Antennas Exam 10/01/2023

Exercise One

a.) ii) Directivity, $D = \frac{U_m}{U_{ave}} = \frac{U_m}{P/4\pi}$

iii) Gain, Two def's:

$$G = \frac{U_m}{P_{in}/4\pi}$$

$$G = \frac{U_m/r^2}{P_{in}/(4\pi r)^2}$$

iv.) Radiation efficiency, $e_r = \frac{G}{D}$

I didn't want to write the wordy definitions again.
Did I make a mistake here with the equations or the explanations?

In your email you said that I didn't answer the first question well so I want to check all of this.

b.) i) $P_{max.} = A_e \cdot \vec{S}$

$\therefore A_e = \frac{P_{max.}}{\vec{S}}$

ii) $G = \frac{4\pi}{\lambda^2} \cdot A_e$

$\therefore \frac{G \cdot \lambda^2}{4\pi} = A_e = f(G)$

Same question for these answers

C.) Friss trans. eq.

If trans. ant. were isotropic:

$$\vec{S} = \frac{P_T}{4\pi r^2}$$

As trans. ant. has gain:

$$\vec{S} = G_T \frac{P_T}{4\pi r^2}$$

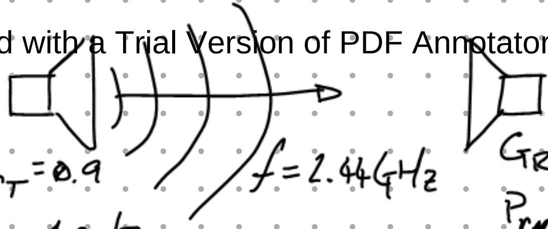
Given effec. area eq., for recieving ant. can be expressed as:

$$P_R = A_{eR} \cdot \vec{S} = A_{eR} \cdot G_T \frac{P_T}{4\pi r^2}$$

Given effective area formula: $A_{eR} = \frac{G_R \lambda^2}{4\pi}$

$\therefore P_R = G_T \cdot G_R \cdot P_T \cdot \left(\frac{\lambda}{4\pi r}\right)^2$ = <u>FRISS TRANS. EQUATION</u>

d.)



$e_{rT} = 0.9$ $\quad f = 2.44\,GHz$ $\quad G_R = 6\,dB$

$D_T = 10\,dB$ $\quad P_{rmR} = 1\,\mu W$

50m

$P_{inT} = ??$ $\qquad P_T = ??$

I do know log. scale I think that in my work I forgot to convert dB to ordinary gain in this question?? However, I'm not absolutely sure.

Eq's:

$G = e_r \cdot D$

$P_W = 1W \cdot 10^{(P_{dBW}/10)}$

$P_{dBW} = 10 \log\left(\frac{P_W}{1\,W}\right)$

$P_{mW} = 1mW \cdot 10^{(P_{dBm}/10)}$

$P_{dBm} = P_{dBW} + 30$

$P_{dBW} = P_{dBm} - 30$

$G_{dB} = 10 \log\left(\frac{P_{OUT}}{P_{IN}}\right)$

$G = 10^{(G_{dB}/10)}$

$G = \frac{P_{OUT}}{P_{IN}}$

$P_{OUT} = P_{IN} \cdot 10^{(G_{dB}/10)}$

$P_R = G_T \cdot G_R \cdot P_T \cdot \underbrace{\left(\frac{\lambda}{4\pi r}\right)^2}_{\text{UNITLESS}}$

$P_R \to 1\,\mu W$, $\quad G_R \to 6\,dB$, $\quad r \to 50m$

$G_T = e_{rT} \cdot D_T = 0.9 \times 10\,dB$

$= 9\,dB$

$\lambda = \frac{c}{f} = \frac{\approx 3 \times 10^8}{2.44 \times 10^9} \approx 0.123m$

$G_T = 10^{(9dB/10)} \approx 7.943$

$G_R = 10^{(6dB/10)} \approx 3.981$

$P_T = \frac{P_R}{G_T\, G_R \left(\frac{\lambda}{4\pi r}\right)^2} = \frac{1 \times 10^{-6}\,W}{3.981 \times 7.943 \times \left(\frac{0.123}{4\pi \times 50}\right)^2}$

