EE194WIN Spring 2004, HW3 solution:

1

<table>
<thead>
<tr>
<th>Distance (km)</th>
<th>Radio (dB)</th>
<th>Wire (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-6</td>
<td>-3</td>
</tr>
<tr>
<td>2</td>
<td>-12</td>
<td>-6</td>
</tr>
<tr>
<td>4</td>
<td>-18</td>
<td>-12</td>
</tr>
<tr>
<td>8</td>
<td>-24</td>
<td>-24</td>
</tr>
<tr>
<td>16</td>
<td>-30</td>
<td>-48</td>
</tr>
</tbody>
</table>

4 a. Using $\lambda f = c$, we have $\lambda = (3 \times 10^8 \text{ m/sec})/(300 \text{ Hz}) = 1000 \text{ km}$, so that $\lambda/2 = 500 \text{ km}$.
   b. The carrier frequency corresponding to $\lambda/2 = 1 \text{ m}$ is given by:
   \[ f = c/\lambda = (3 \times 10^8 \text{ m/sec})/(2 \text{ m}) = 150 \text{ MHz}. \]

9 We have $P_r = [(P_t) (G_t) (G_r) (c)^2]/(4\pi fd)^2$
   \[ = [(1) (2) (3 \times 10^8)^2]/[(16) (\pi)^2 (3 \times 10^8)^2 (10^4)^2] = 0.76 \times 10^{-9} \text{ W} \]

10 a. From Appendix 2A, $\text{Power}_{\text{dBW}} = 10 \log \text{ (Power}_W) = 10 \log (50) = 17 \text{ dBW}$
   $\text{Power}_{\text{dBm}} = 10 \log \text{ (Power}_W) = 10 \log (50,000) = 47 \text{ dBm}$
   b. Using Equation (5.2),
   \[ L_{dB} = 20\log(900 \times 10^6) + 20\log(100) - 147.56 = 120 + 59.08 + 40 - 147.56 = 71.52 \]
   Therefore, received power in dBm = 47 - 71.52 = -24.52 dBm
   c $L_{dB} = 120 + 59.08 + 80 - 147.56 = 111.52$; $P_{r,\text{dBm}} = 47 - 111.52 = -64.52 \text{ dBm}$
   d The antenna gain results in an increase of 3 dB, so that $P_{r,\text{dBm}} = -61.52 \text{ dBm}$

13 For radio line of sight, we use $d = 3.57 \sqrt{K h}$, with $K = 4/3$, we have
   \[ 80^2 = (3.57)^2 \times 1.33 \times h. \]
   Solving for $h$, we get $h = 378 \text{ m}$.

15 a. Output waveform:
   \[ \sin (2\pi f_1 t) + 1/3 \sin (2\pi (3f_1) t) + 1/5 \sin (2\pi (5f_1) t) + 1/7 \sin (2\pi (7f_1) t) \]
   where $f_1 = 1/T = 1 \text{ kHz}$
   Output power = $1/2 \left(1 + 1/9 + 1/25 + 1/49\right) = 0.586 \text{ watt}$
   b. Output noise power = $8 \text{ kHz \times 0.1 \mu Watt/Hz = 0.8 \text{ mWatt}$
   $\text{SNR} = 0.586/0.0008 = 732.5 \quad (\text{SNR})_{dB} = 28.65$