1) A center-fed Hertzian dipole is excited by a current $I_0 = 20$ A. If the dipole is $\frac{1}{50}$ in length, determine the maximum radiated power density at a distance of 1 km.

2) A 1-m-long dipole is excited by a 1-MHz current with an amplitude of 12 A. What is the average power density radiated by the dipole at a distance of 5 km in a direction that is 45$^\circ$ from the dipole axis?

3) Assume we have an isotropic antenna with EIRP of 5 kW. The receiver is located 10 meters away from the transmitter. Find the following:
   a) Magnetic field strength at the receiving point
   b) Electric field strength at the receiving point
   c) Power density at the receiving point
   d) Draw E and H and show their direction at the receiving point
   e) Calculate the free space impedance for the given values

4) For a given a half-wave Dipole find the following parameters (HINT: Use the Applet to check your answers – check the slides; start with the expressions for E and H filed strengths):
   a) Average power density
   b) Power Density ($S_{max}$)
   c) Normalized radiation intensity, $F$
   d) Directionality, $D$ (from the table)
   e) $P_{\text{radiated}}$
   f) $R_{\text{radiated}}$
   g) Prove that 3dB BW is actually 78 degrees (you can use substitution to prove!)
   h) HINT: Use the applet to check your answers

4) Complete the following table based on the results you obtained above and the results we discussed in the class:

<table>
<thead>
<tr>
<th>Antenna</th>
<th>Gt=D</th>
<th>Rrad</th>
<th>Prad</th>
<th>3dB BW</th>
<th>Eff. Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short Dipole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{2}$ Wave</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5) The general pattern function for a given dipole is defined as follow:

\[
F(\theta) = \frac{\cos\left(\frac{k}{2}\cos\theta\right) - \cos\left(\frac{k}{2}\right)}{\sin\theta}
\]

Using the following Matlab code it is possible to plot the 3D radiation pattern of an antenna. In order to do that it is required to change the `radio` function in the code and define the exact relationship between the length of the dipole and the wavelength, e.g., `len` value in the code. Answer the following questions:

a) Show that the given pattern function can be reduced to your answer in Part C of Question 4 above: Normalized radiation intensity, \( F \).

b) Plot the radiation pattern for a half-wavelength dipole.

c) Plot the radiation patterns for a quarter-wavelength dipole.

d) Compare the differences in radiation patterns for \( \frac{1}{4} \)- and \( \frac{1}{2} \)-wavelength dipoles.

```
len = 1/8; % of lambda
k=2*pi;
theta = 130; % Samples on Elevation
n_phi = 130; % Samples on Azimut
[thet,(phi)=meshgrid(csa.pi./n_theta-1):pi,...
0:2*pi./n_phi-1:2*pi);]
radio = % YOU FUNCTION IS HERE! %
X=radio.*sin(theta).*cos(phi);
Y=radio.*sin(theta).*sin(phi);
Z=radio.*cos(theta);
surf(X,Y,Z)
view ight
shading interp
colorbar
axis image
TITile('3D-Pattern plot')
```