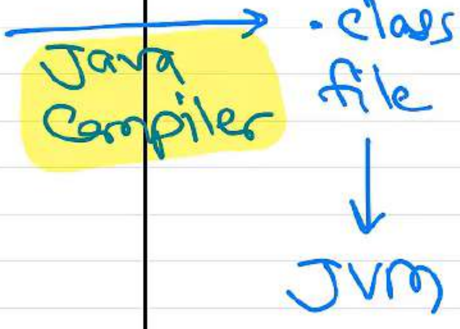
Since Java 5.0

```
class Box<TYPE> {
    private TYPE obj;
    public void set(TYPE obj) {
        this.obj = obj;
    }
    public TYPE get() {
        return this.obj;
    }
}
```



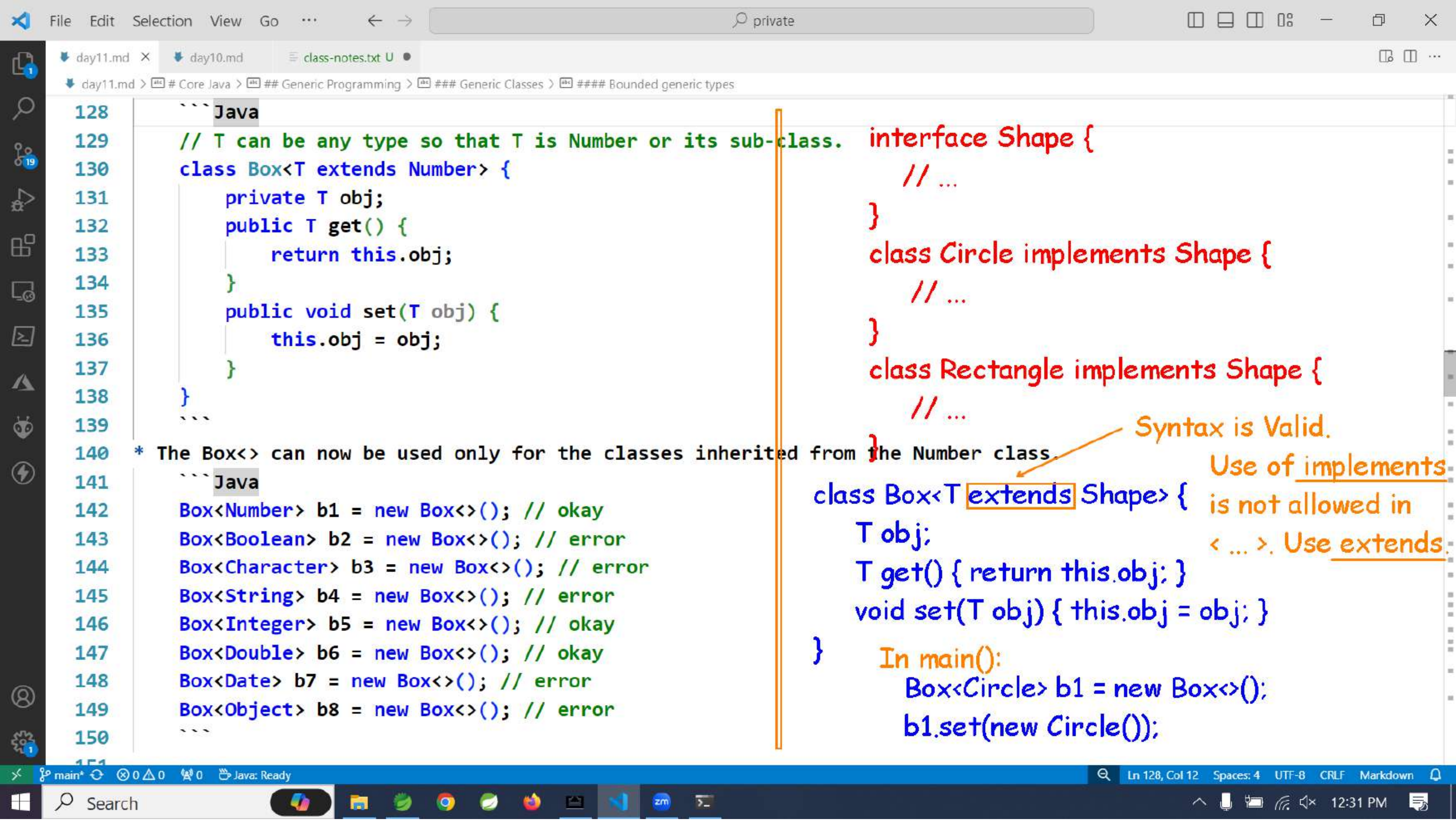
```
class Box {
    private Object obj;
    public void set(Object obj) {
        this.obj = obj;
    }
    public Object get() {
        return this.obj;
    }
}
```

```
main():
    Box<String> b1 = new Box<String>();
    b1.set("Hello");
    String r1 = b1.get();
    Box<Double> b2 = new Box<Double>();
    b2.set(3.14);
    Double r2 = b2.get();
```

The type-safety of Java generics is ensured by the compiler. JVM doesn't do any type-checking at runtime.

For JVM all references are like Object references.

There is no type info present in .class file. This called as Type Erasure.



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private
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day11.md > # Core Java > ## Generic Programming > ### Generic Classes > #### Bounded generic types
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~~~
    ```Java
    // T can be any type so that T is Number or its sub-class.
    class Box<T extends Number> {
        private T obj;
        public T get() {
            return this.obj;
        }
        public void set(T obj) {
            this.obj = obj;
        }
    }
    ```
* The Box<> can now be used only for the classes inherited from the Number class.
    ```Java
    Box<Number> b1 = new Box<>(); // okay
    Box<Boolean> b2 = new Box<>(); // error
    Box<Character> b3 = new Box<>(); // error
    Box<String> b4 = new Box<>(); // error
    Box<Integer> b5 = new Box<>(); // okay
    Box<Double> b6 = new Box<>(); // okay
    Box<Date> b7 = new Box<>(); // error
    Box<Object> b8 = new Box<>(); // error
    ```
~~~

