Problem 1

a) $g(x) = x^3 + x + 1 = 1011$

data = 1001

CRC =

```
        101
     ________
1011 | 1001000
       1011
       ----
         1000
         1011
         ----
          110
```

CRC = 110

data transferred = 1001110

b) Error in first bit

data received = 0001110

```
         1
     ________
1011 | 0001110
          1011
          ----
           101
```

Rem = 101 thus, error in received.

Problem 2

a) GFC + VPI + VCI + T + CLP + CRC
4 8 16 3 1 8

0000 0000 0000 0 0000000 00001111 0000 + CRC.

= 11110000 + CRC (36 bits).

$G(x) = x^8 + x^2 + x + 1$

$= 100000111$

data = 1111 0000 00000000

```
                       11110010
100000111 ) 1111 0000 00000000
            1000 0011 1
            111 0011 10
            100 0001 11
             11 0010010
             10 0000111
              1 00101010
              1 00000111
              0 00 101101000
                   100000111
                    11011110
```

CRC = 11011110.

b) Yes this code can detect single bit errors because the generator has more than one non zero bits.

Problem 3

a) $1MB = 8Mb$

$BER = 10^{-6}$

$P\left(\begin{array}{c}\text{file transmitted}\\ \text{with no errors}\end{array}\right) = P(\text{all bits received correctly})$

$= \binom{N}{N} \cdot (1-p) \cdot p^{N-N}$

$= (1-p)^N$

$= (1-10^{-6})^{8000000}$

$= \underline{\underline{0.00033\,55}}$

b) File is divided into blocks transmitted seperately

For each block, number of bits $= \dfrac{8000000}{N} = S$

Probability that block is received correctly $q = (1-10^{-6})^{\frac{8000000}{N}}$

~~For N blocks~~ $= \cancel{\left((1-10^{-6})^{\frac{8000000}{N}}\right)^N}$

$= \cancel{(1-10^{-6})^{8000000}}$

~~Therefore no~~

For file to be received correctly, all blocks must succeed

$\therefore \binom{N}{N} \cdot (q)^N \cdot (1-q)^0$

$= \left((1-10^{-6})^{\frac{8000000}{N}}\right)^N$

$= (1-10^{-6})^{8000000}$

$= \underline{0.000335\,5}$

$\therefore$ Dividing file into blocks does not help to increase probability of it being received error free.

c) Propagation is negligable.

Average number of transmissions $= \dfrac{1}{0.000335}$

$= \underline{2980.6}$

transmission time for file $= \dfrac{8000000}{1000000} = 8s.$ transmission time for ACK $= a$

~~Neglecting ACK transmission time & delays, total = 8 × 298.~~
~~= 2384.501 s~~
~~= 39.742 minutes.~~

The sender sends the file and waits for an ACK from the receiver. If ACK is received, the sender proceeds to send next file otherwise if ACK is not received, after the time out time, the sender re transmits the file to the receiver.

~~P(received correctly) = 0.0035 . 0.0035^{2979}~~
=

Total time $= \underline{\underline{(8 + a) \times 2980.6}}$

Neglecting $a = 8 \times 2980.6$
$= 23845s$
$= \underline{\underline{6.62hrs}}$

d) For $N = 80,800$.

time to transmit $= \frac{8000000}{80,800} \div 1000000$

$= \frac{\cancel{1000}}{101} \times \frac{1}{\cancel{1000}\,000}$

$= \frac{1}{101000}$ s

P(receiving block correctly) $= (1-10^{-6})^{\frac{80,00,000}{80800}}$

$= 0.9999$

Average Number of transmissions $= \frac{1}{0.9999}$

$= 1.00010001$

Total time $= \cancel{80,800}^{8} \times \frac{1}{\cancel{101000}} \times 1.0001$

$= 8.0008$ s

For $N = 8000$

time to transmit $= \frac{\cancel{8000000}}{\cancel{8000}} \div 1000000$

$= \frac{1000}{1000000}$

$= \frac{1}{1000}$ s

P(receiving correctly) $= (1-10^{-6})^{\frac{\cancel{8000000}}{\cancel{8000}}}$

$= (1-10^{-6})^{1000}$

$= 0.999005$

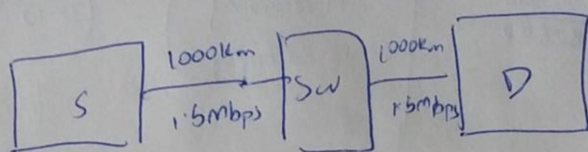
Average number of transmissions $= \frac{1}{0.999005}$

$= 1.001$

$= \cancel{8000} \times \frac{1}{\cancel{1000}} \times 1.001$

$= 8.008$ s

e) When over head is taken into account, ~~the~~ the size of the blocks would increase therefore the probability of receiving it incorrectly would too.
If size of blocks is kept the same, then the ~~a~~ content of file would reduce and thus more blocks would be needed to transmit.
⇒ Overall, the time taken to transmit the file would therefore increase.



Problem 4

64000 bytes.

Each packet = 32 byte header + content.

$= 32 + 2000 - 32$

content size per packet $= 2000 - 32$

$= \underline{1968}$.

$\therefore$ Number of packets $= \frac{64000}{1968}$

$= 32.52$ packets

$\approx$ 33 packets.

bit error rate $= 10^{-6}$

Propagation delay $= 2 \times \frac{1000}{2 \times 10^5}$

$= \frac{1}{100} = \underline{0.01\,s}$

Transmission delay per packet $= \cancel{64000}\ \frac{2000 \times 8}{1.5 \times 10^6}$

$= \frac{16\cancel{000}}{1500\cancel{000}}$

$2 \times \frac{16}{1500}$ s

$= \frac{32}{1500} = \underline{0.0213\,s}$

$$P\begin{pmatrix}\text{Packet is}\\ \text{received}\\ \text{incorrectly}\end{pmatrix} = \left(1-10^{-6}\right)^{10000}$$

$$= \underline{\underline{0.984}}$$

$$\text{Number of packet transmissions} = \underline{\underline{\frac{1}{0.984}}}$$

$$\text{Total time per packet} = \frac{1}{0.984}\left[0.01 + 0.0213\right]$$

$$= \underline{0.032\,s}$$

$$\text{For whole file} = 32 \times 0.032$$

$$= \underline{\underline{1.018\,s}}$$

Problem 5

$P(\text{send backlogged \& receive new}) = pe$

$P(\text{don't send \& don't receive}) = (1-e)(1-p)$

$P(\text{send backlogged \& don't receive}) = p(1-e)$

$P(\text{don't send \& receive}) = e(1-p)$.

~~P(need second~~ $P(\text{number of backlogged}) = pe + p(1-e) + e(1-p) + (1-e)(1-p)$

$= \cancel{pe} + p - \cancel{pe} + e - ep$

$p + e - ep$

b) average increase $= \dfrac{1}{p+e-ep+(1-e)(1-p)}$

c) The system is unstable if $e > p$ where more packets will arrive than those departing thus causing a buildup in the number of backlogged packets.