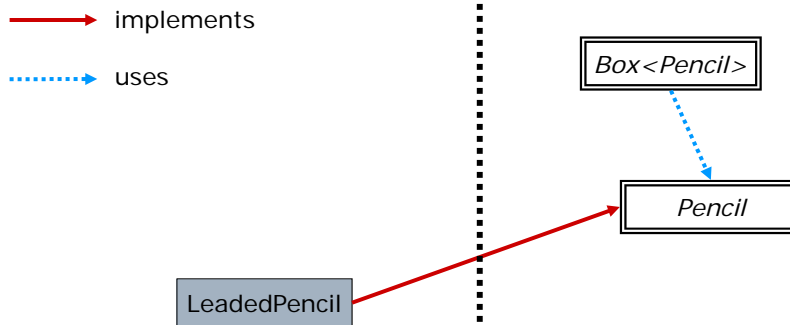
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- Declaration

```
interface Box<T> { . . . }
```
- In body of interface declaration, T can now be used as a type

```
boolean contains(T target)
void insert(T item)
T removeAny()
```
- See Box.java
- Vocabulary:
  - T is called a *naked type*
  - Box (ie without < >'s) is called a *raw type*

# Box of Pencils



# Example: Generic Implementation

- Declaration

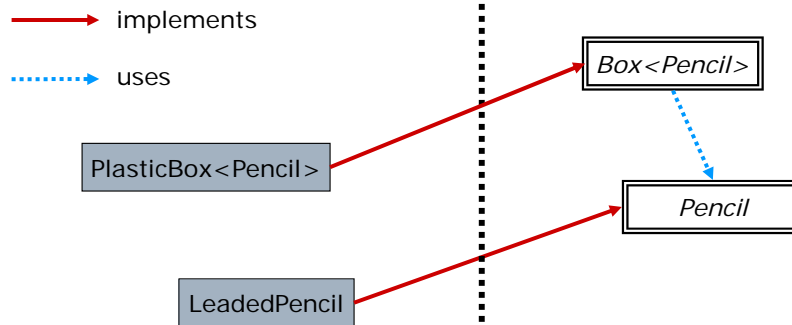
```
class PlasticBox<T> implements Box<T> {  
    . . .  
    PlasticBox() { . . . }  
}
```
- In body of class definition, T can now be used as a type
  - In fields

```
private T value
```
  - In methods

```
public void insert (T item)
```
- See `PlasticBox.java`
  - Note: Name of constructor in class definition is `PlasticBox()`, not `PlasticBox<T>()`

# Box of Pencils

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# Example: Client Use of Generic

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- To use generic type: classname<type>
- Usual rules of coding to the interface apply

```
Box<Pencil> bp = new PlasticBox<Pencil>();  
bp.insert(new LedgedPencil());  
Pencil p = bp.remove();
```

*// the following are all errors...*

```
String s = bp.remove();  
LedgedPencil p2 = bp.remove();  
Box<Pencil> bp2 = new PlasticBox<String>();  
Box<Pencil> bp3 = new Box<Pencil>();
```

## Example: Comparable Interface

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- Some classes have natural orderings
  - eg `Integer(3) < Integer(14)`
- `java.lang.Comparable`

```
public interface Comparable<T> {  
    int compareTo(T o)  
}
```

  - Returns negative integer, 0, or positive integer if this object is `<`, `=`, or `>` argument `o`
- Typical use

```
if (p1.compareTo(p2) < 0) // p1 < p2  
if (p1.compareTo(p2) == 0) // p1 == p2  
if (p1.compareTo(p2) > 0) // p1 > p2
```

## Good Practice: Total Ordering

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- `compareTo` should induce a total ordering on its type parameter
  - Reflexive

```
x.compareTo(x) == 0
```
  - Transitive

```
x.compareTo(y) < 0 && y.compareTo(z) < 0  
==> x.compareTo(z) < 0
```
  - Antisymmetric

```
x.compareTo(y) <= 0 && y.compareTo(x) <= 0  
==> x.equals(y)
```
  - Total
    - Any two instances of `T` can be compared

