# ECE 480A8: Waves in Photonic Integrated Circuit Elements

## IN

### Physics and Engineering
- Basic knowledge about optics and waves including basic units, wave phenomena, and energy-frequency-wavelength relations
- Familiarity with Maxwell’s equations and their time-harmonic solutions represented as complex quantities
- Definition and use of frequency-dependent complex dielectric constant and material absorption
- EM wave eq’n and solutions including transmission and reflection at dielectric boundaries, dependence on polarization

### Mathematics
- Apply differential equations with boundary conditions and their solutions to physical problems

### Computer Science
- Compute and plot solutions to algebraic equations
- Manipulate data including in arrays

### Pre-requisites
- ECE340 with a minimum grade of C or ECE342 with a minimum grade of C; MATH340 with a minimum grade of C; PHYS142 with a minimum grade of C; CS162 with a minimum grade of C; CS163 with a minimum grade of C or CS164 with a minimum grade of C

## OUT

### PIC Structure & Overview
- List and distinguish PIC elements
- Identify, draw, and discuss PIC layers

### EM Waves in Waveguides
- Recognize and use EM equations and solutions for modeling waveguide modes.
- Calculate and plot transverse mode profiles.
- Apply EM boundary conditions to TE and TM modes

### Analysis of Specific PIC Elements
- Calculate I/O relationships for amplitude and phase of PIC elements in steady-state
- Multimode-interference devices
- Amplitude & phase modulators
- PIC-compatible interferometers
- Ring-resonators
- Periodic index structures

### Modal overlap analysis
- Calculate and apply confinement factors for waveguide modes
- Calculate coupling and overlap factors between different modes in waveguides

## Concepts:
- Brief review of EM waves
- Typical structure of PICs
- Common passive elements of PICs including waveguides, splitters, couplers, interferometers, resonators, modulators, gratings, and reflectors
- Impact of PIC elements on amplitude and phase of EM waves
- Spectral dependence of wave propagation in PICs

## Applications:
- Impact of spectral properties of PIC elements on optical communications
- Use of PIC-based MZIs for refractometry
- Use of PIC-based ring resonators for refractometry
- Use of PIC gratings for spectral filtering

## Tools:
- **Mathematics:** Algebra of complex variables; calculus; differential equations; small matrices
- **Small programming:** Matlab, Python, or other common languages of student’s choice for calculations and plotting
- **Online calculators:** 1-D optical waveguide modes using free online calculators