Course: Computer Networks (EEL 703)
Total Time: Two hours.
All questions are compulsory.

1. Consider a single wired link connecting two nodes, A and B. A has to transfer a file using TCP to B. The packet size is $1KBytes$, acknowledgement size is $100Bytes$, one-way link propagation delay is $1ms$ and the link capacity is $1MBytespersecond$ (both, for packet and acknowledgement). The buffer size on the sender side (A) is b packets. The receiver acknowledges each and every packet it receives successfully.

   (a) Find the maximum value of window size that can be used. $5Marks$

   (b) If the TCP connection is always in slow start phase (i.e., increases its window by 1 packet for every acknowledgement), find the first packet number that will be lost due to buffer overflow. Assume that the initial window used by the sender is 1. $5Marks$

   (c) Suppose the TCP sender follows the slow start algorithm till it has reached a *window* of W packets. Find the *minimum* value of buffer size b that ensures no packet drops till the sender has reached window of W. $5Marks$

   (d) Repeat the previous problem with congestion avoidance. For simplicity, assume that the sender increases window by one packet in each round trip time and the sender starts with an initial window of 1 and is always in congestion avoidance phase. $5Marks$

2. Consider a TCP controlled file transfer where each packet is lost independently with probability p.

   (a) For slow start controlled file transfer with initial window of W packets, find the distribution of *number of round trip times* (i.e., the number of windows acknowledged) till which no loss occurs. $5Marks$

   (b) Repeat the previous part for congestion avoidance algorithm of TCP with initial window of W packets. $5Marks$

3. Consider a network consisting of two links, 1 and 2, in tandem. The capacities of these links are C_1 and C_2 respectively. Assume that there are three connections (*Users* of Kelly's model) where connection 1 uses links 1 and 2, connection 2 uses only link 1 while connection 3 uses only link 2. Find the optimal rate allocation and the corresponding link prices assuming,

   (a) $U_s(x) = x$, $s = 1, 2, 3$, $5Marks$

   (b) $U_s(x) = \log(x)$, $s = 1, 2, 3$. $5Marks$