# Implementing Comparable

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- Simple case for typical use

```
public class LeadPencil implements
    Pencil, Comparable<LeadPencil> {
    public int compareTo(LeadPencil o) { . . . }
}
```
- Or even better (coding to the interface!)

```
public class LeadPencil implements
    Pencil, Comparable<Pencil> {
    public int compareTo(Pencil o) { . . . }
}
```
- Or even better (but we'll talk about extends later)

```
public interface Pencil
    extends Comparable<Pencil> { ... }
public class LeadPencil implements Pencil {
    public int compareTo(Pencil o) { . . . }
}
```

# Example: Lists

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- Array size fixed by instantiation with new

```
Integer[] A = new Integer[145];
```
- What if you need the array to grow?
  - Allocate new (larger) array
  - Copy old values into new
- Better approach: `java.util.List<T>`
  - Generic interface
  - Holds a (ordered) list of Ts
  - Can be accessed by index like an array
  - But also has a dynamically changeable size
- Implementations: `ArrayList`, `LinkedList`, `Vector`
  - `ArrayList` more efficient, need `Vector` for threads

## Using List (and ArrayList)

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```
import java.util.List;
import java.util.ArrayList;

List<String> list = new ArrayList<String>();
list.add("Hello");
list.add("there");
list.add(0, "Sam");
System.out.println(list.get(1)); // "Hello"

for (String str : list) {
    System.out.println(str);
} // prints "SamHellothere"
```

## Methods

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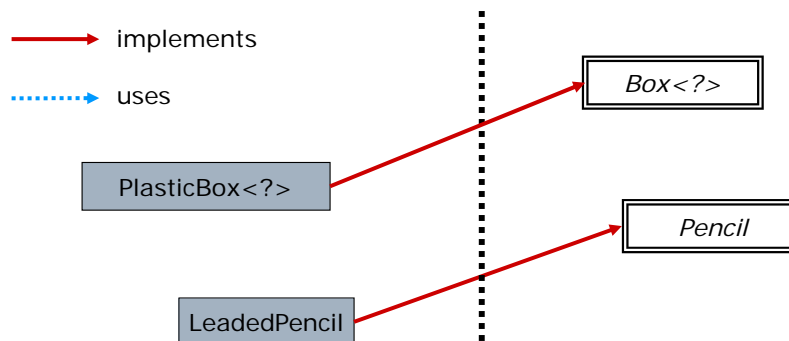
- ❑ Array-like
  - set / get for index-based access
- ❑ Adding items
  - add(T) / add(int,T)
  - Causes the List to grow
- ❑ Removing items
  - remove(int) / removeRange(int,int)
- ❑ Memory management
  - isEmpty / size

# Type Erasure

- Note: `PlasticBox<Pencil>` and `PlasticBox<String>` are *not* two separate classes
  - They are two generic type *invocations* of *one* class, `PlasticBox`

```
Box<Pencil> b1 = new PlasticBox<Pencil>();
Box<String> b2 = new PlasticBox<String>();
assert b1.getClass() == b2.getClass(); //passes
```
- Think of `<Pencil>` as constructor information, so the compiler can do appropriate casting and type checking
- At run-time, no generic type information remains in `PlasticBox` objects
  - The type parameter, `T`, has been "*erased*"
  - Left with one class: `PlasticBox<?>` (pronounced "plastic box of unknown")

# Box of Pencils



## Consequences of Type Erasure

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- ❑ All type-instances share the same static members

```
static int nextID; //shared by all Box<?>
```
- ❑ Static members can not refer to naked type

```
private static T value; //compile error
```
- ❑ New instances and arrays of naked type can not be created

```
T value = new T(); //compile error
T[] myArray = new T[50]; //compile error
```
- ❑ Casts ignore parameter type information

```
Box<String> x = (Box<String>) b; //unchecked
Box<?> y = (Box<?>) b; //ok
```

## Summary

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- ❑ Genericity through type parameters
  - Declaration of generic interfaces/classes
  - Use of generic interfaces/classes
- ❑ Comparable interface
  - Total ordering, strongly typed thanks to generics
- ❑ List (and ArrayList)
  - Like arrays, but better!