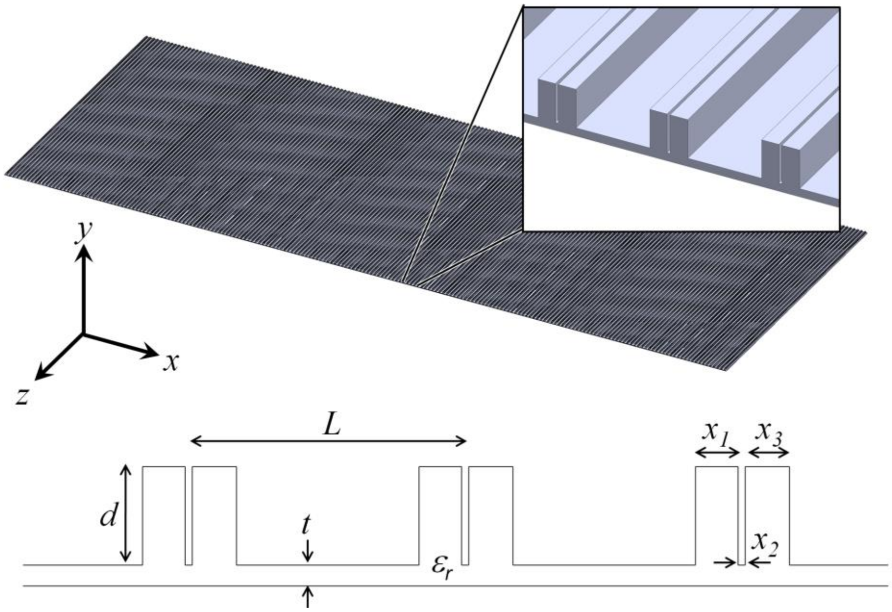
Description of the Problem

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.



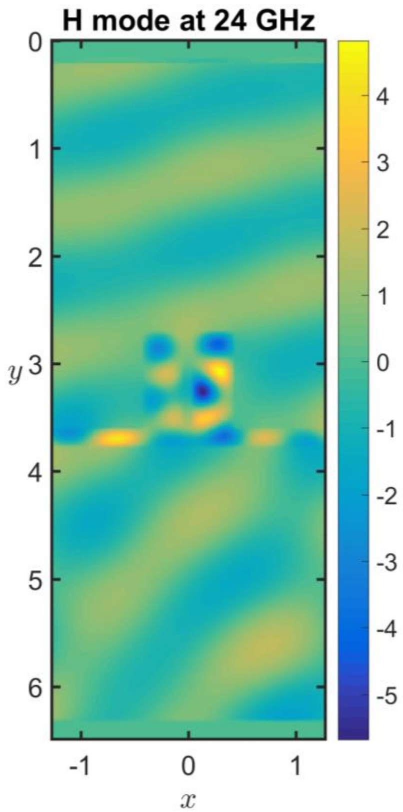
$$\lambda_{\mathrm{d}} = c_0 / (8.0\ \text{GHz})$$
$$x_1 = 0.1040\lambda_{\mathrm{d}}$$
$$x_2 = 0.0175\lambda_{\mathrm{d}}$$
$$x_3 = 0.1080\lambda_{\mathrm{d}}$$
$$L = 0.6755\lambda_{\mathrm{d}}$$
$$d = 0.2405\lambda_{\mathrm{d}}$$
$$t = 0.0510\lambda_{\mathrm{d}}$$
$$\mu_r = 1.0$$
$$\varepsilon_r =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

In Homeworks 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 from the lecture notes exactly.

Problem #1: Implement the FDFD-2D Method

Starting with the code you wrote for Homework #7, add a new section that simulates the device at 24 GHz using a two-dimensional finite-difference frequency-domain (FDFD) method. Your new code should be able to simulate both the *E* mode and the *H* mode at any frequency and at any angle of incidence specified in the dashboard. Use the `calcpml2d()` and `yeeder()` functions from Homework #6. Do not break your code into any other functions! Follow the outline presented in the lecture notes exactly.

