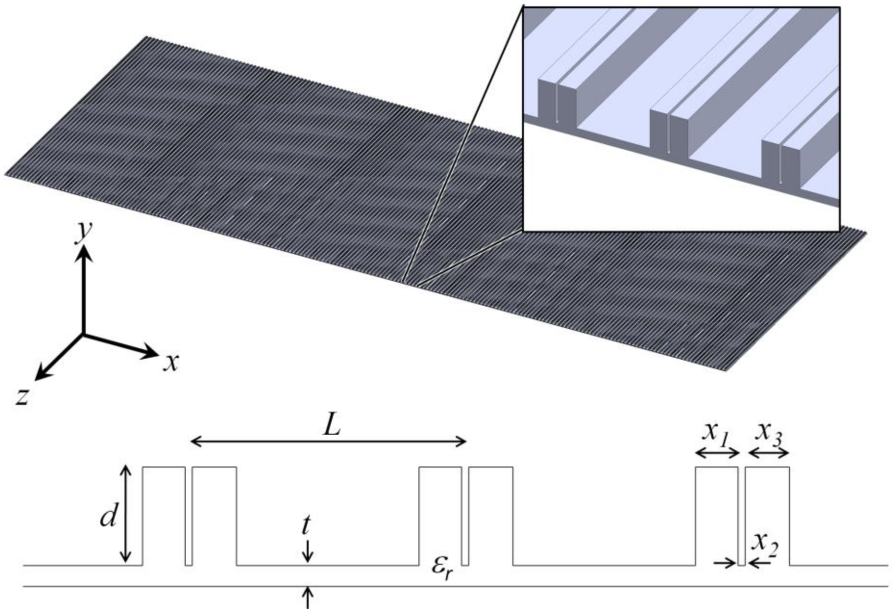
Description of the Problem

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.



$$\lambda_{\mathrm{d}} = c_0 / (8.0\ \mathrm{GHz})$$
$$x_1 = 0.1040\lambda_{\mathrm{d}}$$
$$x_2 = 0.0175\lambda_{\mathrm{d}}$$
$$x_3 = 0.1080\lambda_{\mathrm{d}}$$
$$L = 0.6755\lambda_{\mathrm{d}}$$
$$d = 0.2405\lambda_{\mathrm{d}}$$
$$t = 0.0510\lambda_{\mathrm{d}}$$
$$\mu_r = 1.0$$
$$\varepsilon_r = 10.0$$

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:

```
% 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;
clc;
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:

```
Nx = 259
Ny = 662
dx = 0.0097736
dy = 0.0097962

Nx2 = 518
Ny2 = 1324
dx2 = 0.0048868
dy2 = 0.0048981
```

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…