CREOL OSE 6120: Theoretical Foundations of Optics

College of Optics and Photonics, Fall 2021
University of Central Florida

COURSE SYLLABUS

Instructor:	Dr. Miguel A. Bandres	Term:	FALL 2021
Office:	A222	Class Meeting Days:	Monday/Wednesday
		Class Meeting Hours:	4:30pm-5:45pm
E-Mail:	bandres@creol.ucf.edu	Class Location:	A214
Office Hours:	Thursday 2:30pm-3:30pm	Lab Location:	No Lab

Additional Note: Office hours are planned for Thursday 2:30pm-3:30pm, but I will be happy to discuss the material with you at anytime. Please send me an email if you would like to schedule a meeting.

I. University Course Catalog Description

Mathematical concepts used in Optics. Topics covered include linear algebra, orthogonal expansions of functions, Fourier transforms, ordinary differential equations, partial differential equations.

II. Course Overview

This course aims to provide graduate students with common mathematical concepts used in Optics and Physics. The emphasis will be in practical understanding the mathematical concepts to effective use them as tools to study Optics and Physics. The topics to be covered (in a context related to Optics and Physics) are: linear algebra, orthogonal expansions, Fourier theory, distributions, ordinary differential equations, partial differential equations and group symmetries. **See the list full of the topics at the end.**

III. Course Prerequisites

Graduate standing or consent of instructor.

IV. Course Credits

3 Credit hours.

V. Required Texts and Materials

No textbook requires. Notes will be provided for relevant topic.

VI. Supplementary (Optional) Texts and Materials

Before each topic I will give a list of specific reference for that topic. But in general the following books are a good in case you need extra references:

G. J. Gbur, "Mathematical Methods for Optical Physics and Engineering," Cambridge University, 2011.

M. Mansuripur, Mathematical Methods in Science and Engineering (Applications in Optics and Photonics) Cognella Academic Publishing, 2018

G. B. Arfken and H. J. Weber, "Mathematical Methods for Physicists," Academic Press, 2005.

VII. Basis for Final Grade

Assessment	Percent of Final Grade
Homework (~10 assignments)	80%
Exercises	20%
	100%

Homework is due 1 week after assigned. The lowest graded homework will be dropped.

I expect you to work independently on the homework and then you can discuss just verbally (not showing your homework or explicit calculations/procedures) with your colleagues.

The Exercises will be presented at class and are due 24hr after the class.

Grading Scale (%)	
95 – 100	A
90 – 94	A –
85 – 89	B +
80 – 84	B
70 – 79	B –
65 – 69	C
55 – 64	C –

VIII. Grade Dissemination

Graded tests and materials in this course will be returned individually (by CANVAS) and not posted publicly. You can access your scores at any time using "myUCF Grades" in the portal. Please note that scores returned mid-semester are unofficial grades. If you need help accessing myUCF Grades, see the online tutorial: https://myucfgrades.ucf.edu/help/.

Whenever you want to know your grade progress in the course

IX. Course Policies: Grades

Late Work Policy:

Homework and Exercises turned in late will be assessed a penalty: 7% will be deduced for each day late and will not be accepted if overdue by more than 6 days.

Extra Credit Policy:

The homework (one) with the lowest grade will not count for the final grade.

Grades of "Incomplete":
The current university policy concerning incomplete grades will be followed in this course. Incomplete grades are given only in situations where unexpected emergencies prevent a student from completing the course and the remaining work can be completed the next semester. Your instructor is the final authority on whether you qualify for an incomplete. Incomplete work must be finished by the end of the subsequent semester or the "I" will automatically be recorded as an "F" on your transcript.

X. Course Policies: Technology and Media

Email: **Feel free to email me regarding any question** or concern about the class or to request a meeting.

XI. Course Policies: Student Expectations

Disability Access:
The University of Central Florida is committed to providing reasonable accommodations for all persons with disabilities. This syllabus is available in alternate formats upon request. Students who need accommodations must be registered with Student Disability Services, Ferrell Commons Room 185, phone (407) 823-2371, TTY/TDD only phone (407) 823-2116, before requesting accommodations from the professor.

Attendance Policy:
Regular class attendance is required in this course and is necessary for students to understand many of the topics covered. Students must be on time to class. If missed a class, it is the responsibility of the student to find out the materials covered.

Financial Aid and Attendance:
Students' academic activity at the beginning of each course must be documented. To document that you began this course, **students must complete the academic participation verification question** posted on CANVAS no later than a week after the first class. Failure to do so will result in a delay in the disbursement of financial aid.

