ELEC351 Homework Problems #6

Problem 9.8 Ulaby 6th edition
Problem 9.15
Problem 9.19
Problem 9.20
Problem 9.21

Problem 9.8 Ulaby 6th edition

Efficiency is ξ=0.9=10*log(0.9)= -0.4576dB

G=ξD=ξ(dB)+D(dB)= -0.4576dB+7.0=6.54dB

Problem 9.15 6th edition

For a dipole antenna of length l=3λ/2, the time average power density is given by:

$$S(\theta) = \frac{15 I_0^2}{\pi R^2} \left[\frac{\cos(\frac{3\pi}{2}\cos\theta)}{\sin\theta} \right]^2$$

a)The normalized radiation pattern F(θ)=S(θ)/Smax is plotted in part-c. Directions of maximum radiation are obtained numerically from the radiation pattern: $\theta = 42.52^o$, $\theta = 137.48^o$.

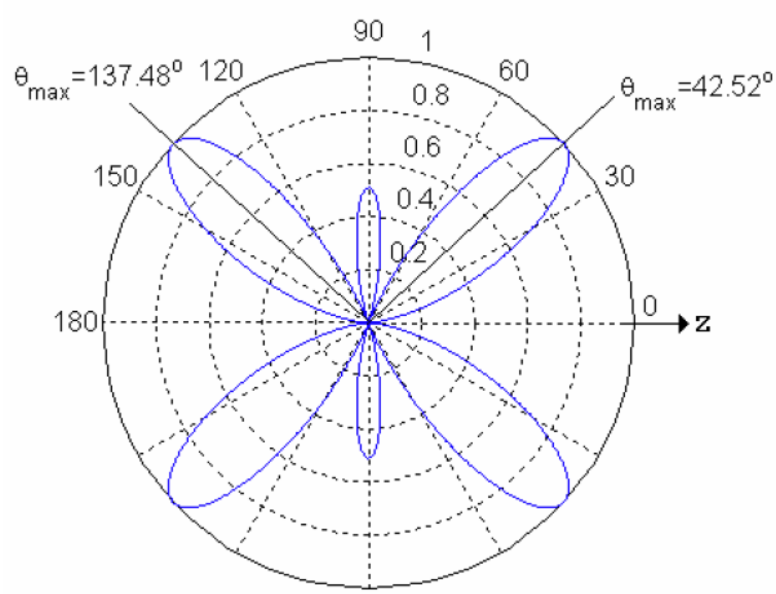
b)At $\theta = 42.52^o$

$$\left[\frac{\cos(\frac{3\pi}{2}\cos\theta)}{\sin\theta} \right]^2 = 1.958.$$

Then

$$S_{\max} = \frac{15 I_0^2}{\pi R^2} \times 1.958 = \frac{29.36 I_0^2}{\pi R^2}$$

c)



Matlab code used to generate the radiation pattern plot:

```
theta=linspace(0.01,2*pi,1800);lambda=1;l=1.5*lambda;
for i=1:length(theta)
   s(i)=((cos(pi*l/lambda*cos(theta(i)))-cos(pi*l/lambda))/sin(theta(i)))^2;
end
smax=max(s);s=s/smax;polar(theta,s)
```

d) The radiation pattern obtained in part-c is the same as the one shown in figure 9-17c in the textbook. Note that z axis corresponds to θ=0° and the dipole is along the z-axis..

Problem 9.19 6th edition

Since the frequency is 100 MHz, The wavelength becomes $\lambda = \frac{c}{f} = 3$ m.

For a half-wave dipole, the directivity is $D = 1.64$. The effective area is

$$A_e = \frac{\lambda^2 D}{4\pi} = \frac{3^2 \times 1.64}{4\pi} = 1.175 \quad m^2 .$$

Physical area can be obtained by

$$A_p = \ell \times 2\pi r = 1.5 \times 2\pi \times 0.01 = 0.09425 \quad m^2 .$$

Problem 9.20 6th edition

We assume the radiation efficiencies to be

$$\xi_t = \xi_r = 1.$$

Having the operating frequency, the wavelength is $\lambda = \frac{c}{f} = 0.1$ m.

The received power delivered to the receiver is

$$P_{\text{int}} = p_{rad} \frac{A_t A_r}{\lambda^2 R^2}$$

where

$$A_t = A_r = \pi r^2 = 0.7854 \quad m^2 .$$

To have 10 nW power at the receiver, the transmitted power should be

$$P_t = P_{rec} \frac{\lambda^2 R^2}{\xi_t \xi_r A_t A_r} = 10 \times 10^{-9} \frac{(0.1)^2 (40 \times 10^3)^2}{1 \times 1 \times (0.7854)^2} = 259 \text{ mW}.$$

For a good reception, the transmitted power should be at least 259 mW. Note that we assumed to have 100% efficiency, or $\xi_t = \xi_r = 1$.

Problem 9.21 6th edition

The given parameters are

$P_t = 10^3$ W

$G_r = 2 = 3$ dB

$R = 30 \times 10^3$ m

$f = 50$ MHz

For a half-wave dipole, the directivity is $D = 1.64$. Let's assume that the efficiency is 100%. We can obtain the maximum gain of the transmitter by

$$G_t = \xi D = 1.64 .$$

The received power is

$$P_{rec} = P_t G_r G_t \left(\frac{\lambda}{4\pi r} \right)^2 = 10^3 \times 2 \times 1.64 \left(\frac{6}{4\pi \times 30 \times 10^3} \right)^2 = 830.83 \text{ nW}.$$