1. Why does circuit switching waste bandwidth if the traffic is bursty? Under what traffic conditions is circuit switching optimal?

2. You may have noticed that at busy events (e.g., concerts, sporting events, etc.) the Internet connection on your mobile device can become unstable or stop working entirely. Provide two hypotheses, each one focusing on a different part of the network stack, for why this degradation in performance might be happening.

3. Give two examples of multiplexing in a real-world system not related to computing: one that behaves more like a circuit-switched network and that behaves more like a packet-switched network. In each example, describe the (a) characteristics that make it more packet/circuit-like, (b) explain what is being multiplexed, and (c) how overloading of the underlying resource manifests itself.

4. An office has an Internet link with a capacity of 120 Mbps full-duplex. Each user requires 15 Mbps when transmitting and each user is active 15% of the time.

   (a) Initially a static allocation of bandwidth is made for each user. How many users can the link support?

   (b) The office actually has 25 people who need to use the Internet. As a result, they decide that the static allocation is not particularly efficient and decides to use a statistical approach instead. What is the probability that *exactly* 8 users are transmitting at any given moment?

   (c) What is the probability that more than 8 users are transmitting at any given moment?

5. Popular mobile phone apps, such as Uber and WhatsApp benefit massively from the layered architecture of the Internet. List three ways of how the layered design of the network stack simplified their creation and enable their day-to-day operation.

6. Which layers of the networking stack must routers on the Internet implement? Why is it that routers on the Internet only need to implement a subset of the layers that make up the networking stack?

7. (a) Sketch the signal on a wire if the bit sequence 10111010 is to be transmitted using Manchester Coding. Note: It will be easier to make this sketch if you draw a reference clock signal.

   (b) One of the reasons why Manchester-coding is used, despite having a bitrate that is half the baud rate, is because the receiver can synchronize with the sender's clock using the data stream. One technique for a receiver to determine the clock the sender is using is for a sender to send a *preamble* consisting of alternating 0 and 1 bits. Why is sending this preamble of alternating pattern of 0's and 1's helpful for determining the sender's clock?

   (c) A *quad-level code*, which encodes two bits of data using four distinct signalling levels, has a bitrate that two times the baud rate. What is the bitrate in terms of a baud rate of an 8-level (oct-level?) code? Explain what physical limits exist that prevent an arbitrarily large amount of data to be sent using a very low baud rate.

8. The *repetition code* is a very basic example of forward error correction. In this code, every input bit is encoded by repeating it three times. For example, encoding the bitstring 0110 would produce 000111111000, which is the data that is sent on the wire.

   (a) If we make the assumption that *at most* one bit might be flipped, explain how a receiver would be able to extract the original (i.e., unencoded) bitstring correctly.

   (b) If we make the assumption that up to two arbitrary bits could be flipped, can it be guaranteed that a receiver is able to perform forward error correction to recover the original data?