UNIVERSITY OF CENTRAL FLORIDA

# OSE 5312 - Light Matter Interaction

**Section:** 0001

*Optics and Photonics*

## Course Information

**Term:** Spring 2026
**Class Meeting Days:** TR
**Class Meeting Time:** 10:30AM - 11:45AM
**Class Meeting Location:** CROL 0102
**Modality:** P
**Credit Hours:** 3.00

## Instructor Information

**Name:** Romain Gaume
**Title:** Associate Professor
**Office Location:** A339
**Office Hours**
Tue 12-1 pm
**Email:** gaume@ucf.edu

## Course Description

OSE 5312 OPT-OPT 3(3,0)Light Matter Interaction: PR: Graduate standing or C.I. Microscopic theory of absorption, dispersion, and refraction of materials; classical

and quantum mechanical description of optical properties. Fall, Spring.

**Course Overview**

This course discusses the interaction of light with matter. We will find that many important optical properties can be described quite accurately using surprisingly simple models. Initially, we will model atoms as classical dipole oscillators ("electrons on springs"). We will use the calculated behavior of these model atoms together with Maxwell's equations to obtain expressions for the frequency dependent refractive index, absorption, and susceptibility. Using this theory, we will be able to understand the optical properties of gases, liquids and solids, including metals, semiconductors and dielectrics. To improve on our model descriptions, we will discuss the foundations of quantum mechanics and derive a quantum mechanical description of the refractive index. We will include the interaction of light with oscillations of atoms (molecular vibrations and rotations, phonons) and consider how quantum mechanics affects molecular absorption spectra.

***List of topics covered:***

Maxwell's Equations and the Dielectric Function: free charges, meaning of susceptibility and polarization response, bound electron polarization and magnetization, causality & Kramers-Kronig relations, Optical Properties of Solids, Liquids and Gases: molecules, liquids, metals, insulators, semiconductors, Classical Treatment of Light-Matter Interaction: Lorentz oscillator, Drude model, Debye model, calculation of susceptibility and complex refractive index, Sellmeier equations and Abbe number, electronic transitions in atoms, anharmonic classical oscillator model, second order effects, third order effects, molecular rotational/vibrational transitions in molecules, dipole-active and Raman-active modes, phonons in solids, acoustic modes, optical modes, Quantum-mechanical description of Light-Matter Interaction: operators, Eigenfunctions, orthonormal complete sets, Dirac notation, wavefunctions, observables, commutation, ensemble averages, energy Eigenfunctions, time independent Schrödinger equation, infinite and finite wells, barriers, time dependent Schrödinger equation, time dependent perturbation theory, Fermi Golden Rule, expectation value of Polarization, susceptibility, oscillator strength, dopants / impurities in dielectric hosts, Kronig-Penney model and Energy bands, Bandgaps, Excitons, impurities (n- and p-type), blackbody radiation, Einstein coefficients, Thermal distributions (Bose-Einstein, Fermi-Dirac, Maxwell-Boltzmann).

## Student Learning Outcomes

After successful completion of this course, students will be able to identify materials based on reflection, transmission, absorption spectra, predict optical properties based on dopant concentrations and resonances, predict refractive index spectra

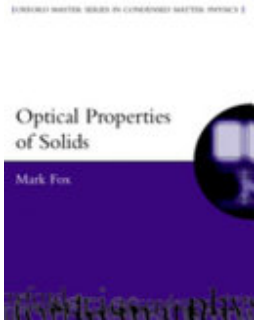
based on absorption spectra, and understand the role of quantum mechanics in optical properties.

Recommendations for success in this course include attending class on a routine basis, using office hours and connecting with the Teaching Assistant (TA).

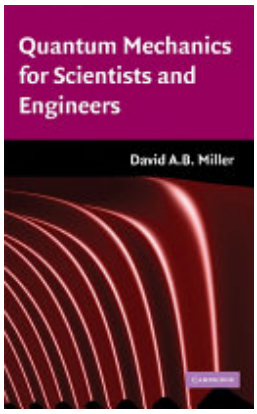
## Required Course Materials and Resources

