

ECE 475/575 - Introduction to Electro-Optics and Optoelectronics

Welcome to ECE 475/575 at the University of New Mexico!

Land Acknowledgment:

The University of New Mexico (founded in 1889) 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.

General Information:

Course Title: Introduction to Electro-Optics and Optoelectronics

Course Number: ECE 475/575

Instructor: Prof. Daniel Feezell

E-mail: dfeezell@unm.edu

Office Location: CHTM 112B

Office Phone: 505-272-7823

Office Hours: After class or by appointment

Course Credits: 3

Class Meeting Day(s): TR

Class Time: 11:00 am – 12:15 pm

Instruction mode: Face-to-face

Class Location/Room: CHTM 101

Term / Semester: Fall 2023

Course Description:

Basic electro-optics and opto-electronics, with engineering applications. Interaction of light with matter. Introduction to optics of dielectrics, metals and crystals. Introductory descriptions of electro-optic, acousto-optic and magneto-optic effects and related devices. Light sources, displays and detectors. Elementary theory and applications of lasers, optical waveguides and fibers.

Course Goals:

- Provide an introductory treatment of electro-optics and optoelectronics that ranges from the fundamental electrical and optical processes, to devices, to systems and applications.
- Provide an opportunity for students to perform group research on electro-optics and optoelectronics and to present that research to the class in a seminar format. Students will also perform peer evaluations.

Student Learning Outcomes:

At the end of the course, you should be able to:

- Understand the fundamental optical and electrical process associated with optoelectronics and electro-optics.
- Understand the components of semiconductor optoelectronics and electro-optics, including constituent materials, waveguides, active regions, optical coatings, and fiber-optic systems.

- Understand the operation of a variety of optoelectronic and electro-optic devices, including lasers, light-emitting diodes (LEDs), photodetectors, modulators, and amplifiers.
- Apply the learned concepts, principles, rules, and theories to understand more complex electro-optic and optoelectronic devices.
- Perform research in a group format and deliver the findings to an audience in a seminar style presentation.
- Use what you learned to objectively evaluate your own performance and the performance of your peers.
- Explain what you learned during the course.

Required Text:

- “Optoelectronics and Photonics: Principles and Practices,” S. O. Kasap, Pearson, 2nd edition (2013), ISBN-13: 978-0-13-215149-8. There is also a digital 2nd edition available for \$44.99, ISBN-13: 978-0-13-308179-4.

*If you purchased a copy of the 2nd edition, there are many student web resources available. To access them, go to: <https://optoelectronics.usask.ca/Resources-all-readers/index.html>. The website explains how to find the required passwords.

Reference Texts:

- “Semiconductor Optoelectronic Devices,” P. Bhattacharya, Prentice Hall, 2nd edition (1997), ISBN-13: 0-13-495656-1
- “Fundamentals of Photonics,” B.E.A. Saleh and M.C Teich, Wiley, 2nd edition (2007), ISBN: 978-0-471-35832-9

Prerequisite or Concurrent Enrollment:

ECE 371 or equivalent (or instructor approval) – you are expected to have knowledge of basic semiconductor physics such as energy band diagrams, doping, Fermi-Dirac distribution, density of states, electrons and holes, pn junctions, ideal diode equation.

Technology Requirements:

Access to UNM Canvas

See <https://canvasinfo.unm.edu/> for more information about Canvas

Access to Zoom (in case we are forced to move classes online)

See <https://at.unm.edu/media-collaborative-apps/zoom-web-conferencing.html> for more information about Zoom at UNM.

Laptop/Tablet

See <https://at.unm.edu/coronavirus/student-tech-access.html> for UNM tech support to students at this time.

Class Website:

<https://canvas.unm.edu/>

I will post the syllabus, homework assignments and solutions, lecture slides, and other course materials. The website requires you to login using your UNM NetID. A detailed course schedule is also available on the course website. This schedule includes the material to be covered,

recommended sections of the book for reading, exam dates, and homework assignments and due dates. Please note that the schedule is approximate.

