Functional Programming

Functions and Lambda Expressions

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#java-advanced

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Lambda Expressions

What is a Function?

- Mathematic function

Name → $f(x) = x^2$

Input

Output

A **function** is a special relationship where **each** input has a **single** output

X	$f(x)$
3	9
1	1
0	0
4	16
-4	16

Lambda Expressions

- Lambda expression - **unnamed function**

  - Has parameters and a body

```
(parameters) -> {body}
```

Lambda Syntax

- Use the lambda operator **->** Read as "**goes to**"

Lambda Expressions

- **Implicit** lambda expression

```
(msg) -> { System.out.println(msg); }
```

Parameters can be enclosed in parentheses ( )

The body can be enclosed in braces { }

- **Explicit** lambda expression

```
String msg -> System.out.println(msg);
```

Declares parameters' type

Lambda Expressions

- Can have a different number of parameters:

  - **Zero** parameters
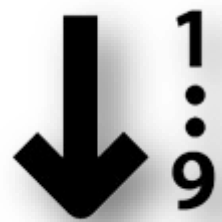
    ```
    () -> { System.out.println("Hello!"); }
    () -> { System.out.println("How are you?"); }
    ```

  - **More** parameters

    ```
    (int x, int y) -> { return x + y; }
    (int x, int y, int z) -> { return (y - x) * z; }
    ```

Problem: Sort Even Numbers

- **Read** Integers from the console

- **Print** the even numbers

- **Sort** the even numbers

- **Print** the sorted numbers

4, 2, 1, 3, 5, 7, 1, 4, 2, 12

4, 2, 4, 2, 12

2, 2, 4, 4, 12

Check your solution here: https://judge.softuni.bg/Contests/1513/Functional-Programming-Lab

Solution: Sort Even Numbers

```java
//TODO: Read numbers and parse them to List Of Integers

numbers.removeIf(n -> n % 2 != 0);

// TODO: Print the even numbers

numbers.sort((a, b) -> a.compareTo(b));

//TODO: Print the sorted numbers
```

Check your solution here: https://judge.softuni.bg/Contests/1513/Functional-Programming-Lab

Functions

Mathematical and Java Functions

Java Functions

- In Java, we can create functions analogical to mathematical functions

$$f(x) = x^2$$

Output Type

Input Parameter

Return Expression

```
Function<Integer, Integer> func = x -> x * x;
```

Input Type

Name

Lambda Expression

Function<T, R>

- In Java **Function<T,R>** is an interface that accepts a parameter of type **T** and returns a variable of type **R**

```java
int increment(int number) {
    return number + 1;
}
```
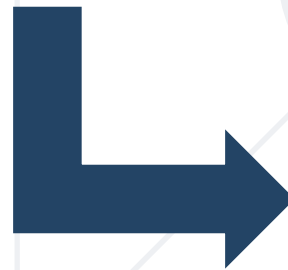
- We use function with **.apply()**

```java
Function<Integer, Integer> increment =
                          number -> number + 1;
int a = increment.apply(5);
int b = increment.apply(a);
```

Problem: Sum Numbers

- **Read** numbers from the console

- **Print** their count

- **Print** their sum

- Use a **Function**

```
4, 2, 1, 3, 5, 7, 1, 4, 2, 12
```

```
Count = 10
Sum = 41
```

Solution: Sum Numbers

```java
// TODO: Read input
if (input.length < 2) {
    System.out.println("Count = " + input.length);
    System.out.println("Sum = " + input[0]);
} else {
    Function<String, Integer> parser = x -> Integer.parseInt(x);
    int sum = 0;
    for (String s : input) sum += parser.apply(s);
    // TODO: Print output
}
```

Check your solution here: https://judge.softuni.bg/Contests/1513/Functional-Programming-Lab

Other Function Types

Special Functions

Consumer<T>

- In Java **Consumer<T>** is a void interface:

```
void print(String message) {
    System.out.println(message);
}
```

