

Theory: BigInteger

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§1. Using large numbers in Java

As you might remember, the standard primitive integer types cannot store very large numbers. It is not possible to assign the following large number to a variable of the type `int` (or even `long`):

```
1 | int y = 62957291795228763406253098; // compilation-error: integer number too large
```

That is also the reason why operations with numbers can sometimes lead to **type overflow**. For example, check out the following code:

```
1 | int a = Integer.MAX_VALUE; // 2147483647
2 | a += 2; // -2147483647
```

Fortunately, the Java Class Library provides a class called `BigInteger` for processing very large numbers (both positive and negative). The size of a stored number is only limited by the available memory.

The `BigInteger` class is **immutable** which means methods of the class return new instances instead of changing existing ones.

Although this type can store any integers, including small numbers, `BigInteger` should only be used if it is absolutely necessary. Using it is less intuitive compared to built-in types and, more importantly, there is always a performance hit associated with its use. `BigInteger` operations are substantially slower than operations on built-in integer types.

§2. Creating objects of BigInteger

The class `BigInteger` belongs to the `java.math` package. We import it by writing the following statement:

```
1 | import java.math.BigInteger;
```

Here is an instance of the class that stores the large number presented above:

```
1 | BigInteger number = new BigInteger("62957291795228763406253098");
```

It is also possible to create an instance by passing a long value to the method `valueOf`:

```
1 | BigInteger number = BigInteger.valueOf(1_000_000_000);
```

In addition, the class has several useful constants:

```
1 | BigInteger zero = BigInteger.ZERO; // 0
2 | BigInteger one = BigInteger.ONE;   // 1
3 | BigInteger ten = BigInteger.TEN;   // 10
```

Using them is a good practice because constants allow you to reuse an already created object. This is particularly important considering that instance of `BigInteger` is actually quite big. Except for a memory optimization point, the code with constants is easier to read.

Compare the code below:

```
1 | if (something) {
2 |     return new BigInteger("1");
3 | }
```

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and its analog with constants:

```
1  if (something) {  
2      return BigInteger.ONE;  
3  }
```

Remember it and try to use built-in `BigInteger` constants whenever possible.

§3. Methods of BigInteger

The class has a set of non-static methods to perform all standard arithmetic operations. The following example demonstrates the addition.

```
1  BigInteger eleven = ten.add(one);  
2  System.out.println(eleven); // 11  
3  
4  System.out.println(ten); // 10, it has not changed!
```

Keep in mind, that the arithmetic methods do not change instances but create a new one.

Other arithmetic methods (subtraction, multiplication, integer division) are listed below:

```
1  BigInteger nine = ten.subtract(BigInteger.ONE); // 10 - 1 = 9  
2  BigInteger oneHundredTen = ten.multiply(eleven); // 10 * 11 = 110  
3  BigInteger twelve = oneHundredTen.divide(nine); // integer division: 12
```

The method `negate` returns a new `BigInteger` with the changed sign, like this:

```
1  nine.negate(); // -9
```

The method `divideAndRemainder` returns an array consisting of two numbers: the result of integer division and the remainder.

```
1  BigInteger[] pair = oneHundredTen.divideAndRemainder(nine); // 12 and 2
```

The class also provides methods for performing more complex math operations. The method `abs` returns a new `BigInteger` whose value is the absolute value of this `BigInteger`.

```
1  BigInteger number = new BigInteger("-8");  
2  System.out.println(number.abs()); // 8
```

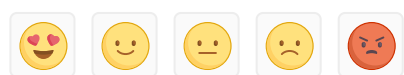
The method `gcd` returns the greatest common divisor of two numbers.

```
1  BigInteger three = BigInteger.valueOf(3);  
2  BigInteger six = BigInteger.valueOf(6);  
3  System.out.println(three.gcd(six)); // 3
```

The class has methods for performing bitwise and bitshift operations as well, but we do not consider them here.

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