Figure 1: Processes for Question 1.

1. Figure 1 describes three processes P0, P1 and P2, and there are several events that occurred in these processes. Mention the Vector time for all the events in the figure. Explain your answer.

> **Solution:** P_0 : {P_0:7, P_1:1, P_2:2}; P_1 : {P_0:6, P_1:3, P_2:2}; P_2 : {P_0:0, P_1:0, P_2:2}

2. What is mutual exclusion?

> **Solution:** It is often necessary to protect a shared resource within a Distributed System. Mutual exclusion refers to ensuring that only one process or thread accesses a shared resource at any given time, to prevent conflicts or inconsistent. Examples include Centralized, Distributed and Token Ring.

3. Briefly discuss (one sentence per topic) each of the centralised, distributed and token ring mutual exclusion techniques under the following topics; fairness, resource use time/efficiency, failure.

> **Solution:**
>
> - Centralised: Fair, no resource idling if no bottleneck of coordinator, single point of failure.
>
> - Distributed: Fair, all processes must maintain a list of the current processes in the group, many points of failure
>
> - Token Ring: Fair, need to wait for token even if resource free, lost token kills the system

4. What do we mean by Election Algorithms? Illustrate the workings of the bully algorithm with an illustrative example. Explain the step-by-step procedure in the election of the COORDINATOR.

> **Solution:** Some Distributed Systems require that one of the processes play a particular role. In such situations, we need to employ a mechanism for selecting the 'leader' process. We term such a mechanism an Election Algorithms.
>
> The Ring Algorithm and the Bully Algorithm are examples of election algorithms.
>
> See notes for Bully algorithm.

5. Briefly describe what statefull and stateless file services are. List two advantages and disadvantages of each?

> **Solution:** Stateful: The File Server keeps a copy of a requested file in memory until the client has finished with it. Stateless: The File Server treats each request for a file as self-contained.
>
> Stateful file services have increased performance as fewer disk accesses are performed. Stateless file services can have slower request processing. However, for a stateful file service in the event of a server crash, data is lost and cannot be replaced when the server is restarted. With stateless servers, the effects of server failures and recovery are almost unnoticeable.

6. What is a flat file system? Describe the architecture of a flat file system. Write a sentence discussing each of its 3 main components.

> **Solution:** A flat file system refers to a way of storing data where files are stored as individual entities without a hierarchical structure, unlike in traditional file systems that organize data into directories or folders. All files are stored in a single level: There are no subdirectories or nested folders.
>
> - Flat File Service: Concerned with implementing operations on the contents of files.
> - Directory Service: Provides a mapping between text names for files and UFIDs.
> - Client Module: Integrates and extends the operations of the flat file service and the directory service under a single API.

7. Research the Sun Network File System (NFS) mentioned in lecturers. Write down 3-4 points (bullet point format will suffice) regarding each of the following aspects of the file system:

   - **Objective**: What are the design objectives of the file system?
   - **Security**: How is access to the file system controlled?
   - **Naming**: What resource-naming scheme is used? (You should also show how this affects the various transparencies that are possible in a distributed file system.)
   - **The File Access Model**: i.e. Upload/Download v/s Remote Access, etc.

- **Cache Update**: Is caching used in the system? What is the update policy used to achieve caching?
- **Consistency**: How does the NFS ensure file consistency?
- Other relevant information. Please include any other information you deem relevant.

Please check the course book, internet and other resources in addition to the course slides to prepare the answers.

Solution: See book, will not be on exam.