Solutions to Assignment 3

Question 1

The receiver's differential output is:

$$u(t) - v(t) = \sin(2\pi ft) - \sin(2\pi f(t-\tau))$$

Using the identity given in the question we can rewrite this as:

$$2\cos\left(\frac{2\pi ft + 2\pi ft - 2\pi f\tau}{2}\right)\sin\left(\frac{2\pi ft - 2\pi ft + 2\pi f\tau}{2}\right)$$

or

$$2\cos(2\pi ft - \pi f\tau)\sin(\pi f\tau)$$

and by inspection the frequency of the differential interference signal is f (60 Hz) and the amplitude is $\sin(\pi f\tau) = \sin(\pi \times 60 \times 0.001) \approx 0.187$.

Question 2

(a) The capacity of the AWGN channel (the question does not specify this, but we will assume the noise is white and Gaussian) is

$$C = B\log_2\left(1 + \frac{S}{N}\right)$$

and for $B = 200 \times 10^3$ and $\frac{S}{N} = 10^{21/10} = 126$, $C \approx 1.4$ Mb/s.

(b) For a low-pass channel the maximum symbol rate that can be transmitted without ISI is $2B$ or 400 kHz.

(c) The capacity is a limit on the information rate while the second answer is simply the symbol rate that can be transmitted without ISI. The numbers are different because: (1) the number of bits of information transmitted per symbol can vary; and (2) ISI does not limit the symbol rate since it may be possible to determine which symbols were transmitted even if they were corrupted by ISI.

Question 3

When PPP framing is used an escape character must be inserted before each escape (0x7d) or flag (0x7e) character in the data. Thus two out of the 256 (2^8) possible byte values will need to be escaped. For completely random 8-bit data all byte values are equally likely and thus the fraction of bytes needing to be escaped is $\frac{2}{256} \approx 1\%$.

Question 4

(a) Since the same character does not appear in the same position in more than one codeword, the distance between all codewords is 4 and the minimum Hamming distance of the code is 4.

The number of errors in each codeword that can be detected is $d_{min} - 1 = 4 - 1 = 3$. The number of errors in each codeword can be corrected is $\lfloor \frac{d_{min}-1}{2} \rfloor = \lfloor \frac{4-1}{2} \rfloor = \lfloor 1.5 \rfloor = 1$.

(b) The symbol ADAD is not a valid codeword so the channel must have introduced an error. The distances from the received codeword to the valid codewords are 2, 4, 2 and 4. Since two codewords are at distance 2, the receiver cannot unambiguously choose the closest valid codeword.

(c) The symbol DAAC is not a valid codeword so the channel must have introduced an error. The distances from the received codeword to the valid codewords are 4, 4, 3 and 1. So the decoder would choose the last valid codeword (DABC) as the one most likely to have been transmitted.

Question 5

(a) The destination address is the first six bytes of the header: `00 1d 7e 2f b5 9b`. The OUI of the destination interface is the first three bytes: `00 1d 7e`.

(b) The source address is the second six bytes of the header: `00 24 1d 73 df ce`. The OUI of the source interface is the first three bytes: `00 24 1d`.

(c) The value of the length/type field is the last two bytes of header, 0x0800 which has a decimal value of $8 \times 256 = 2048$. Since this is more than 1500, this is a type value and indicates the protocol used in the payload.