Department of Physics, IIT Kanpur

PHY677: Optical Imaging

2026-2027 Semester I

Instructor: Venkata Jayasurya Yallapragada
Email: jayasurya@iitk.ac.in

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

1. A knowledge of undergraduate level calculus, electromagnetism, differential equations and Fourier transforms
2. Proficiency in programming using MATLAB, Python + numpy + matplotlib, or equivalent.
3. **Please contact the instructor (Jayasurya, jayasurya@iitk.ac.in) before registering for the course.**

Contents

1. **Review**
   Review of electromagnetic wave propagation, light-matter interactions, Fourier transforms and sampling.
2. **Foundations**
   Wave optics, Diffraction, Eikonal approximation, Basic imaging optics: lenses, telescopes, microscopes, Aberrations, light sources and detectors.
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, Holography and interferometric 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 and Ptychography.

References

1. J. Mertz, *Introduction to 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	50
Mid-Semester Examination	20
Final Examination	30
Total	100

Note: Some assignments will involve programming in Python or MATLAB.

Policy: Collaboration is allowed in the homework reports, but the results should be written by each student on his/her own and should not be a copy of another student's work. Any plagiarism or copying in reports, deliberate data fabrication or falsification, or cheating in examinations to any extent whatsoever (including the use of digital devices), if found, will be punished by awarding a F grade in the course. In addition, the findings will be reported to the relevant authorities in the Institute for disciplinary action.