Programming Languages [Fall 2018]
Test I

NAME: _____

Instructions:

1) This test is 7 pages in length.

2) You have 75 minutes to complete and turn in this test.

3) Short-answer and essay questions include a guideline for how much to write. Respond in complete English sentences and avoid using bulleted and itemized lists.

4) For full credit on ML-response questions, implementations must avoid the @ operator and run in linear (O(n)) time.

5) This test is closed books, notes, laptops, phones, smartwatches, friends, neighbors, etc.

6) 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.

7) Write and sign the following: "I pledge my Honor that I have not cheated, and will not cheat, on this test."

_____

_____

Signed: _____

1. [5 points]
What is a programming language? [1-2 sentences]

2. [13 points] [Essay, 5-8 sentences]
Compare and contrast left associativity with right associativity. Provide examples of each.

3. [15 points]
Consider the function zip(L1,L2). The SML documentation says that zip will "combine the two lists L1 and L2 into a list of pairs, with the first element of each list comprising the first element of the result, the second elements comprising the second element of the result, and so on. If the lists are of unequal lengths, zip ignores the excess elements from the tail of the longer one".

(a) What is the type of zip?

(b) Implement zip subject to the constraints of Assignment I.

(c) Implement zip subject to the constraints of Assignment II (including with currying).

4. [12 points]
Consider the function porder L. My documentation says that porder will "reorder L, placing it in 'pong' order, that is, bouncing between left and right elements. For example, porder [1,2,3,4,5] returns [1,5,2,4,3] and porder [1.1,2.2] returns [1.1,2.2]." Implement porder subject to the constraints of Assignment II.

5. [55 points]
For this problem, N always refers to a natural number, so you never need to write N nat.
(a) Define inference rules for deriving less-than and inequality relationships between natural numbers. The judgment forms are $N_1<N_2$ and $N_1 \neq N_2$.

(b) Prove that < is asymmetric. **Theorem**. $\forall N_1, N_2, N_3$: $((N_1<N_2 \wedge N_2<N_3) \Rightarrow N_1 \neq N_3)$

(c) Define inference rules for deriving sums and remainders of natural numbers. The judgment forms are $N_1+N_2=N_3$ and $N_1\%N_2=N_3$. For example, 3 divided by 2 has a remainder of 1, so $S(S(S(Z)))\%S(S(Z))=S(Z)$ is a valid judgment. Your definition of remainders may use judgments from Part (a) but not addition judgments.

(d) Prove that the difference between a number and its remainder has zero remainder. In case you need it, the following page provides additional space for your proof.

Theorem. $\forall N_1, N_2, N_3, N_4: ((N_1+N_2=N_3 \wedge N_3\%N_4=N_1) \Rightarrow N_2\%N_4=Z)$

[This page provides additional space for Problem 5(d).]

[Undergraduates stop here. The remaining problem is for graduate students.]

6. [10 points]
Consider the function unzip L. The SML documentation says that unzip "returns a pair of lists formed by splitting the elements of L. This is the inverse of zip for equal length lists."

(a) Implement unzip subject to the constraints of Assignment I.

(b) Implement unzip subject to the constraints of Assignment II.