Problem 1 (Problem 6, Chapter 3 - 3 points) - Consider our motivation for correcting protocol rdt2.1. Show that the receiver, shown in figure 3.57 of your book, when operating with the sender, shown in figure 3.11 of your book, can lead the sender and receiver to enter into a deadlock state, where each is waiting for an event that will never occur.

Problem 2 (Problem 7, Chapter 3 - 3 points) - In protocol rdt3.0, the ACK packets flowing from the receiver to the sender do not have sequence numbers (although they do have an ACK field that contains the sequence number of the packet they are acknowledging ). Why is it that our ACK packets do not require sequence numbers?

Problem 3 (Problem 24, Chapter 3 - 4 points) - Answer true or false to the following questions and briefly justify your answer.
  a - With the SR protocol, it is possible for the sender to receive an ACK for a packet that falls outside of its current window.
  b - With GBN , it is possible for the sender to receive an ACK for a packet that falls outside of its current window.

Problem 4 (Problem 26, Chapter 3 - 6 points) - Consider transferring an enormous file of L bytes from Host A to Host B. Assume an MSS of 536 bytes.
  a - What is the maximum value of L such that TCP sequence numbers are not exhausted? Recall that the TCP sequence number field has four bytes.
  b - For the L you obtained in (a), find how long it takes to transmit the file. Assume that a total of 66 bytes of transport, network and data-link header are added to each segment before the resulting packet is sent out over a 155 Mbps link. Ignore flow control and congestion control so A can pump out the segments back to back and continuously.

Problem 5 (Problem 27, Chapter 3 - 6 points) - Hosts A and B are communicating over a TCP connection, and Host B has already received from A all bytes up through byte 126. Suppose Host A then sends two segments to Host B back-to-back. The first and second segments contain 80 and 40 bytes of data respectively. In the first segment, the sequence number is 127, the source port number is 302, and the destination port number is 80. Host B sends an acknowledgment whenever it receives a segment from Host A.
  a - In the second segment sent from Host A to B, what are the sequence number, source port number, and destination port number?
b - If the first segment arrives before the second segment, in the acknowledgment of the first arriving segments, what is the ACK number, the source port number, and the destination port number?
c - If the second segment arrives before the first segment, in the ACK of the first arriving segment, what is the ACK number?

**Problem 6 (Problem 31, Chapter 3 - 4 points)** - Suppose that the five measured SampleRTT values are 106ms, 120ms, 140ms, 90ms, and 115ms. Compute the EstimatedRTT after each of these SampleRTT values is obtained, using a value of alpha = 0.125 and assuming that the value of EstimatedRTT was 100ms just before the first of these 5 samples were obtained. Compute also the DevRTT after each sample is obtained, assuming a value of beta = 0.25 and assuming the value of DevRTT was 5ms just before the first of these five samples was obtained. Last, Compute the TCP TimeoutInterval after each of these samples is obtained.

**Problem 7 (Problem 40, Chapter 3 - 4 points)** - Consider Figure 3.58 of your book, assuming TCP Reno is the protocol experiencing the behaviour shown in the figure, answer the following question. In all cases, you should provide a short discussion justifying your answer.

a - Identify the intervals of time when TCP slow start is operating.
b - Identify the intervals of time when TCP congestion avoidance is operating.

g - In the long run, will these two connections get the same share of the bandwidth of the congested link? Explain.

**Problem 8 (Problem 44, Chapter 3 - 4 points)** - Consider sending a large file from a host to another over a TCP connection that has no loss.

a - Suppose TCP uses AIMD for its congestion control w/o slow start. Assuming cwnd increases by 1MSS every time a batch of ACKs is received and assuming approximately constant round-trip times, how long does it take for cwnd increase from 6MSS to 12MSS (Assuming no loss events)?
b - What is the average throughput (in terms of MSS and RTT) for this connection up through time = 6RTT?

g - If both C1 and C2 at time t0 have a congestion window of 10 segments, what are their congestion window sizes after 1000ms?

g - In the long run, will these two connections get the same share of the bandwidth of the congested link? Explain.

