

Problem 3 (15 marks)

Part A. [8 marks]

Evaluate the lambda expression below by the interpreter based on context and closure. You are asked to show the context at some point of evaluation. Assume that initial context is $CT0 = \{z \rightarrow 4\}$. Just show your answer to each question. You don't need to show how you derive your answer. This is how the evaluation starts:

```
eval
  ((lambda (f x) (+ (f z) (f x))) (lambda (u) (* 2 u)) 3)
in CT0
```

(i) Show the context when $(+ (f z) (f x))$ is evaluated.

Answer: $CT1 = \{f \rightarrow [(\lambda u. (* 2 u)), CT0], x \rightarrow 3\} \cup CT0$

(ii) Show the context when $(f x)$ is evaluated.

Answer: In $CT1$

(iii) Show the context when $(* 2 u)$ is evaluated.

Answer: $(* 2 u)$ is evaluated twice:

(i) Continuing from `eval (f x)`, the next is `eval (* 2 u)` in $\{u \rightarrow 3\} \cup CT0$

(ii) Continuing from `eval (f z)`, the next is to `eval (*2 u)` in $\{u \rightarrow 4\} \cup CT0$.

(iv) What is the result of this evaluation?

Answer: 14.

Part B. [7 marks]

Compile the following lambda function to SECD code.

```
(lambda (x) ((lambda (z) (+ x x z)) 4))
```

Note that the body of the outside lambda function is an application $((\lambda z. (+ x x z)) 4)$. To decompose the overall task, you should first show the SECD code for this expression and denote it by, e.g., e' . Then, plug it into the full solution.

Answer: $(LDF) (e' \mid\mid (RTN))$, where e' is

$e = (NIL \text{ LDC } 4 \text{ CONS } (LDF \text{ (LD (2.1) LD (1.1) LD (1.1) ADD RTN)) AP)$