Daniel Detore
EE441

HW 1

$d = 22$
$G_r = G_t = 1$

$\lambda = \frac{c}{f_c} = \frac{3e8}{950e6} = .3158m$

a) $P_t = 38$ dBm

$P_t = \frac{10^{38/10}}{1000} = 6.3096$ W

$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi d}\right)^2 = 6.3096\left(\frac{.3158}{4\pi \cdot 22}\right) = 7.2074e{-3}$ W

$P_r = 10\log_{10}(1000 \cdot 7.2074e{-3}) = \boxed{8.5778 \text{ dBm}}$

b) $P_r = -100$ dBm $= 10^{(-100)/10}/1000 = 1e{-13}$ W

$P_t = P_r\left(\frac{4\pi d}{\lambda\sqrt{G_r G_t}}\right)^2 = 10^{-13}\left(\frac{4\pi 22}{.3158}\right) = 8.7543e{-11}$ W

$P_t = 10\log_{10}(1000 \cdot 8.7543e{-11}) = \boxed{-70.5778 \text{ dBm}}$

c) $\lambda = \frac{c}{f_c} = \frac{3e8}{2.45e9} = .1224$ m

$P_t = 10^{-13}\left(\frac{4\pi 22}{.1224}\right) = 2.2587e{-10}$ W

$P_t = 10\log_{10}(1000 \cdot 2.2587e{-10}) = \boxed{-96.4614 \text{ dBm}}$

2.

$G_r = G_t = 1$.

$P_r = -30\ dBm$

$d = 50, 15, 90$

$\lambda = \frac{c}{f_0} = \frac{3e8}{2.4e9} = .1250\ m$

$P_r = \frac{10^{-30/10}}{1000} = 1e\text{-}6\ W$

$P_t = P_r\left(\frac{4\pi d}{\lambda}\right)^2 = \begin{cases} 10^{-6}\left(\frac{4\pi 50}{.1250}\right)^2 = 25.2662\ W \\ 10^{-6}\left(\frac{4\pi 15}{.1250}\right)^2 = 2.2740\ W \\ 10^{-6}\left(\frac{4\pi 90}{.1250}\right)^2 = 81.8624\ W \end{cases}$

$P_L = 20\log_{10}(d) - 20\log_{10}(\lambda) + 20\log_{10}(4\pi)$

$= 20\log(50) - 20\log(.1250) + 20\log_{10}(4\pi)$

$= 74.0254\ dB$ when $d = 50m$

$= 20\log(15) - 20\log(.1250) + 20\log(4\pi)$

$= 65.5678\ dB$ when $d = 15m$

$= 20\log(90) - 20\log(.1250) + 20\log(4\pi)$

$= 79.1308\ dB$ when $d = 90m$

$= 10\log_{10}(25.2662) + 30 = 44.0254\ dBm$ when $d = 50m$

$= 10\log_{10}(2.2740) + 30 = 33.5679\ dBm$ when $d = 15m$

$= 10\log_{10}(81.8624) + 30 = 49.1308\ dBm$ when $d = 90m$

3)

$\delta = 2000$ m
Find d

$SIR = 16$ dB $= 10^{16/10} = 39.81$ $\quad \gamma = .28$

$$SIR = \frac{P_r}{P_I} \geq 16 \text{ dB}$$

max distance $d = \sqrt{2}$ km $= 1.414$, interferer at $d_I = d - 1$

one interference $P_i = P/(d-1)^{\gamma}$
because 2 interfering powers,

$$SIR = \frac{P_R}{2P_I} = \frac{1}{2}\left(\frac{d-1}{\sqrt{2}}\right)^{0.28} = 39.81$$

$$\left(\frac{d-1}{\sqrt{2}}\right)^{.28} = 79.62$$

$$\frac{d-1}{\sqrt{2}} = \sqrt[.28]{79.62} = 6.1564\,e6$$

$$d - 1 = 8.7072\,e6$$

$$\boxed{d = 6.7072\,e6 \text{ Km}}$$

4) $f_c = 800\ MHz = 8\times10^8\ Hz$

$h_t = 7,\ h_r = 7.2m$ (outdoor) $\qquad h_t = .8,\ h_r = .25$ (indoor)

$\lambda = \frac{c}{f_c} = \frac{3\times10^8}{8\times10^8} = .375\ m$

$d_c = \frac{4h_t h_r}{\lambda} = \frac{4(7)(7.2)}{.375} = 164.2667\ m$ outdoor

$\frac{4(.8)(.25)}{.375} = 2.1333\ m$ indoor

5) $f_c = 890\ MHz = 8.9\times10^8 Hz,\ P_t = 24dB,\ h_t = 4^m h_r = .95^m,\ d = 100$

$\tau = \frac{(x+x') - l}{c} = \frac{\sqrt{(h_t+h_r)^2+d^2} - \sqrt{(h_t-h_r)^2+d^2}}{3e8}$

$d = 2d_c$ where $d_c = \frac{4\pi h_t h_r}{\lambda P} = 318.7460\ m$

$\Rightarrow d = 637.4920$

$\Rightarrow \boxed{\tau = 8.9404\ e\text{-}11s}$

$d = 1.5 d_c = 478.1190\ m$ $\qquad P_t = 24\ dB = 10^{24/10} = 2.5119\ e2$

$P_r = P_t G_r G_t \left(\frac{h_t h_r}{d^2}\right)^2 = 3.5139\ e\text{-}7\ mW$

$= 10\log_{10}(3.5139\ e\text{-}7) = \boxed{-64.542\ dBm}$