**Lab 8**

1. Short answer
   1. Name two differences between imperative and functional programming

1)Programs are declarative (“what”) rather than imperative (“how”). Makes code more self-documenting – the sequence of function calls mirrors precisely the requirements

2) Functions have referential transparency – two calls to the same method are guaranteed to return the same result

3) Functions do not cause a change of state; in an OO language, this means that functions do not change the state of their enclosing object (by modifying instance variables). In general, functions do not have side effects; they compute what they are asked to compute and return a value, without modifying their environment (modifying the environment is a side effect)

* 1. Explain the meaning of *declarative programming.* Give an example.

The declarative style of functional programming makes it possible to write methods (and programs) just by declaring what is needed, without specifying the details of how to achieve the goal.

List<String> names;

names.toStreams().forEach(System.Out::println);

* 1. Explain the difference between *functional interface, functor,* and *closure*, and give examples of each using Java 7 syntax

whether an interface is a functional interface is that it must have exactly one abstract method, not counting any methods from Object that have been re-declared

An implementation of a functional interface is called a functor

A closure is a functor embedded inside another class, that is capable of remembering the state of its enclosing object

* 1. Name three benefits of including functional style programming in Java

concise readable thread safe parallelizable maintainable

* 1. Express the functions defined below using Java 8 lambda notation:
     1. f(x) = x + 2x2x->x+2\*x\*x
     2. g(x,y) = y – x + xy(x.y)->y-x+Math.Pow(x,y)
     3. h(x,y,z) = z – (x + y)  
        (x,x,z)->z-(x+y)
  2. For each lambda expression below, name the parameters and the free variables.

Blue are the parameters and red is free variables

i. Runnable r = ()   
 {

int[][] products = new int[s][t];  
**for** (**int** i = 0; i <s; i++) {  
 for(int j = i + 1; j < t; j++) {   
products[i][j] = i \* j;

}   
}

}

ii. BiFunction<U, V, R> f = (double u, double v)



(Note: the right hand side of the “” is mathematical notation, not Java, but it can be converted to a large block of Java code having the same free variables. See lecture code to review the BiFunction functional interface.)

iii.Comparator<String> comp = (s, t)   
{  
 if(ignoreCase == true) {  
 return s.compareToIgnoreCase(t);

} else {

return s.compareTo(t);

}

}

* 1. In the lecture, one of the examples of a method reference of type *object::instanceMethod* was this::equals. Since every lambda expression must be converted to a functional interface, find a functional interface in the java.util.function package that would be used for this lambda expression.

Hint #1: The implicit reference `this’ refers to the currently active object. So, to answer this question, create a class MyClass in which you have referenced this::equals with an appropriate type; add a method myMethod(MyClass cl) which uses this method expression to return true if cl is equal to ‘this’.   
  
Hint #2: Take a look at the api docs here: <http://docs.oracle.com/javase/8/docs/api/java/util/function/package-summary.html>

## Interface BiFunction<T,U,R>

* 1. An example of a method reference is   
     System.out::println

Do the following:

1. Convert this method reference to a lambda expression.
2. Determine which type of method reference this is (in the lecture three different types of method reference were mentioned). Explain carefully.
3. An example of a method reference is:

Math::random

Its corresponding functional interface is Supplier<Double>. Do the following:

* 1. Rewrite this method reference as a lambda expression
  2. Put this method expression in a main method in a Java class and use it to print a random number to the console
  3. Create an equivalent Java class in which the functional behavior of Math::random is expressed using an inner class (implementing Supplier); call this inner class from a main method and use it to output a random number to the console. The behavior should be the same as in part b.

1. *Comparators.* 
   1. Look at the code in the package lesson8.lecture.comparator2. Suppose we sort using the sort method in the EmployeeInfo class together with the NameComparator. Look at the compare method in the NameComparator: If two Employee objects have the same name, what is the return value of compare? This tells us that these Employee objects should be *equal*, but is this always true? Give an example of two Employee objects having the same name but that should *not* be considered equal. Rewrite the compare method so that, if compare does return 0, the Employee objects are indeed equal. (This issue is known as *consistency with equals.*)
   2. Fix the compare method, as in part A, for the Comparatorused in lesson8.lecture.comparator3
   3. Fix the compare method, as in part A, for the lambda expression used to compareEmployee objects in lesson8.lecture.lambdaexamples.comparator3

3. Consider the following lambda expression. Can this expression be correctly typed as a BiFunction? (See lesson8.lecture.lambdaexamples.bifunction.) (Hint: Yes it can.)

(x,y) -> {

List<Double>list = **new** ArrayList<>();

list.add(Math.*pow*(x,y));

list.add(x\*y);

**return**list;

};  
  
Demonstrate you are right by doing the following: In the main method of a Java class, assign this lambda expression to an appropriate BiFunction and call the apply method with arguments (2.0, 3.0), and print the result to console.

4. Implement a method with the following signature and return type:

**publicint** countWords(List<String> words, **char** c, **char** d, **int** len)

which counts the number of words in the input listwords that have length equal to len, that contain the character c, and that do not contain the character d. Create a Good and Better solution, as described in the slides (see lesson8.lecture.filter) – a Good solution creates a lambda expression each time values are passed into countWords, whereas a Better solution has parametrized lambda expressions pre-made, and so a call to countWords simply substitutes values into these expressions. Try also creating a Best solution in which there is just one lambda expression.

5. Redo lesson7.lab4.prob4 in two different ways:

a. Use a lambda expression instead of directly defining a Consumer

b. Use a method reference in place of your lambda expression in (a)

6. Finish the Examples exercise that was given in class (file: *Lambda and Method Reference Exercises*)