

Homework 6

Due Tuesday, Nov. 15th in class

1. (**Dielectric Waveguide**) A symmetric dielectric slab waveguide, as shown in Figure 1, has $n_1 = 1.462$, $n_2 = 1.460$. Suppose the operating wavelength is $\lambda_0 = 1550$ nm.
- (a) What is the maximum slab thickness $2d$, for which there would only be a single mode that could propagate in the waveguide?
 - (b) Assume $d = 12$ μm . How many TE modes can propagate simultaneously in the waveguide?

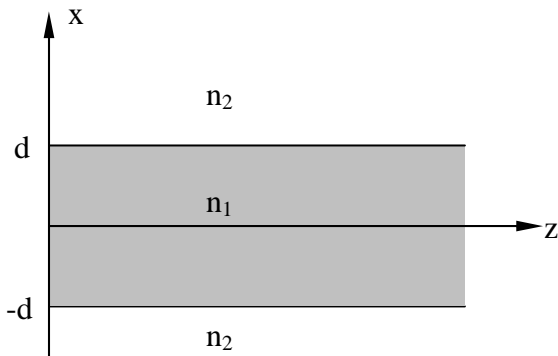


Figure 1.

2. **(Metal Waveguide)** A parallel-plate guide is partially filled with two lossless dielectrics (Figure 2) where $\epsilon_{r1} = 4.0$, $\epsilon_{r2} = 2.1$, and $d = 1\text{cm}$. At a certain frequency, it is found that the TM_1 mode propagates through the guide without suffering any reflective loss at the dielectric interface. (a) Find this frequency. (b) Is the guide operating at a single TM mode at the frequency found in part (a)? *Hint:* Remember Brewster's angle?

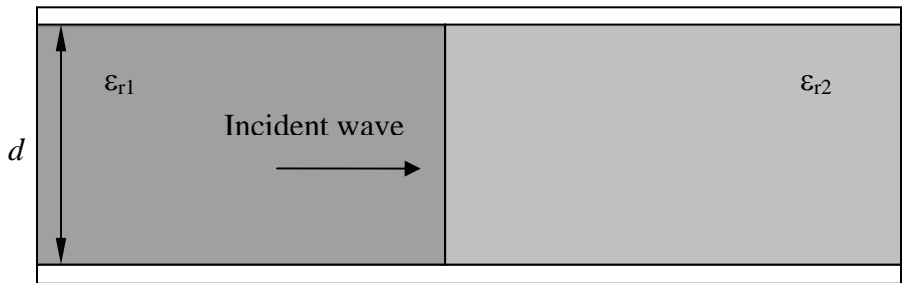


Figure 2.

In the guide of Figure 2, it is found that that $m = 1$ modes propagating from left to right totally reflect at the interface, so that no power is transmitted into the region of dielectric constant ϵ_{r2} . (a) Determine the range of frequencies over which this will occur. (b) Does your part (a) answer in any way relate to the cutoff frequency for $m = 1$ modes in either region? *Hint:* Remember the critical angle?

3. **(Thin Film-On-Conductor Waveguide)**. A thin film-on-conductor waveguide is made of a thin film of lossless dielectric (ϵ_d, μ_0) of thickness d on a perfectly conducting ground plane, as shown in Figure 3. The thin film is protected by a lossless dielectric coating (ϵ_1, μ_0). Assume the widths and heights of the coating and the ground plane extend to infinity. The wave propagates in the y direction. Find the cut-off frequencies for the TE modes.

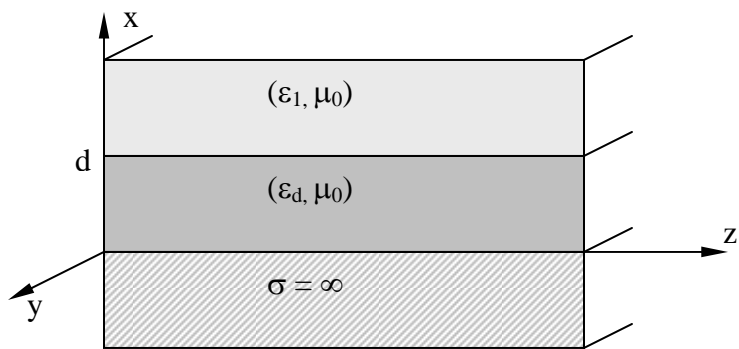


Figure 3.

