OPTI 600G: Laser Beams and Resonators
Spring Semester 2022

Course Description:

Starting from the ray optical treatment of first-order optical systems this class develops the ideas and approaches underpinning the properties of laser beam propagation and its application to optical resonators. Topics range from ABCD ray transfer matrices, classification and stability of optical resonators, to the properties of a variety of common optical resonators. The goal of the class is to provide the students with the skills to analyze basic laser beam propagation and resonator properties.

Pre-requisites:

It is preferred that students have already taken OPTI 501 and 502, but a basic understanding of geometric optics, at the level of paraxial optics, and wave optics, at the level of the Helmholtz equation, may suffice. Familiarity with a high level programming language such as MATLAB for problem solving is required.

Number of Units/ component:

1 unit

Locations and Times:

TBA

Dynamically dated course:

Instructor Information:

Prof. Ewan M. Wright
Meinel 636
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Office hours: By appointment

Expected Learning Outcomes:

- Apply ray transfer matrices to the analysis of optical systems and optical resonators.
- Evaluate Gaussian and higher-order mode propagation with application to stable two-mirror resonators.
- Analyze the properties of more general optical resonator modes, such as unstable and gain-guided lasers.

Required Texts:

Course notes will be provided on the class website.

Topics and/or general calendar:

Part 1. Paraxial ray optics

1. Basics: Fermat's principle, calculus of variations, ray equations, paraxial rays.

2. First-order optical systems: Lenses, mirrors, graded-refractive-index (GRIN) media.

3. ABCD matrices: Matrix treatment of optical systems, examples, optical path length.

4. Periodic optical systems: Eigenray analysis, geometric stability conditions.

5. Optical Resonators: Stable and unstable optical resonators, examples.

Part 2: Paraxial wave optics

1. The paraxial wave equation for beam propagation, Gaussian beam solution and the complex beam parameter in free-space, the Guoy phase-shift.

2. Higher-order transverse modes, Hermite-Gaussian and Laguerre-Gaussian modes.

3. ABCD law for Gaussian beams, beam propagation through optical systems, examples.

4. Plane-parallel Fabry-Perot, transmission characteristics for normal incidence and the Airy function, free-spectral range, frequency bandwidth, and finesse, longitudinal modes, Gaussian mode of a curved mirror Fabry-Perot resonator and mode-matching, higher-order transverse modes, transverse mode resonances.

5. Optical resonators with curved mirrors, equivalent periodic systems, wave optical stability, transverse modes of stable optical resonators, transverse mode frequencies.

Part 3: Generalized resonator theory

1. Complex ABCD transfer matrices, ABCD law for Gaussian beams, generalized Gaussian beam analysis including finite mirror losses and/or a gain profile.

2. Unstable optical resonators, transverse mode discrimination, high power lasers.

3. Gain-guided lasers, mode properties, optically pumped lasers.

4. Numerical results for the properties of unstable and gain guided lasers.

Number of Exams and Papers:

Evaluation of knowledge shall be done with three homework assignments plus a paper.

Course Policies:

Grading Policy

Homework (3 assignments total)	75%
Term paper	25%
Total	100%

The grade will be determined according to the cumulative percentage earned such that 90-100% = A, 80-89% = B, 70-79% = C, 60-69% = D, below 60% = E.

Academic Integrity (http://web.arizona.edu/~studpubs/policies/cacaint.htm)

According to the Arizona Code of Academic Integrity, "Integrity is expected of every student in all academic work. The guiding principle of academic integrity is that a student's submitted work must be the student's own." Unless otherwise noted by the instructor, work for all assignments in this course must be conducted independently by each student. Co-authored work of any kind is unacceptable. Misappropriation of exams before or after they are given will be considered academics misconduct.

Misconduct of any kind will be prosecuted and may result in any or all of the following:

- Reduction of grade
- Failing grade
- Referral to the Dean of Students for consideration of additional penalty, i.e. notation on a student's transcript re. academic integrity violation, etc.

Attendance Policy

It is important to attend all classes, as what is discussed in class is pertinent to adequate performance on assignments and exams. If you must be absent, it is your responsibility to obtain and review the information you missed. This is especially important in this course where a substantial amount of course material will emerge through class discussion.

"All holidays or special events observed by organized religions will be honored for those students who show affiliation with that particular religion. Absences pre-approved by the UA Dean of Students (or Dean's designee) will be honored."

Classroom Behavior

The Arizona Board of Regents' Student Code of Conduct, ABOR Policy 5-308, prohibits threats of physical harm to any member of the University community, including to one's self. See: http://policy.web.arizona.edu/threatening-behavior-students.

Students with Disabilities

If a student is registered with the Disability Resource Center, he/she must submit appropriate documentation to the instructor if he/she is requesting reasonable accommodations. (http://drc.arizona.edu/instructor/syllabus-statement.shtml).

The information contained in this syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.