Task 1: Mode Analysis of a Symmetric Planar Waveguide (MATLAB)

1.1. Checklist

- MATLAB is installed and activated on your PC (if not, please follow the instructions at https://help.eng.cam.ac.uk/software/matlab/).

1.2. Mode Analysis using MATLAB

- Search for the refractive indices of silicon and silicon dioxide at 1550 nm using reliable online sources (e.g., https://refractiveindex.info/).
- Open MATLAB and write a script to identify the modes supported by a symmetric silicon-on-insulator (SOI) planar waveguide with a core thickness of 300 nm, operating at 1550 nm. Use the cutoff condition for planar waveguides (refer to Eq. 1.9):

$$\Delta n = (n_2 - n_1) > \frac{m_s^2 \lambda_0^2}{4 t_g^2 (n_2 + n_1)}, \quad m_s = 0,1,2,3, \ldots \tag{1.9}$$

  where n_2 and n_1 are the refractive indices of the core (Si) and cladding (SiO_2), respectively, m_s is the mode order, λ_0 is the operating wavelength, and t_g is the core thickness.
- Sweep the waveguide core thickness from 200 nm to 1 μm in steps of 100 nm. For each thickness, determine the number of supported modes, and plot the number of modes supported by the planar waveguide against its core thickness in MATLAB. **[Include in your Report 1]**
- Repeat the above analysis using different waveguide core materials (e.g., silicon nitride and lithium niobate), i.e., search for the refractive index data for these materials at 1550 nm, import the data into MATLAB, and plot the supported mode count – core thickness relationship for each material. Compare the results to that of the silicon waveguide and comment on how core material affects mode support. **[Include in your Report 1]**
- Repeat the analysis for a silicon waveguide at different wavelengths (e.g., 1310 nm, 1600 nm, etc.). Consider material dispersion—note that the refractive indices of materials vary with wavelength. Again, plot "Number of Supported Modes vs. Core Thickness" for each wavelength. Compare and discuss how operating wavelength affects the number of supported modes. **[Include in your Report 1]**