Department of Physics, IIT Kanpur

# PHY677A: Optical Imaging

2022-2023 Semester II

Instructor:
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## 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 and electromagnetism, differential equations, Fourier transforms, and basic programming using MATLAB, Python + numpy + matplotlib, or equivalent.
2. **Please contact the instructor (Jayasurya,** jayasurya@iitk.ac.in**) before registering for the course.**

## Contents

1. **Review**
   Review of electromagnetic wave propagation, Fourier transforms
2. **Foundations**
   Wave optics, Diffraction, Eikonal approximation, Basic imaging optics: lenses, telescopes, microscopes, 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 and Ptychography.

## Reference books

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 | $10 \times 5 = 50$ |
| Mid-Semester Examination | 25 |
| Final term-paper / presentation | 25 |
| **Total** | 100 |

**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.