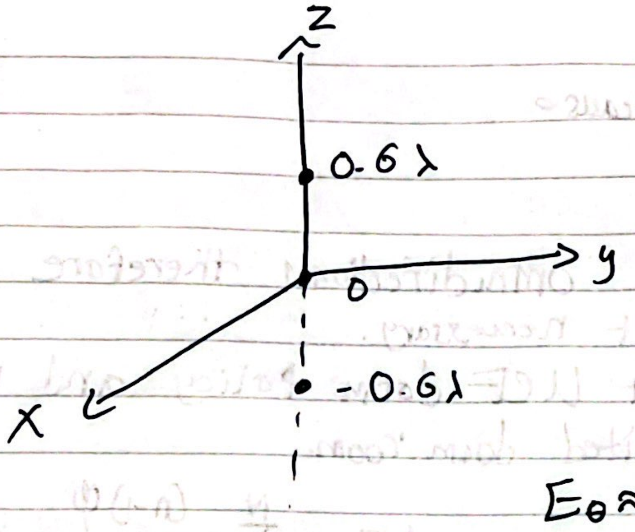
①



$AF = 1 + e^{jkd\cos\theta}, - e^{jkd\cos\theta}$

$AF = 1 + 2\cos(kd\cos\theta)$

$kd = \frac{2\pi}{\lambda}\cdot\frac{6\lambda}{10} = 1.2\pi$

$AF = 1 + 2\cos(1.2\pi\cos\theta)$

$E_\theta \approx j\eta \underbrace{\frac{kI_0Le^{-jkr}}{8\pi r}}_{C_1} \sin\theta$ (small dipole) $\rightarrow E_\theta = C_1 \sin\theta$

HPBW $\approx 105° - 75° \approx 30°$
(from plot)

$\cancel{U = r^2 W_{rad} = \frac{\eta^2 k^2 I_0^2 L^2 \cdot 2\pi \cdot \frac{4}{3}}{64\pi^2 \cdot 2\eta}}$

$W_{rad} = \frac{C_1^2}{2\eta}\sin^2\theta$

$\cancel{U = \frac{-j\eta k^2 I_0^2 L^2}{64\pi^2 \cdot 2}\sin^2\theta}$

$\cancel{P_{rad} = \frac{C_1^2 \cdot 2\pi}{2\eta}\int_0^\pi \sin^3\theta \, d\theta}$

$\cancel{P_{rad} = \frac{8\pi}{8\eta} = \frac{4\pi C_1^2}{3\eta}}$

$W_{rad} = \cancel{E_t} \approx (AF \cdot E_\theta)^2 = \frac{(1+2\cos(1.2\pi\cos\theta))^2 \sin^2\theta}{2\eta} \cdot C_1^2$

$U(\theta) = r^2 W_{rad}$ $\quad U_{max} = 9\,C_1^2/2\eta$ $\quad P_{rad} \approx 29.59$ (matlab)

$D_0 = \frac{4\pi U_{max}}{P_{rad}} = 3.822$

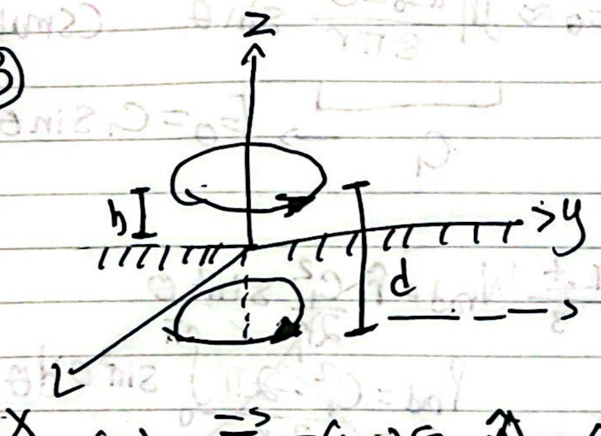
$D_0\,(dB) \approx 13.4079$

The designers choose 3 elements because they wanted higher directivity and better power handling, and to avoid interference with sky objects, since all cell users are on the ground. Five elements would have a lower HPBW which may cause cell user to have a bad signal based on their elevation. ~~and if th~~

② Rabbit ear because

- Cheaper
- OTA channels are omnidirectional therefore a high gain anttena is not neccessary.
- Could be aganist UCF dorm Policy and will occupy more space in limited dorm room.

