**Midterm project, ECE 222b, UCSD**

Consider a layered medium with $N-2$ layers staked in the z-direction, each layer having different relative permittivity $\varepsilon_i$ and thickness $d_i$, where $i=2,...,N-2$. The first and last medium has the relative permittivity $\varepsilon_1$ and $\varepsilon_N$, respectively.

1) Give a "recipe" how one can calculate the reflection coefficient and dispersion relations for the TE or TM polarization and any angle (for incidence from material 1) using the ABCD matrix approach. Provide all details required for a numerical implementation.
2) Computation of the reflection coefficient. (You may use the provided functions.)
   a. Consider the case of a single slab (layer), in which the relative permittivities are $\varepsilon_1=\varepsilon_3=1$, $\varepsilon_2=4$ and the thickness of the slab is $d_2=1\text{cm}$. Show the magnitude of the reflection coefficient as a function of the frequency in the range 1 GHz – 40 GHz for two incident angles 0, $\pi/4$ (in the x-z plane) and two slab thicknesses $d_2=1\text{cm}$ and $d_2=2\text{cm}$, each case for two different polarizations (eight curves total).
   b. Repeat the same as in item 2.a but for the five-layer case (i.e. for $N=7$) with $\varepsilon_2=8, \varepsilon_3=1, \varepsilon_4=8, \varepsilon_5=1, \varepsilon_6=8$.
   c. For the single slab case in item 1.a and for the frequency $f=10\text{ GHz}$ show the magnitude of the reflection coefficient in the two ranges of angles: $\theta=0:\pi/2$ and $\theta=\pi/2+[0:3]*j$. Make conclusions with respect to the observed behavior.
3) Computation of the guided modes. (You may use the provided functions.)
   a. Consider again the case of a single slab (layer), in which the relative permittivities are $\varepsilon_1=\varepsilon_3=1$, $\varepsilon_2=4$ and the thickness of the slab is $d_2=1\text{cm}$. Calculate the dispersion relations for the TM and TE polarizations, i.e. the curves of the guided mode wavenumbers versus frequency in the range 1 GHz – 20 GHz (pay attention that there may be multiple guided modes, so that multiple curves should be given on the same figure).
   b. Repeat item 3.a but for the five-layer case (i.e. for $N=7$) with $\varepsilon_2=8, \varepsilon_3=1, \varepsilon_4=8, \varepsilon_5=1, \varepsilon_6=8$.
4) Computation of resonant frequencies. (You may use the provided functions.)
   a. Consider again the case of a single slab (layer), in which the relative permittivities are $\varepsilon_1=\varepsilon_3=1$, $\varepsilon_2=4$ and the thickness of the slab is $d_2=1\text{cm}$. However, now the structure is closed by two infinite perfect electrically conducting surfaces at x=0 and x=6 cm. Find the resonant frequencies in the range 1 GHz – 40 GHz.
   b. Repeat item 4.a but for the five-layer case (i.e. for $N=7$) with $\varepsilon_2=8, \varepsilon_3=1, \varepsilon_4=8, \varepsilon_5=1, \varepsilon_6=8$.