Course Requirements:

Homework Assignments

There will be 6 homework assignments spread throughout the semester. Homework assignments will primarily be based off problems in the Kasap text and will be posted on the course Canvas page. See detailed schedule for due dates. After the homework due dates, solutions to the problems will be provided on the course Canvas page. Homework assignments constitute 30% of the course grade.

Homework is due at the *beginning* of the class period on the due date. Homework should be neatly written, with each problem labeled and the pages stapled together. Show your work in a logical fashion to get maximum credit and ***please box your final answers!*** If the problem says “plot” you should use Excel, Matlab, or some other numerical tool, if the problem says draw or sketch, you may do it by hand.

Late homework policy:

< 1 hour	Loss of 10% of possible points
1 hour – 8 hours	Loss of 25% of possible points
8 – 48 hours	Loss of 50% of possible points
More than 48 hours	No credit

Midterm Exam

The midterm exam will be administered during one of the class periods and will cover materials from Chapters 1-3 of the Kasap text and be open book and open notes. The midterm exam constitutes 20% of the course grade.

Group Research Presentation

You will give a group presentation on an electro-optics or optoelectronics-related topic in a seminar format to the class. Presentations should be given in Microsoft Power Point format and last for 20 minutes (*17 minute talk with 3 minutes for questions*). ***Each team member must participate in delivering a portion of the presentation.*** Not all team members will necessarily receive the same grade. Individual grades will be based on my assessment of your contribution and the confidential reviews provided by your team members. The presentations will be judged on content, clarity of delivery, and slide format/aesthetics. Slides should contain the relevant images, text, and equations necessary to discuss the technology. Sources must be cited. More details about the presentation requirements will be given in a separate document provided after the midterm exam. Presentations will be given during the last class session of the semester. The research presentation constitutes 30% of the course grade.

Final Exam

The final exam will be administered at the time assigned to the course by the Registrar’s Office and will cover materials from Chapters 4-7 of the Kasap text and be open book and open notes. The final exam constitutes 20% of the course grade.

Grading (ECE 475)

<u>Letter grade</u>	<u>Percentage Points</u>
<u>A+:</u>	<u>96-100</u>
<u>A:</u>	<u>92-95.9</u>
<u>A-:</u>	<u>88-91.9</u>
<u>B+:</u>	<u>84-87.9</u>
<u>B:</u>	<u>80-83.9</u>
<u>B-:</u>	<u>76-79.9</u>
<u>C+:</u>	<u>72-75.9</u>
<u>C:</u>	<u>68-71.9</u>
<u>F:</u>	<u>Below 68</u>

Grading (ECE 575)

<u>Letter grade</u>	<u>Percentage Points</u>
<u>A+:</u>	<u>98-100</u>
<u>A:</u>	<u>94-97.9</u>
<u>A-:</u>	<u>90-93.9</u>
<u>B+:</u>	<u>86-89.9</u>
<u>B:</u>	<u>82-85.9</u>
<u>B-:</u>	<u>78-81.9</u>
<u>C+:</u>	<u>74-77.9</u>
<u>C:</u>	<u>70-73.9</u>
<u>F:</u>	<u>Below 70</u>

Assessment: Activity

Homework assignments
Midterm exam
Group research presentation
Final exam

Percentage Contribution

30%
20%
30%
20%

Course Schedule:

The course schedule is approximate and subjected to change.