```
interface Shape {
   // ...
}
class Circle implements Shape {
    // ...
}
class Rectangle implements Shape {
    // ...
}
```

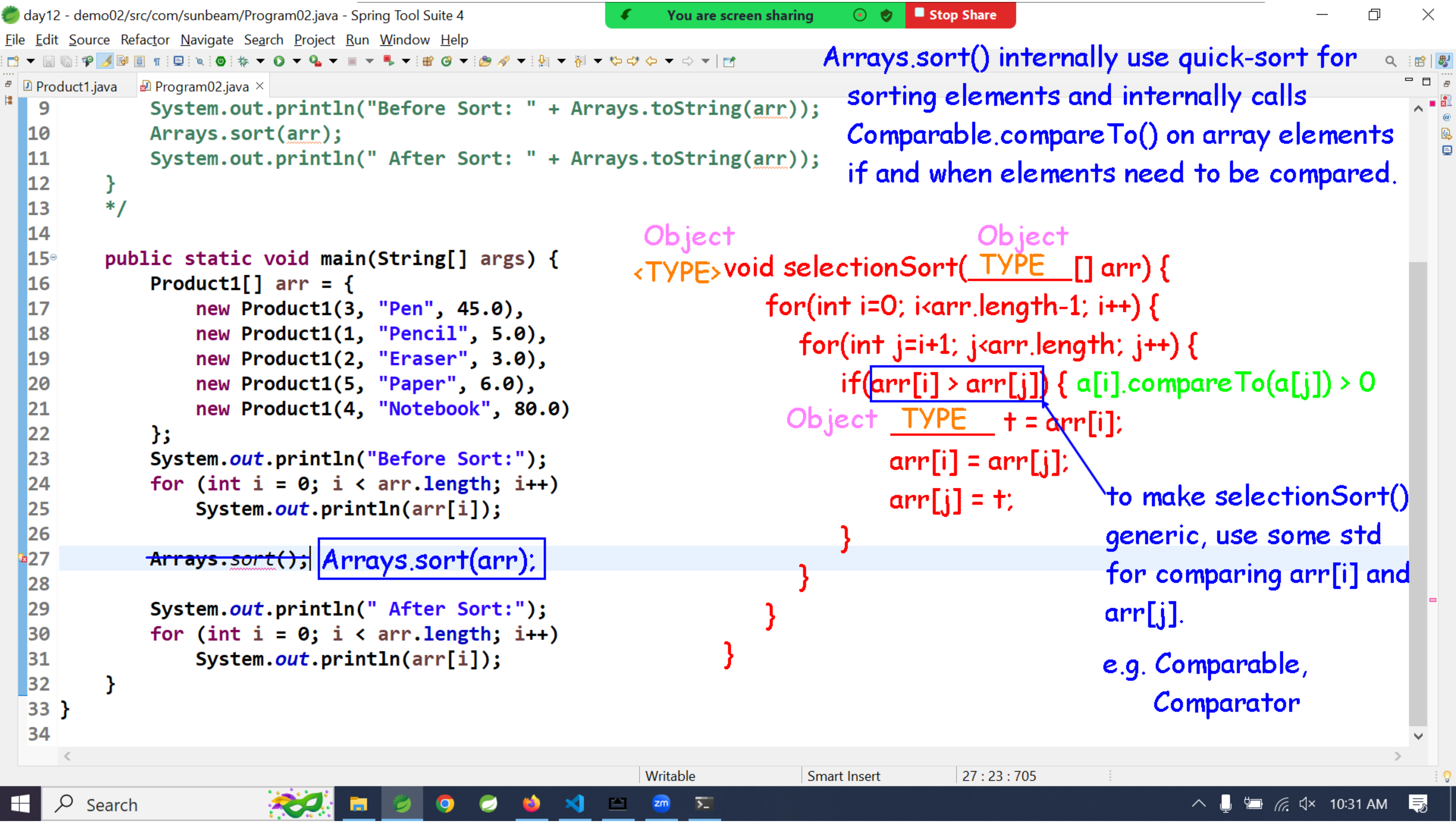
Syntax is Valid.

```
class Box<T extends Shape> {
    T obj;
    T get() { return this.obj; }
    void set(T obj) { this.obj = obj; }
}
```

Use of implements is not allowed in < ... >. Use extends.

In main():

```
Box<Circle> b1 = new Box<>();
b1.set(new Circle());
```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Program02.java
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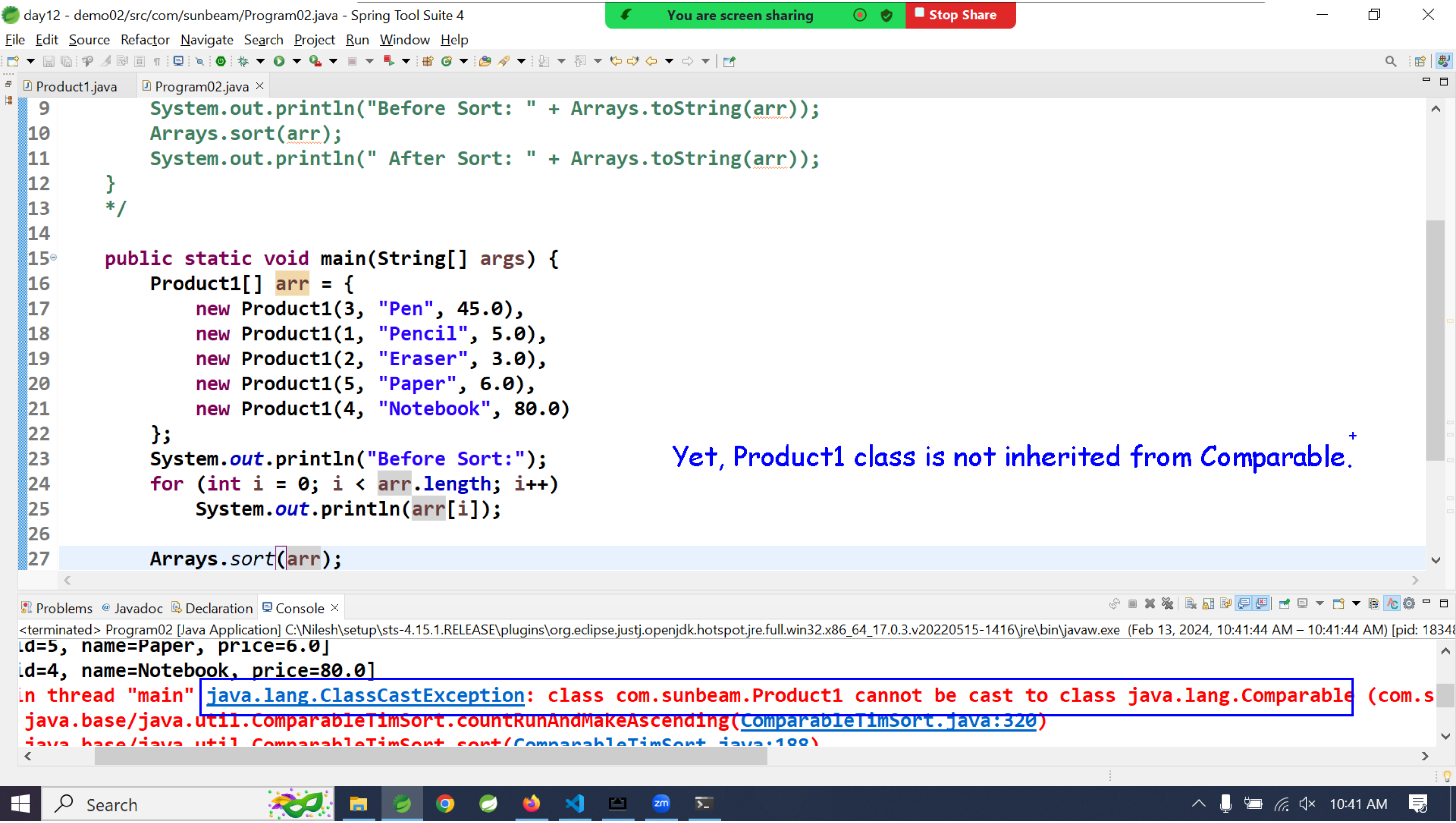
```java
        System.out.println("Before Sort: " + Arrays.toString(arr));
        Arrays.sort(arr);
        System.out.println(" After Sort: " + Arrays.toString(arr));
    }
    */

    public static void main(String[] args) {
        Product1[] arr = {
            new Product1(3, "Pen", 45.0),
            new Product1(1, "Pencil", 5.0),
            new Product1(2, "Eraser", 3.0),
            new Product1(5, "Paper", 6.0),
            new Product1(4, "Notebook", 80.0)
        };
        System.out.println("Before Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);

        ~~Arrays.sort();~~ Arrays.sort(arr);

        System.out.println(" After Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);
    }
}
```

Arrays.sort() internally use quick-sort for sorting elements and internally calls Comparable.compareTo() on array elements if and when elements need to be compared.

