Programming in Java – Primitive type wrappers, Enumerations, and Generics

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Primitive types

- `byte`
- `short`
- `int`
- `long`
- `character`
- `float`
- `double`
- `boolean`
- `void`

✓ *Primitive types are not objects!*

✓ *Primitive types are used for performance reasons, however many situations require an object*

✓ *Most Java classes have methods that works on Objects and not on primitive type.*

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Primitive types are not objects

```
public interface List {

    boolean isEmpty();

    int getSize();

    boolean contains(Object value);

    Object[] getValues();

    Object get(int index);

    void add(Object value);

    void insertAt(int index, Object value);

    void remove(int index);

    int indexOf(Object value);
}
```

- ✓ *The same interface and consequently the same implementation cannot be used for primitive types*
- ✓ *We would need one interface for the int type, one for the long type, one for the short type, and so forth*

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Primitive type wrappers

- `byte`
- `short`
- `int`
- `long`
- `character`
- `float`
- `double`
- `boolean`

- `Byte`
- `Short`
- `Integer`
- `Long`
- `Character`
- `Float`
- `Double`
- `Boolean`

✓ *There exist one wrapper class for each primitive type*

✓ *Wrappers are classes that wrap primitive types within an object*

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From primitive value to wrapper object

The static factory method valueOf() is the recommended way to convert a primitive value to an object

```
int i = 60;
Integer i1 = Integer.valueOf(i);
Integer i2 = new Integer(i);
```

The use of primitive type wrapper's constructors is deprecated.

Why?
Hint: consider the boolean case

```
boolean b = true;
Boolean b1 = Boolean.valueOf(b);
Boolean b2 = new Boolean(b);
```

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Caching of wrapper objects

If the value *p* being boxed is the result of evaluating a constant expression (§15.29) of type `boolean`, `byte`, `char`, `short`, `int`, or `long`, and the result is `true`, `false`, a character in the range `'\u0000'` to `'\u007f'` inclusive, or an integer in the range `-128` to `127` inclusive, then let *a* and *b* be the results of any two boxing conversions of *p*. It is always the case that *a* == *b*.

From The Java Language Specification, Java SE 17 Edition, p. 123

```
public static void main(String[] args) {
    System.out.println(Integer.valueOf(127) == Integer.valueOf(127));
    System.out.println(Integer.valueOf(128) == Integer.valueOf(128));
}
```

The operator == tells you if two references point to the same object.
No unboxing is performed here.

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From wrapper object to primitive value

```java
Boolean b = Boolean.FALSE;
boolean b1 = b.booleanValue();

Character c = Character.valueOf('a');
char c1 = c.charValue();
```

What about numerical values?

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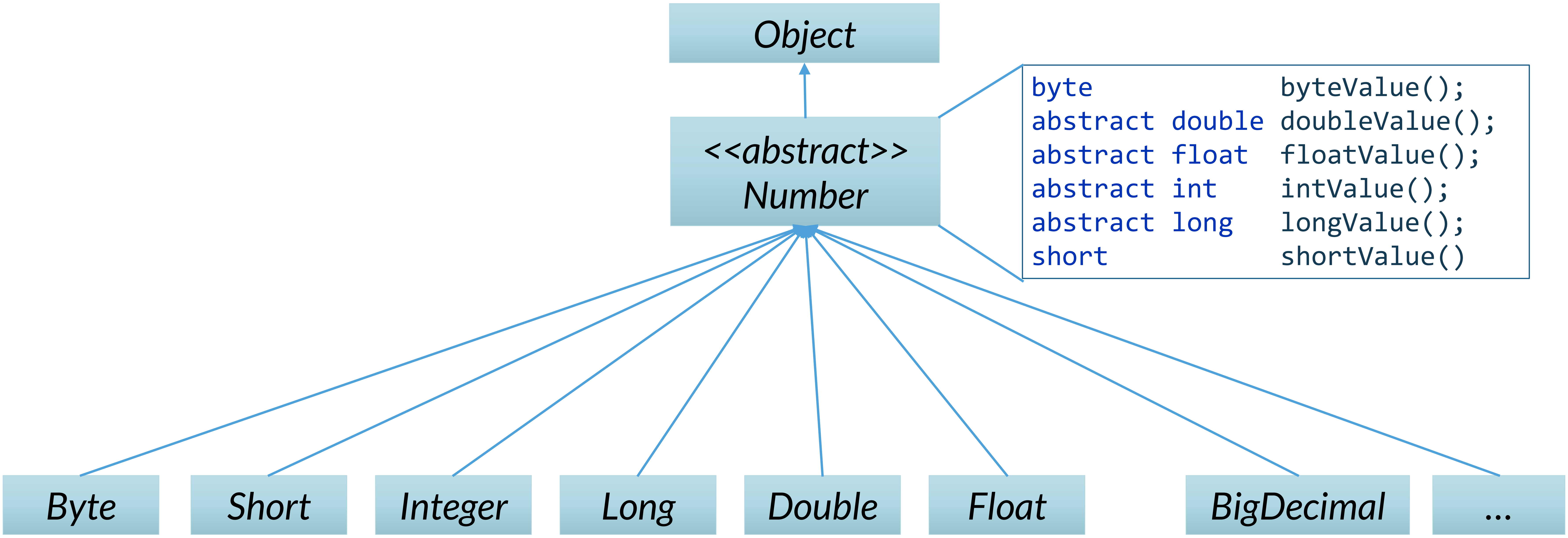
The Number hierarchy



