Description of the Problem

The grating shown below was designed to operate at 8.0 GHz. For this assignment, assume the device is infinitely periodic in the $x$-direction, is of infinite extent in the $z$-direction, and is finite in the $y$-direction. The device resides in air and all the device parameters are provided below.

\[
\begin{align*}
\lambda_d &= c_0/(8.0 \text{ GHz}) \\
x_1 &= 0.1040 \lambda_d \\
x_2 &= 0.0175 \lambda_d \\
x_3 &= 0.1080 \lambda_d \\
L &= 0.6755 \lambda_d \\
d &= 0.2405 \lambda_d \\
t &= 0.0510 \lambda_d \\
\mu_r &= 1.0 \\
\varepsilon_r &= 10.0
\end{align*}
\]

In Homework 7-9, you are going to develop a 2D FDFD code to simulate this device. The program will be able to simulate both the $E$ mode and the $H$ mode at any frequency and at any angle of incidence. You must follow the outline presented in Lecture 14 exactly.
Problem #1: Dashboard for FDFD-2D Simulation

Begin a new MATLAB program with the following header:

```matlab
% Homework #7, Problem 1
% EE 5337 - COMPUTATIONAL ELECTROMAGNETICS
% This MATLAB script file implements the FDFD method
to model transmission and reflection from a grating.

% INITIALIZE MATLAB
close all;
clear all;

% OPEN FIGURE WINDOW
fig = figure('Color','w');

% UNITS
centimeters = 1;
millimeters = 0.1 * centimeters;
meters      = 100 * centimeters;
degrees     = pi/180;
seconds     = 1;
hertz       = 1/seconds;
gigahertz   = 1e9 * hertz;

% CONSTANTS
c0 = 299792458 * meters/seconds;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% DEFINE SIMULATION PARAMETERS
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% SOURCE PARAMETERS
f0 = 24.0 * gigahertz; %operating frequency
lam0 = c0/f0; %operating wavelength in free space
theta = 15 * degrees; %angle of incidence
MODE = 'H'; %electromagnetic mode, 'E' or 'H'

% GRATING PARAMETERS
fd = 8.0 * gigahertz; %design frequency
lamd = c0/fd; %design wavelength
x1 = 0.1040*lamd; %width of tooth 1
x2 = 0.0175*lamd; %width of slot
x3 = 0.1080*lamd; %width of tooth 2
L = 0.6755*lamd; %period of grating
d = 0.2405*lamd; %grating depth
t = 0.0510*lamd; %substrate thickness
ur = 1.0; %relative permeability of grating
er = 10.0; %dielectric constant of grating

% EXTERNAL MATERIALS
ur1 = 1.0; %permeability in the reflection region
er1 = 1.0; %permittivity in the reflection region
ur2 = 1.0; %permeability in the transmission region
er2 = 1.0; %permittivity in the transmission region

% GRID PARAMETERS
NRES = 40; %grid resolution
BUFZ = 2*lam0 * [1 1]; %spacer region above and below grating
NPML = [20 20]; %size of PML at top and bottom of grid
```
Problem #2: Calculate Optimized Grid

Add a new section to your code to calculate an optimized grid for this problem. This section will calculate both the 1× and the 2× grid. While your answers may different slightly than mine, here are my parameters:

\[ \begin{align*}
N_x &= 259 \\
N_y &= 662 \\
d_x &= 0.0097736 \\
d_y &= 0.0097962 \\
N_{x2} &= 518 \\
N_{y2} &= 1324 \\
d_{x2} &= 0.0048868 \\
d_{y2} &= 0.0048981
\end{align*} \]

Do not hard-code these values into your program!!! Calculate them from the parameters in your dashboard using the practices taught in the lectures.

Report your values of the above parameters.

Problem #3: Build the Device on the 2× Grid

Add a new section to your code to build the device into the arrays \( UR2 \) and \( ER2 \) which represent the permeability and permittivity respectively on the 2× grid. In a single figure window, visualize the relative permeability \( UR2 \) and the relative permittivity \( ER2 \) using the subplot() and imagesc() commands. Be sure your graphics are professional quality. Your results should look something like...