```
Object                          Object
<TYPE>void selectionSort(TYPE[] arr) {
    for(int i=0; i<arr.length-1; i++) {
        for(int j=i+1; j<arr.length; j++) {
            if(arr[i] > arr[j]) { a[i].compareTo(a[j]) > 0
   Object       TYPE t = arr[i];
                arr[i] = arr[j];
                arr[j] = t;
            }
        }
    }
}
```

to make selectionSort() generic, use some std for comparing arr[i] and arr[j].

e.g. Comparable,
Comparator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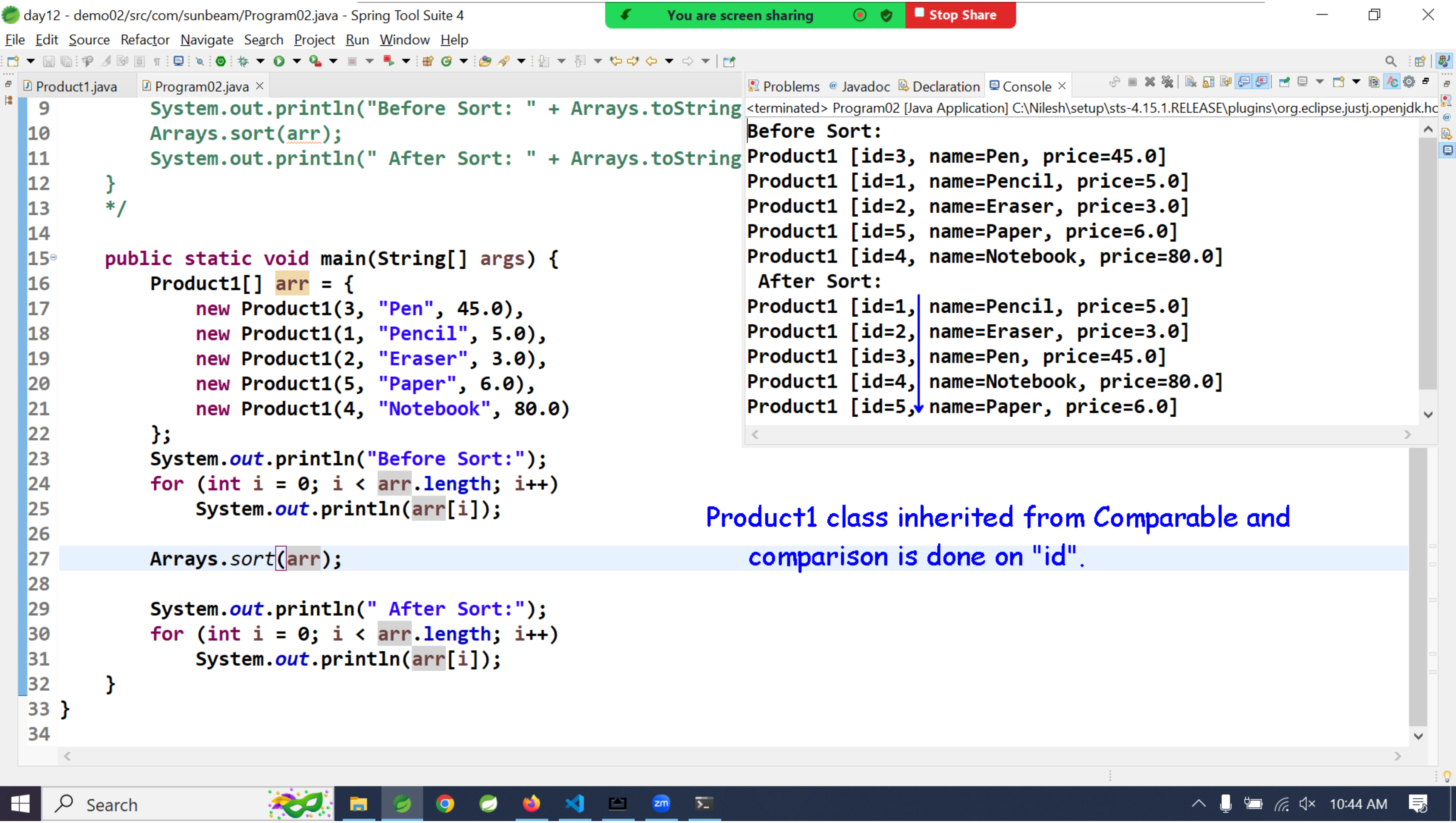
```java
        System.out.println("Before Sort: " + Arrays.toString(arr));
        Arrays.sort(arr);
        System.out.println(" After Sort: " + Arrays.toString(arr));
    }
    */

    public static void main(String[] args) {
        Product1[] arr = {
            new Product1(3, "Pen", 45.0),
            new Product1(1, "Pencil", 5.0),
            new Product1(2, "Eraser", 3.0),
            new Product1(5, "Paper", 6.0),
            new Product1(4, "Notebook", 80.0)
        };
        System.out.println("Before Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);

        Arrays.sort(arr);
```

Yet, Product1 class is not inherited from Comparable.

