

1. (5%) What is the purpose for using timers in reliable data transfer protocols? Explain.
2. (5%) What is the purpose for using sequence numbers in reliable data transfer protocols? Explain.
3. (5%) Suppose the UDP receiver computes the Internet checksum for the received UDP segment and finds that it matches the value carried in the checksum field. Can the receiver be absolutely certain that no bit error has occurred? Explain.
4. (10%) Consider a reliable data transfer protocol that uses only negative acknowledgements. In a NAK-only protocol, a loss of packet with sequence number x is only detected by the receiver when packet with sequence number $x+1$ is received.
 - (a) Suppose the sender sends data only infrequently. Would a NAK-only protocol be preferable to a protocol that uses ACKs only? Why?
 - (b) Now suppose the sender has a lot of data to send and the end-to-end connection experiences few losses. Would a NAK-only protocol be preferable to a protocol that uses ACKs only? Why?
5. (5%) Consider the go-back- n protocol with a sender window size of 5 and a sequence number range of 512. Suppose that at time t , the next in-order packet that the receiver is expecting has a sequence of 97. Assume that the medium does not reorder messages. What are the possible sets of sequence numbers inside the sender's window at time t ? Justify your answer. 92 96 98 96 97
6. (5%)
 - (a) What are the two most important network-layer functions in a datagram network? 97 98 99 100 101
 - (b) What are the three most important network-layer functions in a virtual-circuit network?
7. (5%)
 - (a) What is head-of-the-line (HOL) blocking?
 - (b) Does it occur at input ports or output ports?
8. (5%) A datagram of 2000 bytes (20 bytes of IP header plus 1980 bytes of IP payload) arrives at a router and must be forwarded to a link with an MTU of 500 bytes. How many fragments are generated? What are the offsets of the fragments?
9. (10%) Describe how network address translation (NAT) works.
10. (10%) Describe how dynamic host configuration protocol (DHCP) works?
11. (10%) Describe the three-way handshake procedure to establishing a TCP connection.

12. (15%) Consider a datagram network using 32-bit host addresses. Suppose a router uses longest prefix matching and has four links, numbered 0 through 3. Packets are to be forwarded to the link interfaces as follows:

Destination address range	Link interface
11100000 00000000 00000000 00000000 through 11100000 00000000 11111111 11111111	0
11100000 00000001 00000000 00000000 through 11100000 00000001 11111111 11111111	1
11100000 00000001 00100000 00000000 through 11100000 00000001 00111111 11111111	2
Otherwise	3

- (a) Provide a forwarding table that has four entries.
 (b) Determine the outgoing interfaces of the following destination addresses:

11001000 10010001 01010001 01010101
 11100000 00000001 00110010 10010001

13. (16%) Consider a datagram network using 8-bit host addresses. Suppose a router uses longest prefix matching and has the following forwarding table:

Prefix Match	Link Interface
0	0
01	1
011	2
otherwise	3

For each of the four interfaces, give the associated range of destination host addresses and the number of addresses in the range.