Academic Conduct Policy:
Academic dishonesty in any form will not be tolerated. If you are uncertain as to what constitutes academic dishonesty, please consult The Golden Rule, the University of Central Florida's Student Handbook (http://www.goldenrule.sdes.ucf.edu/) for further details. As in all University courses, The Golden Rule Rules of Conduct will be applied. Violations of these rules will result in a record of the infraction being placed in your file and receiving a zero on the work in question AT A MINIMUM. At the instructor's discretion, you may also receive a failing grade for the course. Confirmation of such incidents can also result in expulsion from the University

XII. Important Dates to Remember

All the dates and assignments are tentative, and can be changed at the discretion of the professor.

Drop/Swap Deadline:	Fri, August 27th 2021
Grade Forgiveness Deadline:	Fri, December 3th 2021
Withdrawal Deadline:	Fri, October 29th 2021
Thanksgiving:	Thu, Nov 24th – Sat, Nov 27th

Calendar:

August (3) / September (8)		October (8)		November (8)		December (3)	
23	25	4	6	1	3		1
30	1	11	13	8	10		
6 Labor Day	8	18	20	15	17		
13	15	25	27	22	24		
20	22			29			
27	29						

XIII. List of Topics

1. **Linear Algebra.**
    1. Linear vector spaces
    2. Linear and bi-linear operators
        1. Inner produce and Scalar (Dot) Product
        2. Symmetric and Orthogonal operators
        3. Hermitian and Unitary operators
    3. Dual Vector Spaces
    4. Nonorthogonal Basis
    5. Projector Operators
    6. Stability of a Basis
    7. Eigenvalues and eigenvectors of a linear operator
    8. Matrices, powers of matrices and functions of matrices
    9. Non-Hermitian operators

2. **Orthogonal Expansions**
    1. Infinite dimensional vector spaces
    2. Linear space of functions
    3. Scalar product of function
    4. Orthogonal polynomials and completeness
    5. Expansions of functions

3. **Fourier Theory**
    1. Fourier series and convergence
    2. Fourier transform and its inverse
    3. Dirac Delta Function
    4. Properties of the Fourier transform
    5. Eigenfunctions of the Fourier transform
    6. 2D Fourier transform and Hankel transform
    7. Discrete Fourier transform
    8. Fast Fourier Transform, advantages, and dangers
    9. Sampling Theory
    10. Compress sensing (basic concepts)
    11. Fractional Fourier Transform
    12. 3D, nD, Fourier Transform

4. **Theory of Distributions**
    1. Properties of Distributions
    2. Test Functions
    3. Regular and Singular Distributions
    4. The Dirac Delta Distribution
    5. Fourier Transform of Distributions

5. **Ordinary Differential Equations**
    1. Linear ODEs
    2. Sturm-Liouville Theory
    3. Diffusion equation
    4. 1D wave equation
    5. Boundary Conditions
    6. Series Solutions / Integral Transforms
    7. **Green Functions**
    8. Integral transform solution
    9. System of differential equations
    10. Invariances/Symmetries in ODES

6. **Partial Differential Equations (PDEs)**
    1. Helmholtz Equation
        1. Coordinate systems

2. Separation of variables: plane waves, spherical waves, cylindrical waves.
3. Non-diffractive solutions
4. Green's function: exact and approximate Huygens' principle

2. Paraxial wave equation
    1. Approximation
    2. Separation of variables
    3. Hermite, Laguerre Gaussian beams
    4. Airy beams

7. **Group Symmetries**
    1. Definition and properties
    2. Rotational group
    3. ABCD paraxial transformations

Religious Observances

Students are expected to notify their instructor in advance if they intend to miss class to observe a holy day of their religious faith. For a current schedule of major religious holidays, see the Faculty Center's main web page under "Calendars," and for additional information, contact the Office of Diversity Initiatives at 407-823-6479.

Regarding COVID-19

Notifications in Case of Changes to Course Modality

Depending on the course of the pandemic during the semester, the university may make changes to the way classes are offered. If that happens, please look for announcements or messages in Webcourses@UCF or Knights email about changes specific to this course.

COVID-19 and Illness Notification

Students who believe they may have a COVID-19 diagnosis should contact UCF Student Health Services (407-823-2509) so proper contact tracing procedures can take place.

Students should not come to campus if they are ill, are experiencing any symptoms of COVID-19, have tested positive for COVID, or if anyone living in their residence has tested positive or is sick with COVID-19 symptoms. CDC guidance for COVID-19 symptoms is located here: (https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html)

Students should contact their instructor(s) as soon as possible if they miss class for any illness reason to discuss reasonable adjustments that might need to be made. When possible, students should contact their instructor(s) before missing class.

In Case of Faculty Illness

If the instructor falls ill during the semester, there may be changes to this course, including having a backup instructor take over the course. Please look for announcements or mail in Webcourses@UCF or Knights email for any alterations to this course.

Course Accessibility and Disability COVID-19 Supplemental Statement

Accommodations may need to be added or adjusted should this course shift from an on-campus to a remote format. Students with disabilities should speak with their instructor and should contact sas@ucf.edu to discuss specific accommodations for this or other courses.