```
<terminated> Program02 [Java Application] C:\Nilesh\setup\sts-4.15.1.RELEASE\plugins\org.eclipse.justj.openjdk.hotspot.jre.full.win32.x86_64_17.0.3.v20220515-1416\jre\bin\javaw.exe  (Feb 13, 2024, 10:41:44 AM – 10:41:44 AM) [pid: 1834
id=5, name=Paper, price=6.0]
id=4, name=Notebook, price=80.0]
in thread "main" java.lang.ClassCastException: class com.sunbeam.Product1 cannot be cast to class java.lang.Comparable (com.s
 java.base/java.util.ComparableTimSort.countRunAndMakeAscending(ComparableTimSort.java:320)
 java.base/java.util.ComparableTimSort.sort(ComparableTimSort.java:188)
```



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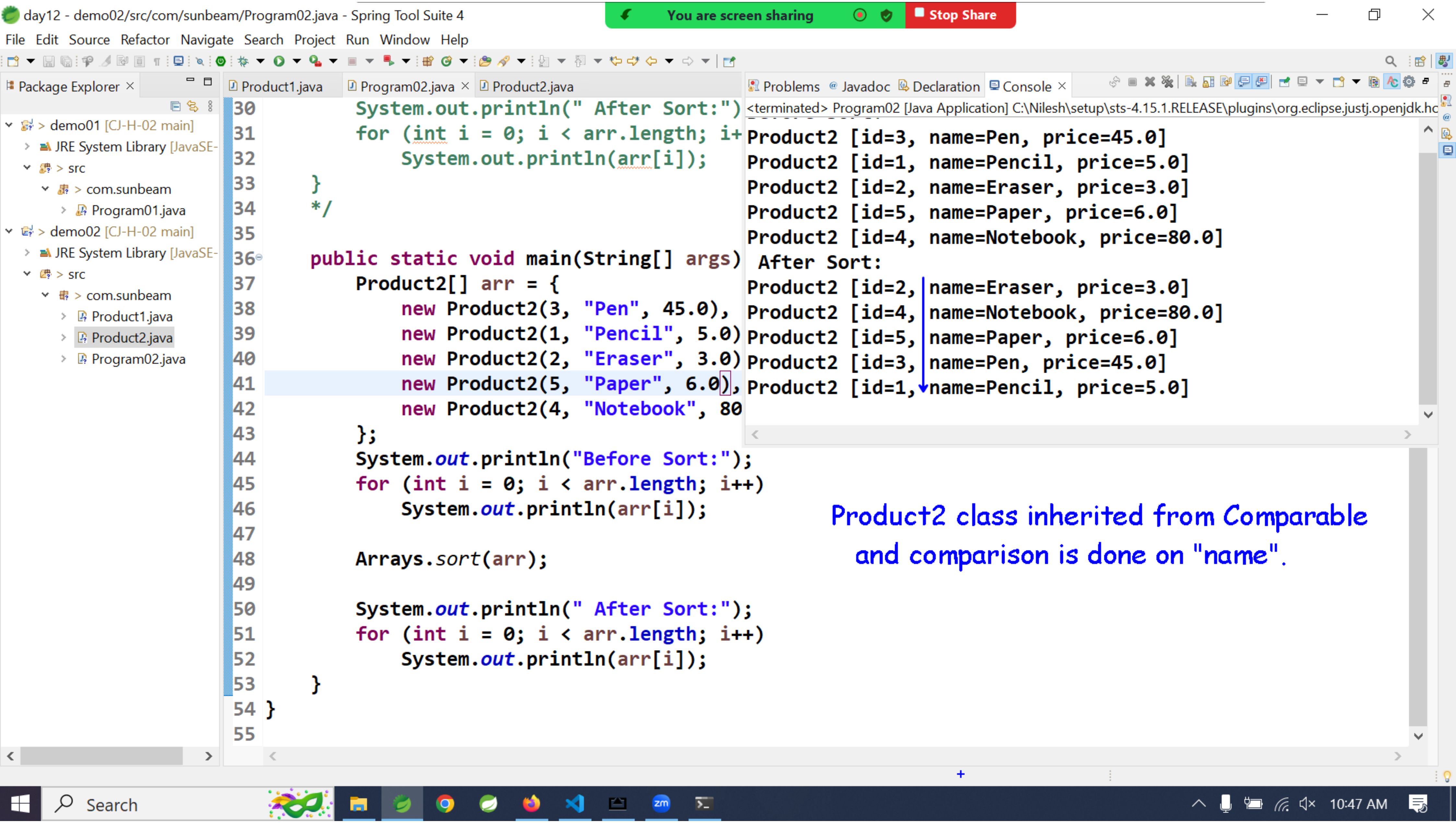
```java
        System.out.println("Before Sort: " + Arrays.toString
        Arrays.sort(arr);
        System.out.println(" After Sort: " + Arrays.toString
    }
    */

    public static void main(String[] args) {
        Product1[] arr = {
            new Product1(3, "Pen", 45.0),
            new Product1(1, "Pencil", 5.0),
            new Product1(2, "Eraser", 3.0),
            new Product1(5, "Paper", 6.0),
            new Product1(4, "Notebook", 80.0)
        };
        System.out.println("Before Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);

        Arrays.sort(arr);

        System.out.println(" After Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);
    }
}
```

```
<terminated> Program02 [Java Application] C:\Nilesh\setup\sts-4.15.1.RELEASE\plugins\org.eclipse.justj.openjdk.hc
Before Sort:
Product1 [id=3, name=Pen, price=45.0]
Product1 [id=1, name=Pencil, price=5.0]
Product1 [id=2, name=Eraser, price=3.0]
Product1 [id=5, name=Paper, price=6.0]
Product1 [id=4, name=Notebook, price=80.0]
 After Sort:
Product1 [id=1, name=Pencil, price=5.0]
Product1 [id=2, name=Eraser, price=3.0]
Product1 [id=3, name=Pen, price=45.0]
Product1 [id=4, name=Notebook, price=80.0]
Product1 [id=5, name=Paper, price=6.0]
```

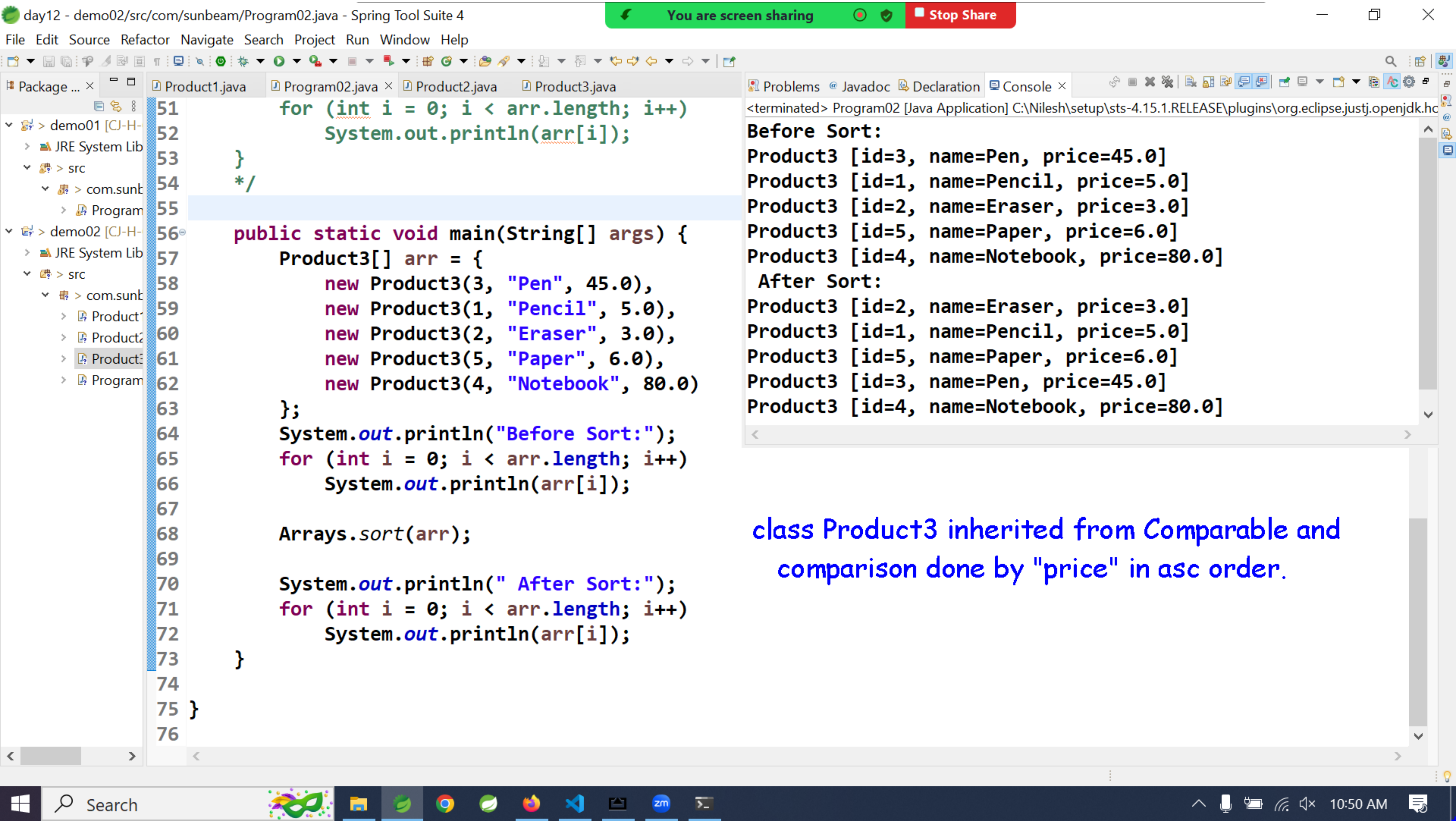
Product1 class inherited from Comparable and comparison is done on "id".



