ECE363 Assignment 2 Solutions

1. Let 01111110 be the FLAG. To transmit the flowing bit string 011110000111110001111110 at the data link layer, what is the string actually transmitted after bit stuffing?

   Solution: $011110000111110\mathbf{0}00011111\mathbf{0}10$

2. The following character encoding is used in a data link protocol: A: 01111000; B:01111100; FLAG: 01111110; ESC: 11100000
   Show the bit sequence transmitted (in binary) for the four-character frame: "A B ESC FLAG" when FLAG bytes with byte stuffing is used.

   Solution: $011110000111110011100000111000001110000001111110$
   (A B ESC ESC ESC FLAG)

3. An 8-bit byte with binary value 10101100 is to be encoded using Hamming code. What is the binary value after encoding? [Hint: use 4 check bits]

   Solution:

bit position:	1	2	3	4	5	6	7	8	9	10	11	12
(binary)	1	10	11	100	101	110	111	1000	1001	1010	1011	1100
data bits:			1		0	1	0		1	1	0	0
check bits:	0	1		1				0				
codeword:	0	1	1	1	0	1	0	0	1	1	0	0

4. A bit stream 10011100 is transmitted using the standard CRC method. The generator polynomial is $x^3 + 1$.

   a) Show the actual bit string transmitted.

   Solution: Divide (modulo 2) 10011100000 by 1001, the remainder is 101. The actual bit string is 10011100101.

   b) Suppose one bit is inverted during transmission. Show that this error is detected at the receiver's end.

   Solution: Let $T(x)$ be polynomial corresponding to the original bit string. For a single bit error at $(i+1)$-th bit (from the right), the received bit string corresponds to $T(x) + E(x)$ (modulo 2), where $E(x) = x^i$. Since x^i is not divisable by $G(x) = x^3 + 1$ (modulo 2), any single error bit can be detected with the CRC method.

5. With the 2-D parity method, a block of bits with n rows and k columns uses horizontal and vertical parity bits for error correction or detection. During the class, we show that 2-D parity method can correct single bit errors.

   (a) Whether the 2-D method can detect double errors? Triple errors?

   Solution: For any two blocks data with 2-D parity bits, the minimal Hamming distance is 4. Therefore, the 2-D parity method can detect double errors, and triple errors.

   (b) Find an example of a pattern of six errors that cannot be detected by the use of 2-D parity method.

   Solution:

	-	1	1	0	-
	-	1	0	1	-
	-	0	1	1	-

   For any three rows i_1, i_2, and i_3, and any three columns j_1, j_2, and j_3, a pattern of six errors in positions (i_1, j_1), (i_1, j_2), (i_2, j_2), (i_2, j_3), (i_3, j_1), and (i_3, j_3) will fail to be detected.