1) A bit string, 0111101111101111110, needs to be transmitted at the data link layer. What is the string actually transmitted after bit stuffing?

   Insert a 0 after every consecutive 1s: 011110111110011111010

2) What is the remainder obtained by dividing $x^7 + x^5 + 1$ by the generator polynomial $x^3 + 1$? (give your answer as bit string)

   Get remainder $-x^2 + x + 1$, correspond to bit string 111

3) A channel has a bit rate of 4 kbps and a propagation delay of 20 msec. For what range of frame sizes does stop-and-wait give an efficiency of at least 50 percent?

   $50\% \le \frac{\frac{\text{FrameSize}}{4\times10^3\ \text{bps}}}{\frac{\text{FrameSize}}{4\times10^3\ \text{bps}}+2*20\times10^{-3}\text{s}}$

   Solve it and get FrameSize >= 160 bits

4) Consider an error-free 64-kbps satellite channel used to send 512-byte data frames in one direction, with very short acknowledgements coming back the other way. What is the maximum throughput for window sizes of 1, 7, 15? The earth-satellite propagation time is 270 msec. (give your answer as an integer)
   - 4.a) for window size=1
     - Total time per frame: $T = \text{TransmissionDelay} + 2 \times \text{PropagationDelay} = \frac{512\times8\ \text{bits}}{64\times10^3\ \text{bps}} + 2 * 270 \times 10^{-3}\text{s} = 0.604s$
     - $\text{TP} = \frac{\text{WindowSize} \times \text{FrameSize}}{\text{TotalTime}} = \frac{1\times4096\ \text{bits}}{0.604s} = 6781\text{bps}$
   - 4.b) for window size=7
     - $\text{TP} = \frac{\text{WindowSize} \times \text{FrameSize}}{\text{TotalTime}} = \frac{7\times4096\ \text{bits}}{0.604s} = 47470\text{bps}$
   - 4.c) for window size=15
     - $\text{TP} = \frac{\text{WindowSize} \times \text{FrameSize}}{\text{TotalTime}} = \frac{15\times4096\ \text{bits}}{0.604s} = 101722\text{bps}$, but it transcends the channel capacity, so the maximum throughput is 64000 bps

5) A 100-km-long cable runs at the T1 data rate. The propagation speed in the cable is $\frac{2}{3}$ the speed of light in vacuum. How many bits fit in the cable?
   - $\text{T1} = 1.554\ \text{Mbps}$
   - TransmissionDelay $= \frac{100\times10^3 m}{2\times10^8\ \text{m/s}} = 5 \times 10^{-4} s$
   - "Bits fit" $= \text{bandwidth-delay product} = 5 \times 10^{-4} s \times 1.554 \times 10^6\ \text{bps} = 777\ \text{bits}$

6) A CRC generator polynomial is $G(X) = X^{16} + X^{15} + X^2 + 1$. How many bits will the checksum(发送方进行计算后得到余数的位数) be?
   - The degree of the generator polynomial is 16, so the checksum will be 16 bits.

7) Assume the sequence number has 3 bits. What is the maximum number of outstanding sending frames for a go back N protocol?
   - $W_{T(\max)} = 2^3 - 1 = 7$
   - The maximum number of outstanding sending frames is 7.

8) Assume the sequence number has 5 bits. What is the maximum number of outstanding sending frames for a selective repeat protocol?
   - $W_{T(\max)} = 2^{5-1} = 16$
   - The maximum number of outstanding sending frames is 16.

9) A CSMA/CD Ethernet network has a length of 10 km, a data rate of 10 Mb/s, and a signal propagation speed of 200 m/µs. What' s the minimum frame length for this network?
   - $\text{minFrameLength} = \text{DataRate} \times \text{ContentionPeriod} = 10 \times 10^6 \text{ bps} \times 2 \times \frac{10 \times 10^3 m}{200 \times 10^6 \text{ m/s}} = 1000 \text{ bits}$

10) After the sender first sends frames from 0 to 6 and at the end of timeout receives the acknowledgements for frame 1, 3, and 5, the next frame it will re-transmit is which frame? (assume the protocol is go-back-N)
   - Frame 6, from which timeout starts.