4. **(Dielectric Waveguide)** A symmetric dielectric slab waveguide, as shown in Figure 4, has a core region of thickness $2d$. Consider the fundamental TE mode.

- (a) Show that outside the core region, $E \times H|_z \neq 0$.
- (b) Calculate the portion of power carried outside the core as a function of d .

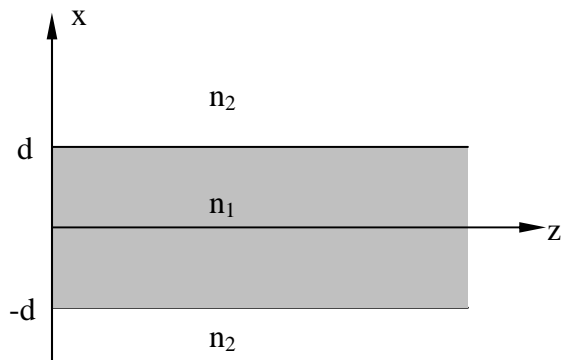


Figure 4.

5. **(FEMLAB simulation)** Use FEMLAB (2D In-plane TE waves model) to simulate the wave propagation in a dielectric slab waveguide. The structure of the waveguide is given in Figure 5. The working wavelength is 1550nm.

- a). Use the uniform and Gaussian E field distributions at the input to excite the fundamental guided mode. Calculate and compare the coupling coefficients of the two cases. Plot the E field.
- b). Is the TE_2 mode supported? If so, use a proper source to excite it so that the coupling coefficient is better than 90%. Plot the E field.

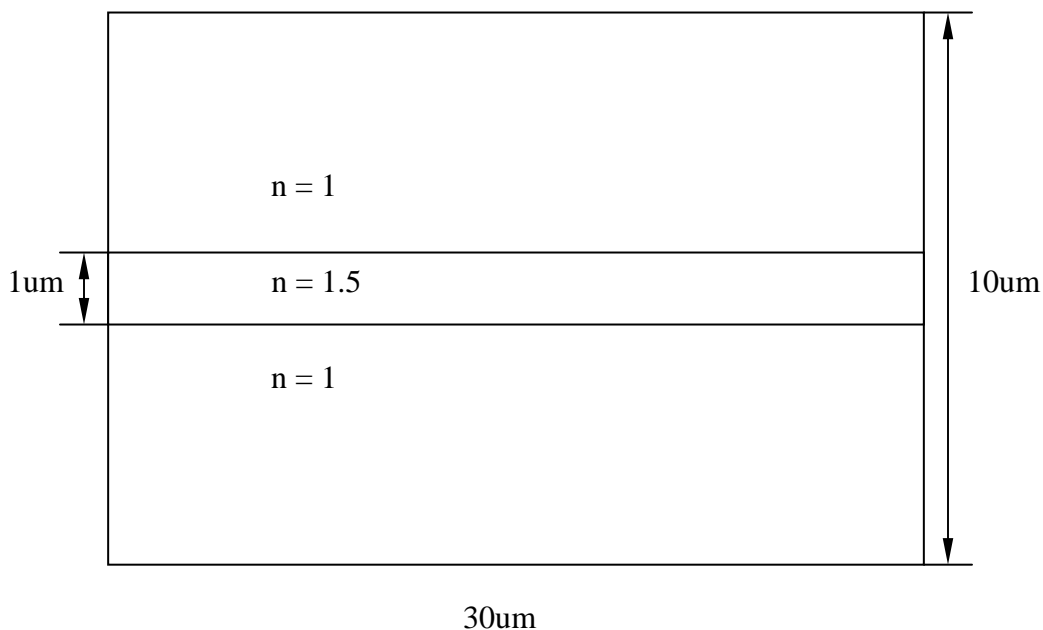


Figure 5.