I. University Course Catalog Description
Microscopic theory of absorption, dispersion, and refraction of materials; classical and quantum-mechanical description of optical properties.

II. 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:
wells, barriers, time dependent Schrödinger equation, time dependent perturbation theory, Fermi Golden Rule, 
evaluation 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)

III. Course Objectives
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.

IV. Course Prerequisites
Graduate standing or consent of instructor.

V. Recommended Texts and Materials
- Course notes (online PDF)
- Optical Properties of Solids M. Fox (Oxford University Press)
- Quantum Mechanics for Scientists and Engineers D. A. B. Miller (Cambridge)

VI. Supplementary (Optional) Texts and Materials
- Introduction to Solid State Physics C. Kittel (Wiley)
- Optical Electronics in Modern Communications A. Yariv (Oxford)

VII. Basis for Final Grade
The semester’s grade will be obtained from the following assessments and weights:

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Percent of Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework (6)</td>
<td>60%</td>
</tr>
<tr>
<td>Midterm</td>
<td>20%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

Plus and minus will be used according to the scale below:

<table>
<thead>
<tr>
<th>Grading Scale (%)</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>94-100</td>
<td>A</td>
</tr>
<tr>
<td>90-93</td>
<td>A-</td>
</tr>
<tr>
<td>87-89</td>
<td>B+</td>
</tr>
<tr>
<td>84-86</td>
<td>B</td>
</tr>
<tr>
<td>80-83</td>
<td>B-</td>
</tr>
<tr>
<td>77-79</td>
<td>C+</td>
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<tr>
<td>74-76</td>
<td>C</td>
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<tr>
<td>70-73</td>
<td>C-</td>
</tr>
<tr>
<td>67-69</td>
<td>D+</td>
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<tr>
<td>64-66</td>
<td>D</td>
</tr>
<tr>
<td>60-63</td>
<td>D-</td>
</tr>
<tr>
<td>0 - 59</td>
<td>F</td>
</tr>
</tbody>
</table>
VIII. 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.

IX. Course Policies: Grades

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. Essays 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.

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.

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.

Laptop/Tablet Usage: If you like, you are welcome to take notes with your personal laptop or tablet during the lectures.

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.

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.

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

Drop/Swap Deadline: Fri, Jan 14th, 2022
Spring Break: Sun, Mar 6th to Sun, Mar 13th, 2022
Withdrawal Deadline: Fri, Mar 25th, 2022
Grade Forgiveness Deadline: Mon, Apr 25th, 2022
Final Examination: Thu, May 3rd, 2022, 10:00am-12:50pm

XIII. Schedule

The following dates are tentative and updates will be provided based on course progression.

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

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Subjects covered</th>
<th>Description</th>
<th>Notes</th>
<th>Fox</th>
<th>Miller</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>11-Jan</td>
<td>Introduction - broad overview of topics to be covered</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>13-Jan</td>
<td>Review of Maxwell's equations</td>
<td>continuum</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>18-Jan</td>
<td>Wave propagation in dispersive media</td>
<td>continuum</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>20-Jan</td>
<td>Kramers-Kronig relations</td>
<td>continuum</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>25-Jan</td>
<td>Dielectrics - the Lorentz model (1)</td>
<td>oscillator (classical)</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>27-Jan</td>
<td>Dielectrics - the Lorentz model (2)</td>
<td>oscillator (classical)</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>1-Feb</td>
<td>Metals and doped semiconductors - Drude model</td>
<td>oscillator (classical)</td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>3-Feb</td>
<td>More on Lorentz model, anharmonic oscillator and pathways to NLO</td>
<td>oscillator (classical)</td>
<td>15</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>8-Feb</td>
<td>Nonlinear optics; frequency mixing: sum and difference frequency generation</td>
<td>oscillator (classical)</td>
<td>15</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>10-Feb</td>
<td>Nonlinear optics; frequency mixing: sum and difference frequency generation</td>
<td>oscillator (classical)</td>
<td>15</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>15-Feb</td>
<td>Midterm Exam</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Th</td>
<td>17-Feb</td>
<td>QM1 - Introduction to Schrödinger equation, states of an infinite well</td>
<td>quantum</td>
<td>-</td>
<td>2</td>
<td></td>
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<tr>
<td>T</td>
<td>22-Feb</td>
<td>QM2 - States of a finite well</td>
<td>quantum</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>24-Feb</td>
<td>QM3 - Time dependence, expectation values, orthonormal complete sets</td>
<td>quantum</td>
<td>-</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>1-Mar</td>
<td>QM4 - Example basis sets, Harmonic oscillator, Hydrogen atom</td>
<td>quantum</td>
<td>-</td>
<td>3, 10</td>
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<tr>
<td>Th</td>
<td>3-Mar</td>
<td>QM5 - Time dependent perturbation</td>
<td>quantum</td>
<td>-</td>
<td>7</td>
<td></td>
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<tr>
<td>T</td>
<td>8-Mar</td>
<td>No Class (Spring Break)</td>
<td></td>
<td></td>
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<tr>
<td>Th</td>
<td>10-Mar</td>
<td>No Class (Spring Break)</td>
<td></td>
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<tr>
<td>T</td>
<td>15-Mar</td>
<td>QM6 - From time dependent amplitudes to absorption coefficient</td>
<td>quantum</td>
<td>-</td>
<td>B</td>
<td></td>
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<tr>
<td>Th</td>
<td>17-Mar</td>
<td>QM7 - From time dependent amplitudes to susceptibility</td>
<td>quantum</td>
<td>-</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>22-Mar</td>
<td>Molecular vibrations, quantum rotor, vibration - rotation spectra</td>
<td>oscillator (Q &amp; class)</td>
<td>10.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>24-Mar</td>
<td>Classical and quantum description of vibrations in molecules</td>
<td>oscillator (classical)</td>
<td>6.10</td>
<td></td>
<td></td>
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<tr>
<td>T</td>
<td>29-Mar</td>
<td>Classical and quantum description of vibrations in molecules II</td>
<td>oscillator (classical)</td>
<td>6.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>31-Mar</td>
<td>Vibrations in solids I; phonon dispersion in linear chains of atoms</td>
<td>oscillator (classical)</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>5-Apr</td>
<td>Vibrations in solids II; reciprocal space, phonon dispersion in real materials</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
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<tr>
<td>Th</td>
<td>7-Apr</td>
<td>Vibrations in solids III; reciprocal space, phonon dispersion in real materials</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>12-Apr</td>
<td>Optical properties of semiconductors - Kronig-Penney Model and Bandgaps</td>
<td>QM &amp; band structure</td>
<td>11</td>
<td>3, C</td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>14-Apr</td>
<td>Optical properties of semiconductors - Band structure</td>
<td>QM &amp; band structure</td>
<td>11</td>
<td>3, C</td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>19-Apr</td>
<td>Optical properties of semiconductors - Interband transitions</td>
<td>QM &amp; band structure</td>
<td>11</td>
<td>3, C</td>
<td></td>
</tr>
<tr>
<td>Th</td>
<td>21-Apr</td>
<td>Optical properties of semiconductors - excitons, impurities, FCA</td>
<td>QM &amp; band structure</td>
<td>11</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>26-Apr</td>
<td>Optical properties of semiconductors - excitons, impurities, FCA</td>
<td>QM &amp; band structure</td>
<td>11</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>28-Apr</td>
<td>No Class</td>
<td></td>
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<tr>
<td>Th</td>
<td>3-May</td>
<td>FINAL EXAM: 10:00am-12:50 am Room 102</td>
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