```
        System.out.println(" After Sort:")
        for (int i = 0; i < arr.length; i+
            System.out.println(arr[i]);
    }
    */

    public static void main(String[] args)
        Product2[] arr = {
            new Product2(3, "Pen", 45.0),
            new Product2(1, "Pencil", 5.0)
            new Product2(2, "Eraser", 3.0)
            new Product2(5, "Paper", 6.0),
            new Product2(4, "Notebook", 80
        };
        System.out.println("Before Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);

        Arrays.sort(arr);

        System.out.println(" After Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);
    }
}
```

```
<terminated> Program02 [Java Application] C:\Nilesh\setup\sts-4.15.1.RELEASE\plugins\org.eclipse.justj.openjdk.hc
Product2 [id=3, name=Pen, price=45.0]
Product2 [id=1, name=Pencil, price=5.0]
Product2 [id=2, name=Eraser, price=3.0]
Product2 [id=5, name=Paper, price=6.0]
Product2 [id=4, name=Notebook, price=80.0]
 After Sort:
Product2 [id=2, name=Eraser, price=3.0]
Product2 [id=4, name=Notebook, price=80.0]
Product2 [id=5, name=Paper, price=6.0]
Product2 [id=3, name=Pen, price=45.0]
Product2 [id=1, name=Pencil, price=5.0]
```

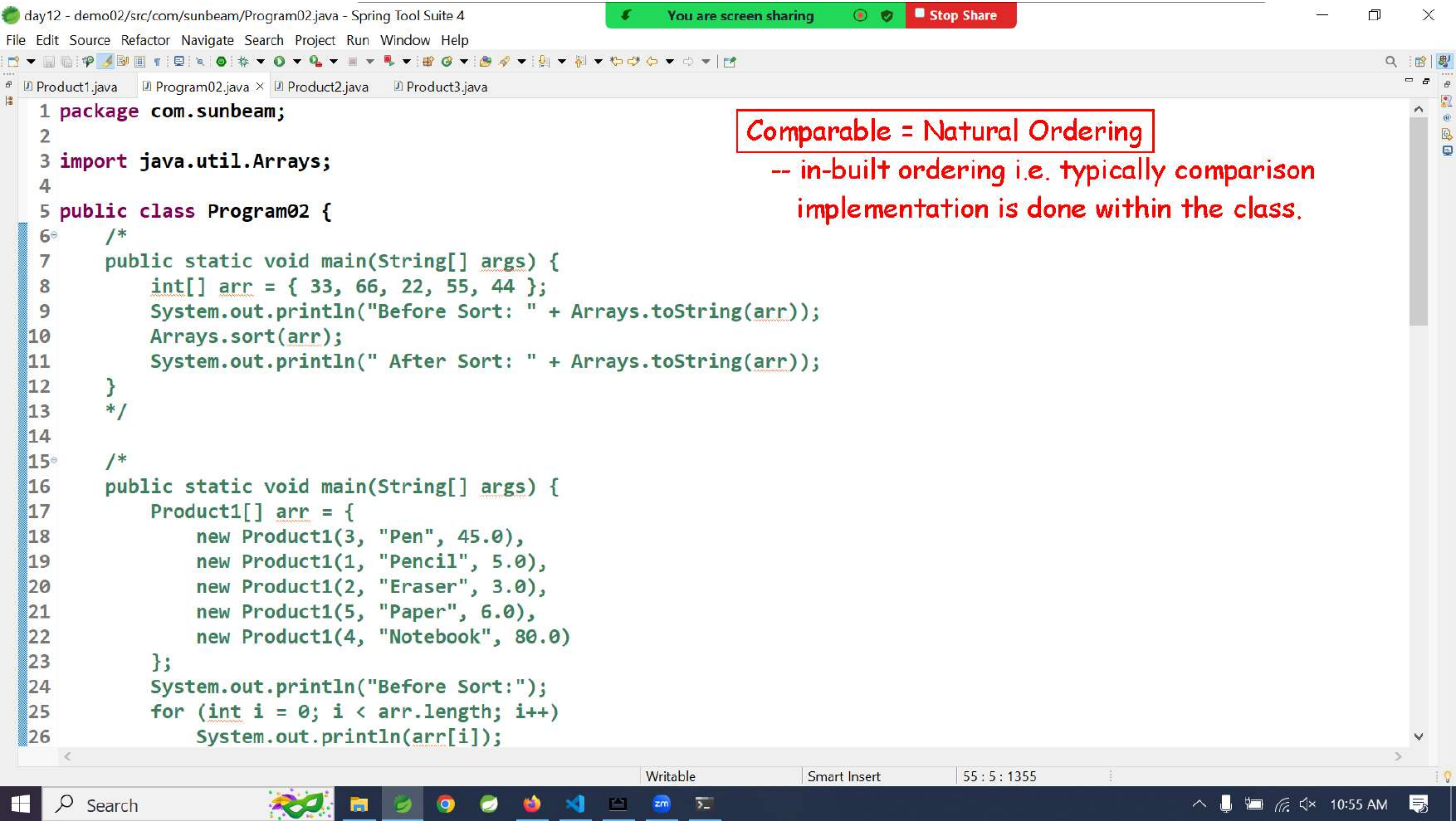
Product2 class inherited from Comparable and comparison is done on "name".