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Boxing and unboxing

Also known as auto-boxing and auto-unboxing

```
Boolean b = false;
boolean b1 = b;

Character c = 'a';
char c1 = c;

int i = 60;
Integer i1 = i;
Double d1 = i;
Double d1 = i.doubleValue();
int i2 = i + i1;
```

Boxing is the process by which a primitive type is automatically wrapped into its equivalent type wrapper whenever an object of that type is needed. There is no need to explicitly construct an object.

Unboxing is the process by which the value of a boxed object is automatically extracted from a type wrapper when its value is needed. There is no need to call a method such as `intValue()` *or* `doubleValue()`*. Unboxing can lead to NullPointerExceptions*

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Assignment

Explore the API of the primitive type wrappers.
If you haven't yet done so.

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Enumerations

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Enumerations

```
enum Degree {
    HIGH_SCHOOL, BACHELOR, MASTER, PHD
}
```

An enumeration declaration is a list of named constants that define a new data type and its legal values.

Each enumeration constant is a public static final member of the Degree class

Once it is declared, an enumeration cannot be changed at runtime.

```
Degree d1 = Degree.PHD;
Degree d2 = Degree.BACHELOR;

if (d1 == d2) {
    System.out.println("This seems a bit unusual!");
}
```

You cannot instantiate an enumeration, but you can reference its members

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Enumerations in switch statements

In switch statements the enumeration constants don't need to be qualified by their enumeration type name

```
Degree d = getDegree();

switch (d) {
    case HIGH_SCHOOL -> System.out.println("High School");
    case BACHELOR -> System.out.println("Bachelor");
    case MASTER -> System.out.println("Master");
    case PHD -> System.out.println("PhD");
}
```

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Enumerate enumerations

Enumerations automatically get two static methods, one to enumerate the constants and one to get a constant from its name

```
public static enum-type [ ] values( )
public static enum-type valueOf(String str )
```

Each enumeration constant has an ordinal value

```
final int ordinal( )
```

```
Degree d1 = Degree.PHD;
Degree d2 = Degree.valueOf("PHD");

if (d1 == d2) {
    System.out.println("This looks ok!");
}

for (Degree dd : Degree.values()) {
    System.out.println(dd.getOrdinal() + " " + dd);
}
```

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Enumerations are first class classes

```
enum Degree {
    HIGH_SCHOOL(5), BACHELOR(3), MASTER(2), PHD(3);

    private final int duration;

    Degree(int duration) {
        this.duration = duration;
    }

    public int getDuration() {
        return duration;
    }
}
```

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Generics

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Generalized classes

```java
public class GeneralizedStack {

    public int getSize();

    public Object top() {…}

    public Object pop() {…}

    public void push(Object value) {…}

}
```

Before the introduction of generics in Java 5, generalized classes, interfaces and methods operated with references to Object instances, with consequent problems of type safety

```java
public static void main(String[] args) {

    GeneralizedStack stack = new GeneralizedStack();

    stack.push("Hello,");
    stack.push("World!");
    stack.push(new Object());

    while (stack.getSize() > 0) {
        String text = (String) stack.pop();
        System.out.println(text);
    }
}
```

