Ph.D. Qualifying Exams - Programming Language Structures 1
Spring 2022
2 hours

- If any of the questions are not clear, please state your assumptions. If they are reasonable, they will be taken into consideration.
- There are 8 questions. The total grade is 100.

Page	Max	Grade
1	20	
2	30	
3	25	
4	25	
Total	100	

- **Page 1 (20 pts):**

Question 1 (10 pts) Consider the following code written in a language in which variables are immutable and the language uses lexical scoping. Considering these two properties, what value does the code-snippet print at the end? Justify your answer.

```
let x = 42;

let f (x, y) = x + y;

let x = 22;

let y = 4;

let z = f (x, y)

print (z)
```

Question 2 (10 pts) What is the Diamond Problem in Object-Oriented Programming? It is an important problem that arises in inheritance scenarios. Can you describe an example where the Diamond Problem can cause issues?

- **Page 2 (30 pts):**

Question 3 (15 pts) Explain a scenario where a *Pass-by-Value* parameter passing model is a better model to choose when compared against *Pass-by-Reference* parameter passing model.

Question 4 (15 pts) What is the output of the 3 print statements in the following Java code? Justify your answers.

```java
import java.util.*;

public class Main {
    public static void main(String[] args) {
      int x = 5;
      System.out.println(x++ + x++);

      x = 5;
      System.out.println(x++ + ++x);

      x = 5;
      System.out.println(++x + ++x);
    }
}
```

- **Page 3 (25 pts):**

Question 5 (10 pts) What is the main difference between concurrency and parallelism? Can you give a scenario (pseudo-code is not needed) where using parallelism is more beneficial than concurrency?

Question 6 (15 pts) Implement a recursive function in your preferred programming language that takes a string and returns the reverse of the string. Your function cannot refer to any global or static data.

E.g. if the input is *plquals*, the output should be *slaqlp*.

- **Page 4 (25 pts):**

Question 7 (15 pts) Using a programming language from the Lisp family of Programming Languages (such as Common Lisp, Racket, etc.), write a function *powerfour* that given an integer n, returns true if n is a power of four, else returns false. An integer n is a power of four, if there exists an integer x such that n == 4^x. You have to use recursion to solve this question.

Question 8 (10 pts) In a declarative logic-based language like Prolog, write rules in order to find the last element from a given list.
E.g. the following will be a successive outcome of your set of rules: findLast(X, [6,3,5,2,8]). will result in the binding $X = 8$