Question 1. (10 + 10 = 20 points)
(a) Are failure detectors of any use in group communication systems? Explain your answer.

(b) Different applications of group communication demand different types of ordered multicast. Consider the problem of maintaining a shared calendar by four different secretaries of the President of a company. Each secretary will propose an update of its copy of the calendar, and it will be sent to the secretaries maintaining the other three copies. The requirement is that after any finite set of updates, all four copies of the calendars must be identical, and it must be meaningful (thus if you first make an appointment at 10 AM on January 3, 2010 with one secretary, and then change it to 9 AM on January 4, 2010 with another secretary, then the last entry will prevail).

What kind of ordered multicast will you recommend? Explain your answer.

Question 2. (15 + 5 = 20 points)
Three processes 0,1,2 of a group communicate with one another, and the requirement is causal order multicast. A message from process 0 has a vector timestamp (1, 2, 0) reaches node 2 whose local vector clock is (0, 1, 2).

(a) Draw a diagram reconstructing the exchange of all the messages in the group.
(b) Will the message be accepted by process 2? Explain.

Question 3. (20 points)
Transis group communication system considers a multicast message delivery to be
safe, when every member receives the acknowledgment from every other member in the group.

Assume process 0 wants to send a safe message $M$ to a group of six members $\{0, 1, 2, 3, 4, 5\}$, and meanwhile $\{4, 5\}$ left the group and $\{6\}$ joined the group, changing the membership from $\{0, 1, 2, 3, 4, 5\} \rightarrow \{0, 1, 2, 3, 6\}$.

If $\{0, 1, 2, 3\}$ receive acks from themselves, but due to the partition, do not receive any acks from 4 or 5, then can $\{0, 1, 2, 3\}$ deliver the safe message $M$ to their application layers? Consider all possible scenarios to explain your answer.