1. *10 marks*

   Construct a solution to reliable, totally ordered multicast in a synchronous system, using a reliable multicast and a solution to the consensus problem.

2. *20 marks*

   (a) Which type of faults are called Byzantine faults?

   (b) Prove that it is impossible to reach agreement in a system with three processes if one of them is Byzantine faulty.

   (c) How can the above proof be generalised for a system with n processes?

   (d) Is it possible to reach agreement in a system with three processes if one of them is Byzantine faulty by using authentication (unforgeable signatures)? If your answer is yes, describe an algorithm. If your answer is no give a proof to support it.

3. *5 marks*

   Three computers together provide a replicated service. The manufacturers claim that each computer has a mean time between failures of five days; a failure typically takes four hours to fix. What is the availability of the replicated service?

4. *5 marks*

   (a) In the State machine approach for replication each replica processes the stable request with the least unique id. What is the definition of stable request?

   (b) How can a replica use logical clocks to determine the stability of a request in a fail-stop system?

5. *20 marks*

   All processors of a ring-network $G(V, E)$ want to hide their identities and they act as they have no unique ids. a) Is there a symetric protocol that can assign them unique ids? If your answer is yes describe a protocol and prove its time complexity and its communication complexity. If your answer is no give a proof of your claim. b) Is there a non-symmetric protocol that can assign them unique ids? If your answer is yes describe a protocol and prove its time complexity and its communication complexity. If your answer is no give a proof of your claim.