③



$$AF = \sum_{n=1}^{N} e^{(n-1)\psi} \qquad \psi = kd\cos\theta$$

$$AF = 1 + (-1)e^{jkd\cos\theta} \qquad kd = \frac{2\pi}{\lambda}\cdot 2h\cos\theta$$

$$\psi = 2kh\cos\theta$$

$$E_\phi = j\frac{kI_m l\sin\theta}{4\pi r}\left[1+\frac{1}{jkr}\right]e^{-jkr}$$

(a) $\vec{E}_t = (AF)(E_\phi\hat{\phi}) = (1 - e^{2jkh\cos\theta})\left(\frac{jI_m l\sin\theta}{4\pi r}\right)\left[1+\frac{1}{jkr}\right]e^{-jkr}$

(b) $AF = 1 - \cos(4\pi(\cos\theta)) - j\sin(4\pi(\cos(\theta)))$

$AF = 0$ when $\theta = 0, \pi/3, \pi/2, 2\pi/3, \pi$

(plotted on desmos) $\theta = 0°, 60°, 90°, \cancel{270}°, 120°, 180°$

(C) $\vec{E}_t = [1 - e^{jkd\cos\theta}]\,\cancel{[1+\frac{1}{jkr}]\left[j\frac{kI_m l\sin\theta}{4\pi r}\right]e^{-jkr}}$

$\theta = \pi/3$

$$1 - e^{-jkd\cos(\pi/3)} \Longrightarrow 1 - \exp(-j\tfrac{1}{2}\cdot\tfrac{2\pi}{\lambda}\cdot 2h) \quad h = \alpha\lambda$$

$$\Longrightarrow 1 = \exp(-j2\pi\alpha) = \cos(2\pi\alpha) + j\sin(2\pi\alpha)$$

$$2\pi\alpha = \pi \Longrightarrow \alpha = 1/2 \longrightarrow h = 2\alpha\lambda$$

$$\alpha = 1, 2, 3, \ldots, n$$

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$e_{cd} = \frac{\quad}{R_r + R_L}$

(4) $R_{series} = \frac{Na}{b} R_s$ (1 MHz, 100 turns)

$R_s = \sqrt{\frac{2\pi f \mu_0}{2\sigma}} = \sqrt{\frac{2\pi \times 10^6 \times 4\pi \times 10^{-7}}{2 \times 5.8 \times 10^7}} = 260 \mu\Omega$

a: loop radius = 1/2 cm

b: wire radius = 100 um

$R_{ohmic} \approx 1.3044 \Omega$

$R_f \approx 20\pi^2 \left(\frac{C}{\lambda}\right)^4 N^2 \mu_{cer}^2 = 20\pi^2 \left(\frac{2\pi \cdot 1/2 \cdot 1/100}{3 \times 10^8 / 10^6}\right) 100^2 \cdot 100$

$R_f = 2 \times 10^9 \cdot \pi^2 \left(\frac{\pi/100}{300}\right)^4 = 2.37 \mu\Omega$

$e_{cd} = \frac{2.37 \mu\Omega}{2.37 \mu\Omega + 1.3044 \Omega} = 1.8 \times 10^8 \% \approx 0$

(dipole)

$R_r = 80\pi^2 \left(\frac{l}{\lambda}\right)^2$

$\lambda_{1MHz} = \frac{3 \times 10^8}{10^6} = 300 M$

$R_r \approx 80 (10) \left(\frac{3/4}{300}\right)^2$

$R_r \approx 5.13 m\Omega$

$\lambda_{98MHz} = \frac{3 \times 10^8}{98 \times 10^6} = \frac{300}{98} m = 3.0$

$R_{loss} = \frac{l}{2\pi a} \sqrt{\frac{2\pi f \mu_0}{2\sigma}} = \frac{0.75}{2\pi \times 10^{-3}} \sqrt{\frac{4\pi^2 \cdot 10^6 \cdot 10^{-7}}{2 \cdot 5.8 \times 10^7}} = 0.75 \sqrt{\frac{1}{12+}}$