Date	Class	Topics Covered	Reading	HW Due
22-Aug	1	class introduction, plane waves, phase velocity, Maxwell's wave equation, beam divergence	1.1	
24-Aug	2	refractive index, dispersion, group velocity, group index, magnetic field, irradiance, Poynting vector	1.2-1.4	
29-Aug	3	Snells Law, TIR, Fresnel equations	1.5 - 1.6	
31-Aug	4	AR coatings, DBRs, absorption, coherence	1.7-1.9	
5-Sep	5	interference, cavities, diffraction, photonic crystals (time permitting)	1.10-1.12	
7-Sep	6	dielectric slab waveguides	2.1	
12-Sep	7	step index optical fibers	2.2-2.3	HW 1 Due
14-Sep	8	NA, dispersion in fibers	2.4-2.6	

19-Sep	9	bit rate, bandwidth, GRIN fibers, attenuation in fibers	2.7-2.9	
21-Sep	10	recombination lifetime, heterojunctions	3.8-3.10	
26-Sep	11	LED basic principles, QW LEDs	3.11-3.12	HW 2 Due
28-Sep	12	LED materials and structures, efficiency definitions, basic characteristics	3.13-3.17	
3-Oct	13	Stimulated Emission, Ruby Lasers, Einstein Coefficients, Absorption, Gain, EDFAs	4.1-4.3	
5-Oct	14	Gas Lasers, Cavity Modes	4.4-4.5	
10-Oct	15	Threshold Gain, Output Power, Photon Lifetime, Transverse Modes	4.5-4.7	HW 3 Due
12-Oct	No Class Fall Break			
17-Oct	Midterm	Covers material from chapters 1-3		
19-Oct	16	Semiconductor Diode Lasers 1 (principles and structures)	4.9-4.11	
24-Oct	17	Semiconductor Diode Lasers 2 (elementary characteristics)	4.12-4.13	HW 4 Due
26-Oct	18	Semiconductor Diode Lasers 3 (rate equations, single-freq laser)	4.13-4.14	
31-Oct	19	Semiconductor Diode Lasers 4 (single-freq lasers, VCSELs)	4.14-4.15	
2-Nov	20	SOAs, SLDs, RC-LEDs, modulation of lasers	4.16-4-18	
7-Nov	21	pn junction photodiodes	5.1-5.4	HW 5 Due
9-Nov	22	Responsivity and pin photodiodes	5.4-5.5	
14-Nov	23	APDs	5.6	
16-Nov	24	Photoconductors	5.10	
21-Nov	25	Photoconductors continued	5.10	
23-Nov	No Class Thanksgiving			

28-Nov	26	Solar cells	5.14	
30-Nov	27	Polarization, birefringence, LCDs	6.1-6.5	HW 6 Due
5-Dec	28	Electro-optics effects, integrated optical modulators	6.6-6.7	
7-Dec	Presentations 2 hour class	Group presentations on selected research topics (3-4 groups, 20 minutes each)		
Week of 12/11	Final	Primarily covers Ch. 4, Ch. 5, Ch. 6, date and time are TBD		

General Campus Policies:

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 dfeezell@unm.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 us know that you need support so that we can connect you to the right resources and please be aware that UNM will publish information on websites and email about any changes to our public health status and community response.

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.

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

COVID-19 Symptoms and Positive Test Results: Please do not come to a UNM campus if you are experiencing symptoms of illness, or have received a positive COVID-19 test (even if you have no symptoms). Contact your instructors and let them know that you should not come to class due to symptoms or diagnosis. Students who need support addressing a health or personal event or crisis can find it at the [Lobo Respect Advocacy Center](#).

Communication on Change in Modality: The President and Provost of UNM may direct that classes move to remote delivery at any time to preserve the health and safety of the students, instructor and community. The instructor will provide any updates about our class and please check <https://bringbackthepack.unm.edu> regularly for general UNM updates about COVID-19 and the health of our community.

