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. *25 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. *10 marks*

   (a) Describe briefly the three basic aproaches to handle replication.

   (b) Describe in more detail the quorum consensus method.

   (c) Use the quorum consensus method to build a distributed replicated stack. The stack should be impemented on top of 5 replicas and should tolerate 2 replica crashes for both *push* and *pop* operations.

4. *15 marks*

   (a) Describe an algorithm that processors of an asynchronous network $G=(V,E)$ can use in order to broadcast information. The processors of the network are the nodes of the graph $G=(V,E)$ and the physical links that connect the processors are the edges of $G=(V,E)$.

   (b) What is the time and communication complexity of your algorithm? Prove it.

   (c) Give the definition of the time and communication complexity of a distributed algorithm.