$P_T \approx 0.825$ Watts Power radiated by transmitter

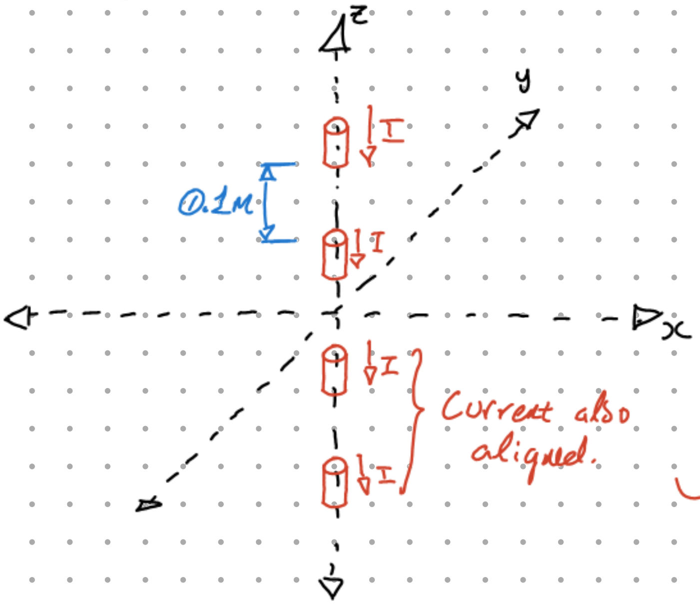
$P_{inT} = P_T / G_T = 0.825 / 7.943 = 0.104$ Watts Power @ input of trans.

I think I must have made a mistake in this question by forgetting to convert gain in dB to "ordinary" gain.

Exercise Three

Array of 4 antennas, aligned in Z-axis. $freq = 3GHz$

$\alpha = 0$



Aligned along z???
(Imagine these are monopoles)
Is this the correct interpretation??
In the exam I forgot the ψ_{NULL} and ψ_{MAX} eq's so could not complete this question.

Eq's:

$$\psi = \beta \times a \times \cos(\theta) + \alpha$$

$\beta \rightarrow 2\pi/\lambda \rightarrow \frac{2\pi}{0.1} \approx 62.832$

$a \rightarrow 0.1M$

a.) $\psi_{MAX} = \pm 0, \pm 2\pi, \pm 4\pi, \pm 6\pi \ldots$

$\psi_{NULL} = \pm 2k\pi/N \quad k \neq N, 2N, 3N \ldots$
$(4, 8, 12 \ldots)$

$\psi = 0 \quad \cos^{-1}\left(\frac{0}{62.832 \times 0.1}\right) = \cos^{-1}(0) = \pm\frac{\pi}{2}$ Rad $= \pm 180°$

$\psi = \pm 2\pi \quad \theta_{MAX} = \cos^{-1}\left(\frac{2\pi}{62.832 \times 0.1}\right) = \pm 0.00216$ Rad $\approx \pm 0.12°$

$\psi = \pm 4\pi$ Non-real result.

$\psi = \pm 6\pi$ Non-real result

$\psi = \pm 8\pi$ Non-real result

likely no more Maximas

Exercise Three cont...

a.) cont... $k=1$:

$$\frac{2\pi}{4} = 62.832 \times 0.1 \times \cos(\theta)$$

$$\Rightarrow \theta = \cos^{-1}\left(\frac{2\pi/4}{62.832 \times 0.1}\right) = \pm 1.546 \text{ Rad} \approx \pm 88.56^\circ$$

$k=2$

$$\frac{4\pi}{4} = 62.832 \times 0.1 \times \cos(\theta)$$

$$\theta = \cos^{-1}\left(\frac{\pi}{62.832 \times 0.1}\right) = \pm 1.521 \text{ Rad} \approx \pm 87.15^\circ$$

$\Psi_{max} = 0, \pm 2\pi, \pm 4\pi, 6\pi$

$k=3$

$$\frac{6\pi}{4} = 62.832 \times 0.1 \times \cos(\theta)$$

$$\theta = \cos^{-1}\left(\frac{(3/2\,\pi)}{62.832 \times 0.1}\right) = \pm 1.496 \text{ Rad} \approx \pm 85.71^\circ$$