Accommodation Statement: In accordance with University Policy 2310 and the Americans with Disabilities Act (ADA), academic accommodations may be made for any student who notifies the instructor of the need for an accommodation. It is imperative that you take the initiative to bring

such needs to the instructor's attention, as I am not legally permitted to inquire. Students who may require assistance in emergency evacuations should contact the instructor as to the most appropriate procedures to follow. Contact [Accessibility Resource Center](#) at 277-3506 or arcsrvs@unm.edu for additional information. UNM is committed to providing courses that are inclusive and accessible for all participants. As your instructor, it is my objective to facilitate an accessible classroom setting, in which students have full access and opportunity. If you are experiencing physical or academic barriers, or concerns related to mental health, physical health and/or COVID-19, please consult with me after class, via email/phone or during office hours. You are also encouraged to contact [Accessibility Resource Center](#) at arcsrvs@unm.edu or by phone 277-3506.

Academic Integrity: The University of New Mexico believes that academic honesty is a foundation principle for personal and academic development. All University policies regarding academic honesty apply to this course. Academic dishonesty includes, but is not limited to, cheating or copying, plagiarism (claiming credit for the words or works of another from any type of source such as print, Internet or electronic database, or failing to cite the source), fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. The University's full statement on academic honesty and the consequences for failure to comply is available in the college catalog and in the *Pathfinder*.

Credit-Hour Statement: This is a three credit-hour course. Class meets for two 75-minute sessions of direct instruction for fifteen weeks during the Fall 2023 semester. Please plan for a *minimum* of six hours of out-of-class work (or homework, study, assignment completion, and class preparation) each week.

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, especially the LoboRESPECT Advocacy Center and the support services listed on its website (<http://loborespect.unm.edu/>). Please note that, because UNM faculty, TAs, and GAs are considered "responsible employees" by the Department of Education, 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 at the [Office of Compliance, Ethics, and Equal Opportunity](#). For more information on the campus policy regarding sexual misconduct, please see: <https://policy.unm.edu/university-policies/2000/2740.html>.

Cell Phones and Technology: As a matter of courtesy, please turn off cell phones, pagers, and other communication and entertainment devices prior to the beginning of class. Notify me in advance if you are monitoring an emergency, for which cell phone ringers should be switched to vibrate.

Library and Tutorial Services: UNM-Main campus provides many library services and some tutorial services for distance students. For library services, go to <http://www.unm.edu/libraries/> to link to a specific library or to contact a librarian. For tutorial services, go to <http://caps.unm.edu/online> to explore UNM's online services.

Weather Policy: In the event of severe weather conditions UNM may close. Please call 277-SNOW to check UNM's status during questionable weather conditions.

Copyright Policy and Law: *(University Counsel's Office - Subject to Change Without Notice)*

The unauthorized distribution of copyrighted material, including through peer-to-peer file sharing, may subject a student to criminal and civil penalties. The laws that govern copyright are not specific to any one technology. Students can violate the rights of a copyright holder using many different types of technology. Both uploading and downloading of files can pose a violation of the copyright law. Students should be cautious when obtaining any copyrighted material. As a rule of thumb, before a student receives anything for free, they should research whether that source provides material licensed by the copyright owner. A group called EDUCAUSE has a list of legal file sharing alternatives at <http://www.educause.edu/legalcontent>.

Individuals who violate copyright law by illegally uploading and downloading copyrighted files may be subject to civil penalties of between \$750 and \$150,000 per song. These penalties are established by federal law. In the past, pre-litigation settlements offered by copyright owners have been in the \$3,000 to \$4,000 and up range while juries in some jurisdictions have issued verdicts of hundreds of thousands and up. In addition, a court may, in its discretion, grant the copyright owner reasonable attorney fees. Although criminal prosecution of students for file sharing is extremely rare, federal law lays out criminal penalties for intentional copyright infringement which can include fines and jail time. In addition to potentially violating the law, unauthorized distribution or receipt of copyrighted material is a violation of University Business Policies and Procedures Manual 2500. That policy states that: "Users shall respect all copyrights including software copyrights...Use of University computing services in violation of applicable laws or University policy may result in sanctions, including withdrawal of use privilege; disciplinary action, up to and including, expulsion from the University or discharge from a position; and legal prosecution under applicable federal and/or state law."