Problem 1. IP and MAC addresses. If you want to try out a few interactive examples showing the difference between MAC and IP addresses, check out: http://gaia.cs.umass.edu/kurose_ross/interactive/link_layer_addressing.php Note that solutions are given to the problems on this page.

a) Suppose you (a sender connected to a LAN on the UMass campus) want to send an IP datagram to a friend whose laptop is connected to a LAN, at Boston University in Boston. Does your laptop know the 48-bit MAC address of your friend’s laptop at BU? If so, how does it get the MAC address, if not, then explain why it does not need to know the MAC address.

b) Consider the link-layer frame that arriving at your friend’s computer that contains the IP datagram that you sent from your UMass-connected computer. Consider the source MAC address in that frame - what is the network device (host, router) whose MAC address is the source MAC address in that frame?

c) Now consider the IP datagram inside the frame arriving at your friend’s computer. What is the network device (host router) whose IP address is the source IP address in the IP datagram contained in that frame?

Problem 2. ARP and Learning Switches. Consider the network shown below.
Suppose that source node A wants to send an IP datagram, encapsulated in an Ethernet frame to node H. Before doing so, A uses ARP to find H’s MAC address. A then sends an Ethernet frame to H and H then sends a reply back to A. Suppose that initially the switch tables are empty at all switches, and that all ARP tables are empty.

a) Give the switch tables for \( S_1, S_2, S_3 \) and \( S_4 \) after the ARP request packet is received at H.

b) How many of hosts A through I receive the ARP request?

c) Give the switch tables for \( S_1, S_2, S_3 \) and \( S_4 \) after the ARP reply packet has been sent by H and has been received at A.

d) Give the switch tables for \( S_1, S_2, S_3 \) and \( S_4 \) after the IP datagram has been sent by A and has been received at H.

e) How many of hosts A through I receive the frame containing the A-to-H datagram?

**Problem 3:** In this problem we’ll consider three multiple access LAN protocols – TDMA, polling, and CSMA/CD. Suppose there are 100 nodes on the LAN. In TDMA, assume that each slot is 10 milliseconds long, that each node is assigned one frame per second, and that a frame takes 10 milliseconds to send. In the case of polling, assume that a polling request takes 1 milliseconds to get from the central polling node to any node in the network.

a) Suppose that nodes on the LAN want to send a lot of network traffic and so any given node almost always has a frame that it wants to send. For each of the three multiple access LAN protocols, what is longest possible time that a node can wait before successfully (i.e., collision free) send its frame into the LAN.

b) Now suppose that there is almost no traffic in the LAN, so that whenever a node has a frame to send, there are no other nodes that also have a frame to send. In this case, for each of the three multiple access LAN protocols, what is the average amount of time until a node is able to successfully send its frame?