```java
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);
    }
    */

    public static void main(String[] args) {
        Product3[] arr = {
            new Product3(3, "Pen", 45.0),
            new Product3(1, "Pencil", 5.0),
            new Product3(2, "Eraser", 3.0),
            new Product3(5, "Paper", 6.0),
            new Product3(4, "Notebook", 80.0)
        };
        System.out.println("Before Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);

        Arrays.sort(arr);

        System.out.println(" After Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);
    }

}
```

```
<terminated> Program02 [Java Application] C:\Nilesh\setup\sts-4.15.1.RELEASE\plugins\org.eclipse.justj.openjdk.hc
Before Sort:
Product3 [id=3, name=Pen, price=45.0]
Product3 [id=1, name=Pencil, price=5.0]
Product3 [id=2, name=Eraser, price=3.0]
Product3 [id=5, name=Paper, price=6.0]
Product3 [id=4, name=Notebook, price=80.0]
 After Sort:
Product3 [id=2, name=Eraser, price=3.0]
Product3 [id=1, name=Pencil, price=5.0]
Product3 [id=5, name=Paper, price=6.0]
Product3 [id=3, name=Pen, price=45.0]
Product3 [id=4, name=Notebook, price=80.0]
```

class Product3 inherited from Comparable and comparison done by "price" in asc order.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Program02.java
Product2.java
Product3.java
Writable
Smart Insert
55 : 5 : 1355
Search
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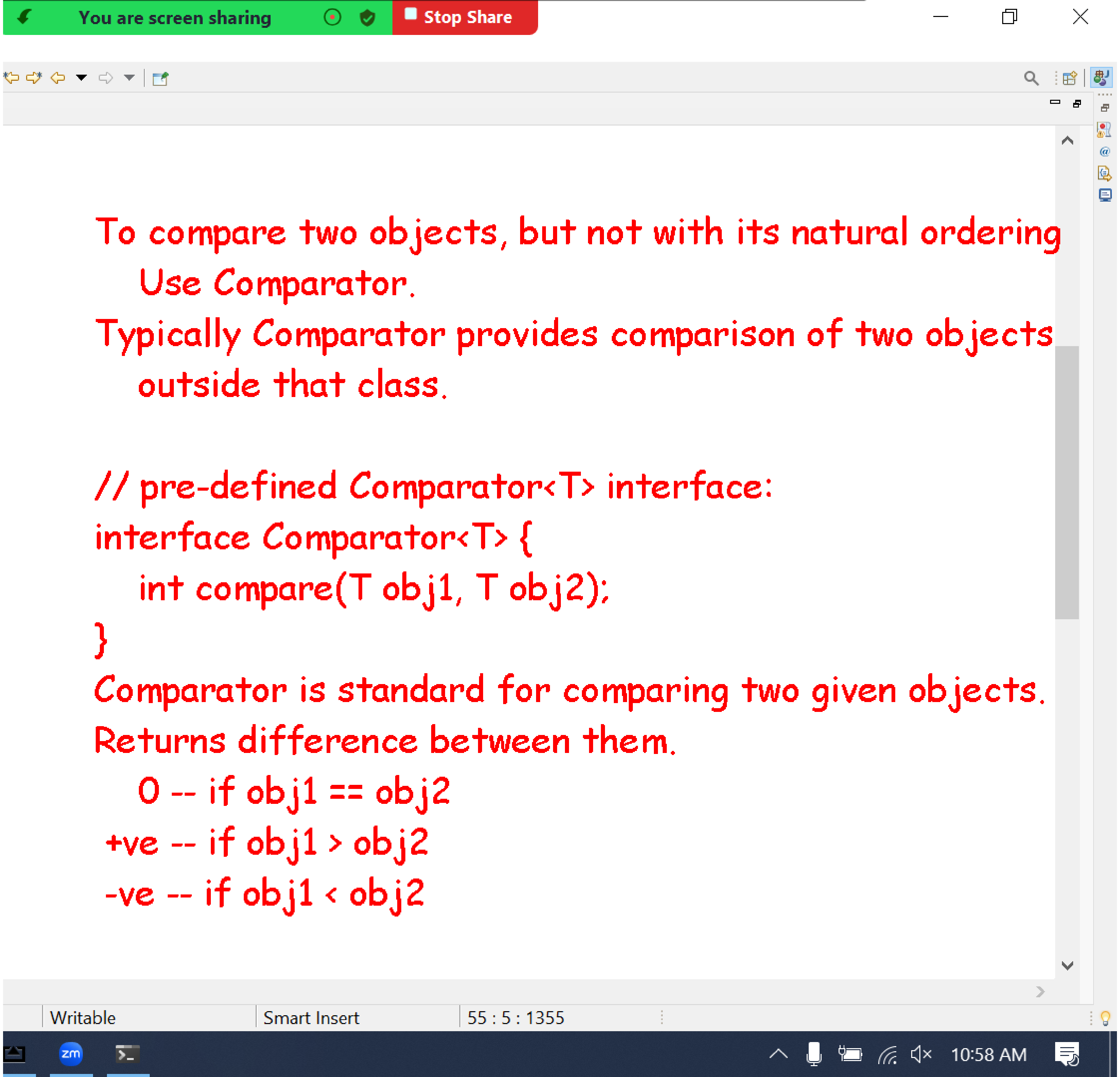
Comparable = Natural Ordering

-- in-built ordering i.e. typically comparison implementation is done within the class.

```java
package com.sunbeam;

import java.util.Arrays;

public class Program02 {
    /*
    public static void main(String[] args) {
        int[] arr = { 33, 66, 22, 55, 44 };
        System.out.println("Before Sort: " + Arrays.toString(arr));
        Arrays.sort(arr);
        System.out.println(" After Sort: " + Arrays.toString(arr));
    }
    */