$R_{loss} \approx 22.02 m\Omega$

$e_{cd} = \frac{5.13}{22.02 + 5.13} \approx 19 \%$ efficiency

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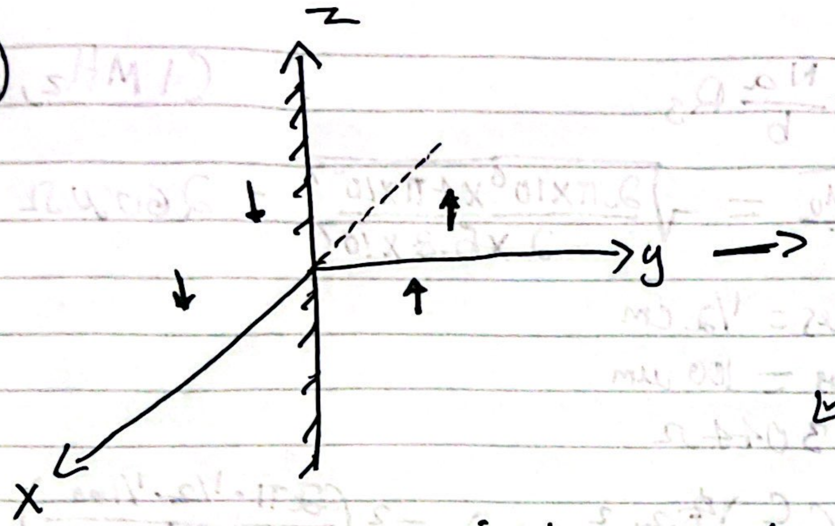
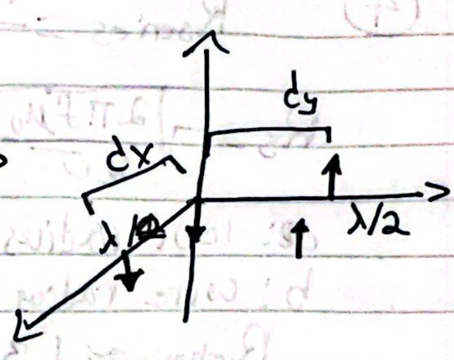
(5)





$$AF = \cancel{e} + (-1) - e^{jk\,dx\sin\theta\cos\phi} + e^{jk\,dy\sin\theta\sin\phi}$$

$$+\, e^{jk\,dx\sin\theta\cos\phi}\, e^{jk\,dy\sin\theta\sin\phi}$$

$$k\,dx = \frac{2\pi}{\lambda}\cdot\frac{\lambda}{2} = \pi$$

$$k\,dy = \pi$$

$$AF = -1 - e^{j\pi\sin\theta\cos\phi} + e^{j\cancel{kdy}^{\pi}\sin\theta\sin\phi} + e^{j\pi(\sin\theta\cos\phi + \sin\theta\sin\phi)}$$