**Lecture notes from Instructor**

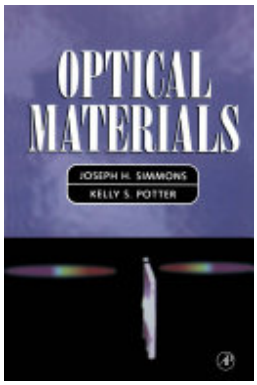
## Recommended Course Materials



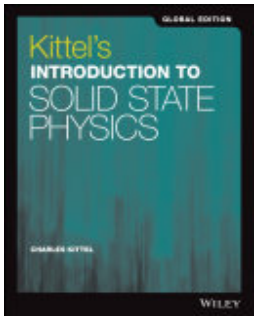

**Title: Optical Properties of Solids**
**ISBN:** 9780198506126
**Authors:** Anthony Mark Fox
**Publisher:** Oxford University Press, USA
**Publication Date:** 2001-01-01




**Title: Quantum Mechanics for Scientists and Engineers**
**ISBN:** 9781139471275
**Authors:** David A. B. Miller
**Publisher:** Cambridge University Press
**Publication Date:** 2008-04-21




**Title: Optical Materials**
**ISBN:** 9780080513201
**Authors:** Joseph H. Simmons, Kelly S. Potter
**Publisher:** Elsevier
**Publication Date:** 1999-11-02




**Title: Introduction to Solid State Physics**
**ISBN:** 9781119454168
**Authors:** Charles Kittel, Paul McEuen
**Publisher:** John Wiley & Sons
**Publication Date:** 2018-01-01

## Course Assessment and Grading Procedure

The semester's grade will be obtained from the following assessments and weights:

| Assignments | Grade Weighting |
|---|---|
| Homework (6) | 60% |
| Midterm Exam (1) | 20% |
| Final Exam (1) | 20% |
| **Total** | **100%** |

| Grade | | Description |
|---|---|---|
| 94-100<br>90-93 | A<br>A- | Excellent, has a strong understanding of all concepts and is able to apply the concepts in all and novel situations. Has full mastery of the content of the course. |
| 87-89<br>84-86<br>80-83 | B+<br>B<br>B- | Good, has a strong understanding of most or all of the concepts and is able to apply them to stated and defined situations. |
| 77-79<br>74-76<br>70-73 | C+<br>C<br>C- | Average, has a basic understanding of the major concepts of the course and is able to apply to basic situations. |

| | | |
|---|---|---|
| 67-69<br>64-66<br>60-63 | D+<br>D<br>D- | Below average, has a basic understanding of only the simple concepts and is able to apply to only a limited number of the most basic situations. |
| 0- 59 | F | Demonstrates no understanding of the course content. |

**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.

## Grading Scale

Grading Scale

| Letter Grade | Percentage |
|---|---|
| A | 94-100% |
| A- | 90-93% |
| B+ | 87-89% |
| B | 84-86% |
| B- | 80-83% |
| C+ | 77-79% |
| C | 74-76% |
| C- | 70-73% |
| D+ | 67-69% |
| D | 64-66% |
| D- | 61-63% |
| F | 0-60% |

## Policies for Course Grade

**Late Work Policy**: Homework posted in late will be assessed a penalty: a half-letter grade if it is one day late, or a full-letter grade for 2-7 days late. Homework will not be accepted if overdue by more than seven days or after solutions are posted. Makeup exams will only be offered with prior permission from instructor.

**Make Up Policy:** If an emergency arises and a student cannot submit assigned work on or before the scheduled due date or cannot take an exam on the scheduled date, the student **must** give notification to the instructor **no less than 24 hours before** the scheduled date and **no more than 48 hours after the** scheduled date.

**Grade Objections:**
All objections to grades should be made **in writing within one week** of the work in question. Objections made after this period has elapsed will **not** be considered – NO EXCEPTIONS.

**Grade Dissemination**
Graded tests and materials in this course will be returned individually only by request. You can access your scores at any time using the Grade Book function of Webcourses. Please, note that scores returned mid-semester are **unofficial grades**.

## Artificial Intelligence (AI) Use Policy

Use of Generative AI (GenAI) is freely permitted but must be disclosed. Students are allowed to use Generative Artificial Intelligence tools on assignments if the usage is properly disclosed and credited. For example, text generated from Copilot should include a citation such as: “Copilot. Accessed 2026-12-03. Prompt: ‘How do I determine the electron collision time parameter from the reflectivity spectrum of a metal?.’ Generated using Copilot.” Any attempt to represent GenAI output inappropriately as your own work will be treated as plagiarism. Ultimately, students are responsible for the accuracy and veracity of submitted work whether AI-generated or not.

