Lecture 3 – Exercises

The series is to be handed-out on Moodle by 09.10.2025 at 9:00 (AM).

Implement a transfer matrix method (TMM) script in python following the details discussed during the lecture.

Your code should:

1. Work for a range of wavelengths;
2. Work for a range of incidence angles;
3. Work for both TE and TM polarizations;
4. At least be able to make 1D plots of the reflectance/transmittance (RT) versus wavelengths and 2D plots of RT versus incidence angles and wavelengths;
5. Be able to interpolate dispersive material data.

Once the code is implemented, reproduce the results seen in the last part of the lecture.

Specifically:

1. Plot the RT versus wavelengths and incidence angles for a TE and TM polarized waves incident from $Si0_2$ onto a 40-nm thick layer of Gold. The material after gold is air.
2. Plot the RT versus wavelengths and incidence angles for a TE and TM polarized waves incident from $Si0_2$ onto a stack of two dielectric materials (Bloch surface wave). Use the parameters provided in the lecture.

The dispersive material data (e.g., for Gold) can be found on the website https://refractiveindex.info. To get the data for Gold: select the entry **Au (Gold)** in the **Book** menu. Typically, for Gold, we use the data from Johnson and Christy 1972, which should be the default option. Scroll down the page, you should see links to download the data as CSV or tab separated text files. Pick the format you prefer. Note that the data provides the values n and k, which correspond to the real and imaginary parts of the refractive index. Since your TMM script takes as an input the permittivity and not the refractive index, you must convert the n-k data into a complex relative permittivity using: $\epsilon_\mathrm{r} = n^2 - k^2 + j2nk$. To interpolate this data, load it into your python script and use the `interp` function from the `numpy` library (click here for an example).

For the surface plasmon case, answer the following questions:

1. What happens when the thickness of the Gold layer is increased or decreased?
2. What is the maximum thickness of the Gold layer still allowing surface plasmon coupling?
3. What prevents surface plasmon coupling beyond this maximum thickness?
4. Study the sensitivity of the system to a small increase of the permittivity of the air. Hint: make 1D plots of the RT versus wavelengths for a specific incidence angle. Plot the shift in wavelength of the plasmon resonance versus permittivity increase.

Write a short PDF report in which you put your plots and the responses to these questions. Make a zip archive containing your report and your python script (make sure that the script works and that it generates some plots so that I can easily test it). Upload it to Moodle.