# Language Syntax, Semantics, Runtime Errors 

CS 536: Science of Programming, Spring 2023

## Due Thu Feb 9, 11:59 pm

## 2023-02-09 pp 1, 2

## Problems [60 points]

## Class 5: Language Syntax/Operational Semantics

1. [12 $=2 * 6$ points] Translate the program below into our programming language.
a. $m=x=0 ; y=1$; while $(m++<n)\{y=++x ; y *=x ;\} ; m=m * m$
b. $m=n ; p=y=1$; while $(--m<n)\{p=p$ * $(y++) ;\}$

For Problems 2 and 3, write out the operational semantics as a directed graph. With $\langle S, \sigma\rangle \rightarrow$ $\left\langle S^{\prime}, \sigma\right\rangle$, the two configurations become nodes and the semantics $\rightarrow$ becomes a graph $\rightarrow$.. For these problems, it's okay to draw your answers on paper and scan it in to be part of your pdf. If the same configuration occurs more than once, don't write it out as two separate nodes; make it just one node.
2. [2023-02-09] [10 points] Let $S \equiv$ if $x>0$ then $x:=x{ }^{*} z$ fi; $y:=y^{*} z$

Evaluate $\langle S,\{x=-5, y=-2, z=-2\}\rangle$ to completion. [Hint: remember to expand the if-then]
3. [8 points] Let $W \equiv$ while $m \neq n$ do $S$ od where $S$ is $m:=m+1 ; x:=x+m{ }^{*} m$. Let $\sigma_{0}=\{m=0$, $x=1, n=4$. Evaluate $\left\langle W, \sigma_{0}\right\rangle$ to completion. Show all configurations of the form $\langle W$, state $\rangle$ and the final $\langle E$, state $\rangle$. You can use $\rightarrow^{n}$ to skip other configurations if you like, or you can show them (your choice).

## Class 6: Denotational Semantics, Runtime Errs

4. [12 $=2{ }^{*} 6$ points] As in Problem 2, let $I F$ be if $x>0$ then $x:=x^{*} z$ fi fi; $y:=y^{*} z$. For both parts below, write your answer as a succession of $M$ (... ) steps. (See Example 1 in the Class 6 notes).
a. What is $M(I F,\{x=3, y=5, z=9\})$ ?
b. What is $M(I F,\{x=0, y=2, z=8\})$ ?
5. [14 points total] Let $W \equiv$ while $m \neq n$ do $S$ od where $S$ is $m:=m+1$; $x:=x{ }^{*} x$.
a. [3 points] Let $\tau(m)=\alpha$ and $\tau(x)=\beta$. Calculate $M(S, \tau)$.
b. [3 points] Let $\sigma_{0}=\{m=0, x=2, n=\delta\}$. What values of $\delta$ make $M\left(W, \sigma_{0}\right)=\perp_{d}$ ? Briefly explain.
c. [8 points] Consider the $\sigma_{0}$ where $\delta$ isn't one of the ones in part b. That is, $M\left(W, \sigma_{0}\right)=\tau$ for some $\tau \neq \perp$. Give a simple description of the $\tau(x)$ values [2023-02-09] phrasing seemed to confuse some people something the level of " $\tau(x)$ is the sum of the even integers $\geq-0$ and $<\delta$ " (Except that that's a wrong answer.)
c. [8 points] In part b you identified the $\delta$ that make the program diverge. Now look at the opposite $\delta$ 's the one tht
6. [4 points] Let $S \equiv x:=b[m+1] / \operatorname{sqrt}(k)$ and let $\sigma=\{m=\alpha, k=\beta, b=\delta\}$. Let $\eta$ be the length of $b$, so $\delta(0), \ldots, \delta(\eta-1)$ are the values of $b[0], b[1], \ldots$ in $\sigma$. Describe the set of all $\sigma$ that make $M(S, \sigma)=\left\{\perp_{e}\right\}$. [2023-02-09]
