1. (10 pts) Using the example network given in Figure 1, give the virtual circuit tables for all the switches after each of the following connections is established. Assume that the sequence of connections is cumulative, that is, the first connection is still up when the second connection is established, and so on. Also assume that the VCI assignment always picks the lowest unused VCI on each link, starting with 0.

(a) Host A connects to host B.
(b) Host C connects to host G.
(c) Host E connects to host I.
(d) Host D connects to host B.
(e) Host F connects to host J.
(f) Host H connects to host A.

![Figure 1: Example network for Problem 1](image)

2. (5 pts) Propose a mechanism that might be used by datagram switches so that if one switch loses all or part of its forwarding table, affected senders are informed of the failure.

3. (5 pts) What aspect of IP addresses makes it necessary to have one address per network interface, rather than just one per host? In light of your answer, why does IP tolerate point-to-point interfaces that have nonunique addresses or no addresses?

4. (5 pts) Why do you think IPv4 has fragment reassembly done at the endpoint, rather than at the next router? Why do you think IPv6 abandoned fragmentation entirely?

5. (5 pts) Having ARP table entries time out after 10 to 15 minutes is an attempt at a reasonable compromise. Describe the problems that can occur if the timeout value is too small or too large.

6. (10 pts) Suppose routers in the network (shown in Figure 2 ) run a distance vector routing protocol. Suppose a simple synchronized model. That is, routers send out distance vectors at fixed time intervals. Suppose at time t=0, all routers start running the distance vector protocol, and send out new distance vectors every second. At what time will the distance vector routing protocol converge? Please list the distance vectors each router sends at each round until the protocol converges.

7. (10 pts) Now suppose routers in the same network switch to a link-state routing protocol. Show how node D builds its forwarding table using the variant of dijkstra algorithm the “forward search” algorithm we learned in class. (Please refer to Page 257-258 of the textbook or Slides 18-20 in lecture 12.)
8. (10 pts) BGP in the wild. Download the BGP routing table data from http://www.cs.duke.edu/courses/spring16/compsci356/homework/bgp-data.tgz. The tarball includes some scripts for you to analyze the data, but for some questions, you may need to write your own programs to analyze the data. Using the data to answer the following questions about BGP.

(a) Sometimes an AS may use a technique called AS-path prepending to artificially inflate the length of an AS path. That is, an AS prepends its own AS number multiple times before it exports a route. What is AS-path prepending used for? In the BGP table dump, what is the largest number that an AS number is prepended?

(b) What is the average AS path length used for packet forwarding?

(c) How many address prefixes are there in this BGP table? If origin ASes aggregate their address prefixes before announcing them in BGP, how many address prefixes will there be?

9. (6 pts) Figure 3 shows an AS-level network topology. Each circle represents an AS. A dashed line indicates a peering relationship between two ASes, and an arrowed line indicates a customer-provider relationship between two ASes, with the arrow pointing to the provider. Suppose all ASes run BGP and use common BGP routing polices. Answer the following questions.

- What is the best AS path selected by AS F to reach AS G?
- What is the best AS path selected by AS F to reach AS H?
- What is the best AS path selected by AS F to reach AS I?