Assignment 2

Q1

(a) Codewords 00000, 10101, 01010

(i) 00000 vs 10101
- 3 differences, Hamming Distance = 3

(ii) 00000 vs 01010
- 2 differences, Hamming Distance = 2

(iii) 10101 vs 01010
- 5 differences, Hamming Distance = 5

	00000	10101	01010
00000	0	3	2
10101	3	0	3
01010	2	5	0

(b) Codewords: 000000, 010101, 101010, 110110

(i) 000000 vs 010101
- 3 differences, Hamming Distance = 3

(ii) 000000 vs 101010
- 3 differences, Hamming Distance = 3

(iii) 000000 vs 110110
- 4 differences, Hamming Distance = 4

(iv) 010101 vs 101010
- 6 differences, Hamming Distance = 6

(v) 010101 vs 110110
- 3 differences, Hamming Distance = 3

(vi) 101010 vs 110110
- 3 differences, Hamming Distance = 3

	000000	010101	101010	110110
000000	0	3	3	4
010101	3	0	6	3
101010	3	6	0	3
110110	4	3	3	0

Q2

$30_{10} = 11110_2$, $20_{10} = 10100_2$, $10_{10} = 01010_2$, $5_{10} = 00101_2$

110010

$11110_2 + 10100_2 + 01010_2 + 00101_2 = 00010_2$

Complement of Total

$11111 - 00010 = 11101$

The checksum is 11101

Q3 Data Rate (R) = $2 \cdot B \cdot \log_2(M)$

Bandwith, B = $12.67MH_z - 12.63MH_z = 0.04\,MH_z = 40\,KH_z$

$R = 2 \times 40{,}000 \times 2 = 160{,}000$ bps

$= 160$ kbps

Q4

Data Rate (R) = 2400 kbps = 2.4 Mbps
Modulation : 16-QAM
Minimum distance factor (r) = 0.5

(a) Number of Levels (M)
In M-ary QAM, the number of levels M corresponds to the Modulation scheme.
16-QAM means M = 16

(b) Number of bits per signal element (K)

$K = \log_2(M)$

$K = \log_2(16) = 4$ bits

(c) Baud Rate :

$S = \frac{R}{K}$, $R = 2400$ Kbps , $K = 4$

$S = \frac{2400}{4} = 600$ KBaud

Bandwidth (B)

$$B = \frac{S}{1+d} \qquad S = 600\ kBaud,\ d = 0.5$$

$$B = \frac{600}{1+0.5} = \frac{600}{1.5} = 400\ kHz$$

25 Data per signal element K = 3 bits.

Bandwidth range 400 kHz to 480 kHz

Minimum distance factor d = 0

② Available Bandwidth (B)

$$B = 480\ kHz - 400\ kHz = 80\ kHz$$

③ Carrier Frequency

$$f_c = \frac{\text{Upper} + \text{lower}}{2} = \frac{480 + 400}{2} = 440\ kHz$$

④ Number of Levels (M)

$$M = 2^k$$

$$M = 2^3 = 8 \text{ levels}$$

⑤ Signal Rate (Baud Rate, S)

$$S = \frac{B}{2\Delta f} \qquad M = \frac{B}{2\Delta f} \qquad 2\Delta f = \frac{B}{M} = \frac{80}{8} = 10\ kHz$$

$$S = \frac{B}{2\Delta f} = \frac{80}{10} = 8\ kBaud$$

⑥ Maximum Bit Rate (R)

$$R = S \cdot K$$

S = 8k Baud and K = 3

$$R = 8 \times 3 = 24\ kbps$$

⑦ Value of $2\Delta f$

$$2\Delta f = \frac{B}{M} = \frac{80}{8} = 10\ kHz$$

Q6] D = 1101 , G = $x^3 + x + 1$

$G = x^3 + x + 1$

$G = 1011$

- Append four zeroes (Since G is a degree 4 polynomial) to the data word

$G = 10010000$

```
        0101
     ------------
1011 | 11010000
       1011
       ----
        1100
        1011
        ----
         1110
         1011
         ----
          1010
          1011
          ----
           0010
           0000
           ----
            0000
```

Final Codeword:

1101 (D) + 0101 (R)

= 11010101

Q7]

Codeword : 1001001 → $x^6 + x^3 + 1$

Generator 101 → $x^2 + 1$

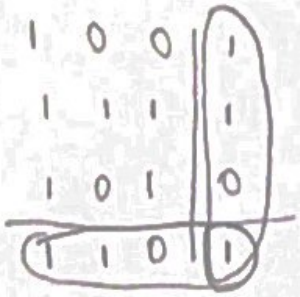
```
          x^4 - x^2 + 1
        ----------------
x^2+1 | x^6 + 0  0  0  x^3  1
        x^6      x^4
        ------------------
        0  - x^4  0  0  x^3  1
           - x^4  - x^2
        ------------------
           0   0   0   0   x^2  1
               0   0   x^2
               ----------------
                   0   0   -x^2
```

Remainder is $x + 1$

Since the remainder is not zero,

The (codeword) contains an error

Q8



Q9

Position of check bits are powers of 2 (1, 2, 4, 8,)

Inserting check bits _ _ 1 _ 1 0 0 0 _ 1 0

P_1 : Parity for 1, 3, 5, 7, 9, 11

Parity (1+1+0+0+1) = 1 (Odd, so $P_1 = 1$)

P_2 . .

Q10