ECE5340/6340: Homework 10

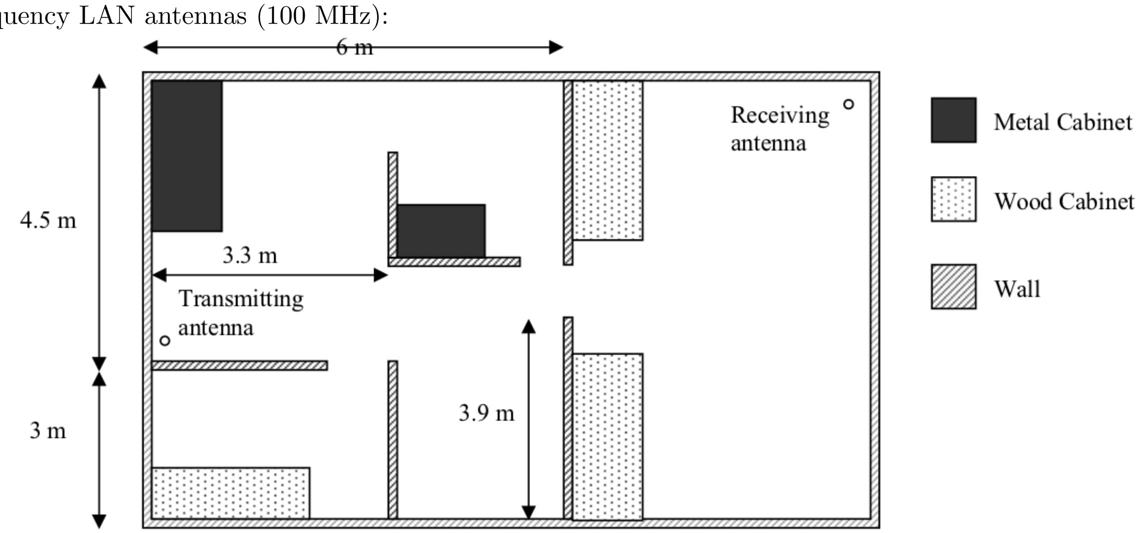
Write your section (ECE5340 or ECE6340) by your name. Turn in a printed copy containing the problem solutions, plots, and the code used to generate them. Remember to comment and format the code so is legible to the graders. Label the plots appropriately, including units for each axis and for the values plotted. Assume all units to be SI units unless stated differently. Due next Wednesday BEFORE class begins.

Problem 1

(10 points) Obtain from the WEB the 2D TM PML code. Make sure that the code is working properly, with the excitation pulse being well absorbed by the boundary conditions. Turn in a plot of the E field at 200 iterations. In the plot title include the values for dt and dz with units.

Problem 2

Consider the following approximation of the floor plan an office space with low frequency LAN antennas (100 MHz):



Wall thickness is 30 cm, the office space is 9.9 x 7.5 m, and some of the other dimensions are indicated in the figure. All the cabinets are 0.9 x 1.8 m, with only a smaller one of dimensions 0.9 x 0.9 m near the center of the room. Doors are 0.9 m wide. Consider the metal as perfect conductors, wood characterized by $\epsilon_r = 3$ and $\sigma = 0.001$ S/m, and the wall by $\epsilon_r = 10$ and $\sigma = 0.02$ S/m. Input the floor plan in a FDTD grid suitable for operation at a frequency of at least 100 MHz. Position your feed (Transmitting antenna) as in the figure. Note that the choice of the low frequency is motivated by the desire to reduce the size of the computational space; In reality, frequencies around 2.4 GHz should be used for these kind of applications. However, the approach at this higher frequency would be the same.

1. (20 points) Plot the building floor plan.
2. (30 points) Launch a pulse containing frequencies of at least 200MHz. Perform the DFT of the input pulse and of the signal you receive at the location of the receiving antenna in the figure at the following frequencies: 50 MHz, 75 MHz, and 100 MHz. What is the ratio between received and input signals for each frequency?
3. (20 points) Repeat the problem but using a sinusoid at 100 MHz this time. Do you get the same results for each frequency as before? Why?
4. (20 points) Study how do your results change by altering the conductivity and dielectric constant of the walls and the wood cabinets. Would you reccommend using more wooden cabinets or more metal cabinets? Why?

HINT: Example of DFT routine that you would need in your code.
At the beginning of the code, you need to initialize some vectors

```
% Frequencies of interest
freque=1.e6*[100. 125. 150. 175. 200.];
inr_ez=zeros(1,length(freque));
ini_ez=zeros(1,length(freque));
```

Within each cycle, you need to update the Fourier transform:

```
inr_ez=inr_ez+ez(Observation point)*cos(2*pi*freque*dt*t);
ini_ez=ini_ez+ez(Observation point)*sin(2*pi*freque*dt*t);
```

Finally, obtain magnitude and phase:

```
ampinc=sqrt(inr_ez.^2+ini_ez.^2);
phaseinc=atan2(ini_ez,inr_ez);
```

HINT: Example of definition of a cabinet (or any other material in the FDTD grid).

Before the simulation starts, after initializing the arrays, you need something like:

```
eps=3.;
cond=0.001;
for i=16:21,
  for j=16:18,
    ga(i,j)=1./(eps+(cond*dt/epsz));
    gb(i,j)=cond*dt/epsz;
  end
end
```

The code above will define a block from cell 16 to 21 in the x direction and from 16 to 18 in the y direction of material with $\epsilon_r = 3$ and $\sigma = 0.001$ S/m.

Alternatively, you can keep two extra arrays for conductivity and permittivity, eps(i,j) and cond(i,j), and load them from a text file as it was done in the previous homework with the 1-D example.

HINT: Example of sinusoidal source For the sinusoidal source, your code will look something like (for a progressive excitation)

```
if(T<np/2.)
  pulse =0.5*(1.-cos(2*pi*freq*T*dt))*1000.*sin(2*pi*freq*T*dt);
else
  pulse =1000.*sin(2*pi*freq*T*dt);
end;
```

Problem 3 (Optional, Extra Credit)

Consider a rectangular waveguide, with its cross-section modeled in a 2D FDTD TM mesh. You can choose the dimensions of your waveguide and try your code for different dimensions. Place an excitation pulse in a point in the cross-section of the waveguide and choose another point where to record the history of the electric field. Save the history of the electric field in an array, and take the DFT of this array using Matlab's fft() function as shown in class.

1. By plotting the magnitude of the DFT vector, can you find the TM-mode cutoff frequencies of the waveguide? Why? Explain, and include a plot of the DFT.
2. Compare the TM-mode cutoff frequency value you obtained on the first part with the theoretical value.
3. Comment on the changes you see by altering the resolution of the grid and the length of time of the simulation.