Runtime exception

We had to rely on inherently unsafe casting

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Specialized classes

```java
public class StringStack {

    private final GeneralizedStack data =
            new GeneralizedStack();

    public int getSize();
        return data.getSize();
    }

    public String top() {
        return (String) data.top();
    }

    public String pop() {
        return (String) data.pop();
    }

    public void push(String value) {
        data.push(value);
    }
}
```

```java
public static void main(String[] args) {

    StringStack stack = new StringStack();

    stack.push("Hello,");
    stack.push("World!");
    stack.push(new Object());    Compile time error

    while (stack.getSize() > 0) {
        String text = stack.pop();
        System.out.println(text);
    }
}
```

No need for class casting, but specialized classes required boilerplate code and a considerable use of cast operations.

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What are Generics?

```
public class Stack<T> {

    public int getSize() {…}

    public void push(T value) {…}

    public T top() {…}

    public T pop() {…}
}
```

Java 5 introduced the concept of parameterization of interfaces, classes and methods. A parameterized interface or class is called parameterized type or generic.

In generic classes, generic interfaces, and generic methods the type of data upon which they operate is specified as a parameter

```
public static void main(String[] args) {

    Stack<String> stringStack = new Stack<>();

    stringStack.push("Hello,");
    stringStack.push("World!");
    stringStack.push(new Object());

    while (stringStack.getSize() > 0) {
        String text = stringStack.pop();
        System.out.println(text);
    }
}
```

Compile time error

Parameterized types are used to improve type safety when compared with the use of Object and they are used to reduce boilerplate code.

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Parameters bounding

```
public class Stack<T> {

    public int getSize() {…}

    public void push(T value) {…}

    public T top() {…}

    public T pop() {…}
}
```

The parameter T can be replaced by any class type.

```
public class NumberStack<N extends Number> extends Stack<N> {

    double average() {
        double sum = 0;
        for (Number number : data) {
            sum += number.doubleValue();
        }
        return sum / getSize();
    }
}
```

N is a bounded parameter, N can be replaced only by the superclass Number or by a subclass of the superclass Number.

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Multiple bounding & intersection types

The parameter T can be bounded to a class and to any number of interfaces.

In that case, the bounding class must be specified first and T will be bounded to the intersection type.

```
public class Stack<T extends KeylessCar & AutonomousCar> {

    public int getSize() {…}

    public void push(T value) {…}

    public T top() {…}

    public T pop() {…}
}
```

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Wildcard arguments 1/3

```
public class Stack<T> {

    public int getSize() {…}

    public void push(T value) {…}

    public T top() {…}

    public T pop() {…}

    public void sameSize(Stack<T> other) {
        return getSize() == other.getSize();
    }
}
```

```
public static void main(String[] args) {

    Stack<String> stringStack = new Stack<>();
    Stack<Double> doubleStack = new Stack<>();

    doubleStack.sameSize(stringStack);
}
```

This code doesn't compile.
The `sameSize` *method expects* `Stack<Double>`.

