ECE 462 **Data and Computer Communications**
Solutions to Homework 2

Problem 3.3

a. $\sin(2\pi ft - \pi) + \sin(2\pi ft + \pi) = 2\sin(2\pi ft - \pi)$ [or $2\sin(2\pi ft + \pi)$ or $-2\sin(2\pi ft)$]

b. $\sin(2\pi ft) + \sin(2\pi ft - \pi) = \sin(2\pi ft) - \sin(2\pi ft) = 0$

Problem 3.4

N	C		D		E		F		G		A		B		C
F	264		297		330		352		396		440		495		528
D		33		33		22		44		44		55		33	
W	1.25		1.11		1		0.93		0.83		0.75		0.67		0.63

Problem 3.12

Refer to Lecture notes. Retaining the vertical resolution of 483 lines, each horizontal line occupies 52.5 μsec. A horizontal resolution of H lines results in a maximum of H/2 cycles per line, thus the bandwidth of 5 MHZ allows:

5 MHZ = (H/2) / 52.5 μsec
H = 525 lines

Now if we assume the same horizontal resolution of H = 450 lines, then for a bandwidth of 5 MHZ, the duration of one line is:

5MHZ = (450 / 2) / T
T = 45 μsec

Allowing 11 μsec for horizontal trace, each line occupies 56 μsec. The scanning frequency is:

(1/30 s/scan) / V lines = 56 lines / μsec
V = 595 lines

In other words, number of vertical lines X 30 scans/sec gives you the number of lines/sec. So, when you have video line scan duration as 56 μsec, you have 1/56 μsec = 17857 lines/sec, or vertical resolution (number of lines) of 17857/30=595 lines.

Problem 3.13

a. (30 pictures/s) (480 × 500 pixels/picture) = 7.2×10^6 pixels/s
Each pixel can take on one of 32 values and can therefore be represented by 5 bits: R = 7.2×10^6 pixels/s × 5 bits/pixel = 36 Mbps

b. We use the formula: $C = B \log_2 (1 + SNR)$
$B = 4.5 \times 10^6$ Hz = bandwidth, and
SNR dB = 35 = $10 \log_{10}$ (SNR), hence
SNR = $10^{3.5}/10 = 103.5$, and therefore

$$C = 4.5 \times 10^6 \log_2 (1 + 103.5) = 4.5 \times 10^6 \times \log_2 (3163)$$
$$C = (4.5 \times 10^6 \times 11.63) = 52.335 \times 10^6 \text{ bps}$$

c. Allow each pixel to have one of ten intensity levels and let each pixel be one of three colors (red, blue, and green) for a total of 10 × 3 = 30 levels for each pixel element.

Problem 3.14

N = 10 log k + 10 log T + 10 log B
= –228.6 dBW + 10 log 104 + 10 log 107
= –228.6 + 40 + 70 = –118.6 dBW

Problem 3.15

Using Shannon's Formula: $C = B \log_2 (1 + SNR)$
We have W = 300 Hz
(SNR) dB = 3, therefore, SNR = $10^{0.3}$

$$C = 300 \log_2 (1 + 10^{0.3}) = 300 \log_2 (2.995) = 474 \text{ bps}$$

Problem 3.16

Using Nyquist's equation: $C = 2B \log_2 M$
We have C = 9600 bps

a. $\log_2 M = 4$, because a signal element encodes a 4-bit word
Therefore, C = 9600 = 2B × 4, and B = 1200 Hz

b. 9600 = 2B × 8, and B = 600 Hz

Problem 3.17

N = $1.38 \times 10^{-23} \times (50 + 273) \times 10{,}000 = 4.5 \times 10^{-17}$ watts

Problem 3.18

a. Using Shannon's formula: $C = 3000 \log_2 (1+400000) = 56$ Kbps

b. Due to the fact there is a distortion level (as well as other potentially detrimental impacts to the rated capacity, the actual maximum will be somewhat degraded from the theoretical maximum. A discussion of these relevant impacts should be included and a qualitative value discussed.

Problem 3.22

a. Output waveform:
$\sin (2\pi f_1 t) + 1/3 \sin (2\pi(3f_1)t) + 1/5 \sin (2\pi(5 f_1)t) + 1/7 \sin (2\pi (7 f_1)t)$
where $f_1 = 1/T = 1$ kHz
Output power = 1/2 (1 + 1/9 + 1/25 + 1/49) = 0.586 watt

b. Output noise power = 8 kHz × 0.1 μWatt/Hz = 0.8 mWatt
SNR = 0.586/0.0008 = 732.5 (SNR) db = 28.65