This homework is officially due in class on Thursday, September 7. However, it comes with an automatic extension: anything submitted to the labeled bin near CST 4-226 by noon on Friday, September 8 will be accepted as being on time.

You may work singly or in pairs on this assignment: if you work with someone else, (1) make sure you’re both enrolled in the same version of the course (CIS 400 or CIS 632) and (2) turn in a single assignment with both names on it. Make sure you complete and attach a disclosure cover sheet.

**Exercises**

Throughout this assignment, lowercase names are used as action names; uppercase names are process names.

1. (20 points) For each of the following, determine whether or not it’s a syntactically valid CCS process. If so, draw its transition graph; if not, briefly explain why it’s not syntactically valid.

   You should assume that $a$, $b$, $c$, and $d$ are all valid action names.

   (a) $\text{ONE} \equiv a.b.0 + b.\text{ONE}$

   (b) $\text{TWO} \equiv c.\text{ONE}.\text{TWO}$

   (c) $\text{THREE} \equiv a.\text{THREE} + d.0 + d.\text{THREE}$

   (d) $\text{FOUR} \equiv a.\text{FOUR} + d.(0 + \text{FOUR})$

   (e) $\text{FIVE} \equiv a.(b + c).d.0$

2. (10 points) Define a CCS process whose transition graph has the following shape:

   ![Transition Graph](image)

3. (20 points) Consider the following process definitions:

   \[
   \begin{align*}
   \text{Lecture} & \equiv \text{Ramble + Educate} \\
   \text{Ramble} & \equiv \text{talk.Ramble + pause.Ramble} \\
   \text{Educate} & \equiv \text{talk.Educate + teach.Lecture}
   \end{align*}
   \]

   Give a formal derivation for the following transition:

   \[
   \text{Lecture} \xrightarrow{\text{pause}} \text{Ramble}
   \]
4. (20 points) A particular contraption has three buttons (red, blue, and green) and a three-button-sequence combination. When the correct combination is entered, a light goes on and then turns off; the contraption then returns to its initial state. If, instead, the wrong combination is entered, a buzzer sounds; the contraption then ends up in a permanently dead state.

This contraption is very similar to the one [that will be] discussed in lecture, with the following exception: in the case of a wrong combination, the buzzer sounds only after three buttons have been pressed.

Use the events 
{red, blue, green, on, off, buzz}

to write a CCS process for such a contraption, where the correct combination is “red, red, blue”.

Your answer should include both (i) the CCS process itself and (ii) its transition graph.

Caveat: Make sure your process is always prepared to accept any button whenever a combination is being entered.

5. (30 points) For this problem, you need to choose a fairly common activity/machine/scenario to model in CCS. You can choose pretty much anything you want (this is your chance to be creative, and possibly my chance to be entertained), as long as you can fit in the features mentioned below. [Obviously, I don’t want to see an example I’ve already done in class or that comes from a textbook.]

(a) Specify the observable actions (i.e., labels) for your CCS process: you should include at least 5 distinct events.

(b) Write an English description of the activity/machine/scenario being modeled. (What I’m looking for is something similar to the first two paragraphs of Question 4, which describe the contraption’s behavior.) The correspondence between this description and the observable actions you’ve chosen should be obvious.

(c) Write a CCS process that captures your English description of the scenario. Be sure to include the following features: recursion, nondeterministic choice (i.e., summation), and meaningful process names.

Your scenario doesn’t have to be extremely complicated, but it should involve at least 7 distinct states and some interesting branching behavior.

(d) Draw the transition graph for your CCS process.