

PHYS 554.001 and ECE 554.002: Advanced Optics II
CRN: 59949 (Physics) & 59950 (ECE)
Spring Semester 2024

Description of the class

This class is a continuation from Advanced Optics I of the Fall Semester 2023. It covers selected topics from polarization, interference of light, advanced geometrical optics, diffraction, and Fourier optics. Detailed scope of this class can be found in the section “Syllabus Topics”. Content of lectures includes fundamental concepts and applications in realistic optical instruments or devices.

This class is calculus based. Complex algebra, calculus (mainly – integration), 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 (ECE 463) - Advanced Optics I; Electromagnetics or Electricity and Magnetism; Calculus; Differential Equations; Linear Algebra; Complex Algebra; Matrixes.

Lectures:

Mondays and Wednesdays; from 11:30 am to 12:45 pm

Lectures: January 15 through May 1

Room: 1160 PAIS Building

100% face-to-face instruction, but Zoom links are available.

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; 1:00 pm – 2:30 pm. You may also arrange a meeting for another time depending on instructor availability.

TA's office hours: TBA

Textbooks:

Lecture notes are considered as a major and absolutely sufficient source of information for students of this class. PDF files with lecture slides will be e-mailed to all registered students after each lecture. There are also many useful textbooks on the topics of this class. The following textbooks are recommended as additional sources for broader studies of the class topics:

(P3) Frank L. Pedrotti, Leno M. Pedrotti, Leno S. Pedrotti, "Introduction to Optics", 3d edition.

(MF) Miles V. Klein, Thomas E. Furtak, "Optics", 2nd or 3d Edition.
(BW) Max Born, Emil Wolf, "Principles of Optics", 7th or later edition.
(LLP) Lev D. Landau, E. M. Lifshitz and L. P. Pitaevskii, "Electrodynamics of Continuous Media", 2nd Edition or later (Pergamon Press, 1984).
(SO) Joseph W. Goodman, "Statistical Optics", 2nd Ed.
(FO) Joseph W. Goodman, "Fourier Optics", 3rd Ed.

Homework assignments

There are planned 5 homework assignments this semester (3 before the Spring break, and 2 after it). Each assignment typically includes 3 problems. The assignments will be e-mailed to all registered students at least a week before they are due. Solutions to homework problems should be turned in either to instructor's mailbox on the due date by 2:30 pm (hard copies) or to instructor's e-mail on the due date by 23:59 (electronic format). Electronic copies are required to meet major requirements for multiple scanning and re-scanning: use of black ink; resolution at least 300 dpi; black-and-white format is preferable; file format: PDF. Solutions for each homework will be reviewed in class at a lecture that immediately follows a due date of the homework.

Homework submitted after a due date, but before in-class review receives 50% of maximum score (if all problems are solved correctly). Solutions returned after the in-class review are not scored and receive 0 score.

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: 15% (3% each homework);
2. Formal report: 10%
3. Oral presentation: 15%
4. Mid-term exam: 25%
5. Final exam: 35%

Grade brackets:

"D": 0% - 50.0%
"C": 50.1% - 70.0%
"B-": 70.1% - 75.0%
"B": 75.1% - 85.0%
"B+": 80.1% - 85.0%
"A-": 85.1% - 90.0%
"A": 90.1% - 95.9%
"A+": 96.0% - 100%

Exam dates (subject to change):

Mid-term: 03/06 (no makeup date).

Spring Break: 03/11 – 03/15

Final: UNM will provide dates, time, and room number; the week of finals is 05/06 – 05/11

Formal Report:

A formal report is focused on one of the topics from the scope of this class including applications of the fundamental concepts considered in this class. 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. Presentations will be scheduled for the week of April 29 – May 3. Formal Reports can be utilized as a basis for the presentations. Duration: 12 minutes of presentation + 3 minutes for questions/answers. Presentations should cover fundamentals, relevant background information, 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.

1) Advanced Topics on Polarization: reflection from absorbing surfaces (metals); propagation in anisotropic crystals; magneto-optic effects; electro-optic effects; acousto-optic effect; light modulation.

2) Interference of light: interference of two monochromatic waves; Young's experiment; Michelson's experiment; visibility of interference fringes; standing waves; multi-beam interference of monochromatic light; Fabri-Perot interferometer; temporal and spatial coherence; coherence function; interference of partially coherent light; transmission of partially coherent light through optical systems; Van-Cittert-Zernike theorem; statistical properties of light; auto-correlation and mutual correlation functions; thermal noise of light.

3) Advanced geometrical optics: approximation of small wavelength; Eikonal equation; ray equation; limits of validity of geometrical optics; general properties of rays; theorem of Malus and Dupin; characteristic functions of Hamilton; perfect optical imaging; Gaussian optics; matrix methods of geometrical optics; chromatic aberrations; ray tracing; geometrical theory of aberration.

4) Overview of the traditional diffraction theory: Huygens-Fresnel principle; Kirchhoff's theory; Fraunhofer and Fresnel diffraction; diffraction gratings; resolution of imaging systems; diffraction theory of aberrations; imaging beyond the diffraction limit of resolution.

5) Advanced diffraction theory: rigorous formulation of diffraction problems; diffraction by cylinders and absorbing spheres; Mie scattering model; dipole and multi-pole resonances; whispering-gallery modes; Rayleigh scattering.

6) Basics of Fourier optics: basic principles of Fourier optics; 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; applications of Fourier optics in image analysis.

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. *Please bear in mind that special accommodations for mid-term and final exams must be submitted to ARC 3 weeks prior to exam dates.*

Support: Contact me at vgruzdevAPTunm.edu or in office/check-in hours and contact [Accessibility Resource Center \(https://arc.unm.edu/\)](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: Support: Resources to support study skills and time management are available through [Student Learning Support](#) at the Center for Teaching and Learning.

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/>.

Responsible Learning and Academic Honesty

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 (AI), 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 produce incorrect or misleading results. 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.

Respectful Conduct Expectations

I am committed to building with you a positive classroom environment in which everyone can learn. I reserve the right to intervene and enforce standards of respectful

behavior when classroom conduct is inconsistent with University expectations [and/or classroom community agreements]. Interventions and enforcement may include, but are not limited to, required meetings to discuss classroom expectations, written notification of expectations, and/or removal from a class meeting. Removal from a class meeting will result in an unexcused absence. 6 or more unexcused absences may result in permanent removal and a drop from the course (see attendance policy). The University of New Mexico ensures freedom of academic inquiry, free expression and open debate, and a respectful campus through adherence to the following policies: [D75: Classroom Conduct](#), [Student Code of Conduct](#), [University Policy 2240 – Respectful Campus](#), [University Policy 2210 – Campus Violence](#).

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 such as 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.

Wellness

If you do need to stay home due to illness or are experiencing a wellness challenge, please take advantage of the resources below. You can communicate with me at vgruzdev@unm.edu. I can work with you to provide alternatives for course participation and completion. Let me, an advisor, or another UNM staff member know that you need support so that we can connect you to the right resources. UNM is a mask friendly, but not a mask required, community. If you are experiencing COVID-19 symptoms, please do not come to class.

Support:

[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.

[TimelyCare](#): Free 24/7 virtual care services (medical, emotional support, health coaching, self-care, basic needs support. Go to <http://timelycare.com/unm>.

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