12. Numbers

Java

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Instructor: Dr. Masoud Yaghini

Outline

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- Math Class
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Numeric Type Conversions

Numeric Data Types (Review)

Name	*Range*	*Storage Size*
`byte`	-2^7 (-128) to $2^7 - 1$(127)	8-bit signed
`short`	-2^{15} (-32768) to $2^{15} - 1$(32767)	16-bit signed
`int`	-2^{31} (-2147483648) to $2^{31} - 1$(2147483647)	32-bit signed
`long`	-2^{63} to $2^{63} - 1$	64-bit signed
	(i.e., -9223372036854775808 to 9223372036854775807)	
`float`	Negative range: -3.4028235E + 38 to -1.4E-45	32-bit IEEE 754
	Positive range: 1.4E-45 to 3.4028235E + 38	
`double`	Negative range: -1.79769313486231570E+308 to -4.9E-324	64-bit IEEE 754
	Positive range: 4.9E-324 to 1.79769313486231570E+308	

Numeric Type Conversions

- Consider the following statements:

```
byte i = 100;
long k = i * 3 + 4;
double d = i * 3.1 + k / 2;
```

Conversion Rules

- When performing a binary operation involving two operands of different types, Java automatically converts the operand based on the following rules:

1. If one of the operands is double, the other is converted into double.
2. Otherwise, if one of the operands is float, the other is converted into float.
3. Otherwise, if one of the operands is long, the other is converted into long.
4. Otherwise, both operands are converted into int.

Numeric Type Conversions

- For example,
  - the result of 1 / 2 is 0, because both operands int values.
  - the result of 1.0 / 2 is 0.5, because 1.0 is double and 2 is converted to 2.0

Numeric Type Conversions

- You can always assign a value to a numeric variable whose type supports a larger range of values
- Thus, for instance, you can assign a long value to a float variable.

Type Casting

- Type casting is an operation that converts a value of one data type into a value of another data type.
  - Type widening: Casting a variable of a type with a small range to a variable of a type with a larger range.
  - Type narrowing: Casting a variable of a type with a large range to a variable of a type with a smaller range.

Type Casting

- Widening a type can be performed automatically.

```
double d = 3;
```

- Narrowing a type must be performed explicitly.

```
int i = (int)3.0;
int i = (int)3.9;
```

- What is wrong? **int x = 5 / 2.0;**

Type Casting

- Casting does not change the variable being cast.
- For example, d is not changed after casting in the following code:

```
double d = 4.5;
int i = (int)d; // d is not changed
```

Type Casting

- To assign a variable of the int type to a variable of the short or byte type, explicit casting must be used.
- For example, the following statements have a syntax error:

```
int i = 1;
byte b = i; // Error because explicit casting is required
```

Type Casting

- Write a program that displays the sales tax with two digits after the decimal point.
  - purchaseAmount = 197.55
  - tax = purchaseAmount * 0.06
- Tax will be 11.853 , but we want the program display two digits after the decimal point (i.e. 11.85).
- The program:
  - SalesTax.java

Math Class

Math Class

- The Math class contains the methods needed to perform basic mathematical functions.
- This chapter introduces useful methods in the Math class.
- Class constants:
  - `PI (3.141...)`
  - `E  (2.718...)`

Math Class

- Math Class methods:
  - Exponent Methods
  - Rounding Methods
  - min, max, and abs
  - random Methods
  - Trigonometric Methods

Exponent Methods

- public static double exp(double x)
  - Return e raised to the power of x (e^x)
  - Math.exp(1) returns 2.71828
- public static double log(double x)
  - Return the natural logarithm of x (ln(x))
  - Math.log(Math.E) returns 1.0
- public static double log10(double x)
  - Return the base 10 logarithm of x ($\log_{10}(x)$)
  - Math.log10(10) returns 1.0

Exponent Methods

- public static double pow(double x, double b)
  - Return x raised to the power of b (x^b)
  - Math.pow(2, 3) returns 8.0
  - Math.pow(3, 2) returns 9.0
  - Math.pow(3.5, 2.5) returns 22.91765

- public static double sqrt(double x)
  - Return the square root of x
  - Note that the parameter in the sqrt method must not be negative.
  - Math.sqrt(4) returns 2.0
  - Math.sqrt(10.5) returns 3.24

Rounding Methods

- public static double ceil(double x)
  - x rounded up to its nearest integer. This integer is returned as a double value.
  - Math.ceil(2.1) returns 3.0
  - Math.ceil(2.0) returns 2.0
  - Math.ceil(–2.0) returns –2.0
  - Math.ceil(–2.1) returns -2.0

- public static double floor(double x)
  - x is rounded down to its nearest integer. This integer is returned as a double value.
  - Math.floor(2.1) returns 2.0
  - Math.floor(2.0) returns 2.0
  - Math.floor(-2.1) returns -3.0

Rounding Methods

- public static double rint(double x)
  - x is rounded to its nearest integer. If x is equally close to two integers, the **even** one is returned as a double.
  - Math.rint(2.1) returns 2.0
  - Math.rint(2.0) returns 2.0
  - Math.rint(3.5) returns 4.0
  - Math.rint(-2.0) returns –2.0
  - Math.rint(-2.1) returns –2.0
  - Math.rint(2.5) returns 2.0
  - Math.rint(-2.5) returns -2.0

Rounding Methods

- public static int round(float x)
  - Return (int)
  - Math.round(2.6f) returns 3 (int)
  - Math.round(2.5f) returns 3 (int)
  - Math.round(2.4f) returns 2 (int)
  - Math.round(–2.0f) returns -2 (int)

- public static long round(double x)
  - Return (long)
  - Math.round(2.0) returns 2 (long)
  - Math.round(–2.6) returns -3 (long)

min, max, and abs Methods

- The min and max methods are overloaded to return the minimum and maximum numbers between two numbers (int, long, float, or double).
- For example,
  - Math.max(3.4, 5.0) returns 5.0
  - Math.min(3, 2) returns 2
  - Math.max(2, 3) returns 3
  - Math.max(2.5, 3) returns 3.0
  - Math.min(2.5, 3.6) returns 2.5

min, max, and abs Methods

- The abs method is overloaded to return the absolute value of the number (int, long, float, and double).
- For example:
  - Math.abs(-2) returns 2
  - Math.abs(-2.1) returns 2.1

random Method

- random method generates a random double value
  0 <= Math.random() < 1.0.
- You can use it to write a simple expression to generate random numbers in any range.

  a + Math.random() * b
  - Returns a random number between **a** and **a + b**, excluding **a + b**.
- For example:

  (int)(Math.random() * 10)
  - Returns a random integer between 0 and 9.

  50 + (int)(Math.random() * 50)
  - Returns a random integer between 50 and 99.
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View java.lang.Math Documentation

- You can view the complete documentation for the Math class online from:
- Sun Microsystems website:

  http://java.sun.com/javase/6/docs/api/
- **Java 2 SE 6 Documentation on** Course website:

  http://yaghini.iust.ac.ir/Books/j2se6/j2se6.chm

References

References

- Y. Daniel Liang, **Introduction to Java Programming**, Sixth Edition, Pearson Education, 2007. (Chapter 2 & 6)

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