OPTI 512R
Linear Systems and Fourier Transforms

Instructor: Professor Amit Ashok
Lecture Time: Monday and Wednesday 11:00am-12:15pm
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OPTI512R. Linear Systems and Fourier Transform (3). Linear system theory, Fourier optics, Interference and diffraction, Image formation, Optical transfer function.
Pre-requisites: MATH 223, PHYS 142 and PHYS 241

1 Course Goals

1. Learn fundamentals of linear system theory.
2. Learn Fourier transform and its properties.
3. Understand discrete representation of continuous functions (e.g. classical optical fields).
4. Understand diffraction and image formation using linear system theory and Fourier transform.
5. Become proficient in analyzing optical imaging systems using linear system theory.

2 Textbook

Course notes will be provided for all the lectures, free of charge via the class D2L website. Reference books for this course include:

- J. S. Tyo and A. Alenin, "Field Guide to Linear Systems in Optics," SPIE Press, ISBN: 9781628415.
- J. W. Goodman, "Introduction to Fourier Optics," McGraw Hill, New York, 1996. ISBN: 1319119166.

Goodman's book on Fourier Optics is highly recommended (not required) for this course.

3 Course Website

The course's online component will be conducted via the University of Arizona's D2L software system. The D2L can by accessed by this link: `www.d2l.arizona.edu`
Log in using your UA NetID, and you will see a list of all classes that use D2L. All homework assignments, homework solutions, announcements, etc., will be made through D2L. Please check D2L periodically for updates during the semester.

4 Homework Policy

There will be *regular homework assignments* and the due date in *most* cases will be one week from the date of assignment. Assignments in the latter part of the course will involve Matlab exercises to model diffraction and imaging systems. Matlab is available free to all UA Students and employees. If you would prefer to use another computational package, please arrange that with the instructor. All homework assignments are to be turned in class on the due date. There will be a *20% reduction* in the score for assignments turned in within 48 hours of the due date. No assignments will be accepted 48 hours after the due date (unless you have made a prior arrangement with the instructor). The LOWEST homework assignment score may be dropped for the final grade calculation.

5 Examinations

There will be one 75 minute midterm examination as follows:

- **10/18** - Monday - Tentative

The final examination will be a cumulative 2-hour examination:

- **12/13 - Monday - (10:30am-12:30pm)**

6 Exceptions Policy

Only in the **most exigent circumstances** (e.g. serious illness, representing University), there may be an exception granted for late submission of a homework or an alternative exam schedule. Such exceptions must be arranged with the instructor **beforehand**, lest there will be no credit for the missed homework/exam.

7 Distance Learning Students

Students enrolled in this course through the distance learning program will be provided access to lecture videos. Distance learning students will have in general additional time to complete their homeworks (as noted clearly on each homework). The course exam may be taken within in a time window spanning a few days (specified before each exam). Exceptions to the noted deadlines for completing homeworks and exams should be arranged ahead of time with the instructor. Distance learning students are encouraged to contact the instructor through email or phone if they have questions regarding the course, e.g. homework, lecture notes. If you have work related constraints (that are unavoidable) such as travel that will affect a timely completion of homework/class quiz/exam, it is strongly recommended that you make appropriate arrangements with the instructor well ahead of the due date.

8 Grade Distribution

The final grade for the class will have following components:

1. Homework/Matlab Assignments: 40%
2. Midterm Exam: 30%
3. Final Exam: 30%

9 Grading

A: Excellent - in-depth understanding of the material; exceptional performance; exceeds expectations.
B: Good - an acceptable understanding of the material; adequate performance; meets expectations.
C: Average - inadequate understanding of the material; inadequate performance; below expectations.
D: Poor - little to no demonstrated understanding of the material; weak performance.

10 Academic Integrity

Integrity and ethical behavior are expected of every student in all academic work. This Academic Integrity principle stands for honesty in all class work, and ethical conduct in all labs and clinical assignments. This principle is furthered by the student Code of conduct and disciplinary procedures established by **ABOR Policies 5-308 through 5-404**, all provisions of which apply to all University of Arizona students. The Code of Academic Integrity is intended to fulfill the requirement imposed by **ABOR Policy 5-403.A.4** and otherwise to supplement the Student Code of Conduct as permitted by **ABOR Policy 5-308.C.1**.

For more details please see:
`http://deanofstudents.arizona.edu/codeofacademicintegrity`

You are expected and encouraged to consult with your colleagues in the preparation of your homework assignments. As stated above, homework assignments are for the benefit of the student, so if you do not understand the homework you are the only one that will suffer. However, please do not insult your colleagues, the teaching assistant, or me by turning in directly copied homework. If you work with a colleague closely enough that your solutions might appear (legitimately) to be copied, then please disclose the collaboration on the top of the page. It is quite acceptable to consult references, other course notes, other faculty, senior graduate students, etc., in preparing your solutions. However, any consultation with an outside source that contributes significantly to the solution you turn in should be disclosed. Failure to disclose such information will result in a significant grade penalty.

Examinations are to be your own work and exclusively your own work.

Topics Covered

1. **Mathematical and Physical Background (1 Week)**
   (a) Huygen's principle
   (b) Complex numbers
   (c) Signals and Special functions: Delta and related functions
2. **Linear Systems Theory (2 Weeks)**
   (a) Linear Shift Invariant (LSI) Systems and Operators
   (b) Convolution and its properties
3. **Fourier Transforms and Properties (3 weeks)**
   (a) Fourier series
   (b) One and two-dimensional Fourier transform and its properties
   (c) Convolution theorem and other Fourier Theorems
4. **Sampling and Discrete Signal Representation (1 week)**
   (a) Sampling theorem and reconstruction
   (b) Discrete Fourier Transform (DFT) and its properties
5. **Linear System approach to Diffraction and Wave Propagation (3 weeks)**
   (a) Plane waves, Spherical waves
   (b) Wave propagation
   (c) Fresnel diffraction, Talbot effect, Poisson/Argo spot
   (d) Fraunhofer diffraction and Fourier Transforms
   (e) Diffraction from lenses
6. **Imaging Systems and Fourier Optics (3 weeks)**
   (a) Image formation and impact of geometric aberrations
   (b) Fourier optics and frequency domain description
   (c) Coherence and resolution
   (d) Holography or another application (time permitting)