Goal: Calculate the coupling between two identical and non-identical waveguides.

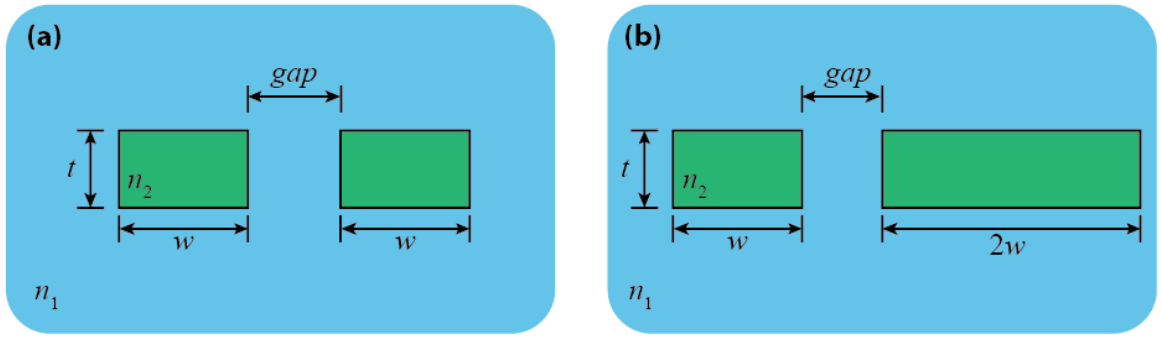

Fig. 1 – Schematic representation of two parallel waveguides for coupled mode theory analysis. Example parameters correspond to a silicon core (n_2 = 3.45) embedded in air (n_1 = 1.00), with thickness *t* = 250 nm and width *w* = 500 nm. The gap between the waveguides is a design variable that should be adjusted to achieve the desired coupling.

Use Coupled Mode Theory (CMT) for both degenerate and non-degenerate modes to:

1. Derive the normalized coupling constant between two optical waveguides.
2. Write down the coupled mode equations.
3. Describe a numerical method to calculate the coupling rate.
4. Design a 50/50 beam splitter coupler for each case by determining the required interaction length for equal power splitting.

Guiding Questions

While developing your design, address the following:

- Validity of CMT
  - For all waveguide gap distances, does CMT remain valid?
  - Is there a limit where it no longer applies? If so, how should you proceed?
- Direct Derivation
  - How could you directly derive the coupled equations for two coupled waveguides starting from the coupled mode basis?
- Design Strategy
  - What is the best practical strategy to achieve precise power splitting in a real device?
  - Does this strategy work for any wavelength?
  - Can you design a device tolerant to variations in the input wavelength?
- Material and Dispersion Effects
  - Does your calculation still hold for different index contrasts between the core and cladding?
  - What changes if you include the dispersion of the silicon refractive index in your calculation?

The report should fit at most a 4 pages description and all the codes used should also be submitted.