$k=5$

$$\frac{10\pi}{4} = 62.832 \times 0.1 \times \cos(\theta)$$

$$\theta = \cos^{-1}\left(\frac{\left(\frac{10\pi}{4}\right)}{62.832 \times 0.1}\right) = \pm 1.446 \text{ Rad} \approx \pm 82.85^\circ$$

$k=6$

$$\frac{12\pi}{4} = 62.832 \times 0.1 \times \cos(\theta)$$

$$\theta = \cos^{-1}\left(\frac{3\pi}{62.832 \times 0.1}\right) = \text{Non-real result}$$

$k=7$

$$\frac{14\pi}{4} = 62.832 \times 0.1 \times \cos(\theta)$$

$$\theta = \cos^{-1}\left(\frac{\left(\frac{14\pi}{4}\right)}{62.832 \times 0.1}\right) = \text{Non-Real result}$$

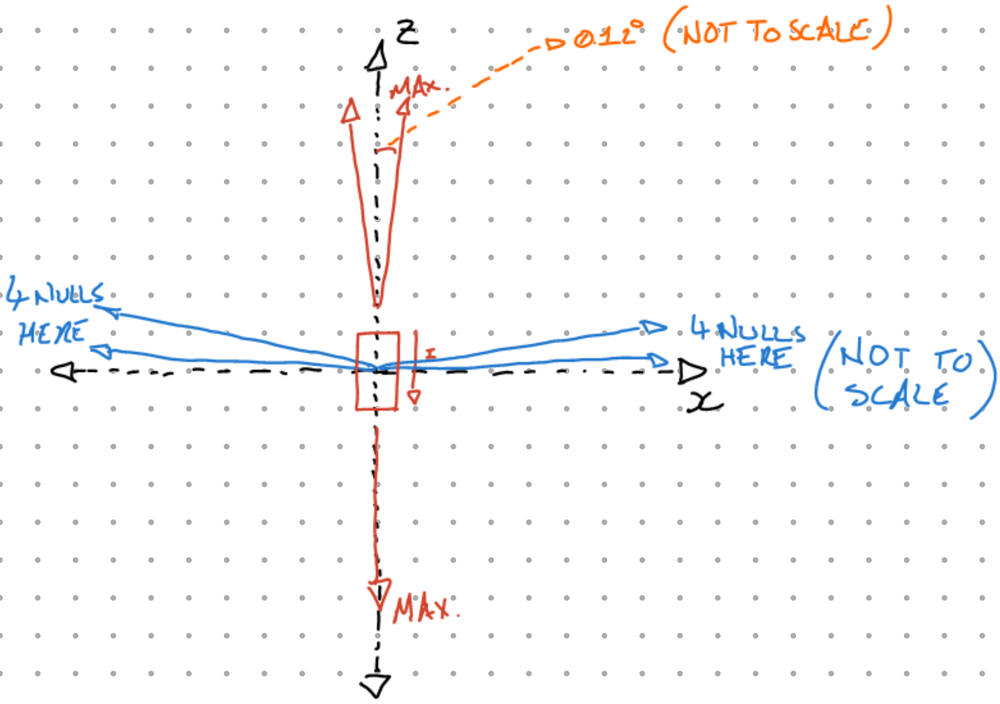
Likely no more real results.

Exercise Three cont...

a.) cont...

i.) MAX. Directions: $\pm 0.12°$, $180°$

NULL Directions: $\pm 88.56°$, $\pm 87.15°$, $\pm 85.71°$, $\pm 82.85°$



Size of main lobes: $\frac{4\pi}{N}$
$= \pi$ Rad.
$= 180°$

No. of Main lobes: $N-1$
$= 3$

Size of side lobes: $\frac{2\pi}{N}$
$= \pi/2$ Rad.
$= 90°$

No. of Side lobes: $N-2$
$= 2$

I can't figure out how to draw this...

Did I get something wrong? I've checked a few times and can't seem to find where, if I've made mistakes.