Question 1

(i) \(3^{rd} = 1.5kHz; \ 1^{st} = 500Hz, \ \text{Period(milliseconds)} = T = 1/500 = 2\text{msec}\)

(ii) Bandwidth(kHz) = 10\(^{th}\) Harmonic = 10*0.5 = 5 kHz

(iii) Sampling rate (baud) = 2*5 \(k\) = 10,000 baud

(iv) Maximum data rate = \(2\log_2 V = 2*3*\log_2 64 = 36\text{kbps}\)

(v) No, most significant harmonics 8\(^{th}\) and 10\(^{th}\) can’t pass through.

(vi) Maximum data rate (kbps) \(S/N = 8dB\), \(10\log(S/N) = 8, S/N = 6.31\)
    \(Hlog_2 (1+6.31) = 3*\log_2 7.31 = 3*2.87 = 8.61 \text{ kbps}\)

(vii) Output signal power (watts)
    \(1.2 = 10\log_{10} \left(\frac{\text{Input}}{\text{Output}}\right)\)
    \(0.12 = \log_{10} \left(\frac{10}{x}\right)\)
    \(10/x = 10^{0.12} = 1.32, \ x = 7.59 \text{ Watts}\)

Question 2

(i) There are 17 levels; so we need = 5bits/sample, Sampling rate = 2*10 K = 20K samples/sec; Maximum data rate (kbps) =20*5 = 100 kbps

(ii) SCR1 = 70 kHz; So sampling rate = 140 kbaud; 16 levels so 4 bits/sample;
    Maximum data rate = 140* 4 = 560 kbps
    SCR2 = 168 kbps
    SRC3 = 42 kHz; So sampling rate = 84 kbaud; 64 levels so 6 bits/sample;
    Maximum data rate = 84 *6 = 504 kbps
    SRC1 = 560/7 = 80/sec, SRC2 = 168/7 = 24/sec, SRC3 = 504/7 = 72/sec
    \# of channels; SRC1: 10, SRC2: 3, SRC3: 9

(iii) It is 1 bit/sample for SRC1 and SRC3. So Combined data rate (kbps) =140 kbps + 168 kbps + 84 kbps = 392 kbps

(iv) \(A\rightarrow B: (8*2000)/50 + 270 = 320 + 270 = 590\)
    \(B\rightarrow C: (8*2000)/20 + 270 = 800 + 270 = 1070\)
    Total Response time = 590 + 1070 = 1660 msec
The 1st 1000 byte packet (transmission time 8000/50 = 160msec; prop. Delay = 270msec) reaches B completely at 430 msec. B starts sending 1st packet from 430 msec onwards. Its last bit is received by C at 1100 msec. Similarly the last bit of the second packet is received by C at 1500 msec (Answer).

Question 3

(i) A 1010  B 1011
AB = 10101011

\[\begin{array}{cccccccccccc}
& c_1 & c_2 & d_1 & c_4 & d_2 & d_3 & d_4 & c_8 & d_5 & d_6 & d_7 & d_8 \\
- & - & 1 & - & 0 & 1 & 0 & - & 1 & 0 & 1 & 1 \\
\end{array}\]

\[\begin{align*}
c_1 &= d_1 + d_2 + d_4 + d_5 + d_7 = 1 \\
c_2 &= d_1 + d_3 + d_4 + d_6 + d_7 = 1 \\
c_4 &= d_2 + d_3 + d_4 + d_8 = 0 \\
c_8 &= d_5 + d_6 + d_7 + d_8 = 1
\end{align*}\]

Data sent (Hexadecimal string) 111001011011

(ii) Checksum = 1111

\[\begin{array}{cccccccccccc}
10101 & 101010110000 & (10000011) & 10101 \\
\end{array}\]

\[\begin{array}{cccccccccccc}
011000 & 10101 \\
\end{array}\]

\[\begin{array}{cccccccccccc}
11010 & 10101 \\
\end{array}\]

\[\begin{array}{cccccccccccc}
1111 \\
\end{array}\]
(iii) Transmission time = 8000/50 = 160 msec  
\[ a = \frac{270}{160} = \frac{27}{16} \]  
\[ U = \frac{1}{1+2*a} = \frac{1}{1+2*\frac{27}{8}} = \frac{8}{35} \]  
\[ \text{Throughput} = \frac{8}{35} \times 50 = 11.43 \text{ kbps} \]

(iv)  
0 \rightarrow 160 \rightarrow 270 \rightarrow 430  \text{ Frame 1}  
(ACK comes back to A at 430+270 or 700 msec)  
700 \rightarrow 860 \rightarrow 970 \rightarrow 1130  \text{ Frame 2}  
\[ \text{Response time (milliseconds)} = 1130 \]

Question 4

(i)  
0,1,2 (Window size = 3 because we are using 2 bit sequence numbers)  
Transmission Time = 200 msec  
F0: 0-200 \rightarrow 270-470 (F0 accepted) ACK sent at 470  
F1: 200-400 \rightarrow 470 – 670 (F1 error, ignored)  
F2: 400-600 \rightarrow 670 – 870 (F2 ignored)  

Acknowledgement for F0 is received at t = 470+270 = 740 msec  
F3: 740-940 \rightarrow 1010 – 1210 (F3 ignored)  

At 1400, F1’s timer times out. Hence, the ones in the current window F1-F3 are sent again  
F1: 1400-1600 \rightarrow 1670-1870 (F1 accepted)  
F2: 1600-1800 \rightarrow 1870-2070 (F2 accepted)  
F3: 1800-2000 \rightarrow 2070-2270 (F3 accepted)  

\[ \text{Response time (milliseconds)} = 2270 \text{ msec} \]

(ii)  
F0: 0-200 \rightarrow 270-470 (accepted) ACK sent at 470  
F1: 200-400 \rightarrow 470 – 670 (F1 error, ignored)  

ACK for F0 received at 740.  
F2: 740-940 \rightarrow 1010 – 1210 (F2 accepted)  
F1 times out at 1400; so F1 is retransmitted:  
F1: 1400-1600 \rightarrow 1670 – 1870 (F1 accepted) ACK sent for F2  

ACK received for F2 at 1870+270 = 2140;  
F3: 2140-2340 \rightarrow 2410-2610  

\[ \text{Response time (milliseconds)} = 2610 \text{ msec} \]