1 True or false questions.

(1) UDP is a connection-oriented transport layer protocol.

(2) Using HTTP persistent connection, a TCP handshake and teardown is performed per each downloaded object.

(3) With the Distance Vector algorithm, each node talks only to its directly connected neighbors.

(4) HTTP is an application program.

(5) When TCP Reno is in congestion avoidance phase and receives a 3 DUPACK, the sending window drops to 1.

(6) IMAP and POP3 are used to push messages to a mail server.

(7) The Internet is popular because it provides quality of service guarantees.

(8) Go-Back-N has better performance than Selective Repeat in noisy channels.

2. **(a)** Suppose a TCP Reno sender is in congestion avoidance phase, with a current congestion window value of 20 segments. Suppose the advertised window from the TCP receiver is 50 segments.
   - What action does the TCP sender perform when it receives 3 DUP ACKs from the receiver?
   - What are the new values for the congestion window and slow start threshold?

(b) Now consider a FTP transfer over a TCP Reno connection that includes a satellite link. The bottleneck bandwidth is 100Mbps, the Round Trip propagation delay = 1s. Segment size is fixed and equal to 1500 bytes.
- Compute the TCP congestion window required to achieve full bottleneck utilization.
- How many round trip times will it take to reach such window during the slow start phase? (NOTE: assume infinite advertised window and slow start threshold, assume no segments is lost and assume receiver does not use delayed ACKs)
- Suppose the sending window reaches the value for full bottleneck utilization and the connection detects a 3 DUPACK. How long will it take to reach again the full bottleneck utilization? (NOTE: assume infinite advertised window and assume receiver does not use delayed ACKs)

4. Suppose two hosts, A and B are separated by 100 kilometers and are connected by a direct link of R=10Mbps. The propagation delay over the link is $10*10^{-6}$ second/km. Assume processing delay and queuing delay are negligible.

   a) What is the end-to-end delay of sending a file of 20,000 bits from A to B?
   b) If host B is running as a Web server and uses non-persistent connection, how long does it take A to download a 5,000 bits HTML with 3 objects (each 5,000 bits)? Assume the transmission time of SYN, SYNACK and ACK segments are negligible, and each file can be transmitted continuously.
   c) If three parallel non-persistent connections are applied, how long does it take A to download 5,000 bits HTML with 3 objects (each 5,000 bits) from B?
   d) If persistent connection with pipelining is applied, how long does it take A to download 5,000 bits HTML with 3 objects (each 5,000 bits) from B?