To confirm that your code is working, visualize the field for the *H* mode using the `imagesc()` command. In the title of the field plot, report which mode was simulated and at what frequency. Your results should look something like the figure below.

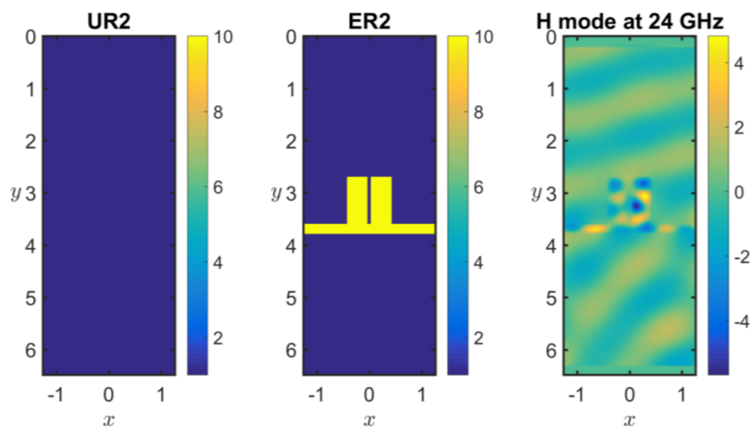


Problem #2: Post Process the Data

Add a new section to your code that calculates the diffraction efficiencies of all the reflected and transmitted diffraction orders, overall reflectance, overall transmittance, and overall conservation of power.

Add another section to report your results. In a single figure window, plot the relative permeability `UR2`, relative permittivity `ER2`, and the resulting field from the simulation. Label the field plot with the mode designation and the frequency of the simulation. In the command window, output all of the dashboard parameters, tables of the diffraction efficiencies for both the reflected and transmitted diffraction orders, and the overall reflectance, transmittance, and conservation of power.

The output of your program should look something like below for the *H* mode. Provide these same results for both the *E* and *H* modes in your homework. Be careful to display the parameters with proper units! You will be graded heavily on accuracy of this simulation. Use best practices!!




```
DASHBOARD PARAMETERS:
        Source Frequency = 24 GHz
      Angle of Incidence = 15 degrees
    Electromagnetic Mode = H
Device Design Frequency = 8 GHz
                      x1 = 3.8973 mm
                      x2 = 0.6558 mm
                      x3 = 4.0472 mm
                       L = 25.3137 mm
                       d = 9.0125 mm
                       t = 1.9112 mm
                      ur = 1
                      er = 10
                     ur1 = 1
                     er1 = 1
                     ur2 = 1
                     er2 = 1
                    NRES = 40
                    BUFZ = [ 2  2]*lam0
                    NPML = [20 20]
```

```
REFLECTION DIFFRACTION ORDERS:
RDE(-1) = 0.78747%
RDE(0) = 0.22295%
RDE(1) = 0.20161%
RDE(2) = 1.4108%

TRANSMISSION DIFFRACTION ORDERS:
TDE(-1) = 61.4221%
TDE(0) = 19.7914%
TDE(1) = 14.9838%
TDE(2) = 1.1522%

OVERALL:
REF = 2.6229%
TRN = 97.3495%
CON = 99.9724%
```

Problem #3: Convergence

Using the same device, set the source frequency to 11 GHz and the angle of incidence to 45°. Calculate reflectance as a function of the grid resolution from $\lambda/4$ to $\lambda/80$ for both the E and H modes. That is, perform parameter sweeps for `NRES = [4:1:80]`. Do NOT write a generic `fdfd2d()` function for this assignment.

Provide the following:

1. Plot reflectance as a function of grid resolution from $\lambda/4$ to $\lambda/80$ for both the E and H modes.
2. Identify on the plots where the model converges. Justify your answers.
3. Discuss the meaning of these plots.
4. Why is convergence being evaluated at 11 GHz?

Your plot should look something like the following for the E mode.