Solutions to HW #1

1. Answer:
   Transmission delay t = 1000bytes / 1Mbps = 1000bytes * 8 / 1000000 bps = 0.008 seconds
   Propagation delay p = 5000 km / 2.5X10^8m/s =0.02 seconds
   So it takes 0.028 seconds to move the packet to the other packet switch.

   More generally,
   The time = L/R + d/s

2. Answer:
   Suppose the N packets is X1,…, XN. Assume the packets are transmitted in the following order P1,…,PN which is a permutation of X1,…,XN.
   For packet P1, its queuing delay is 0.
   For packet P2, its queuing delay is L/R
   More generally, for Packet Pi, its queuing delay is (i-1) * L/R
   So the average queuing time T = (0 + L/R + … + (N-1)* L/R) / N = $\frac{(N-1)*L}{2R}$

3. Answer:
   i) 2 users are supported
   ii) For two or fewer users, bandwidth is sufficient, no queuing
   For three simultaneous users, bandwidth is insufficient and the packet arrival rate is larger than the departure rate.
   iii) 0.1
   iv) Probability = $(0.1)^3$ = 0.001

4. Answer: A protocol defines message format, order of messages, and actions taken upon messages sent & received
5. Answer:
   The Internet is a network of networks, interconnected by routers in a hierarchical structure
   The Internet is a datagram network (packet switching)
   The Internet implements 5-layer protocol stack.