- We use a Consumer with **.accept()**:

```
Consumer<String> print =
        message -> System.out.print(message);
print.accept("Peter");
```

Supplier<T>

- In Java **Supplier<T>** takes no parameters:

```java
int genRandomInt() {
  Random rnd = new Random();
  return rnd.nextInt(51);
}
```

- We use a Supplier with **.get()**:

```java
Supplier<Integer> genRandomInt =
                   () -> new Random().nextInt(51);
int rnd = genRandomInt.get();
```

Predicate<T>

- In Java **Predicate<T>** evaluates a condition:
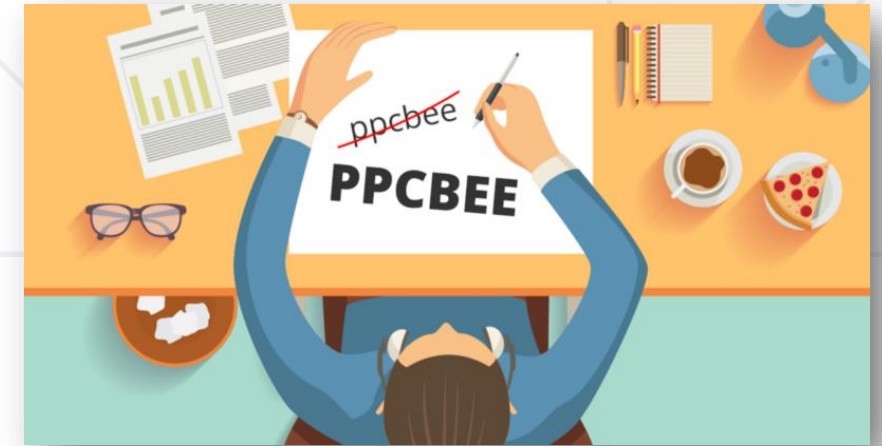
```java
boolean isEven(int number) {
    return number % 2 == 0;
}
```

- We use the Predicate with **.test()**:

```java
Predicate<Integer> isEven =
                number -> number % 2 == 0;
System.out.println(isEven.test(6)); // true
```

Problem: Count Uppercase Words

- Read text from the console

- Find the words starting with an Uppercase letter

- Print the count and the words

- Use a **Predicate**

```
The following example
shows how to use
Predicate
```

➡️

```
2
The
Predicate
```

Solution: Count Uppercase Words

```java
// TODO: Read text

Predicate<String> checkerUpperCase =

                word -> Character.isUpperCase(word.charAt(0));

ArrayList<String> result = new ArrayList<>();
for (int i = 0; i < textAsList.length; i++) {
   if (checkerUpperCase.test(textAsList[i]))
      result.add(textAsList[i]);
}
// TODO: Print results
```
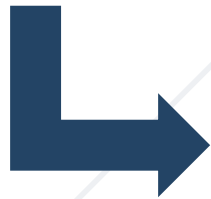
Check your solution here: https://judge.softuni.bg/Contests/1513/Functional-Programming-Lab

Problem: Add VAT

- Read some items' prices from the console

- Add **VAT** of **20%** to all of them

```
1.38, 2.56, 4.4
```

Prices with VAT:
1,66
3,07
5,28

Solution: Add VAT

```java
// TODO: Read input
List<Double> numbers = new ArrayList<>();
for (String s : input)
    numbers.add(Double.parseDouble(s));
UnaryOperator<Double> addVat = x -> x * 1.2;
System.out.println("Prices with VAT:");
for (Double str : numbers)
    System.out.println(String.format("%1$.2f",
                                    addVat.apply(str)));
```

Check your solution here: https://judge.softuni.bg/Contests/1513/Functional-Programming-Lab

