Instructions: You have 1 hour, 20 minutes to complete this test. The test is closed book and closed notes. No calculators are allowed. Make sure to show your work on all problems. No credit will be given for answers without sufficient work.

Problem 1

Problem 2

Problem 3

Problem 4
1) 25 points

How many distinct executions are there for the distributed system having 3 processes and events as shown in the figure below? Assume that the only events are sending and receiving of messages and that non-blocking (asynchronous) message sends are used with blocking receives. You can consider the send from P_2 as one event, even though it has two receivers. Justify your answer.
2) 25 points

Consider execution of the Chandy, Lamport distributed snapshot algorithm on a system with the following characteristics. The system operates in a synchronized fashion where during a single time step, each process experiences one event if at least one event is pending. An event is any of the following:

1) spontaneously initiating the snapshot algorithm without receiving a marker message (this event includes saving the state of the process that initiates on stable storage)
2) saving the state of the process on stable storage (after receiving a marker message)
3) saving the state of a channel on stable storage
4) sending a marker message on all outgoing channels
5) receipt of a message on a single channel

When multiple events are pending at a process, the process prioritizes the events in the order given, where lower numbers indicate higher priorities. Also, whenever incoming messages are pending on multiple channels, the channels are read in alternating fashion according to the following order that repeats in a cyclic fashion, skipping over any channels that do not exist: left incoming channel, right incoming channel, vertical incoming channel.

Trace execution of the snapshot algorithm on the system shown below. At the end of the execution, show the state that was recorded for each channel in the system. Assume that process 1 spontaneously initiates the algorithm at time step 0 and that process 5 also spontaneously initiates at time step 2. Assume that no additional messages are sent by the processes during execution of the algorithm except for marker messages. Show your work.
3) 25 points

Consider a system with \( n \) processes executing the Paxos protocol with a distinguished proposer. Assume there are two processes, \( P_i \) and \( P_j \) that are each trying to propose a different value and assume neither \( P_i \) nor \( P_j \) is the distinguished proposer.

a) What is the minimum number of messages that can be sent by the Paxos protocol before one of the values being proposed by \( P_i \) and \( P_j \) is accepted? Justify your answer.

b) What is the maximum number of messages that the Paxos protocol can send before one of the values being proposed by \( P_i \) and \( P_j \) is accepted? Justify your answer.
4) 25 points

Write Java or Python code to handle browse requests in the book repository application you implemented for Programming Assignment 1. The genre to be browsed should be passed as a parameter to the handler and then the handler should query all the books in that genre and display them one by one using HTML. You do **not** have to write any of the other code for the application, only the part used by the browse feature. Also, do not worry about the case of the genre name nor whether the passed-in name is valid. You can assume that the genre name passed to the handler refers to a valid genre with the proper case that has at least one book.