PHYS 554.001 and ECE 554.001: Advanced Optics II
CRN: 55189 (Physics) & 54521 (ECE)

Description of the class
This class is a continuation from Advanced Optics I of the Fall Semester 2022. It covers the following major sections: optical properties of materials; coherence; statistical optics and fluctuations; and elements of Fourier optics. The first section is focused on optical response of dielectric and semiconductor crystals and incudes the following topics: classical Lorentz oscillator model for ideal dielectric crystals; Drude model of optical response of metals; basics of plasmons; complex optical response; Kramer-Kronig relations; dispersion of optical response; overview of absorption mechanisms in optical materials; reflection from absorbing surfaces; optical response of anisotropic crystals; magneto-optic effects; electro-optic effects; acousto-optic effect; and applications of those effects in devices. The second section covers temporal and spatial coherence; coherence function; interference of partially coherent light; transmission of partially coherent light through optical systems; image formation; and Van-Cittert-Zernike theorem. The third section includes analysis of statistical properties of light, auto-correlation and mutual correlation functions, and thermal noise of light. The fourth section includes basics of Fourier analysis of 2D signals and systems; wave-optics and frequency-domain analysis of optical imaging systems; applications of Fourier optics in spatial filtering, and applications of Fourier optics in image analysis. This class is calculus based. Complex algebra, calculus, Fourier transform, and Taylor series are routinely utilized in class.

This class also includes an oral presentation and a short formal report (see descriptions below).

Pre-requisites
PHYS 463: Advanced Optics I; Electromagnetics or Electricity and Magnetism; Calculus; Differential Equations; Linear Algebra; Complex Algebra; Matrixes; Grad Quantum Mechanics I.

Lectures:
Mondays and Wednesdays; from 4:00 pm to 5:30 pm
Room: 1160 PAIS Building

Instructor:
Dr. Vitaly Gruzdev, Department of Physics and Astronomy
PAIS Building, room 2012
E-mail: vgruzdev@unm.edu

Teaching Assistant:
TBA

Office Hours:
Instructor: Mondays; 2:30 pm – 3:50 pm. You may also arrange a meeting for another time depending on instructor availability.
TA: TBA

Textbooks:
Because of the supply-chain issues, lecture notes are considered as a major source of information for students of this class. However, there are many useful textbooks on the topics of this class. For each of the major topics of this semester, there are recommended 1 or 2 textbooks.

Topic 1: Crystal optics:
(P3) Frank L. Pedrotti, Leno M. Pedrotti, Leno S. Pedrotti, "Introduction to Optics", 3d edition.
(FOX) Mark Fox, "Optical Properties of Solids", 2nd Ed., Oxford University Press, 2010.

Topic 2: Coherence:
(MF) Miles V. Klein, Thomas E. Furtak, "Optics", 2nd or 3d Edition.

Topic 3: Statistical Optics
(SO) Joseph W. Goodman, "Statistical Optics", 2nd Ed.

Topic 4: Fourier Optics:
(FO) Joseph W. Goodman, "Fourier Optics", 3nd Ed.

Additional resources:
Hartmut Haug, Stephan W. Koch, "Quantum Theory of the Optical and Electronic Properties of Semiconductors", 4th or later edition.
Jacques I. Pankove, "Optical Processes in Semiconductors".
Max Born, Emil Wolf, "Principles of Optics", 6th or later edition.
Lev D. Landau, E. M. Lifshitz and L. P. Pitaevskii, "Electrodynamics of Continuous Media", 2nd Edition or later (Pergamon Press, 1984).

Homework assignments
There are planned 6 homework assignments this semester. Each assignment typically includes 3 problems based on the lecture content. The assignments will be given throughout the semester a week before they are due. Solutions to homework problems should be turned in to instructor's mailbox on the due date by 3:30 pm.

If unable to turn in a hard copy, a PDF file with your homework can be e-mailed to instructor by 11:59 pm on the due date. PDF file is the only acceptable electronic version of the homework. Scans of hand-written work by phones will be first checked for quality, and a confirmation will be sent to each student who submits a scanned version. PDF files obtained from various apps are also acceptable.

Late return of a homework assignment reduces maximum possible points by 33.3%.

Grading
The final grade will be based on the homework assignments, mid-term exam, oral presentation and report, and final exam. The contributions to the final grade are as follows:

1. Homework: 18% (3% each homework);
2. Formal report and oral presentation: 18%
3. Mid-term exam: 26%

4. Final exam: 38%

Grade brackets:
"D": 0% - 49.9%
"C": 50% - 66.6%
"B": 66.7% - 80%
"A-": 80% - 90%
"A": 90.1% – 95%
"A+": 95.1% - 100%

Exam dates (subject to change):
Mid-term: **03/08** (no makeup date).
Final exam: **05/08**; makeup date: **05/10**.

