

Department of Physics, IIT Kanpur  
**PHY677A: Optical Imaging**

2021-2022 Semester II

Instructor:

Venkata Jayasurya Yallapragada

Email: jayasurya@iitk.ac.in

Phone: +91-512-259-2253

### Description

The course is advanced undergraduate / graduate course on the physical foundations of optical imaging, with a focus on modern optical microscopy. There have been significant breakthroughs in the field of optical imaging in the last two decades, with the development of several superresolution and computational microscopy techniques.

### Prerequisites

A knowledge of undergraduate level calculus, differential equations, Fourier transforms, and electromagnetism.

### Contents

- 1. Review**  
Review of electromagnetic wave propagation and Fourier transforms
- 2. Foundations**  
Wave optics, Diffraction, Eikonal approximation, Basic treatment of the refracting telescope and compound microscope, Aberrations
- 3. Imaging systems**  
Field and intensity propagation through a lens, systems of lenses, transfer functions, spatial bandwidth and resolution, coherent and incoherent beam propagation through a lens and a  $4f$  system, 3d point spread and transfer functions, depth of field.
- 4. Imaging with transmitted and reflected light**  
Illumination and detection configurations, Coherent and incoherent illumination, Pupil function engineering, Phase Imaging, Holographic Imaging
- 5. Fluorescence microscopy**  
Widefield microscopy, Confocal microscopy, Optical sectioning, Two-photon and multiphoton imaging, Superresolution via PSF engineering and structured illumination, Superresolution via localization and stimulated emission depletion.
- 6. Special topics**  
Quantum enhanced techniques, Nonlinear microscopy, Imaging in scattering media.

### Reference books

1. J. Mertz, *Optical Microscopy* 2nd Edition (Cambridge Univ. Press)
2. E. Hecht, *Optics*, 4th Edition (Pearson) (or any other undergraduate text on Optics)
3. J. W. Goodman, *Introduction to Fourier Optics*
4. M. Born and E. Wolf, *Principles of Optics*, 7th Edition.

### Evaluation

Evaluation mode	Points
Homework Assignments	$10 \times 5 = 50$
Mid-Semester Examination	25
Final term-paper / presentation	25
<b>Total</b>	<b>100</b>

**Policy:** Collaboration is allowed in the homework, but the results should be written by each student on his/her own and should not be a copy of another student's work. Collaboration is allowed in preparation of the final term-paper/presentation, but work should be presented individually.