Computer Science & Engineering Department

I. I. T. Kharagpur

Principles of Programming Languages: CS40032

Elective

Assignment – 2: λ-Calculus Marks: 20

Assign Date: 25th February, 2022 Submit Date: 23:55, 4th March, 2022

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1. Reduce the following λ-expressions. Show every step of α-, β-, η- and δ-reductions. **[2*6 = 12]**
   (a) (λz. z) (λz. z z) (λz. z y)
   (b) (λz. z) (λz. z z) (λz. z y)
   (c) (λx. λy. x y y) (λy. y) y
   (d) (λx. λy. x y y) (λy. y) y
   (e) (λx. (λy. (x y)) y) z
   (f) ((λx. (λy. (x y)) (λy. y)) w)

2. (a) Define a recursive version of this function that takes the recursion point as a parameter. **[1 Mark]**

```
def add x y =
  if iszero y
  then x
  else add (succ x) (pred y)
```

(b) Feed this revised *add* function to the Y combinator and evaluate using the regular rules of lambda calculus. **[4 marks]**

3. Solve: **[3 marks]**
   ((((λf. (λg. (λx. ((fx)(gx)))))(λm. (λn. (nm))))(λn.z))p)