Formal Report:
A formal report is focused on one of suggested topics related to fundamental concepts and/or applications. It can be your lab report or a part of your lab report if the report topic fits the scope of this class. Topic of a report should be discussed with the instructor prior to starting your work on the report. The objective of this task is to master students' writing skills and improve their style of technical/scientific writing. The report can be prepared using MS Word or LaTeX. The style should follow the format of a scientific paper from Physical Review, Optics Letters, or Applied Physics Letters. Length range is from 2 journal pages (minimum) to 4 journal pages (maximum). The report should be submitted to the instructor as a PDF file via e-mail (subject "Formal Report") by 11:59 pm of Friday, **05/05**. The file name should include your Student ID Number in the style "Number_Report". Formal reports and presentations are individual. Samples of journal styles and LaTeX/TeX templates will be provided by instructor via e-mail.

Oral Presentation:
The objective of this task is to improve the skills of public presentation on scientific and technical topics. You will deliver a presentation at the end of the semester on 05/01/23 and on 05/03/23 on the topic of your Formal Report. Duration: 15 minutes of presentation + 5 minutes for questions/answers. It should cover fundamentals, relevant theoretical background, development/state-of-the-art in the field, and applications in science and/or technology. Slides for the presentation can be run from either instructor's laptop or your own laptop. Preferable formats, tips for slide preparation, and suggestions on presentation style will be shared later.

Syllabus Topics

Below is a tentative list of topics and sub-topics that will be covered by this class.

A. Crystal optics

1) Classical Lorentz and Drude models of optical response of solids; dispersion; plasmons;
2) Complex optical response; Kramer-Kronig relations; light absorption;
3) Reflection from absorbing (e. g., metal) surfaces; skin effect;
4) Anisotropic reflectivity; propagation in anisotropic crystals; Fresnel crystal equation;
5) Crystals in magnetic and electric fields: magneto-optical and electro-optical effects;
6) Applications of electro-optical and magneto-optical effects; control of polarization;

B. Coherence

1) Temporal coherence; coherence function; examples of coherence functions;
2) Interferometers; Michelson interferometer; contrast of interference pattern;
3) Spatial coherence; Young's two-slit interference experiment;
4) Transverse coherence; longitudinal coherence;
5) Coherence and imaging, influence of partial coherence on imaging function.

C. Statistical optics and fluctuations

1) Light as a stochastic process; statistical description of random processes; correlations;
2) Statistical optics; autocorrelation function; coherence time and spectral bandwidth;
3) Coherence from the viewpoint of correlation functions; Van Cittert-Zernike theorem;
4) Fluctuations and noise in optics – classical treatment; introduction into quantum analysis;
5) Transmission of partially coherent light through optical systems; optical transfer function.

D. Fourier optics

1) Analysis of 2D signals and systems: 2D Fourier analysis; local spatial frequency.
2) Overview of scalar diffraction theory; Fresnel-Kirchhoff & Rayleigh-Sommerfeld diffraction; angular spectrum of plane waves; Fresnel and Fraunhofer diffraction.
3) Wave-optics analysis of coherent optical systems; Fourier transforming properties of lenses.
4) Frequency analysis of optical imaging systems; resolution beyond the classical limit.
5) Applications in spatial filtering: wave-front modulation, spatial light modulators.
6) Applications in optical-image formation and analysis.

COVID-19 Health and Awareness.

UNM is a mask friendly, but not a mask required, community. To be registered or employed at UNM, Students, faculty, and staff must all meet UNM's Administrative Mandate on Required COVID-19 vaccination. If you are experiencing COVID-19 symptoms, please do not come to class. If you have a positive COVID-19 test, please stay home for five days and isolate yourself from others, per the Centers for Disease Control (CDC) guidelines. If you do need to stay home, please communicate with me at vgruzdevAPTunm.edu; I can work with you to provide alternatives for course participation and completion. UNM faculty and staff know that these are challenging times. Please let me, an advisor, or another UNM staff member know that you need support so that we can connect you to the right resources. Please be aware that UNM will publish information on websites and email about any changes to our public health status and community response.

Student support sources:

Student Health and Counseling (SHAC) at (505) 277-3136. If you are having active respiratory symptoms (e.g., fever, cough, sore throat, etc.) AND need testing for COVID-19; OR If you recently tested positive and may need oral treatment, call SHAC.

