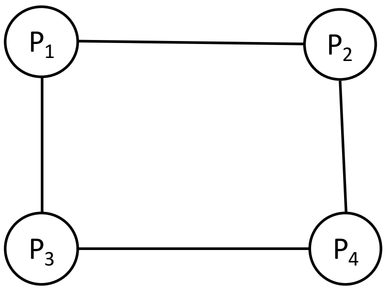
Name: ___SOLUTIONS__________________________________

Quiz 1 – ECE 526 Distributed Algorithms – Fall 2016 – Duration 25 minutes -- 35 points (5 points/question)

Question 1, 2, 3 and 4 relate to the figure below. The figure shows four processes and the point-to-point communication channels between the processes.



In Questions 1, 2 and 3, answer Yes or No, with *a brief justification*.

1. Assume that the system above is **synchronous**, and at most **one** process may **crash**.
   Is it possible to achieve exact consensus in this system?

   YES. Each pair of non-faulty processes can communicate reliable despite one crash failure. Thus, a complete network can be simulated, and we can use the f+1 round algorithm discussed in class.

2. Assume that the system above is **asynchronous**, and at most **one** process may **crash**.
   Is it possible to achieve exact consensus in this system?

   NO. Due to FLP impossibility result.

3. Assume that the system above is **synchronous**, and at most **one** process may be **Byzantine** faulty.
   Is it possible to achieve exact consensus in this system?

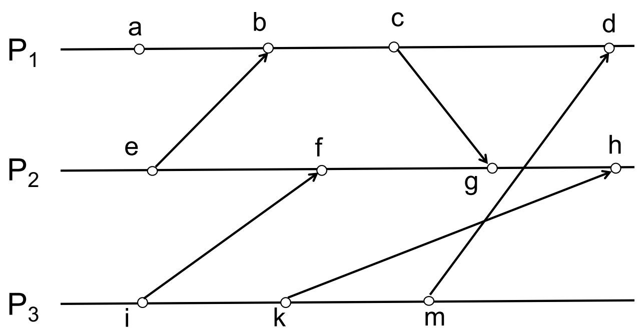
   NO. Need 2f+1 = 3 connectivity for consensus with f Byzantine faults.

4. Consider the Distributed Snapshot algorithm in the Chandy-Lamport paper. Does this algorithm record a consistent cut if the communication channels are not FIFO (first-in first-out) ?

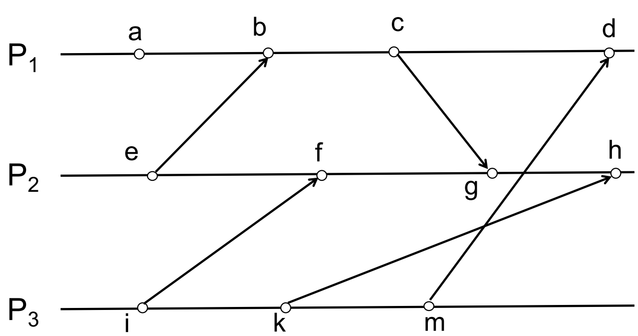
   NO. A marker message M sents after application message M1 may possibly arrive before M1.

5. In the execution below, does there exist a consistent cut that contains event m, but does not contain event e? If you answer yes, show such a consistent cut in the figure.

YES. The maximal consistent cut satisfying these constraints contains events {a,i,k,m}.



6. In the execution below, does there exist a consistent cut that contains event h, but does not contain event b? If you answer yes, show such a consistent cut in the figure. **NO, because b→h.**



7. Suppose that we want to implement an iterative average consensus algorithm in the system shown on the previous page. Assume that the system is **synchronous**, and **no failures** occur. Let us denote by X[t] the vector of states of the four processes, where $X_i[t]$ is the state of process i after t iterations. Recall that the state updates can be expressed in the following matrix form: X[t+1] = M X[t] where M is a square matrix.

Present a matrix M that will result in **average consensus** as t → infinity.

Use the following matrix M, where a < ½.

$$\begin{matrix} 1-2a & a & a & 0 \\ a & 1-2a & 0 & a \\ a & 0 & 1-2a & 0 \\ 0 & a & a & 1-2a \end{matrix}$$

Briefly explain why the specified M will result in average consensus.
The network is strongly connected, the matrix M corresponds to this network, and M is doubly stochastic.