Due at BEGINNING of class, Tuesday, October 8. Where indicated, you must show your work to receive credit. Also, numerical problems must have a final answer, not just a formula. You must do your work on THESE sheets and submit. Please write your name at the top of this sheet and on the BACK of the last sheet.

1. (6 points) In class we described a five-layer protocol stack used in the Internet. Which of these five layers execute at routers inside the network and process packets traveling across the network? Briefly describe the main functionality of each.

2. (4 pts) What is a disadvantage of packet switching compared to circuit switching?

3. (4 pts) Briefly explain why every host on the TCP/IP Internet has at least two addresses.
4. (6 pts) Data is often divided into packets (segments, datagrams, frames) prior to transmission. Give three reasons why it is better to “packetize” a message in this way, than to send it as a single large message of arbitrary size.

5. (6 points) Consider an HTTP message sent from a web server to your browser, when you are connected to a Wi-Fi (802.11) network. Consider the frame as it crosses the wireless channel from a wireless access point to your laptop computer. The frame transmitted on the local network contains the following: (1) HTTP header, (2) TCP header, (3) 802.11 trailer (checksum), (4) 802.11 header, (5) IP header, (6) data payload. Draw a picture of the frame, showing the relative location of each component. Be sure to indicate which end of the frame arrives first at the destination interface card.

6. (6 pts) A freshman says, “I know all about TCP. It’s the same thing as sockets.” Explain to the student the relationship between TCP and a socket.
7. (6 pts) In class we discussed a T1 line, part of a circuit-switched network for voice communication. A T1 line carries 24 voice channels at a bit rate of 1.544 Mbps. Suppose another standard, T1x, is identical to the T1 standard but carries 30 channels. What is the bit rate of the line? Show your work.

8. A reliable protocol will continue trying to deliver a packet to the destination until it receives an acknowledgment for the packet. Assume $L_1$ is the probability that a packet is lost or damaged, and $L_2$ is the probability that an acknowledgment is lost or damaged. Consider a noisy wireless link where $L_1 = 0.4$ and $L_2 = 0.1$.

(a) (2 pts) What is the probability that a packet is reliably delivered and successfully acknowledged on the first attempt? Show your work.

(b) (2 pts) What is the probability that a packet is reliably delivered and acknowledged on the third attempt. That is, the first two attempts fail (either the packet or the acknowledgment is lost), and on the third attempt both packet and acknowledgment arrive intact. Show your work.

(c) (2 pts) What is the probability that at least three attempts are needed to deliver the packet and have it acknowledged? Show your work.

(d) (2 pts) What is the expected number of attempts needed for successful delivery of the packet at the destination AND arrival of its acknowledgment at the source? Show your work.

9. (6 pts) It might be surprising to learn that Domain Name Service, a critical component of the Internet, in most cases uses unreliable UDP instead of reliable TCP. Why does DNS use UDP?
10. Assume we are transmitting data across a high-speed optical fiber channel in a large metropolitan area. The bit rate on the channel is 1 gigabit per second (1,000,000,000 bits per second). The length of the channel is 48 kilometers (48,000 meters). The propagation speed of signals in optical fibers is $3 \times 10^8$ meters per second. The size of a frame (packet) is 1500 bytes (12000 bits).

(a) (2 points) What is the propagation delay across each link, that is, how long does it take for signals to propagate 48 kilometers? Show your work.

(b) (2 points) How many bits “fit” on a link that is 48 km long?

(c) (2 points) How long does it take to transmit an individual packet on a link? (Include only transmission time, not propagation delay.) Show your work.

11. (5 pts) Explain the difference between persistent HTTP and nonpersistent HTTP in terms of their operation and performance.

12. (6 pts) Consider a local business where the mean response time for web requests is 3.0 seconds. The business installs a local web cache with a response time of 100 milliseconds. If the cache hit ratio is 80%, what is the new mean response time, $R$, for web requests? Show your work.