

### 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  $CT0 = \{z \rightarrow 2\}$ . 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) (cons z (f x x))) (lambda (u v) (cons u v)) 5)
in CT0
```

(i) Show the context when `(cons z (f x x))` is evaluated.

A: Let  $e_1$  denote `(lambda (u v) (cons u v))`.

Then, eval `(cons z (f x x))` in the context  $\{f \rightarrow [e_1, CT0], x \rightarrow 5\} \cup CT0$ , where  $[e_1, CT0]$  denotes the corresponding closure. Denote this context by  $CT1$ .

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

A: Continuing the above, eval `(f x x)` in  $CT1$ . Also, eval  $z$  in  $CT1$  (not part of the question), which yields 2.

(iii) Show the context when `(cons u v)` is evaluated.

A: Continuing the above, eval  $f$  in  $CT1$  gives  $[e_1, CT0]$  and eval `(x x)` in  $CT1$  gives  $(5\ 5)$ . Now, apply the function in  $e_1$  and we have

eval `(cons u v)` in the context  $\{u \rightarrow 5, v \rightarrow 5\} \cup CT0$ .

(iv) What is the result of this evaluation?

A: Two applications of `cons` gives us  $(2\ .\ (5\ .\ 5))$ , or you can simplify it to  $(2\ 5\ .\ 5)$ .

#### Part B. [7 marks]

Compile the following lambda function to SECD code.

```
(lambda (x y) (if (eq x y) x (+ 1 y)))
```

Note that the resulting sequence of instructions looks like `(LDF (... RTN))`. Essentially, your answer is about what the code in the place of `...` should be.

A: (LDF  
 ( LD (1.2) LD (1.1) EQ SEL (LD (1.1)) (LD (1.2) LDC 1 ADD)  
 RTN )  
)