1. (5 pts) In addition to writing your name above, also write it CLEARLY on the REVERSE SIDE of this sheet.

2. Consider a channel on a wide-area fiber-optic network connecting node A to node B. The bit rate on the channel is 10 Mbps (10,000,000 bits per second). The length of the cable is 1200 kilometers (1,200,000 meters). Assume the propagation speed of signals is $3 \times 10^8$ meters per second.

   (a) (9 pts) If frames are 10,000 bits long, how many frames "fit" on the channel from A to B (one way)? Show your work.

   $\left(\frac{1 \text{ frame}}{10^4 \text{ bits}}\right) \left(\frac{10^7 \text{ bits}}{\text{sec}}\right) \left(\frac{\text{sec}}{3 \times 10^8 \text{ m}}\right) \left(12 \times 10^8 \text{ m}\right) = \frac{12}{3} = 4 \text{ frames}$

   (b) (8 points) If a stop-and-wait protocol is used, and the channel is error-free, what is the maximum utilization of this channel? You may ignore packet headers and the transmission time for acks (do not ignore propagation delay – both directions – for acks, though). Show your work.

   $U = \frac{F}{F + A + 2CI} = \frac{F}{F + 2(CI/F)} = \frac{1}{1 + 2(4)} = \frac{1}{9}$

   (c) (8 points) If a selective repeat sliding window protocol is used, with a maximum send window size of 16 frames, what is the maximum utilization of the channel, assuming no errors occur? Again, you may ignore packet headers and the transmission time for acks. Show your work.

   $W = \frac{1 + 2CI/F}{16} \geq 1 + 2(4)$

   **Yes!**

   Window is large enough to send continuously, so $U = 1.0$