1) A start-up company claims they have developed a wireless technology that can move 44 Mbps over a link at SNR's as low as 100, and that only requires 100 KHz of bandwidth. [5] Do you believe this claim? Explain:

$$C = W \log_2 (1 + SNR)$$

$$= 100(10^3) \log_2 (101) = 100(10^3) 6.658$$

$$= 665.8 \text{ Kbps}$$

I do not believe this, as the claimed bit rate exceeds the channel capacity. [ANS]

2) A 600 meter long 64 Kbps Fractional T-1 connection runs from your company's boarder router to a carrier's nearby Point of Presence (POP). Assume the EM wave propagation speed is $226(10^6)$ meters/second. [5] If a bit is injected into the cable, will the leading edge of the bit reach the POP before the trailing edge of the same bit is injected by the boarder router? Explain, and back your explanation up with some math.

$$T_{inject} = \frac{1 \text{ bit}}{64 \text{ Kbps}} = 15.62 \mu \text{sec}$$

$$226(10^6) \frac{\text{m}}{\text{sec}} \times 15.62 \mu \text{sec} = 3,531 \text{ m}$$

The leading edge of the bit will reach the POP before the trailing edge, as the EM wave front can move 3,531 m by the time the trailing edge of the bit is injected. This is longer than the distance to the POP. [ANS]
3) A 6.9 M byte file is to be moved over the network shown. The file is to be broken up into segments of equal size S. 50 bytes of layer 2-5 overhead is then added to each segment, yielding S+50 byte frames to be transmitted. The propagation delay on all links is small enough to be ignored. All routers are store and forward devices, and there is no other traffic on the link for the duration of this file transfer.

3a) [5] Write an equation for the message delivery delay in terms of the frame size of S+50 bytes.

3b) [5] Compute the value of S that will minimize the message delivery delay. [Hint: Differentiate equation 3a with respect to S and solve for S.]

\[ \text{# segments} = \frac{6.9 \times 10^6}{S} \]

\[ \text{Segment} \times (S + 50) \times 8 = 8S + 400 \text{ bits} \]

\[ T_{6 \text{Mbps}} = \frac{8S + 400}{6 \times 10^6} = \left(1.333 \times 10^{-6} S + 66.67 \mu \text{s}\right) \text{sec} \]

\[ T_{10 \text{Gbps}} = \frac{8S + 400}{10 \times 10^9} = \left(800 \times 10^{-12} S + 40 \times 10^{-9}\right) \text{sec} \]

\[ T_{\text{Total}} = (\text{# segments} + 1) \times T_{6 \text{Mbps}} + T_{10 \text{Gbps}} \]

\[ = \left(\frac{6.9 \times 10^6}{S} + 1\right) \times \left(1.333 \mu S + 66.67 \mu\right) + \left(800 \times 10^{-12} S + 40 \times 10^{-9}\right) \]

\[ \approx 9.198 + \frac{460}{3} + 1.334 \mu S \text{ - ANS} \]

\[ \frac{dT_{\text{Total}}}{dS} = 0 = -460 S^{-2} + 1.334 \mu \]

\[ 460 \times 1.334 \mu = S^2 = 344.9 \text{m} \Rightarrow S = 18.571 \text{B} \text{ - ANS} \]