$$\cancel{AF = -1 - e^{j\pi}}$$

$$E_t \approx (G\sin\theta)\,AF$$

$$G = j\eta\frac{kI_0 l e^{-jkr}}{8\pi r}$$

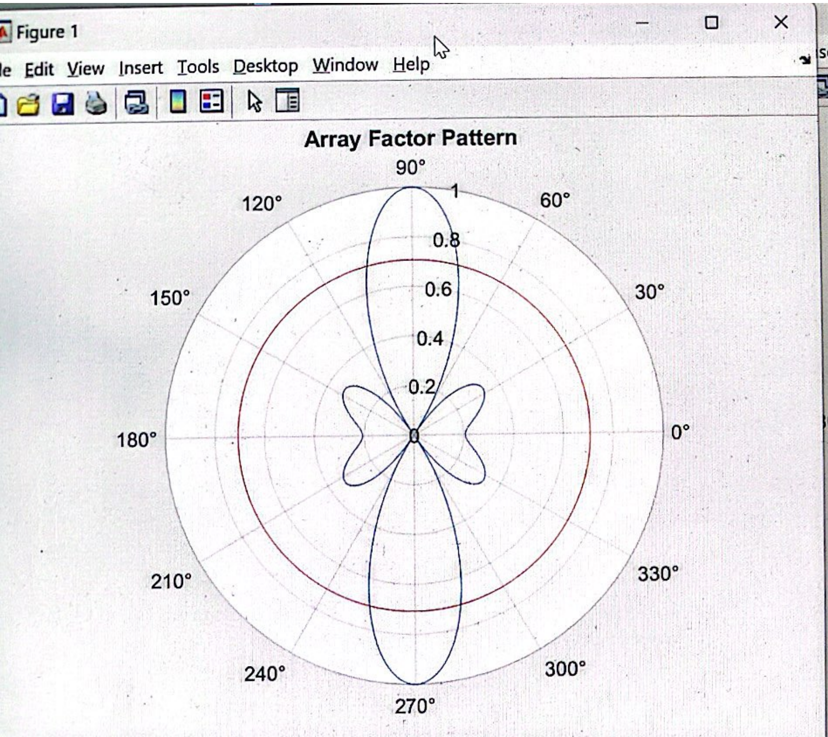
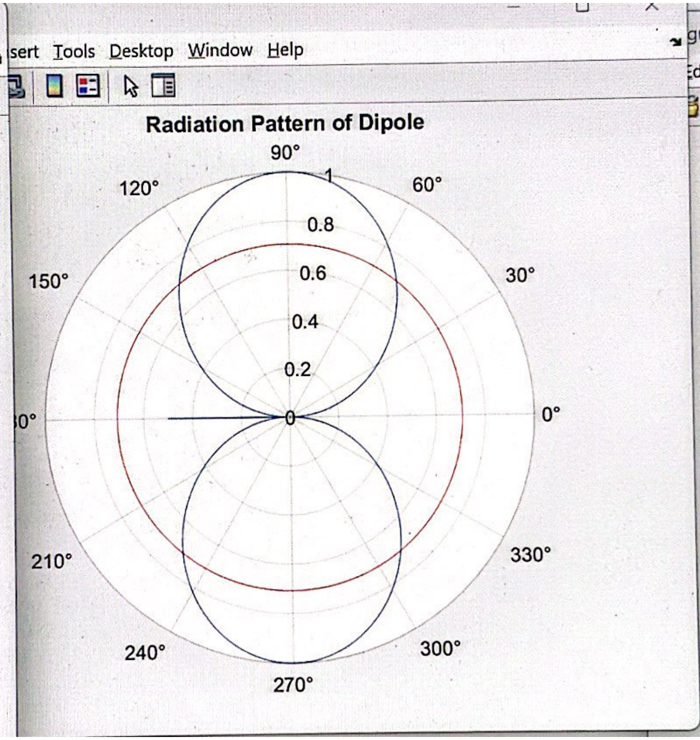
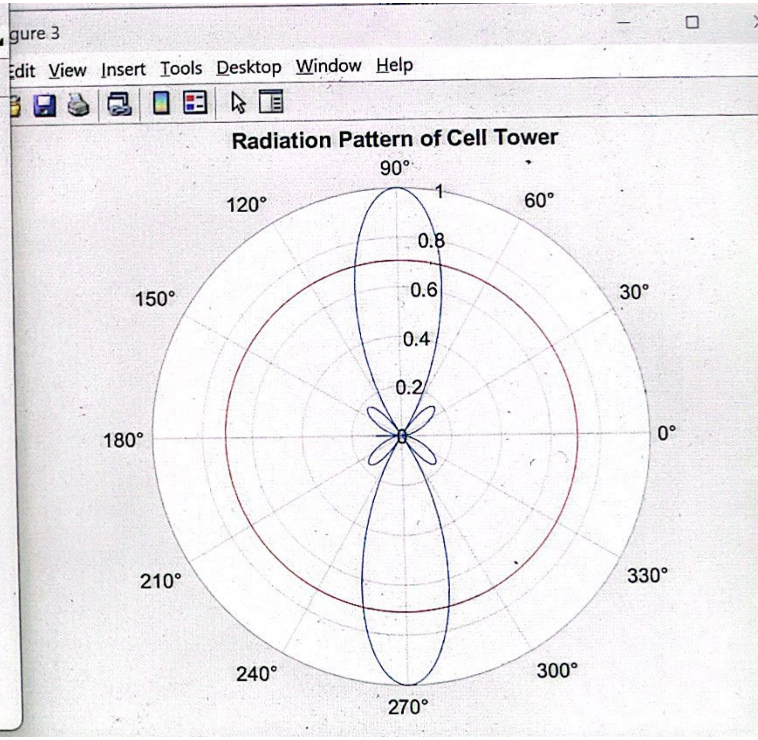
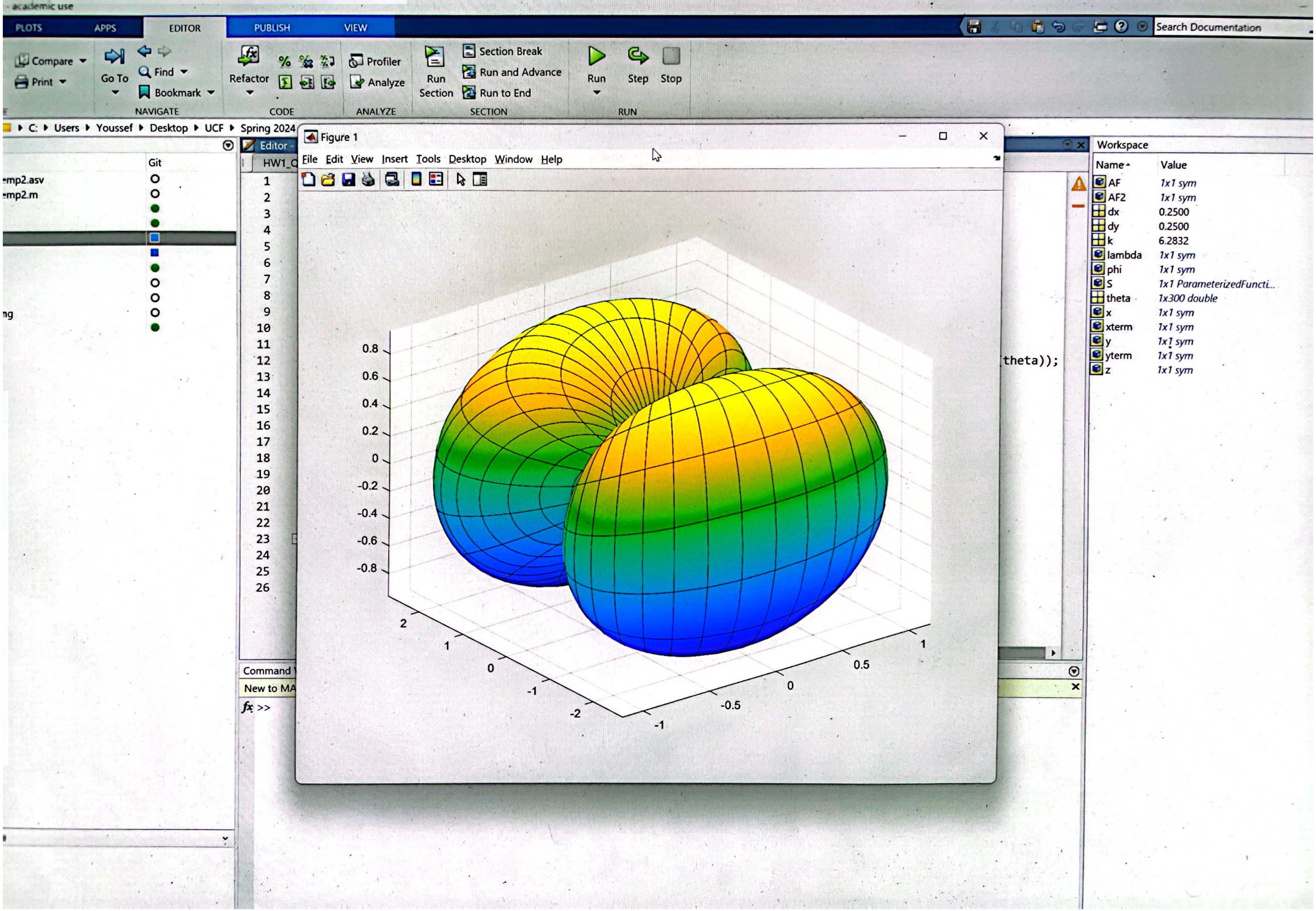