    /*
    public static void main(String[] args) {
        Product1[] arr = {
            new Product1(3, "Pen", 45.0),
            new Product1(1, "Pencil", 5.0),
            new Product1(2, "Eraser", 3.0),
            new Product1(5, "Paper", 6.0),
            new Product1(4, "Notebook", 80.0)
        };
        System.out.println("Before Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);
```

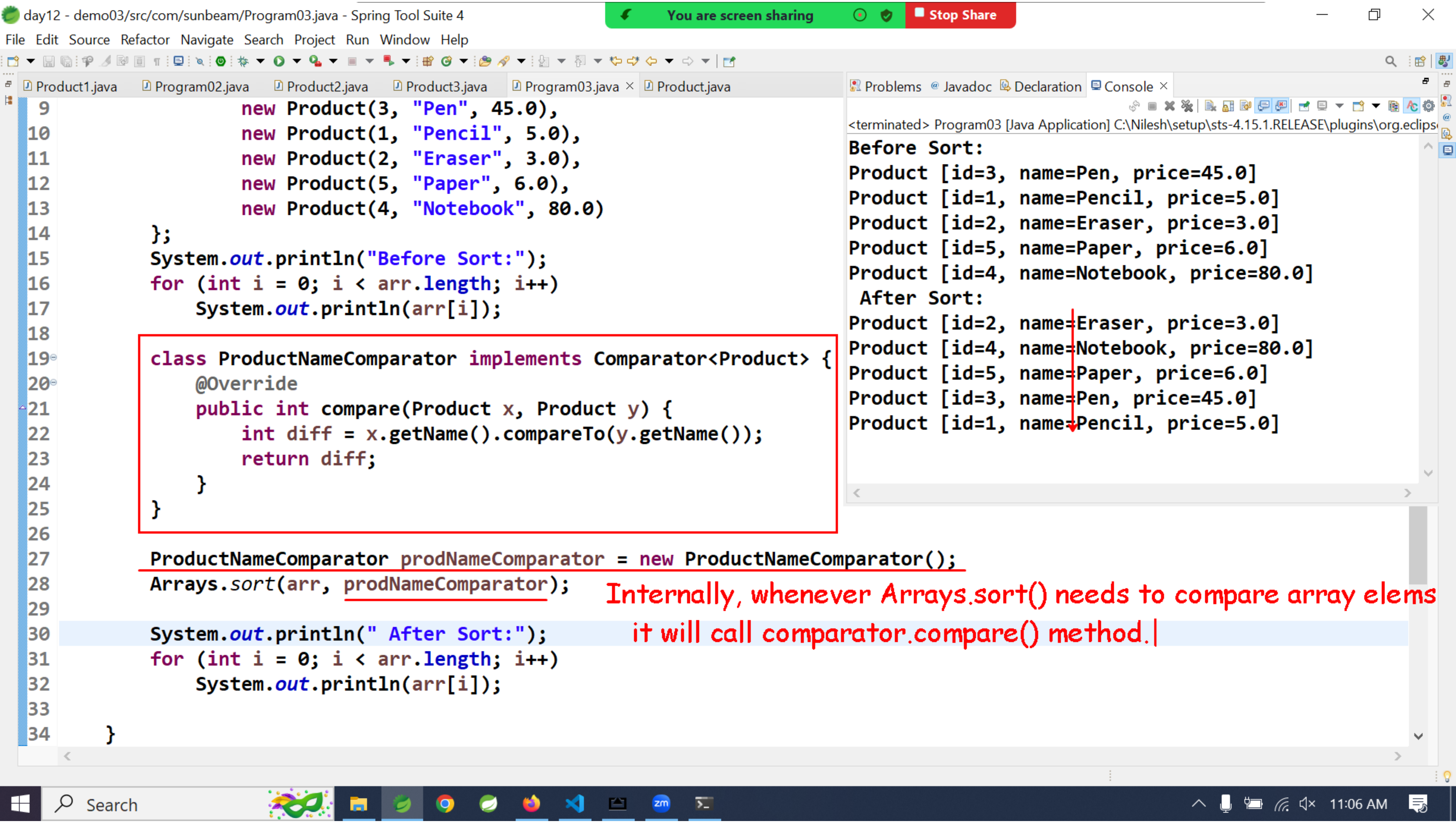


To compare two objects, but not with its natural ordering
    Use Comparator.
Typically Comparator provides comparison of two objects
    outside that class.

```
// pre-defined Comparator<T> interface:
interface Comparator<T> {
    int compare(T obj1, T obj2);
}
```

Comparator is standard for comparing two given objects.
Returns difference between them.

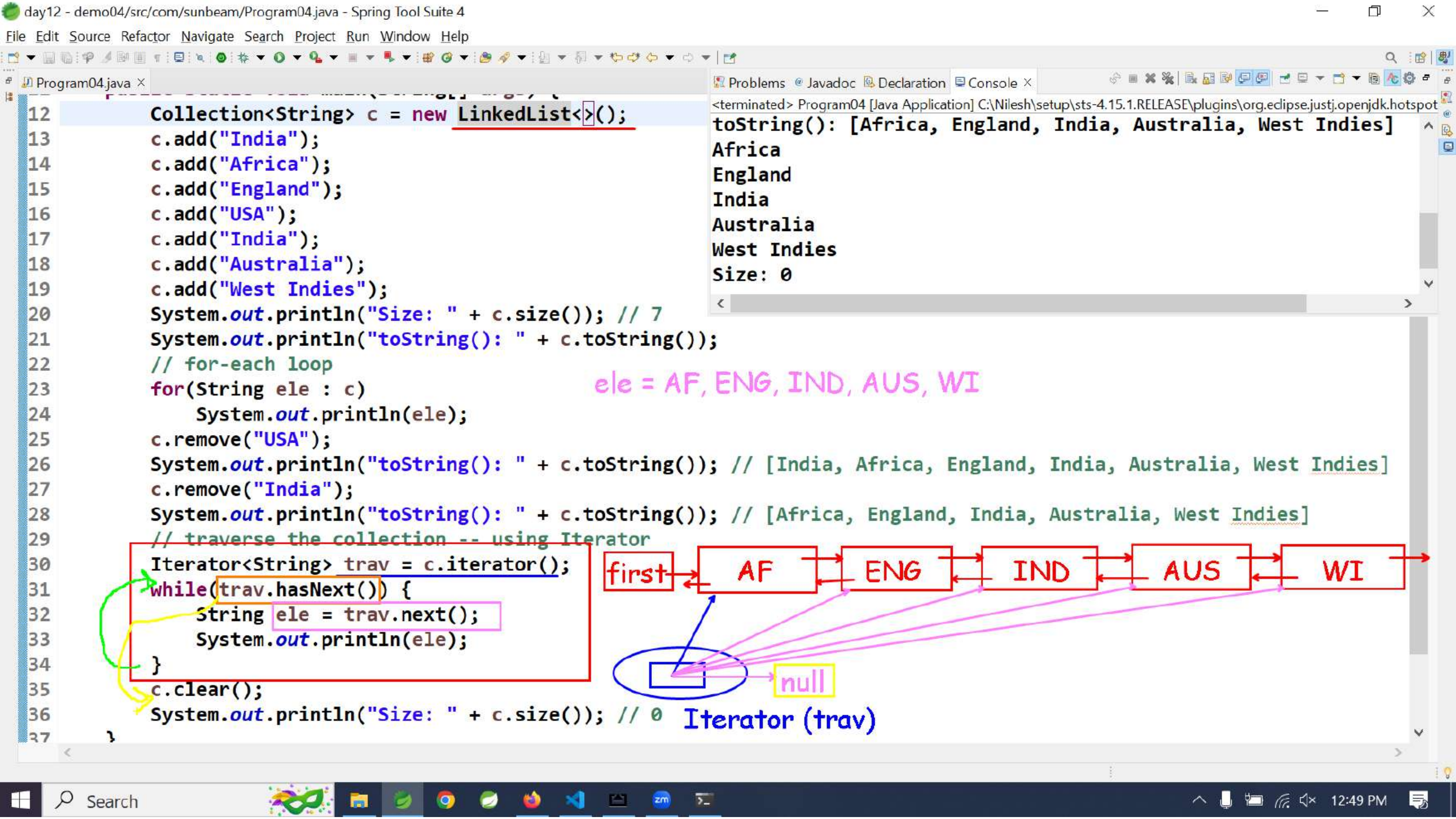
```
    0 -- if obj1 == obj2
 +ve -- if obj1 > obj2
 -ve -- if obj1 < obj2
```