## Disability Access & Accommodations

The University of Central Florida is committed to providing equal access to all students with disabilities (ADHD, learning disabilities, Autism, chronic medical conditions, physical disabilities, etc.). To receive consideration for reasonable disability-related course accommodations, disabled students must contact Student

Accessibility Services (SAS) and complete the steps required for SAS to review accommodation requests. More information can be found on the UCF Student Accessibility Services website under the Start Here tab or by contacting SAS directly (Ferrell Commons 185; sas@ucf.edu; Phone - 407-823-2371).

Approved accommodations are shared with course instructors via the SAS Course Accessibility Letter. Implementing certain accommodations may require discussion about specific considerations of the course design, course learning objectives, and the individual academic and course challenges experienced by the student. While students with disabilities or chronic health needs are also encouraged to discuss any course concerns with professors in addition to contacting SAS, professors are not required to facilitate disability-related adjustments to the course unless the professor has received a Course Accessibility Letter from SAS that outlines approved accommodations.

## Academic Integrity

Students should familiarize themselves with UCF's Code of Conduct at Student Conduct and Integrity Office. According to Section 1, "Academic Misconduct," students are prohibited from engaging in:

1. Academic misconduct is defined as any submitted work or behavior that obstructs the instructor of record's ability to accurately assess the student's understanding or completion of course materials or degree requirements (e.g., assignment, quiz, and/or exam). Examples of academic misconduct include but are not limited to: plagiarism, unauthorized assistance to complete an academic exercise; unauthorized communication with others during an examination, course assessment, or project; falsifying or misrepresenting academic work; providing misleading information to create a personal advantage to complete course/degree requirements; or multiple submission(s) of academic work without permission of the instructor of record.
2. Any student who knowingly helps another violate academic behavior standards is also in violation of the standards.
3. Commercial Use of Academic Material. Selling of course material to another person and/or uploading course material to a third-party vendor without authorization or without the express permission of the University and the

instructor of record. Course materials include but are not limited to class notes, the instructor of record's slide deck, tests, quizzes, labs, instruction sheets, homework, study guides, and handouts.

4. Soliciting assistance with academic coursework and/or degree requirements. The solicitation of assistance with an assignment, lab, quiz, test, paper, etc., without authorization of the instructor of record or designee is prohibited. This includes but is not limited to asking for answers to a quiz, trading answers, or offering to pay another to complete an assignment. It is considered Academic Misconduct to solicit assistance with academic coursework and/or degree requirements, even if the solicitation did not yield actual assistance (for example, if there was no response to the solicitation).

**Responses to Academic Dishonesty, Plagiarism, or Cheating**

Students should also familiarize themselves with the procedures for academic misconduct in UCF's student handbook, *The Golden Rule*. UCF faculty members have a responsibility for students' education and the value of a UCF degree, and so seek to prevent unethical behavior and respond to academic misconduct when necessary. Penalties for violating rules, policies, and instructions within this course can range from a zero on the exercise to an "F" letter grade in the course. In addition, an Academic Misconduct report could be filed with the Office of Student Conduct and Academic Integrity, which could lead to disciplinary warning, disciplinary probation, or deferred suspension or separation from the University through suspension, dismissal, or expulsion with the addition of a "Z" designated on one's transcript.

Being found in violation of academic conduct standards could result in a student having to disclose such behavior on a graduate school application, being removed from a leadership position within a student organization, the recipient of scholarships, participation in University activities such as study abroad, internships, etc.

Let's avoid all of this by demonstrating values of honesty, trust, and integrity. No grade is worth compromising your integrity and moving your moral compass. Stay true to doing the right thing: take the zero, not a shortcut.

## Title IX

Title IX prohibits sex discrimination, including sexual misconduct, sexual violence, sexual harassment, and retaliation. If you or someone you know has been harassed or assaulted, you can find resources available to support the victim, including confidential resources and information concerning reporting options at Let's Be Clear and UCF Cares.

For more information on access and community engagement, Title IX, accessibility, or UCF's complaint processes contact:

- Title IX – ONAC – Office of Nondiscrimination & Accommodations Compliance & askanadvocate@ucf.edu
- Disability Accommodation – Student Accessibility Services – Student Accessibility Services & sas@ucf.edu
- Access and Community Engagement (including the Ginsberg Center for Inclusion and Community Engagement, Military and Veteran Student Success, and HSI Initiatives)
- UCF Compliance and Ethics Office – Compliance, Ethics, and Risk Office & complianceandethics@ucf.edu
- The Ombuds Office is a safe place to discuss concerns.