LoboRESPECT Advocacy Center (505) 277-2911 can offer help with contacting faculty and managing challenges that impact your UNM experience.

Accommodations

UNM is committed to providing equitable access to learning opportunities for students with documented disabilities. As your instructor, it is my objective to facilitate an inclusive classroom setting, in which students have full access and opportunity to participate. To engage in a confidential conversation about the process for requesting reasonable accommodations for this class and/or program, please contact Accessibility Resource Center at arcsrvs@unm.edu or by phone at 505-277-3506.
Support: Contact me at vgruzdevAPTunm.edu or in office/check-in hours and contact Accessibility Resource Center (https://arc.unm.edu/) at arcsrvs@unm.edu (505) 277-3506.

Credit-hour statement

This is a three credit-hour course. Class meets for two 65-minute sessions of direct instruction for fifteen weeks during the Fall 2022 semester. Please plan for a *minimum* of six hours of out-of-class work (or homework, study, assignment completion, and class preparation) each week.
Support: Contact Center for Academic Program Support (CAPS) in case if you need assistance with any items related to the academic side of this class, e. g., if you need more time for the mid-term or final exam. Many students have found that time management workshops can help them meet their goals (consult (CAPS) website under "services").

Title IX:

Our classroom and our university should always be spaces of mutual respect, kindness, and support, without fear of discrimination, harassment, or violence. Should you ever need assistance or have concerns about incidents that violate this principle, please access the resources available to you on campus. Please note that, because UNM faculty, TAs, and GAs are considered "responsible employees" any disclosure of gender discrimination (including sexual harassment, sexual misconduct, and sexual violence) made to a faculty member, TA, or GA must be reported by that faculty member, TA, or GA to the university's Title IX coordinator. For more information on the campus policy regarding sexual misconduct and reporting, please see: https://policy.unm.edu/university-policies/2000/2740.html.
Support: LoboRESPECT Advocacy Center, the Women's Resource Center, and the LGBTQ Resource Center all offer confidential services.

Land Acknowledgement

Founded in 1889, the University of New Mexico sits on the traditional homelands of the Pueblo of Sandia. The original peoples of New Mexico Pueblo, Navajo, and Apache since time immemorial, have deep connections to the land and have made significant contributions to the broader community statewide. We honor the land itself and those who remain stewards of this land throughout the generations and also acknowledge our committed relationship to Indigenous peoples. We gratefully recognize our history.
Faculty Resource: Information provided by UNM's Division for Equity and Inclusion can support building an inclusive classroom, https://diverse.unm.edu/education-and-resources/programs/index.html.

Citizenship and/or Immigration Status

All students are welcome in this class regardless of citizenship, residency, or immigration status. Your professor will respect your privacy if you choose to disclose your status. As for all students in the class, family emergency-related absences are normally excused with reasonable

notice to the professor, as noted in the attendance guidelines above. UNM as an institution has made a core commitment to the success of all our students, including members of our undocumented community. The Administration's welcome is found on our website: http://undocumented.unm.edu/.

Respectful and Responsible Learning

We all have shared responsibility for ensuring that learning occurs safely, honestly, and equitably. Submitting material as your own work that has been generated on a website, in a publication, by an artificial intelligence algorithm, by another person, or by breaking the rules of an assignment constitutes academic dishonesty. It is a student code of conduct violation that can lead to a disciplinary procedure. *Please ask me for help in finding the resources you need to be successful in this course. I can help you use study resources responsibly and effectively.* Off-campus paper writing services, problem-checkers and services, websites, and AIs can be incorrect or misleading. Learning the course material depends on completing and submitting your own work. UNM preserves and protects the integrity of the academic community through multiple policies including policies on student grievances (Faculty Handbook D175 and D176), academic dishonesty (FH D100), and respectful campus (FH CO9). These are in the *Student Pathfinder* (https://pathfinder.unm.edu) and the *Faculty Handbook* (https://handbook.unm.edu).
Support: Many students have found that time management workshops or work with peer tutors can help them meet their goals. These and are other resources are available through Student Learning Support at the Center for Teaching and Learning.

Connecting to Campus and Finding Support

UNM has many resources and centers to help you thrive, including opportunities to get involved, mental health resources, academic support including tutoring, resource centers for people like you, free food at Lobo Food Pantry, and jobs on campus. Your advisor, staff at the resource centers and Dean of Students, and I can help you find the right opportunities for you.