```java
                new Product(3, "Pen", 45.0),
                new Product(1, "Pencil", 5.0),
                new Product(2, "Eraser", 3.0),
                new Product(5, "Paper", 6.0),
                new Product(4, "Notebook", 80.0)
        };
        System.out.println("Before Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);

        class ProductNameComparator implements Comparator<Product> {
            @Override
            public int compare(Product x, Product y) {
                int diff = x.getName().compareTo(y.getName());
                return diff;
            }
        }

        ProductNameComparator prodNameComparator = new ProductNameComparator();
        Arrays.sort(arr, prodNameComparator);

        System.out.println(" After Sort:");
        for (int i = 0; i < arr.length; i++)
            System.out.println(arr[i]);

    }
```

```
<terminated> Program03 [Java Application] C:\Nilesh\setup\sts-4.15.1.RELEASE\plugins\org.eclips
Before Sort:
Product [id=3, name=Pen, price=45.0]
Product [id=1, name=Pencil, price=5.0]
Product [id=2, name=Eraser, price=3.0]
Product [id=5, name=Paper, price=6.0]
Product [id=4, name=Notebook, price=80.0]
 After Sort:
Product [id=2, name=Eraser, price=3.0]
Product [id=4, name=Notebook, price=80.0]
Product [id=5, name=Paper, price=6.0]
Product [id=3, name=Pen, price=45.0]
Product [id=1, name=Pencil, price=5.0]
```

Internally, whenever Arrays.sort() needs to compare array elems
it will call comparator.compare() method.



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Program04.java
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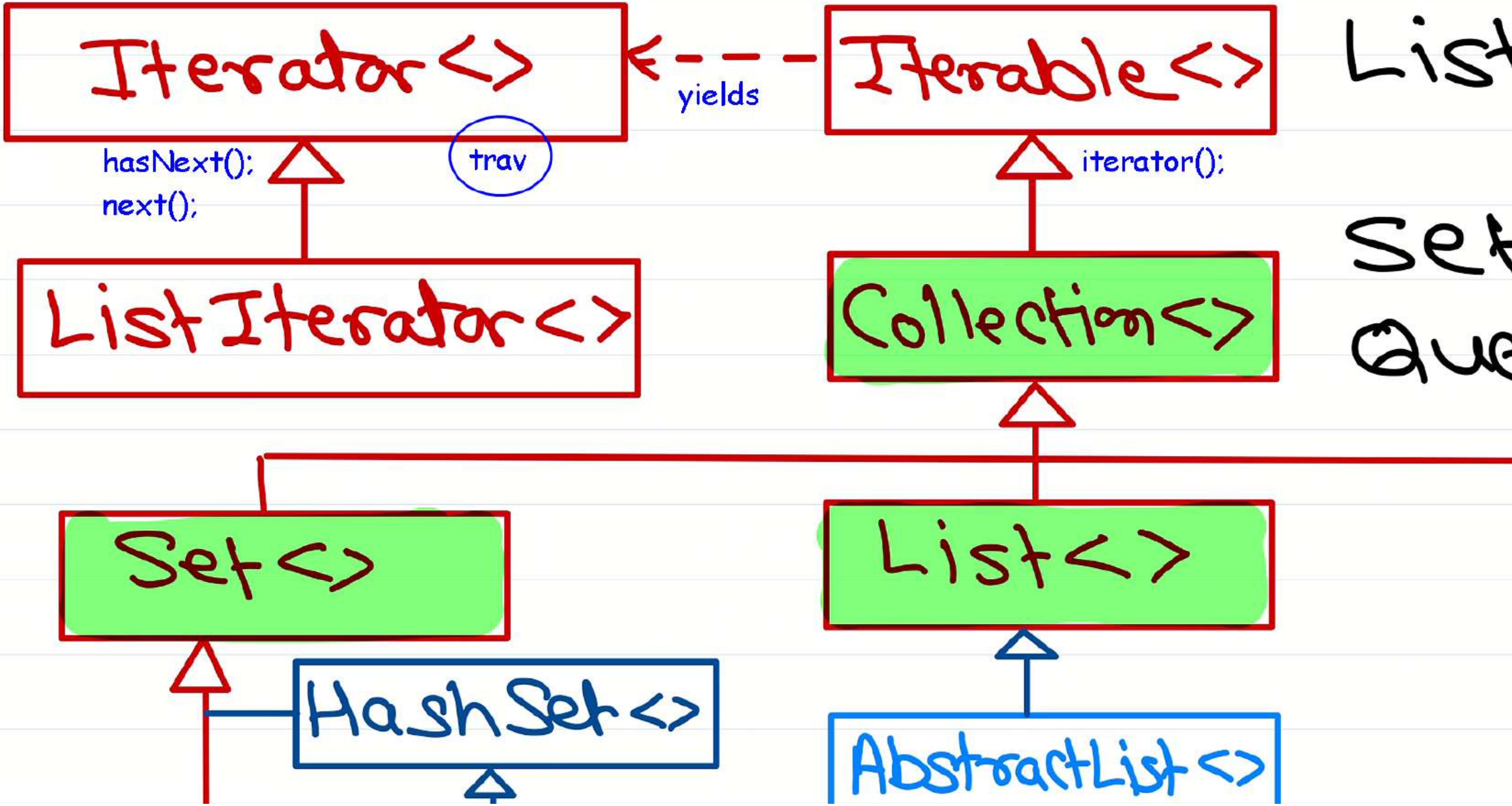
ele = AF, ENG, IND, AUS, WI
first
AF
ENG
IND
AUS
WI
null
Iterator (trav)
Search
12:49 PM

```
        Collection<String> c = new LinkedList<>();
        c.add("India");
        c.add("Africa");
        c.add("England");
        c.add("USA");
        c.add("India");
        c.add("Australia");
        c.add("West Indies");
        System.out.println("Size: " + c.size()); // 7
        System.out.println("toString(): " + c.toString());
        // for-each loop
        for(String ele : c)
            System.out.println(ele);
        c.remove("USA");
        System.out.println("toString(): " + c.toString()); // [India, Africa, England, India, Australia, West Indies]
        c.remove("India");
        System.out.println("toString(): " + c.toString()); // [Africa, England, India, Australia, West Indies]
        // traverse the collection -- using Iterator
        Iterator<String> trav = c.iterator();
        while(trav.hasNext()) {
            String ele = trav.next();
            System.out.println(ele);
        }
        c.clear();
        System.out.println("Size: " + c.size()); // 0
    }
```

```
<terminated> Program04 [Java Application] C:\Nilesh\setup\sts-4.15.1.RELEASE\plugins\org.eclipse.justj.openjdk.hotspot
toString(): [Africa, England, India, Australia, West Indies]
Africa
England
India
Australia
West Indies
Size: 0
```

for-each loop works for any class inherited from Iterable.


Iterator<>
yields
Iterable<>
hasNext();
next();
trav
iterator();
ListIterator<>
Collection<>
Set<>
List<>
HashSet<>
AbstractList<>
List
Set
Que