1. Compute the minimum Hamming distance of the following code:
0000000101111111
0000001010111111
0000010011011111
0000100011101111
1001000011110111
1000000011111110
Ans.
3

2. Suppose we want an error-correcting code that will allow all single-bit errors to be corrected for memory words of length 10.
a. How many parity bits are necessary?
b. Assuming we are using the Hamming algorithm presented in this chapter to design our error-correcting code, find the code word to represent the 10-bit information word: 1001100110. Assume even parity.

Ans.

a. m + r + 1 <= 2^r
10+ r + 1 <= 2^r
11 + r <= 2^r
which implies that r should be 4

b. The code word for 1001100110 is found as follows:

1	0	0	1	1	0	$\boxed{1}$	0	1	1	$\boxed{1}$	0	$\boxed{0}$	$\boxed{0}$
14	13	12	11	10	9	8	7	6	5	4	3	2	1

Parity bit 1 checks 1,3,5,7,9,11,13, so Bit 1 must be 0 (assuming even parity)
Parity bit 2 checks 2,3,6,7,10,11,14, so Bit 2 must be 0
Parity bit 4 checks 4,5,6,7,12,13,14, so Bit 4 must be 1
Parity bit 8 checks 8,9,10,11,12,13,14, so Bit 8 must be 1

3. Using the CRC polynomial 1101, compute the CRC code word for the information word, 01001101. Check the division performed at the receiver.

Ans.

The codeword is 01001101100. Dividing this by 1101 modulo 2 should yield a zero remainder.

Append three 0s to the end of the information word and divide:

```
      ___________
1101 |01001101000
       1101
        1001
        1101
         1000
         1101
          1011
          1101
           1100
           1101
              100 --> remainder
```

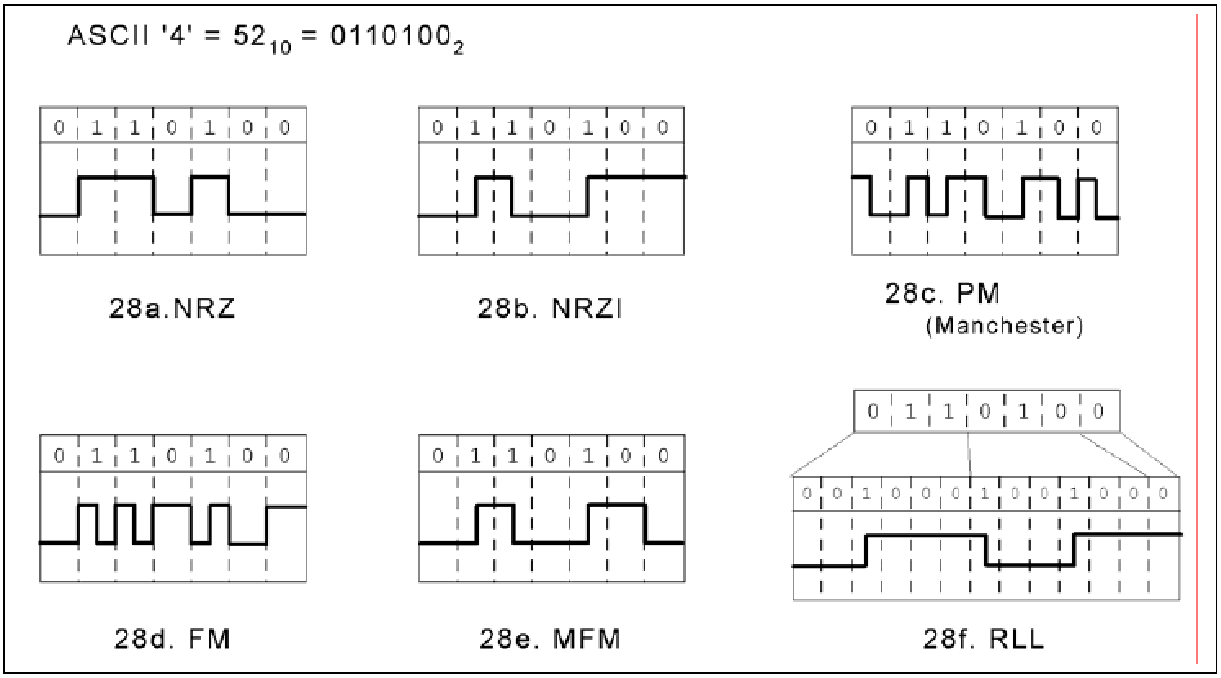
The information word (with appended zeros) + remainder = codeword
so we have: 01001101000 + 100 = 01001101100

To check the division:

```
      ___________
1101 |01001101100
       1101
        1001
        1101
        1000
        1101
         1011
         1101
          1101
          1101
          0000 --> remainder
```

4. Write the 7-bit ASCII code for the character 4 using the following encoding:
a. Non-return-to-zero
b. Non-return-to-zero-invert
c. Manchester Code
d. Frequency modulation
e. Modified frequency modulation
f. Run length limited
(Assume 1 is “high,” and 0 is “low.”)

Ans.



ASCII '4' = 52_{10} = 0110100_2
0 1 1 0 1 0 0
28a.NRZ
28b. NRZI
28c. PM
(Manchester)
28d. FM
28e. MFM
0 0 1 0 0 0 1 0 0 1 0 0 0
28f. RLL