Bi Functions

Using Functions With More Parameters

BiFunctions
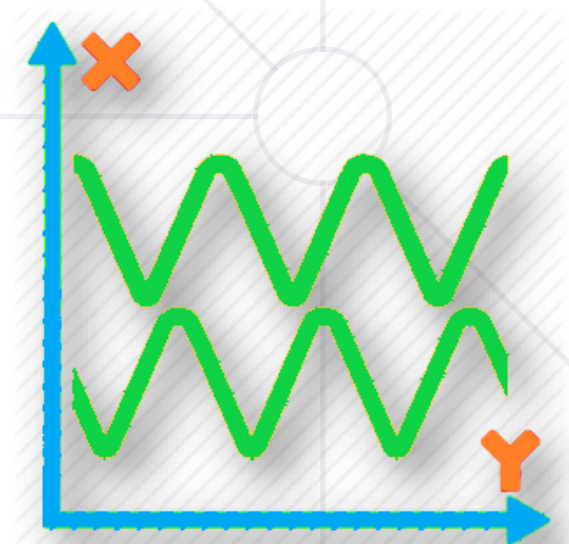
- **BiFunction <T, U, R>**

```
BiFunction <Integer, Integer, String> sum = (x, y) -> "Sum is" + (x + y);
```

Two input parameters

- Analogically you can use:
  - **BiConsumer <T, U>**
  - **BiPredicate <T, U>**

Problem: Sum Numbers

- Read numbers from the console

- Print their count

- Print their sum

- Use **BiFunctions**

```
4, 2, 1, 3, 5, 7, 1, 4, 2, 12
```

```
Count = 10
Sum = 41
```

Solution: Sum Numbers

```java
// TODO: Read input

int length = input.length;

int sum = Integer.parseInt(input[0]);

if (input.length >= 2) {

  BiFunction<Integer, String, Integer> parser =
                              (x, y) -> x + Integer.parseInt(y);

  for (int i = 1; i < input.length; i++)

    sum = parser.apply(sum, input[i]);
}

// TODO: Print output
```

Check your solution here: https://judge.softuni.bg/Contests/1513/Functional-Programming-Lab

Passing Functions to Method

- We can pass **Function<T,R>** to methods:

```java
static int operation(int number, Function<Integer, Integer> function) {
    return function.apply(number);
}
```

- We can use the method like that:

```java
int a = 5;
int b = operation(a, number -> number * 5);   // b = 25
int c = operation(a, number -> number - 3);   // c = 2
int d = operation(b, number -> number % 2);   // d = 1
```

Problem: Filter by Age

- Read from console **n** people with their age

- Read a condition and an age so to **filter** them

- Read **format type** for the output

- Print all people that fulfill the condition

Peter	20
George	18
Raddy	29
Maria	32
Ivan	16

- **Condition - "older"**
- **Age - 20**
- **Format - "name age"**

Peter	20
Raddy	29
Maria	32

Solution: Filter by Age

```
//TODO: Read info from the console

Predicate<Integer> tester = createTester(condition, age);

Consumer<Map.Entry<String, Integer>> printer =

                            createPrinter(format);

printFilteredStudent(people, tester, printer);
```

Check your solution here: https://judge.softuni.bg/Contests/1513/Functional-Programming-Lab

Solution: Filter by Age

```java
static Consumer<Map.Entry<String, Integer>> createPrinter(String format) {

  Consumer<Map.Entry<String, Integer>> printer = null;

  switch (format) {

    case "name age":

      printer = person -> System.out.printf("%s - %d%n",

                            person.getKey(), person.getValue());

      break;   //TODO: Add more cases

  }

  return printer;

}
```

Check your solution here: https://judge.softuni.bg/Contests/1513/Functional-Programming-Lab

Solution: Filter by Age

```java
static Predicate<Integer> createTester(String condition, Integer age) {

    Predicate<Integer> tester = null;

    switch (condition) {

        case "younger":

            tester = x -> x <= age;

            break;   //TODO: Add more cases

    }

    return tester;

}
```

Check your solution here: https://judge.softuni.bg/Contests/1513/Functional-Programming-Lab

Solution: Filter by Age

```java
static void printFilteredStudent(
            LinkedHashMap<String, Integer> people,
            Predicate<Integer> tester,
            Consumer<Map.Entry<String, Integer>> printer) {
    for (Map.Entry<String, Integer> person : people.entrySet()) {
        if (tester.test(people.get(person.getKey())))
            printer.accept(person);
    }
}
```

