Assignment #2

Name: _____ ID: _____

This assignment has **5** questions, for a total of **25** marks.

Recall the following acronyms: SOS (structural operational semantics), COS (contextual operational semantics), SM (small step), BG (big step), CBV (call by value), CBN (call by name).

Question 1: **Safe untypable term** . . . . . 4 marks

Write out a term that is safe (i.e., it does not reduce to fail) but that cannot be typed. Show where the typing fail and how it would reduce if it were a ULC term according to SOS-SM-CBV semantics.

Question 2: **Big step semantics for pairs and sums** . . . . . 6 marks

Write the operational semantics rules for a big-step, call-by-value reduction for pairs and sums. Write the semantically correct ones only, but write them all.

Question 3: **Context typing for pairs and sums** . . . . . 4 marks

Show the typing rules for these evaluation contexts:

- $E.1$

- $\langle v, E \rangle$

- $case\ E\ of\ inl\ x_1 \mapsto t_1 \mid inr\ x_2 \mapsto t_2$

- $inl\ E$

Question 4: **Typing derivation** . . . . . 4 marks

Show the typing derivation of these terms, with the following environment $\Gamma = f : \mathbb{N} \to \mathbb{N}$

- $t_1 = f\ (3 + 5) : \mathbb{N}$

- $t_2 = f\ ((\lambda x : \mathbb{N}.\, x + 2)5) : \mathbb{N}$

Question 5: **Encoding** ..... 7 marks

Encode the following constructs via existing ones such that they behave the same according to COS-SM-CBV semantics.

- sequencing: $t ::= \cdots \mid t; t'$ such that t is evaluated first, then t' is evaluated.

- let-in: $t ::= \cdots \mid let\ x = t\ in\ t'$ such that t is evaluated into a value v and then t' is evaluated for v in place of x.

- arrays of length 4: $t ::= \cdots \mid [t, t, t, t]$. Values thus include value arrays $v ::= \cdots \mid [v, v, v, v]$.

- array field access: $t ::= \cdots \mid t.i \ \ (i \in 0..3)$ such that for $i \in 0..3$ we have that $[v_0, v_1, v_2, v_3].i$ returns v_i. Show the encodings for at least two cases of i.

- array update: $t ::= \cdots \mid t.i = t \ \ (i \in 0..3)$ such that for $i \in 0..3$ we have that $[v_0, v_1, v_2, v_3].2 = v$ returns $[v_0, v_1, v, v_3]$. Show the encodings for at least two cases of i.