City University of Hong Kong
Department of Electronic Engineering

EE3009 Data Communications and Networking

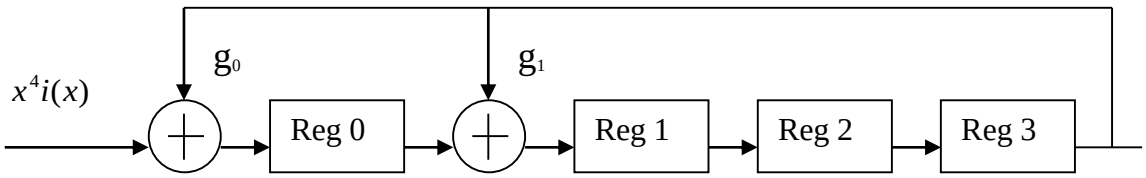
Solution to Tutorial 4

1. The receiver makes a decoding error if two or more out of the three bits are in error.
   Therefore, $P_{error} = \binom{3}{2} p^2(1-P) + p^3 = 3(10^{-3})^2(1-10^{-3}) + (10^{-3})^3 \approx 3(10^{-6})$

2. b_0= 11111111 11111111=2^{16}-1= 65535
   b_1= 11111111 00000000= 65280
   b_2= 11111111 11110000= 61680
   b_3= 11000000 11000000= 49344
   x= b_0+ b_1+ b_2+ b_3 modulo 65535 = 241839 modulo 65535 = 45234
   b_4= -x modulo 65535 = 20301
   so the internet checksum = 01001111 01001101

3.

   i)



   ii) The encoding can be done either by polynomial division, or the more compact way of doing the division without explicitly writing the power of *x*.

$$
\begin{array}{r}
x^9 + x^8 \qquad\qquad + x^3 + x \\
x^4 + x + 1 \overline{)\, x^{13} + x^{12} + x^{10} + x^8 + x^7 + x^5 + x^4} \\
\underline{x^{13} \qquad + x^{10} + x^9} \\
x^{12} \qquad + x^9 + x^8 + x^7 + x^5 + x^4 \\
\underline{x^{12} \qquad + x^9 + x^8} \\
x^7 + x^5 + x^4 \\
\underline{x^7 \qquad + x^4 + x^3} \\
x^5 \qquad + x^3 \\
\underline{x^5 \qquad\qquad + x^2 + x} \\
x^3 + x^2 + x \quad \leftarrow \text{remainder}
\end{array}
$$

codeword = 11010110111110

or,

```
             1100001010
      ______________________
10011 ) 11010110110000
        10011
        ______________
          10011
          10011
          ____________
                10110
                10011
                ______
                  10100
                  10011
                  _____
                   1110  ← remainder
```

codeword = 11010110111110

iii) Turn bit 7 (counting from the least significant bit) of the codeword from 0 to 1, and decode the codeword.

```
             1100001110
      ______________________
10011 ) 11010111111110
        10011
        ______________
          10011
          10011
          ____________
                11111
                10011
                ______
                 11001
                 10011
                 _____
                  10101
                  10011
                  _____
                   1100 ← remainder
```

Since the remainder is non-zero, an error has been detected.