**Problem 9 (Problem 50, Chapter 3 - 4 points)** - Consider a simplified TCP's AIMD algorithm where the congestion window size is measured in number of segments not in bytes. In additive increase, the congestion window size increases by one segment in each RTT. In multiplicative decrease, the congestion window size decreases by half (if the result is not an integer, round down to the nearest integer). Suppose that two TCP connections, C1 and C2, share a single congested link of speed c segments per second. Assume that both C1 and C2 are in the congestion avoidance phase. Connection C1’s RTT is 50ms and connection C2’s RTT is 100ms. Assume that when the data rate in the link exceeds the link’s speed, all TCP connection experience data segment loss.

a - If both C1 and C2 at time t0 have a congestion window of 10 segments, what are their congestion window sizes after 1000ms?

b - In the long run, will these two connections get the same share of the bandwidth of the congested link? Explain.
Problem 10 (Problem 4, Chapter 4 - 4 points) - Consider the network shown in the figure of Problem 4 of chapter 4 in your book.

a - Suppose that this network is a datagram network. Show the forwarding table in router A, such that all traffic destined to Host H3 is forwarded through interface 3.

b - Suppose that this network is a datagram network. Can you write down forwarding table in routed A, such that all traffic from H1 destined to Host H3 is forwarded through interface 3, while all traffic from H2 destined to Host H3 is forwarded through interface 4? (Hint : this is a trick question)

Problem 11 (Problem 13, Chapter 4 - 3 points) - Consider a router that interconnects three subnets: Subnet 1, Subnet 2 and Subnet 3. Suppose all of the interfaces in each of these three subnets are required to have the prefix 223.1.17/24. Also suppose that Subnet 1 is required to support at least 60 interfaces, Subnet 2 is to support at least 90 interfaces, and Subnet 3 is to support at least 12 interfaces. Provide three network addresses (of the form A.B.C.D/X) that satisfy these constraints.

Problem 12 (Problem 17, Chapter 4 - 4 points) - Consider the topology shown in Figure 4.17 in your book. Denote the three subnets with hosts (starting clockwise at 12:00) as Networks A, B, and C. Denote the subnets w/o hosts as Networks D,E and F.

a - Assign network addresses to each of these 6 subnets, with the following constraints. All addresses must be allocated from 214.97.254/23; subnet A should have enough addresses to support 250 interfaces; subnet B should have enough addresses to support 120 addresses; and subnet C should have enough addresses to support 120 addresses. Of course, subnets D, E, and F should each be able to support two interfaces. For each subnet the assignment should take the form of A.B.C.D/X or A.B.C.D/X - E.F.G.H/Y.

b - Using your answer to part (a), provide the following tables (using longest prefix matching). For each of the three routers.

Problem 13 (Problem 19, Chapter 4 - 3 points) - Consider sending a 2400-byte datagram into a link that has an MTU of 700 bytes. Suppose the original datagram is stamped with the identification number 422. How many fragments are generated? what are the values in the various fields in the IP datagram(s) generated related to fragmentation?

Problem 14 (Problem 21, Chapter 4 - 4 points) - Consider the network setup in Figure 4.22 in your book, suppose that the ISP instead assigns the router the address 24.34.112.235 and that the network address of the home network is 192.168.1/24.

a - Assign addresses to all interfaces in the home network.

b - Suppose each host has two ongoing TCP connections, all to port 80 at host 128.119.40.86. Provide the six corresponding entries in the NAT translation table.
Problem 15 (Problem 22, Chapter 4 - 4 points) - Suppose you are interested in detecting the number of hosts behind a NAT. You observe that the IP layer stamps an identification number sequentially on each IP packet. The identification of the first IP packet generated by a host is a random number, and the identification numbers of the subsequent IP packets are sequentially assigned. Assume all IP packets generated by hosts behind the NAT are sent to the outside world.

a - Based on this observation and assuming you can sniff all packets sent by the NAT to the outside, can you outline a simple technique that detects the number of unique hosts behind a NAT? justify your answer.

b - If the identification numbers are not sequentially assigned but randomly assigned, would your technique work? justify your answer.

Extra credit - Include the answers to Wireshark lab problems of Chapter 3 and 4 for extra 20 points.