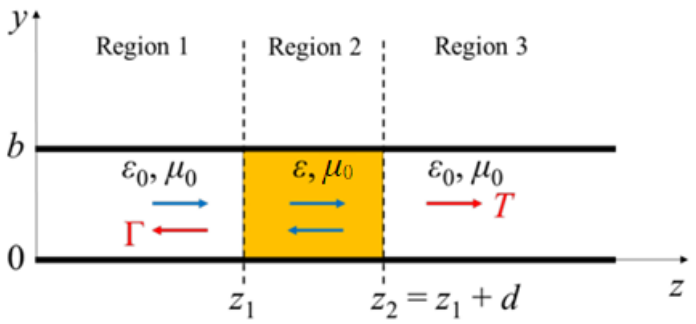
Electromagnetics Class Project (2 Credits) Spring 2021

Topic 1

You will work on the class project of the Electromagnetics course, which accounts for 2 credits, during this semester. You are to team up with one other student in the class for all the technical portion of the project. You can simply adopt the grouping of your previous lab sessions. There are in total **two project topics** you need to finish. The first one is related to waveguide and the second one is about antenna. One team turn in one project report for each topic and both team members get the same grade for this class project.

The report for the first topic is due June 5, 23:59 pm.

The first class project pertains to the measurement of permittivity and permeability using rectangular waveguides. Schematic configuration of this problem is shown below. A rectangular waveguide is used, with the propagation direction in *z*, long side in *x* and short side in *y*. The incident wave propagating in +*z* direction is in air-filled Region 1 and hits the material to be measured in Region 2. The material to be investigated is machined into a rectangular-shaped slab having a cross sectional dimension of $a \times b$ and a thickness of d in the z direction, which can guarantee that the material can exactly fit inside the waveguide (no air gap between the material and the metal walls of the waveguide). Some wave will be transmitted to Region 3, which is also air-filled. In reality, we can measure the reflection coefficient Γ and transmission coefficient T using a vector network analyzer (VNA) and derive the dielectric properties from these two measured factors, both with amplitude and phase. The material to be tested can be assumed to be nonmagnetic and lossless, which can greatly simplify the problem. You need to first write out the electric and magnetic fields in all the three regions using the method we have studied in class. Then solve for the reflection and transmission coefficients, which will be expressed in terms of the permittivity of the material under test. Finally, derive the permittivity of the material under test in terms of the reflection and transmission coefficients.



We provide some polymer bricks made by a 3D printer to serve as the lossless material to be tested. You can also bring some other kinds of materials you would like to measure, but they

should be solid and can be shaped into a brick with proper size that can fill into the waveguide you use. Experiments will be done using a VNA. We have in total six different waveguide sets working at different frequency bands for you to choose, including S band (2.60–3.95 GHz), H band (3.95–5.85 GHz), C band (5.85–8.20 GHz), X band (8.20–12.4 GHz), Ku band (12.4–18.0 GHz), and K band (18.0–26.5 GHz). Each group will draw lots to choose one of them. For groups choosing the same type of waveguide, the printed material for testing should have different thickness.