Figure 1
le Edit View Insert Tools Desktop Window Help
Array Factor Pattern
90°
120°
60°
150°
30°
180°
0°
210°
330°
240°
300°
270°
1
0.8
0.6
0.4
0.2
0


sert Tools Desktop Window Help
Radiation Pattern of Dipole
90°
120°
60°
150°
30°
0°
210°
330°
240°
300°
270°
1
0.8
0.6
0.4
0.2
0


gure 3
dit View Insert Tools Desktop Window Help
Radiation Pattern of Cell Tower
90°
120°
60°
150°
30°
180°
0°
210°
330°
240°
300°
270°
1
0.8
0.6
0.4
0.2
0


PLOTS
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NAVIGATE
Refactor
CODE
Profiler
Analyze
ANALYZE
Run Section
Section Break
Run and Advance
Run to End
SECTION
Run
Step
Stop
RUN
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Git
Editor
Figure 1
File Edit View Insert Tools Desktop Window Help
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
2
1
0
-1
-2
1
0.5
0
-0.5
-1
theta));
Command
Workspace
Name
Value
AF 1x1 sym
AF2 1x1 sym
dx 0.2500
dy 0.2500
k 6.2832
lambda 1x1 sym
phi 1x1 sym
S 1x1 ParameterizedFuncti...
theta 1x300 double
x 1x1 sym
xterm 1x1 sym
y 1x1 sym
yterm 1x1 sym
z 1x1 sym