1. ***(5%) What is the purpose for using timers in reliable data transfer protocols? Explain.***

   To handle losses in the channel. If the ACK for a transmitted packet is not received within the duration of the timer for the packet, the packet (or its ACK or NACK) is assumed to have been lost. Hence, the packet is retransmitted.

2. ***(5%) What is the purpose for using sequence numbers in reliable data transfer protocols? Explain.***

   Sequence numbers are required for a receiver to find out whether an arriving packet contains new data or is a retransmission.

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.***

   No, the receiver cannot be absolutely certain that no bit error has occurred. This is because of the manner in which the checksum for the packet is calculated. If the corresponding bits (that would be added together) of two 16-bit words in the packet were 0 and 1 then even if these get flipped to 1 and 0 respectively, the sum still remains the same. Hence, the 1s complement the receiver calculates will also be the same. This means the checksum will verify even if there was transmission error.

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?

   (a) If there is a long delay between the transmission of x and the transmission of x+1, then it will be a long time until x can be recovered, under a NAK-only protocol.

   (b) If data is being sent often, then recovery under a NAK-only scheme could happen quickly. Moreover, if errors are infrequent, then NAKs are only occasionally sent (when needed), and ACK are never sent – a significant reduction in feedback in the NAK-only case over the ACK-only case.

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.***

Here we have a window size of N=5. Suppose the receiver has received packet 96, and has ACKed that and all other preceding packets. If all of these ACK's have been received by sender, then sender's window is [97, 101]. Suppose next that none of the ACKs have been received at the sender. In this second case, the sender's window contains 96 and the 5 packets up to and including 96. The sender's window is thus [92,96]. By these arguments, the senders window is of size 5 and begins somewhere in the range [92,97].

6. ***(5%) (a) What are the two most important network-layer functions in a datagram network?***
(b) What are the three most important network-layer functions in a virtual-circuit network?

(a) Forwarding, routing

(b) Forwarding, routing, connection setup

7. ***(5%) (a) What is head-of-the-line (HOL) blocking?***
(b) Does it occur at input ports or output ports?

(a) HOL blocking – a queued packet in an input queue must wait for transfer through the fabric because it is blocked by another packet at the head of the line.

(b) It occurs at input 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?***

The maximum size of data field in each fragment = 480 (20 bytes IP header). Thus the number of required fragments $= \left\lceil \frac{1980}{480} \right\rceil = 5$.

The offsets of the 5 fragments will be 0, 60, 120, 180, 240.

9. ***(10%) Describe how network address translation (NAT) works.***

課本 p. 385

10. ***(10%) Describe how dynamic host configuration protocol (DHCP) works?***

課本 p. 382

11. ***(10%) Describe the three-way handshake procedure to establishing a TCP connection.***

課本 p. 290

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	*0*
11100000 00000000 11111111 11111111	
11100000 00000001 00000000 00000000	
through	*1*
11100000 00000001 11111111 11111111	

11100000 00000001 00100000 00000000

through ***2***

11100000 00000001 00111111 11111111

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

a)

Prefix Match	Link Interface
11100000 00000000	0
11100000 00000001	1
11100000 00000001 001	2
otherwise	3

b) Prefix match for first address is the 4th entry: link interface 3

Prefix match for second address is the 3rd entry: link interface 2

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.

Destination Address Range	Link Interface
00000000 through (64 addresses) 00111111	0
01000000 through (32 addresses) 01011111	1
01100000 through (32 addresses) 01111111	2
10000000 through (128 addresses) 11111111	3