## Reporting an Incident or Issue

If you believe you have experienced discrimination by any faculty or staff member, contact the Office of Nondiscrimination & Accommodations Compliance via the ONAC website or at 407-823-1336. You can also choose to report using the UCF Integrity Line either anonymously or as yourself at 1-855-877-6049 or by using the online form. UCF cares about you and takes every report seriously. For more information see the Reporting an Incident or Issue Webpage.

## Deployed Active-Duty Military Students

Students who are deployed active-duty military and/or National Guard personnel and require accommodation should contact their instructors as soon as possible after the semester begins and/or after they receive notification of deployment to make arrangements.

## Campus Safety

At UCF's Public Safety and Police, safety is the top priority. Emergencies on campus are rare, but if one should arise, it's important to be familiar with some basic safety and security concepts.

- In an emergency, always dial 911.
- Every UCF Classroom has an Emergency Procedure Guide posted on a wall near the door, which will show you how to respond to a variety of situations. This guide can also be found online here.
- In the event of an active threat, remember **AVOID, DENY, DEFEND**. Choose the best course of action and act immediately. Watch the video here to learn more.
    - **AVOID**. Pay attention to your surroundings and have an exit plan. Get as much distance and as many barriers between you and the threat as quickly as possible.
    - **DENY**. When avoiding is difficult or impossible, deny the threat access to you and your space. Lockdown by creating barriers, turning the lights off and remaining quiet and out of sight. Make sure your phone is silenced, but do not turn it off.
    - **DEFEND**. When you are unable to put distance between yourself and the threat, be prepared to protect yourself. Commit to your actions, be aggressive and do not fight fairly. Do whatever it takes to survive.
- For emergencies on campus, UCF will utilize the UCF Alert system. All UCF students, faculty, and staff are automatically enrolled to receive these email and text alerts, however, it's a good idea to frequently ensure your contact information is up to date.

## Financial Aid Accountability

All instructors are required to document students' academic activity at the beginning of each course. In order to document that you began this course, please complete this activity by the end of the first week of classes or as soon as possible after adding the course. Failure to do so may result in a delay in the disbursement of your financial aid.

## Class Schedule

**Tentative schedule - check most recent lecture to see up-to-date info**

| Day | Date | Subjects covered | Description | Notes | Fox | Miller |
|---|---|---|---|---|---|---|
| T | 1/13/2026 | Introduction - broad overview of topics to be covered | | 1 | 1 | |
| Th | 1/15/2026 | Review of Maxwell's equations | continuum | 2 | 2 | |
| T | 1/20/2026 | Wave propagation in dispersive media | continuum | 3 | 2 | |
| Th | 1/22/2026 | Kramers-Kronig relations | continuum | 4 | 2 | |
| T | 1/27/2026 | Dielectrics - the Lorentz model (part 1) | oscillator (classical) | 5 | 2 | |
| Th | 1/29/2026 | Dielectrics - the Lorentz model (part 2) | oscillator (classical) | 5 | 2 | |
| T | 2/3/2026 | Metals and doped semiconductors - Drude model (part 1) | oscillator (classical) | 8 | 7 | |
| Th | 2/5/2026 | Metals and doped semiconductors - Drude model (part 2) | oscillator (classical) | 8 | 7 | |
| T | 2/9/2026 | More on Lorentz model: anharmonic oscillator and NLO (part 1) | oscillator (classical) | 15 | 11 | |
| Th | 2/12/2026 | More on Lorentz model: anharmonic oscillator and NLO (part 2) | oscillator (classical) | 15 | 11 | |
| T | 2/16/2026 | Optical activity | oscillator (classical) | 15 | 11 | |
| Th | 2/19/2026 | Magneto-optic effects | | | | |
| T | 2/23/2026 | Blackbody radiation (part 1) | | | | |
| Th | 2/26/2026 | Blackbody radiation (part 2) | | | | |
| T | 3/3/2026 | Quantum mechanics: Intro to Schrödinger eq., states of an infinite well | quantum | - | | 2 |
| Th | 3/5/2026 | States of a finite well | quantum | - | | 2 |
| T | 3/9/2026 | Time dependence, expectation values, orthonormal complete sets | quantum | - | | 3 |
| Th | 3/12/2026 | From time dependent amplitudes to susceptibility and absorption (part 1) | quantum | - | B | 7 |
| T | 3/16/2026 | No Class (Spring Break) | | | | |
| Th | 3/19/2026 | No Class (Spring Break) | | | | |
| T | 3/23/2026 | From time dependent amplitudes to susceptibility and absorption (part 2) | quantum | - | B | 7 |
| Th | 3/26/2026 | Molecular vibrations, quantum rotor, vibration - rotation spectra | oscillator (Q & class) | 10,7 | | |
| T | 3/31/2026 | Classical and quantum description of vibrations in molecules (part 1) | oscillator (classical) | 6,10 | | |
| Th | 4/2/2026 | Classical and quantum description of vibrations in molecules (part 2) | oscillator (classical) | 6,10 | | |
| T | 4/7/2026 | Vibrations in solids: phonon dispersion in linear chains of atoms | oscillator (classical) | 10 | 10 | |
| Th | 4/9/2026 | Vibrations in solids: reciprocal space, phonon dispersion in real materials (part 1) | | 10 | 10 | |
| T | 4/14/2026 | Vibrations in solids: reciprocal space, phonon dispersion in real materials (part 2) | | 10 | 10 | |
| Th | 4/16/2026 | Optical properties of semiconductors: Kronig-Penney Model and bandgaps | QM & band structure | 11 | 3, C | 8 |
| T | 4/21/2026 | Optical properties of semiconductors: electronic band structure | QM & band structure | 11 | 3, C | 8 |
| Th | 4/23/2026 | Optical properties of semiconductors: interband transitions | QM & band structure | 11 | 3, C | 8 |
| T | 4/28/2026 | No Class | | | | |
| Th | 4/30/2026 | No Class | | | | |
| **T** | **5/5/2026** | **FINAL EXAM: 10:00am-12:50 am Room 102** | | | | |

