1. (5 points) Suppose that users are sending data at a rate of 100Kbps when busy, and the users are busy only 8% of the time. If the shared link capacity is 2Mbps, what is the maximum number of users that can be supported simultaneously under circuit switching?

2. (10 points) Under the same conditions as Q1, if we use statistical multiplexing in packet switching and the user population is 200, what is the probability that 40 or more users are transmitting at the same time? What does this result imply about statistical multiplexing?

3. (15 points) Read a paper titled “End-to-End Arguments in System Design” written by Saltzer, Reed, and Clark. Use an example presented in the paper to explain what the end-to-end argument is, and why the Internet pioneers chose to have that.

4. (15 points) Answer the following questions:

   1) What are the sources of packet delay? Explain it with the help of a car travel example.
   2) Suppose that there is exactly one packet switch between a sending host and a receiving host. The transmission rates between the sending host and the switch and between the switch and the receiving host are $R_1$ and $R_2$, respectively. Assuming that the switch uses store-and-forward packet switching, what is the total end-to-end delay to send a packet of length $L$? (Ignore queuing, propagation delay, and processing delay.)
   3) How is propagation delay affected if the length of the packet is increased?

5. (15 points) How long does it take a packet of length 10,000 bytes to propagate over a link of distance 2,500 km, propagation speed $0.025 \times 10^{10}$ m/s, and transmission rate 2 Mbps? More generally, how long does it take a packet of length $L$ to propagate over a link of distance $d$, propagation speed $s$, and transmission rate $R$ bps? Does this delay depend on packet length? Does this delay depend on transmission rate?

6. (10 pts) What is the goal of Code-Division Multiplexing? Explain how Code-Division Multiplexing works using an example.

7. (10 pts) Explain the goal of phase-shift modulation and how it works using an example.

8. (10 points) CRC is a popular technique used for an error-detection in today’s networks. Study CRC, and compute the CRC bits when data is 1010101010, 1001010101, 0101101010, 1010100000 using the generator G=10011.

9. (10 points) MPLS (Multiprotocol Label Switching) was proposed in the 1990s to improve the forwarding speed of IP routers by adopting the idea of virtual-circuit networks. Study MPLS, and present an example that shows MPLS-enhanced forwarding.