Solutions to Assignment 4

Question 1

A modulator that multiplies the baseband signal with a carrier shifts the baseband signal to the carrier frequency and results in an RF bandwidth which is twice the baseband bandwidth.

If the RF channel has a bandwidth of 5 MHz the maximum allowable bandwidth of the baseband modulating signal must therefor be 2.5 MHz.

Question 2

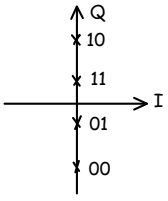
From the 16-QAM 802.11 WLAN constellation diagram on page 3 of Lecture 11 (Modulation), the symbol with bit values 1011 in is transmitted with I=+3 and Q=+1. The maximum magnitude (amplitude) of the constellation as shown is $\sqrt{18}$.

The phase is therefore $\tan^{-1}(\frac{1}{3}) \approx 18°$ and the magnitude is $\sqrt{1^2+3^2} = \sqrt{10} \approx 3.2$.

Question 3

(a) The constellation shown has 4 possible symbol values so $\log_2(4) = 2$ bits can be transmitted per symbol.

(b) On possible assignment of Gray-coded bit values to each of the four possible symbols is as shown:



Question 4

(a) For a $k = 4$-bit ML LFSR the sequence length is $2^k - 1 = 15$ bits.

(b) The subsequent shift register states can be computed by shifting into the left a bit that is the XOR of the two rightmost bits. The initial and the four next states will be:

```
 1101
1110
1111
0111
0011
```

The current output is thus 1 and this will be followed by 0, 1, 1, and 1.

Question 5

A transmission of 200 bits at 350 kb/s takes $\frac{200}{350\times10^3} \approx 571\,\mu$s. Adding a 20 μs guard time results in a time slot duration of about 591 μs. We can thus accomodate $\frac{20\text{ ms}}{591\,\mu\text{s}} \approx 33.8$ slots which must be rounded down to 33 slots. The system will accomodate 33 users.

Question 6

Selective-repeat ARQ gives the best performance, regardless of complexity or cost. The TCP protocol used by most Internet protocols uses go-back-N ARQ with an option to use selective-repeat ARQ.

Question 7

As shown in Figure 4 of RFC 791, an IP header with no options has 20 bytes. If the payload is 512 bytes, the total length will be 512+20=532=0x0214.

bytes (hex)	Field Name
45	Version and IHL (header length)
00	Type of Service
02 14	Total Length
10 00	Identification
00 00	Flags and Offset
10	TTL
01	Protocol (ICMP)
92 E4	Checksum
01 01 01 01	Source Address
02 02 02 02	Destination Address

The checksum was calculated by adding each of the 16-bit words:

```
4500
0214
1000
0000
1001
0000
0101
0101
0202
0202
----
6D1B
```

adding the overflow into the MS 16 bits (0), and inverting all of the bits to get `92E4`.