1. Happens Before in Shared Memory

Consider $n$ processors and $m$ shared variables. Every processor can access every shared variable with atomic read and write operations (i.e., a process can either read from or write to a shared variable and the system guarantees that such accesses of different processes to the same variable happen atomically). Define a happens before relation similar to the one for message passing.

2. Unique Maximal Cut Preceeding a Given Cut

Given a schedule $S$ with a cut $C$. Show that there is a unique consistent cut $C'$ of $S$ which precedes the cut $C$.

3. Happens Before Relation

Let $S$ be a schedule with events $a$, $b$, and $c$. Show that if $a \not\Rightarrow_S b$ and $a \not\Rightarrow_S c$ holds, then there exists some causal shuffle $S'$ of $S$ in which $b$ and $c$ occur before $a$.

4. Logical Clocks

You are given a clique graph on $n$ nodes. Find two executions $A$ and $B$, in which each node sends exactly one message to every other node, such that

- the largest Lamport clock value in $A$ is as small as possible, and
- the largest Lamport clock value in $B$ is as large as possible.