

# Programming Languages [Fall 2016] Practice Test II

NAME: \_\_\_\_\_

## Instructions:

- 1) This test is 3 pages in length.
- 2) You have 75 minutes to complete and turn in this test.
- 3) Short-answer questions include a guideline for how many sentences to write. Respond in complete English sentences.
- 4) This test is closed books, notes, papers, friends, neighbors, phones, smartwatches, etc.
- 5) Use the backs of pages in this test packet for scratch work. If you write more than a final answer in the area next to a question, circle your final answer.
- 6) Write and sign the following: "I pledge my Honor that I have not cheated on this test."

\_\_\_\_\_  
\_\_\_\_\_

Signed: \_\_\_\_\_

1. [20 points]

What are three benefits of type systems? [1-3 sentences]

2. [20 points]

Define an ML datatype for expressions in the untyped lambda calculus.

3. [30 points]

a) Define a  $\lambda_{UT}$  function that takes a Church numeral  $N$  and returns the Church boolean `true` if  $N$  is odd and `false` if  $N$  is even. You may use Church boolean/numeral abbreviations when convenient (e.g., you may write `true` instead of  $\lambda t. \lambda f. t$ ).

b) Using the normal-order strategy, trace the evaluation of applying your function from Part (a) to the Church encoding of the number 2. Show each step of the evaluation, underline redexes, and define and use abbreviations when convenient.

4. [30 points]

Prove the Preservation-Theorem case for diML function-application  $\beta$ -steps.