Problem 1:

BW = 500MHz , $R = 36 \times 10^6$ m , Diameter $= 30 \times 10^{-2}$ m

$\epsilon_{ap} = 80\%$, $T_{re} = 75K$, $P_{radiated} = 100W$

$f = 11.7 \times 10^9 - 12.2 \times 10^9$ Hz

1) Take $f_0 = 12 \times 10^9$ Hz

effective aperture area of the receiver antenna $= \pi \times (15 \times 10^{-2}) \times 0.8 = 0.0565 m^2$

$D_{receiver} = \frac{4\pi A_{re}}{\lambda^2} = 1137 = 30.5 dB$

$D_r = \frac{32400}{\theta_H \cdot \theta_E} \Rightarrow \theta_{Half-power} = \sqrt{32400 \times 1137} = 5.33$ rad.

$\theta_H = \theta_E$

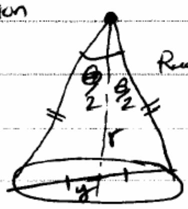
2) $Space\_LF = \left(\frac{\lambda}{4\pi r}\right)^2 = 3.05 \times 10^{-21} = -205.15 dB$

3) $D_t = 33dB$, $\epsilon_{ap} = 0.85$

$\Rightarrow A_{te} = \frac{D_t \cdot \lambda^2}{4\pi} = 0.0992 m^2$

$\Rightarrow$ physical area $= \frac{A_{te}}{0.85} = 0.1167 m^2$

by θ_E, θ_H assumption we have Canonical Radiation pattern.



$y = r \tan \theta/2$, θ is HPBW

$\Rightarrow y = 1.83 \times 10^{7} m^2$

$\Rightarrow$ foot print $= \pi y^2 = 1.0635 \times 10^{15} m^2$

1063.5 km^2

4) Yes we can since we decreased the power by a factor of 10 ($-10dB$) but we increased the transmit gain by 10dB. Therefore, we will end up with the same received power at the receiver. This is calculated to be 0.692 pW.

no

less coverage on Earth!

5) $S/N = ??$

$$P_{received} = \frac{P_{rad}}{4\pi r^2} \cdot G_t G_r \cdot \frac{\lambda^2}{4\pi} = 0.692\ pW$$

$$P_{noise} = KTB = 0.5175 \times 10^{-13}\ W$$

$$\Rightarrow S/N = 1.338 \Rightarrow SNR = 1.26\ dB.$$

yes but I made a mistake ~~it~~ is 1000W!

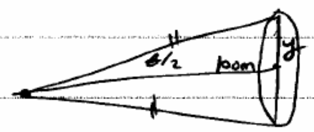
$\Rightarrow$ 11.26 dB!

Problem 2:

a) $A_{re} = \pi r^2 \cdot \epsilon_{ap} = \pi (5\times10^{-2})^2 \times 0.6 = 0.0047\,m^2$

$D_r = \frac{4\pi}{A_{re}} \cdot \lambda^2 = 3901 = 35.9\,dB$

$\theta_{HPBW} = \sqrt{32400/D_r} = 2.88$ rad.



$y = 100 \tan \theta/2 = 765$ m

$\Rightarrow$ View area $= 1.8\,Km^2$!!

b) $D_t = D_r = 35.9\,dB$

$P_r = \frac{\lambda^2 \cdot D_t^2\, \delta}{(4\pi)^3 r^4} \cdot P_{rad} = 5.82\,pW$

c) $P_n = KTB = 2.48\times10^{-14}\,W$

$SNR = 10 \Rightarrow P_{received} = 2.48\times10^{-13}$

$r = \left[\frac{\lambda^2 D_t^2\, \delta}{(4\pi)^3 P_{received}} \cdot P_{rad}\right]^{0.25} = 220$ m.

Problem 3:

$$E_{max} = \frac{90I}{r} e^{j\omega t - kr}$$

$$D_{max} = \frac{U_{max} \cdot 4\pi}{P_{rad}} \quad , P_{rad} = \frac{1}{2} I^2 R_r = 25 I^2$$

$$U_{max} = \frac{(90)^2 I^2}{2 \times 377} \Rightarrow D_{max} = \frac{90}{50 \times 377} \times 4\pi = 5.39$$

$$A_{emax} = \frac{\lambda^2}{4\pi} D_{max} = 0.429 \lambda^2$$

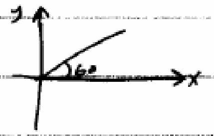
Problem 4:

CW circular polarized antenna

$\Rightarrow E_x = E_y$, $\phi_{E_y} - \phi_{E_x} = -\pi/2$ (+ve z propagation)

$\Rightarrow a_w = \frac{1}{\sqrt{2}}(\hat{a}_x - j\hat{a}_y)$

a)



$\hat{a}_{antenna} = \frac{\hat{a}_x}{2} + \frac{\sqrt{3}}{2}\hat{a}_y$

$PLF = |\hat{a}_w \cdot \hat{a}_{antenna}|^2 = \left|\frac{1}{\sqrt{2}} \cdot \frac{1}{2} - \frac{1}{\sqrt{2}} \cdot \frac{\sqrt{3}}{2}\right|^2$

$= \frac{1}{8} + \frac{3}{8} = \frac{1}{2}$

b) y direction $\hat{P}_a = \hat{a}_y$

$\Rightarrow PLF = \left|\frac{1}{\sqrt{2}}(\hat{a}_x - j\hat{a}_y) \cdot \hat{a}_y\right|^2 = \frac{1}{2}$

c) $\vec{P}_a = \frac{1}{2}(\hat{a}_x + j3\hat{a}_y)$

$\Rightarrow PLF = \left|\frac{1}{2\sqrt{2}} + \frac{3}{2\sqrt{2}}\right|^2 = \frac{16}{4 \times 2} = 2$?

How can it be > 1 ?