

Problem Set 5
Comp 301
Fall 2021
Week 7: 08.11.2020 - 12.11.2020

Instructions:

- Submit your answers to the Blackboard PS4 assignment until November 13th Saturday, at 23.59.
- Please use the code boilerplate for LET language, which includes several tests for you to see if your code is correct.
- Save your code, write your answers for the first two questions on a piece of paper or online environment and include it as a PDF. Zip your code along with the PDF as ID_username.zip with your ID and username, and submit this ZIP file.
(Example: 1234567_alikaratas17.zip)
- Read the questions carefully. Good luck!

Problem 1:¹ Write out the derivation of the following program as a derivation tree. Use figures 1 and 2 as examples.

Let $\rho = [x = [20], y = [15], z = [10]]$

if zero?(-(y, 10)) then -(z, x) else -(z, y)

Example 1: **if zero?**(0) then 5 else 2

$$\frac{(\text{value-of } \langle\text{zero?}(0)\rangle \rho) = (\text{bool-val } \#t)}{(\text{value-of } \langle\text{if zero?}(0) \text{ then } 5 \text{ else } 2\rangle \rho) = 5}$$

FIGURE 1. Derivation tree for "if zero?(0) then 5 else 2"

Example 2: **zero?**(-(x, y))

$$\frac{\frac{(\text{value-of } \langle x \rangle \rho) = 20 \quad (\text{value-of } \langle y \rangle \rho) = 15}{(\text{value-of } \langle -(x, y) \rangle \rho) = 5}}{(\text{value-of } \langle \text{zero?}(-(x, y)) \rangle \rho) = (\text{bool-val } \#f)}$$

FIGURE 2. Derivation tree for "zero?(-(x, y))"

¹Similar to EOPL p.70 Exercise 3.4

Problem 2: Now, we want you to fill in the blanks for the output of this interpreter. Similar to first question let $\rho_0 = [x = [20], y = [15], z = [10]]$. Note that below snippet is not complete, although we only want answers to the `_____`'s, we recommend you to continue the evaluation as a self study exercise.

```
let t = -(x, y) in if zero?(-(x, -(y, t))) then zero?(t) else -(y, z)
```

```
(value-of <<let t = -(x, y) in
  if zero?(-(x, -(y, t)))
  then zero?(t)
  else -(y, z)>> ____[1]____)
```

```
Let  $\rho_1 =$  ____[2]____
```

```
= (value-of <<if zero?(-(x, -(y, t)))
  then zero?(t)
  else -(y, z)>>  $\rho_1$ )
```

```
= (if ____[3]____ (value-of <<zero?(-(x, -(y, t)))>>  $\rho_1$ )
  (value-of <<zero?(t)>>  $\rho_1$ )
  (value-of <<-(y, z)>> ____[4]____))
```

```
= (if ____[5]____
  (value-of <<zero?(t)>>  $\rho_1$ )
  (value-of <<-(y, z)>>  $\rho_1$ ))
```

```
= (value-of <<____[6]____>>  $\rho_1$ )
```

```
= [(-
  [(value-of <<____[7]____>>  $\rho_1$ )]
  [(value-of <<____[8]____>>  $\rho_1$ ))]]
```

Problem 3: Extend the Let language by adding new operations `minus`, `increment`, `factorial`.

Note: For all the parts in this problem you need to work with Let language codes.

Hint: You only need to change `lang.rkt` and `interp.rkt`.

Hint: For parts C and D you can write helper functions for calculating factorial and exponential respectively.

After you finish implementing the operation in each part, uncomment and run the tests that correspond to that part in the `tests.rkt` file. You can also add your own test cases to experiment with the code.

Part A.² Extend the Let language by adding a new operation `minus` that takes one argument `n` and returns `-n`. For example, the value of `minus(-(minus(5), 9))` should be 14.

Part B. Extend the Let language by adding a new operation `increment` that takes one argument `x` and returns `x+1`. For example, `increment(increment(0))` should give the value 2.

²EOPL p.72 Exercise 3.6

Part C. This time add the factorial operation to Let. Factorial takes one argument n and returns $n!$ For example, the value of `factorial(5,2)` should be 6.

Part D. Finally, add the exponential operation which takes two arguments a and b and returns a^b . You can assume that b is greater than or equal to 0. For example, value of `exponential(2,4)` should be 16 and value of `exponential(3,exponential(2,2))` should be 81.