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Wildcard arguments 2/3

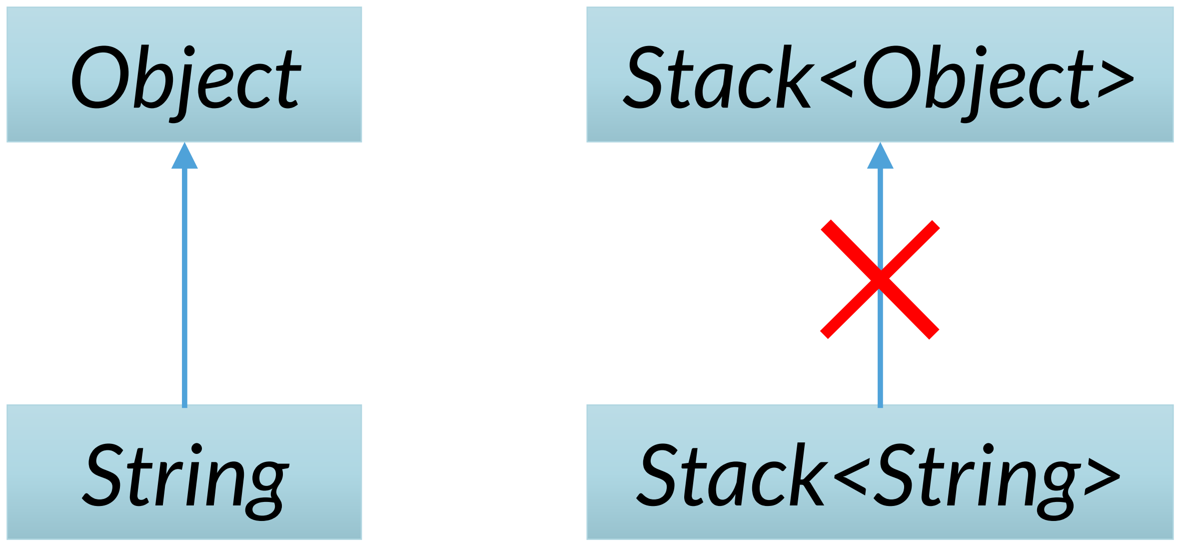
```java
public class Stack<T> {

    public int getSize() {…}

    public void push(T value) {…}

    public T top() {…}

    public T pop() {…}

    public void sameSize(Stack<Object> other) {
        return getSize() == other.getSize();
    }
}
```

```java
public static void main(String[] args) {

    Stack<String> stringStack = new Stack<>();
    Stack<Double> doubleStack = new Stack<>();

    doubleStack.sameSize(stringStack);
}
```

The main method still doesn't compile.

String is a subclass of Object.

Stack<String> is not a "subclass" of Stack<Object>



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Wildcard arguments 3/3

```
public class Stack<T> {

    public int getSize() {…}

    public void push(T value) {…}

    public T top() {…}

    public T pop() {…}

    public void sameSize(Stack<?> other) {
        return getSize() == other.getSize();
    }
}
```

The `sameSize` method now expects a `Stack<?>` that means a Stack with any parameterization.

```
public static void main(String[] args) {

    Stack<String> stringStack = new Stack<>();
    Stack<Double> doubleStack = new Stack<>();

    doubleStack.sameSize(stringStack);
}
```

This code compiles.

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Multiple parameters

A generic can define multiple type parameters

```java
public class Pair<F, S> {

    private final F first;
    private final S second;

    public Pair(F first, S second) {
        this.first = first;
        this.second = second;
    }

    @Override
    public String toString() {
        return "Pair{first=" + first + ", second=" + second + '}';
    }
}
```

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Generic methods 1/3

```
public class Stack<T> {

    public int getSize() {…}

    public void push(T value) {…}

    public T top() {…}

    public T pop() {…}
}
```

Methods inside a generic class can make use of a class type parameter and are, therefore, automatically generic relative to the type parameter.

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Generic methods 2/3

```
public class Stack<T> {

    public int getSize() {…}

    public T top() {…}

    public T pop() {…}

    public void push(T value) {…}

    public <O extends T> void pushAll(Stack<O> other) {
        while (other.getSize() > 0) {
            push(other.pop());
        }
    }
}
```

Type parameters are declared before the return type

Type parameters are used in the argument list

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Generic methods 3/3

```
public class Stack<T> {

    public int getSize() {…}

    public T top() {…}

    public T pop() {…}

    public void push(T value) {…}

    public void pushAll(Stack<? extends T> other) {
        while (other.getSize() > 0) {
            push(other.pop());
        }
    }
}
```

This class is equivalent to the previous one

Wildcards are preferred, they make the code more concise

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Generic interfaces

```
public interface Stack<T> {

    int getSize();

    void push(T value);

    T top();

    T pop();
}
```

A generic interface is declared in the same way as is a generic class.

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Local variable type inference

```
Stack<String> stringStack1 = new Stack<>();
var stringStack2  = new Stack<String>();
```

The second version is shorter and it should be preferred

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Quasi-trivial assignment

```java
public interface Collection {

    boolean isEmpty();

    int getSize();

    boolean contains(Object object);

    Object[] getValues();
}

public interface Stack extends Collection {

    void push(Object object);

    Object pop();

    Object top();
}
```

```java
public interface List extends Collection {

    void add(Object object);

    Object get(int index);

    void insertAt(int index, Object object);

    void remove(int index);

    int indexOf(Object object);

}
```

Implement the Stack and List interfaces, so that they take a generic type.

Hint: `getValues()` *is not trivial. Take a look at* `java.lang.reflect.Array`

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Thank you!

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