2. Using the simple imperative language shown in lecture, write out the derivation trees for the following expressions and statements using operational semantics

P→ *S* *S* → skip | *S*; *S* |*V* = *A* | **if** *B* **then** *S* **else** *S* **end** | **while** *B* **do** *S* **end** *A*→ *N* | *V* |(*A* + *A*) | (*A* − *A*) | (*A* * *A*) *B* → true | false | (*A* <= *A*) | (*B* **and** *B*) | **not** *B* *V* → *Identifier* *N* → *IntegerLiteral*	`x = -1` 1. `((x * 3) - 2)` 2. `((x <= 3)` **and** `(0 <= x))`

$$\frac{\dfrac{\langle x,\sigma\rangle \to -1 \qquad \langle 3,\sigma\rangle \to 3}{\langle (x * 3),\sigma\rangle \to -3} \qquad \langle 2,\sigma\rangle \to 2}{\langle ((x * 3) - 2),\sigma\rangle \to -5}$$

$$\frac{\dfrac{\langle x,\sigma\rangle \to -1 \qquad \langle 3,\sigma\rangle \to 3}{\langle (x <= 3),\sigma\rangle \to \text{true}} \qquad \dfrac{\langle 0,\sigma\rangle \to 0 \qquad \langle x,\sigma\rangle \to -1}{\langle (0 <= x),\sigma\rangle \to \text{false}}}{\langle ((x <= 3) \text{ and } (0 <= x)),\sigma\rangle \to \text{false}}$$

3. Suppose we wanted to add the ternary conditional (B **?** A : A) to our language, where (b ? a1 : a2) evaluates to a1 if b evaluates to true and a2 otherwise. Write rules for the evaluating a ternary conditional using big-step operational semantics.

$$\frac{\langle b,\sigma\rangle \to \text{true} \qquad \langle a_1,\sigma\rangle \to n_1}{\langle (b \ ? \ a_1 : a_2),\sigma\rangle \to n_1}$$

$$\frac{\langle b,\sigma\rangle \to \text{false} \qquad \langle a_2,\sigma\rangle \to n_2}{\langle (b \ ? \ a_1 : a_2),\sigma\rangle \to n_2}$$