Solution to HW2

4.3 (12 pts)
The allowable power loss is $10 \times \log 100 = 20$ dB
a. From Figure 4.3, the attenuation is about 13 dB per km.
Length = (20 dB)/(13 dB per km) = 1.5 km
b. Length = (20 dB)/(20 dB per km) = 1 km
c. Length = (20 dB)/(2.5 dB per km) = 8 km
d. Length = (20 dB)/(10 dB per km) = 2 km
e. Length = (20 dB)/(0.2 dB per km) = 100 km

4.7 (8 pts)
a. Using $\lambda f = c$, we have $\lambda = (3 \times 10^8$ m/sec)/(300 Hz) = 1,000 km, so that $\lambda/2 = 500$ km.
b. The carrier frequency corresponding to $\lambda/2 = 1$ m is given by:
$f = c/\lambda = (3 \times 10^8$ m/sec)/(2 m) = 150 MHz.

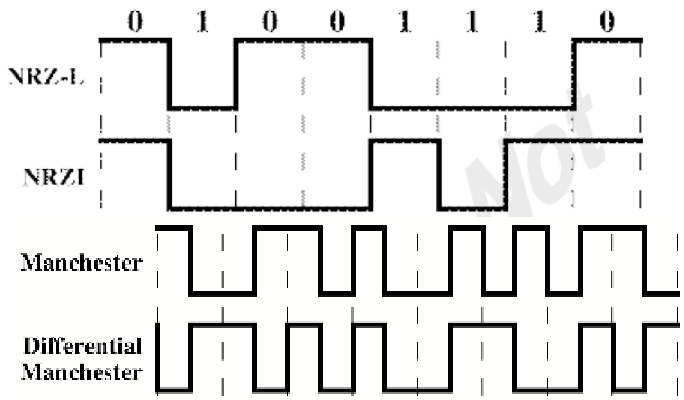
4.11 (10 pts)

Distance (km)	Radio (dB)	Wire (dB)
1	–6	–3
2	–12	–6
4	–18	–12
8	–24	–24
16	–30	–28

4.14 (16 pts)
a. From Appendix 3A, $Power_{dBW} = 10 \log (Power_W) = 10 \log (50) = 17$ dBW
$Power_{dBm} = 10 \log (Power_{mW}) = 10 \log (50{,}000) = 47$ dBm
b. Using Equation (4.3),
$L_{dB} = 20 \log(900 \times 10^6) + 20 \log (100) - 147.56 = 120 + 59.08 + 40 - 147.56 = 71.52$
Therefore, received power in dBm = 47 – 71.52 = –24.52 dBm
c. $L_{dB} = 120 + 59.08 + 80 - 147.56 = 111.52$; $P_{r,dBm} = 47 - 111.52 = -64.52$ dBm
d. The antenna gain results in an increase of 3 dB, so that $P_{r,dBm} = -61.52$ dBm
Source: [RAPP96]

4.15 (12 pts) a. $G = 7A/\lambda^2 = 7Af^2/c^2 = (7 \times \pi \times (0.6)^2 \times (2\times10^9)^2]/(3 \times 10^8)^2 = 351.85$
$G_{dB} = 25.46$ dB
b. 0.1 W x 351.85 = 35.185 W
c. Use $L_{dB} = 20 \log (4\pi) + 20 \log (d) + 20 \log (f) - 20 \log (c) - 10 \log(G_r) - 10 \log(G_t)$
$L_{dB} = 21.98 + 87.6 + 186.02 - 169.54 - 25.46 - 25.46 = 75.14$ dB
The transmitter power, in dBm is 10 log (100) = 20.
The available received signal power is 20 – 75.14 = –55.14 dBm

5.6 (12 pts)



5.21 (10 pts)
a. $(SNR)_{db} = 6.02\ n + 1.76 = 30$ dB
$n = (30 – 1.76)/6.02 = 4.69$
Rounded off, n = 5 bits
This yields $2^5 = 32$ quantization levels
b. R = 7000 samples/s × 5 bits/sample = 35 Kbps

8.1 (10 pts)
a. The available bandwidth is 3100 – 400 = 2700 Hz. A scheme such as depicted in Figure 8.4 can be used, with each of the four signals modulated onto a different 500-Hz portion of the available bandwidth.
b. Each 500-Hz signal can be sampled at a rate of 1 kHz. If 4-bit samples are used, then each signal requires 4 kbps, for a total data rate of 16 kbps. This scheme will work only if the line can support a data rate of 16 kbps in a bandwidth of 2700 Hz.

8.9 (8 pts)
Assuming 4 kHz per voice signal, the required bandwidth for FDM is 24 × 4 = 96 kHz. With PCM, each voice signal requires a data rate of 64 kbps, for a total data rate of 24 × 64 = 1.536 Mbps. At 1 bps/Hz, this requires a bandwidth of 1.536 MHz.

8.11 (14 pts)
a. n = 7 + 1 + 1 + 2 = 11 bits/character
b. Available capacity = 2400 × 0.97 = 2328 bps
If we use 20 terminals sending one character at a time in TDM plus a synchronization character, the total capacity used is:
21 × 110 bps = 2310 bps available capacity
c. One SYN character, followed by 20 11-bit terminal characters, followed by stuff bits.