This assignment will step you through the process of writing a 2D FDTD simulation written in MATLAB for the E_z mode. The FDTD program should use the following header exactly for your code:

```
% HW8_prob1.m
%
% Homework #8
% EE-5303 EM Using FDTD
% Instructor: Dr. Raymond C. Rumpf

% INITIALIZE MATLAB
close all;
clc;
clear all;

% UNITS
meters      = 1;
centimeters = 1e-2 * meters;
millimeters = 1e-3 * meters;
inches      = 2.54 * centimeters;
feet        = 12 * inches;
seconds     = 1;
hertz       = 1/seconds;
kilohertz   = 1e3 * hertz;
megahertz   = 1e6 * hertz;
gigahertz   = 1e9 * hertz;

% CONSTANTS
e0 = 8.85418782e-12 * 1/meters;
u0 = 1.25663706e-6 * 1/meters;
N0 = sqrt(u0/e0);
c0 = 299792458 * meters/seconds;

% FDTD PARAMETERS
Nx    = 100;
Ny    = 100;
NPML  = [20 21 22 23];
dx    = 0.1 * meters;
dy    = 0.1 * meters;
dt    = 1.6e-10 * seconds;
tau   = 3.3e-9 * seconds;
STEPS = 500;
```

Problem #1: Calculate the PML Parameters

Starting with the header above, add the code to calculate the PML parameters `sigx` and `sigy` on a 2× grid. That is, create two 2D arrays in memory (`sigx` and `sigy`) and assign values to each point according to Lecture 15. The size of the PML at each boundary is defined by the 1×4 array `NPML`. The first number corresponds to the *x*-low boundary, the second is the *x* -high boundary, the third is the *y*-low boundary, and the fourth is the *y*-high boundary.

To test your PML parameters, the final statement in your program should be

```
% TEST CONDUCTIVITY TERMS
test_hw8_prob1
```

If your code creates `sigx` and `sigy` correctly, you should receive the message "`Problem #1 items appear to be correct!!`" at the command prompt after running your code.

Problem #2: Calculate the Update Coefficients for the E_z Mode

Starting with your program from Problem #1, add the code to calculate the update coefficients for the E_z mode. First, you will need to define your materials arrays `URxx`, `URyy`, and `ERzz`. Set all of these to free space (i.e. 1.0). Second, add the code to calculate the following update coefficients:

```
mHx1, mHx2, mHx3
mHy1, mHy2, mHy3
mDz1, mDz2, mDz4
mEz1
```

To test your update coefficients, the final statement in this program should be

```
% TEST VALUES
test_hw8_prob2
```

If your code is working correctly, you should receive the following message in the command window after running your code.

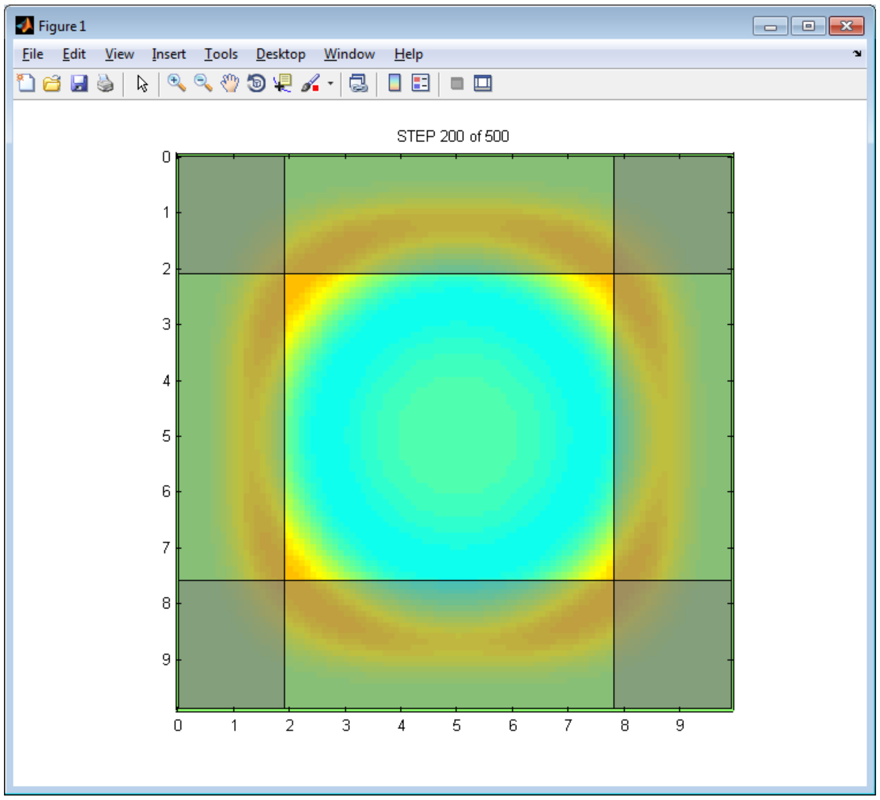
```
Problem #1 items appear to be correct!!
Problem #2 items appear to be correct!!
>>
```

Problem #3: Implement the 2D FDTD Algorithm for the E_z Mode

Modify your program from Problem #2 by adding the following functions:

- Calculate a simple Gaussian source (not TF/SF…yet) just like you did for 1D-FDTD.
- Initialize the fields to zero: `Hx=Hy=Dz=Ez=0`
- Initialize the curl terms to zero: `CEx=CEy=CHZ=0`
- Initialize the integration terms to zero: `ICEx=ICEy=IDz=0`
- Add the main FDTD loop following the block diagram in Lecture 15 exactly.
- Add a segment of code inside the main FDTD loop to visualize the E_z field. Use the `draw2d()` function provided on the course website. This function superimposes the electric field onto the permittivity.

If your code is calculating the update coefficients correctly, you should get the following result at T = 200. Please provide your field visualization at T = 200. Make your final plot look professional and "publication ready."



Here is the help information for the draw2d() function:

```
draw2d    Draw Field Superimposed on Materials for 2D FDTD

h = draw2d(xa,ya,ER,E,NPML)
h = draw2d(xa,ya,ER,E,NPML,OPTS)

This MATLAB function superimposes the field on top of the materials
and plots the image to the current axes.  Fruther, it highlights the
PML regions.

INPUT ARGUMENTS
================
xa, ya        Axis vectors listing the position of each cell in the grid
ER            Permittivity function across the 2D grid
E             The electric field across the 2D grid
NPML          [xlo xhi ylo yhi] size of the PML

OPTS          Options (Optional)
  .emax       maximum value of the electric field
  .cmap       custom colormap
              USA, Mexico, or any MATLAB colormap
              could also be a Nx3 array for custom colormap
  .NCOL       number of shades of color (default 64)

OUTPUT ARGUMENTS
================
h             Handle to the plot
```