PHYSICS OF LINEAR AND NONLINEAR OPTICAL WAVEGUIDES

PROF. SAMUDRA ROY

Department of Physics

IIT Kharagpur

PRE-REQUISITES : Basic calculus, Algebra, Basic complex numbers, Basic concept of electrodynamics

INTENDED AUDIENCE : 3rd year B. Sc Physics , M. Sc Physics , M-Tech (Applied Optics)

COURSE OUTLINE :
Optical waveguide is a physical structure that guides electromagnetic waves and it is the most important component of integrated optical circuits. This course is intended to describe the theoretical basis of optical waveguides. In this course we learn the principal of light guidance by understanding the light-matter interaction in linear and nonlinear regime. We will also discuss different optical components based on waveguides that are used extensively in communication and sensing. This course is mostly self-contained with very basic prerequisites like knowledge of elementary algebra and calculus. The course is prepared for the senior graduate and M.Sc. students having a prior knowledge of electromagnetic theory. The course is also useful to the junior PhD students and M-Tech students whose research interest is related to Photonics. The exam of this course will be based on multiple choice questions and each week the descriptive type practice-assignments will be given to the students as home work.

ABOUT INSTRUCTOR :
Prof. Samudra Roy did his PhD from CGCRI (a CSIR Lab) in 2009 and carried out his post-doctoral research from Hokkaido University, Japan and Max Planck Institute, Germany during 2009-2013. In 2013, he joined in the Physics Department, IIT-Kharagpur as an assistant professor and also associated with the Center for Theoretical Studies-IIT Kharagpur. His research field is nonlinear photonics.

COURSE PLAN :

Week 1**:** Linear and nonlinear optical waveguides & Brief history, Maxwells equation, Plane wave, Wave equation, Snells Law, Total Internal Reflection, Concept of core and cladding

Week 2**:** Numerical Aperture (NA), V-parameter, Cut off wavelength, Ray propagation in optical fibers, Meridonial rays, Skew ray, Concept of discrete ray propagation inside waveguides

Week 3**:** Waveguide characteristics: Loss mechanism, Modal dispersion, Ray Equation, Ray path for step-index waveguide

Week 4**:** Ray equation continue: Ray path for triangular-index waveguide, Ray path for parabolic index waveguide, Transit Time

Week 5**:** Material Dispersion, Group delay, Pulse broadening, Concept of zero dispersion, Birefringence waveguides

Week 6**:** Modes: TE & TM Modes, Modes in slab waveguide, Symmetric and anti-symmetric mode, Calculation of propagation constant

Week 7**:** Modes: Step index optical fibers, Bassel function, Recursion relation, LPlm modes

Week 8**:** Optical waveguide components: Directional coupler, Optical switching, Power coupler, Wavelength Division Multiplexing (WDM), Couple Mode Theory

Week 9**:** Fiber Bragg Grating (FBG), Bragg wavelength, Reflectivity calculation, Linear waveguide array

Week 10**:** Nonlinear Waveguides, Kerr nonlinearity, EM wave propagation under Kerr nonlinearity

Week 11**:** Nonlinear Susceptibility, Second Harmonic Generation (SHG), Third Harmonic Generation (THG), Phase Matching

Week 12**:** Self Phase Modulation (SPM), Nonlinear absorption, Optical Soliton, Supercontinuum Generation