## Miscellaneous

**Deadlines, Holidays, and Significant Semester Events:**

Please refer to the UCF Academic Calendar and the UCF Exam Schedule for more information such as Exam Dates, Add/Drop, Withdrawal, and Grade Forgiveness Deadlines. Important dates include

university holidays or closures, drop/withdrawal deadlines, exam dates, assignment deadlines, or other dates in the UCF Academic Calendar that pertain to your course.

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

**Webcourses**: Webcourses will be used to communicate class notes (pdf files), assignments, grades or general messages to the class. You will also upload your assignments on this platform.

**Professionalism Policy**:
Per university policy and classroom etiquette, mobile phones, iPods, *etc*. **must be silenced** during lectures. Those not heeding this rule will be asked to leave the classroom immediately so as to not disrupt the learning environment. Please, arrive on time for all class meetings. Students who habitually disturb the class by talking, arriving late, *etc*., and have been warned may suffer a reduction in their final class grade.

**Unauthorized Use of Websites and Internet Resources**
There are many websites claiming to offer study aids to students, but in using such websites, students could find themselves in violation of academic conduct guidelines. These websites include (but are not limited to) Quizlet, Course Hero, Chegg Study, and Clutch Prep. UCF does not endorse the use of these products in an unethical manner, which could lead to a violation of our University's Rules of Conduct.

They encourage students to upload course materials, such as test questions, individual assignments, and examples of graded material. Such materials are the intellectual property of instructors, the university, or publishers and may not be distributed without prior authorization. Students who engage in such activity could be found in violation of academic conduct standards and could face course and/or University penalties. Please let me know if you are uncertain about the use of a website so I can determine its legitimacy.

**Unauthorized Distribution of Class Notes**
Third parties may attempt to connect with you to sell your notes and other course information from this class. Distributing course materials to a third party without my authorization is a violation of our University's Rules of Conduct. Please be aware that such class materials that may have already been given to such third parties may contain errors, which could affect your performance or grade. If a third party should contact you regarding such an offer, I would appreciate your bringing this to my attention. We all play a part in creating a course climate of integrity.

**In-Class Recording**

Students may, without prior notice, record video or audio of a class lecture for a class in which the student is enrolled ***for their own personal educational use***. A class lecture is defined as a formal or methodical oral presentation as part of a university course intended to present information or teach enrolled students about a particular subject.

Recording class activities other than class lectures, including but not limited to class discussion, academic exercises involving student participation, test or examination administrations, private conversations between students in the class or between a student and the faculty member, and invited guest speakers is prohibited.

Recordings may not be used as a substitute for class participation and class attendance and may not be published or shared without the written consent of the faculty member. Failure to adhere to these requirements may constitute a violation of the University's Student Code of Conduct as described in the Golden Rule.