Check your solution here: https://judge.softuni.bg/Contests/1513/Functional-Programming-Lab

Summary

- **Lambda expressions** are anonymous methods
- **Function<T,R>** is a function that returns R type
- **Consumer<T>** is a void function
- **Supplier<T>** gets no parameters
- **Predicate<T>** evaluates a condition
- **BiFunction<T, U, R>** accepts two parameters
- Functions can be passed like variables to methods

Questions?
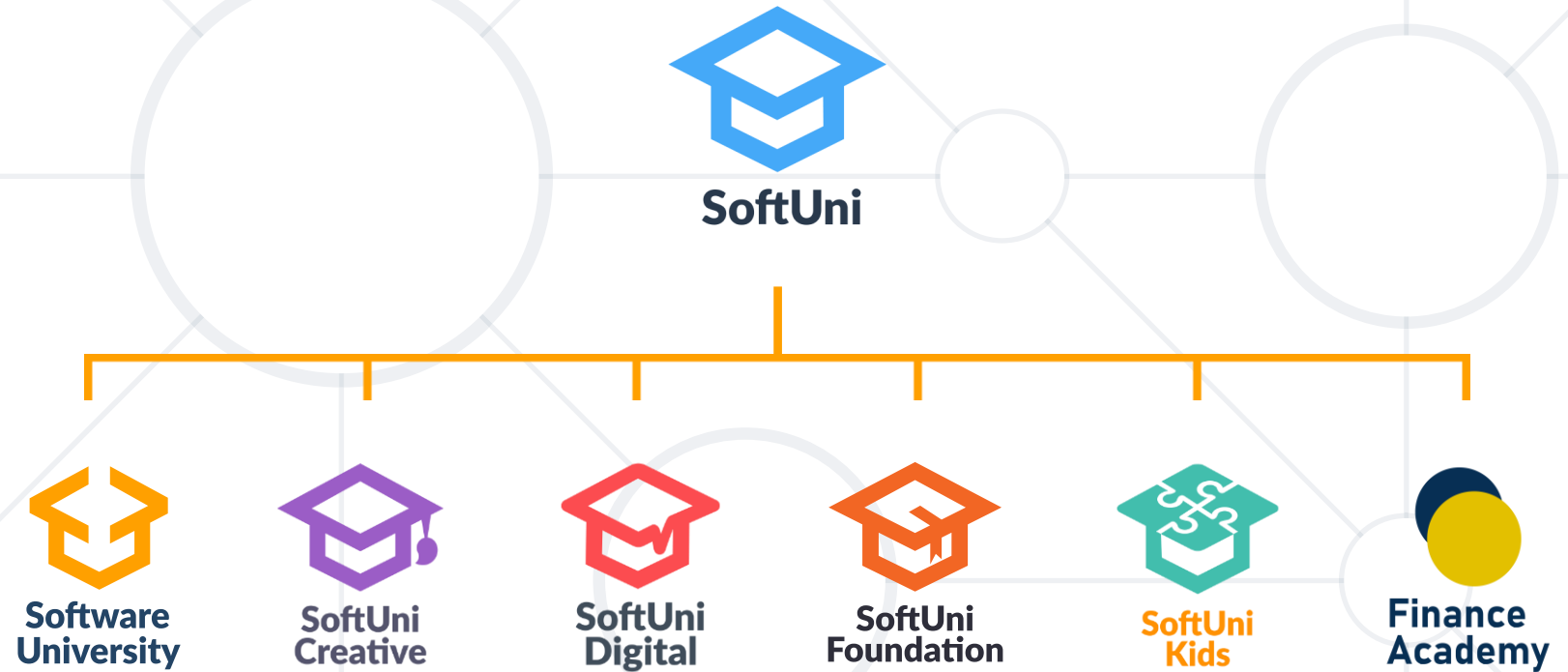
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