Physics 305
Optics
Spring, 2020

Meets:
1:00 pm – 2:50 pm
Tuesday, Thursday
130 Meldrum Hall

Instructor:
Dr. Christopher Cline
278 Meldrum Hall
832-2346
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Textbook:

Required:	*Understanding Physics,* 1st Ed., Karen Cummings et al.
	OpenStax – University Physics.
Supplemental:	*Optics*, 4th Ed., Eugene Hecht.
	Introduction to Optics, 3rd Ed., Pedrotti^3.

Course Description: Physics 305 is a sophomore/junior level course in optics – the study of the behavior light. How we talk about the light depends upon the size of the objects in which light interacts. For interactions with big things, things that are large relative to the wavelength of light, we treat light like a ray or a beam. (A ray is a little like your mental picture of a vector). We call this model *Geometrical Optics*. For interactions with little things that are of the same order of magnitude as the wavelength of light, we treat light as a wave. This is the domain of *Physical Optics*. So, its natural that will divide the course into three sections. The first section will be mostly about Geometrical Optics. The second section we will be more focused on waves in general, while the third section will be about Physical Optics.

In the 1st part of the course, we will begin with geometric optics. In geometric optics, we treat light as if it were a ray, not unlike your mental picture of a vector. Included here are reflection, refraction, mirrors, prisms, lens, and lens systems. Also in geometric optics, there is a nice application of linear algebra, called matrix methods, that radically simplifies the study of light propagation through a lens system. We'll look at this too.

In the 2nd part of the course, we will begin with an overview of oscillations, simple harmonic motion, and fundamental definitions for waves, including transverse waves, longitudinal waves, traveling waves, standing waves, and harmonic waves. We will then briefly look at the electromagnetic spectrum. If we have time, we'll look at color, color space, color perception, and spectroscopy.

In the 3rd part of the course, we will look at waves in more depth, in particular light waves. At first we will consider only generic scalar waves, like those on a string, or sound waves. But, light is a transverse vector wave. This is one of the great predictions of Maxwell's equations. We'll review Maxwell's equations and develop a vector wave equation. We will see that we can often decompose this vector equation into scalar wave equations for both the magnetic and electric fields. The fact that light is a transverse vector wave provides a nice segue in to polarization. We'll look at both linear and elliptical polarization. Finally, we'll end with interference and diffraction. We take a general approach that works for all types of waves. We'll study both multiple slit interference and single slit interference (diffraction).

Conditions of enrollment: Physics 212 (Physics for Scientists & Engineers II) and Math 202 (Calculus II) are prerequisites for all students enrolled in this course.

How to get help: My office hours are MW 1:00 pm-4:00 pm, TTh 11:00 am-12:00 pm, and TTh 3:00 pm-4:00 pm. If you can't come during any of these hours, I will be happy to make an appointment with you for another time. For me, *the* most enjoyable aspect of teaching is working with students one-on-one. *Please, please* come see me often—*especially* if you run into difficulties with concepts and math.

Class Attendance and Participation: Class meetings are TTh 1:00pm-2:50pm. Preparation for class, attendance, and participation will be rewarded.

Optics Course Requirements

Reading Memos: It is nearly useless to read a physics text as you would a novel. "Studying" such a text requires that you be an *active* reader, that you remain engaged in a virtual and *appropriately skeptical* conversation with the author. You should, for example: (1) reserve doubt about everything the text says until it thoroughly convinces you, (2) think about situations to which the author's arguments might not apply, (3) make notes in the margins, (4) draw your own sketches and graphs to help visualize situations and functional behaviors, and *especially* (5) fill in all of the missing steps in any mathematical arguments. Indeed it is *all* too tempting to simply take the author's word for everything including the results of any calculation; after all, he or she wouldn't consciously *lie* to you, right? Well, yes; probably. But if you get into that habit, you will become a *passive* reader. Your mind forms no permanent "hooks" on which to store the information being presented. The time spent in the process may well be reduced, but will also have been essentially wasted.

Perhaps mathematician Paul R. Halmos gave the best advice about how to study: "*Study actively. Don't just read the text; fight it! Ask your own questions, look for your own examples, discover your own proofs.*" (*I Want to Be a Mathematician*, New York: Springer-Verlag, 1985)

Accordingly, in order to help you form or hone these important good study habits, I will ask you to produce and turn in a "Reading Memo" at the beginning of each day for which there is assigned reading. A "Reading Memo" is an informal running collection of thoughts about and reactions to the material in the text. As you study, keep a pencil in hand and note any questions that occur to you; any surprises, insights, or connections to other things you know about; anything you think may be wrong or incomplete and why you think so; anything you think could be said more clearly and your proposed revision; etc. Beyond their effectiveness at helping you to stay engaged as you study, your Reading Memos will also help me to understand those items and topics that may require more attention in class.

Your Reading Memos will be given full (3 pts) or partial credit (1 or 2 pt) *purely* on the basis of whether or not it appears that your good faith effort was involved and *not at all* on the basis of format, sophistication, vocabulary, correctness, etc. In order to allow for extraordinary circumstances (*including* absence for *any* reason), I will throw out up to three "missing" Reading Memos.

Lab Books: The basic idea behind keeping any kind of a notebook is this: *If you look back five years from now, can you figure out what you did well enough so that you can explain it to some else*. Your lab book should have graph ruled lines. ***Do not erase.*** Here is why. You may be wrong in thinking you were wrong! Or, more likely, you may have been partly right. Don't scribble out. Just put one line through the material you think is wrong, and correct it. Some students hate this. They are perfectionists; they want their lab books to be flawless. Science does not work that way. A lab book with clean marked out material is a hallmark of a future scientist who has critically analyzed what they have written, found it wanting, and corrected it. You will do your labs in groups, but your write-up should be your own. ***Please put the name of your lab partners on your labs.***

Each Optics Lab should have:

1) An introduction, where you explain the labs purpose and how you are going to accomplish it. In short, an overview of what you are going to do. Your understanding of the relevant physics goes here.

2) A detail section, where you explain the set up of your experiments, (complete with sketches) how you made your measurement, and the numbers you got. Any calculations you make go here. Any graphs or charts must be properly titled and axis labeled. I will specify in each lab how much focus I want on error analysis. However, ***never*** report numbers with a greater precision than you can justify. You should ***always*** list error values associated with any measurement, like this: 3.14 +/- .05 cm. Sometimes propagating errors through a complex equation can be problematic, and we have one lab explicitly devoted to this problem. Nevertheless, you can always get a rough, but generous, value of your uncertainty by running the highest value, and the lowest value through an equation. And, of course, units are mandatory. Sometimes in this section it is useful to maintain a running monolog of what you did. *"I tried A and B, but that didn't work because I didn't do C. Next I tried A, B, and C and …"*

3) A conclusion. Here you summarize your results, and answer the question: "How well did I accomplish what I set out to do." You should ***never write, "My data fit my model very well."*** Instead, be quantitative, "My model fit my data within the uncertainty of my data. The uncertainty of my data points was +/ <some number>." You should examine and report your sources of uncorrectable errors. Any correctable errors should be corrected.

Homework: I will make regular Homework Assignments due at intervals of very approximately a week and a half to two weeks at the beginning of a specified class meeting.

As you surely know by now, the primary purpose of assigned problems in physics is ***absolutely not*** to see if you can get the right answer. Rather, it is for you to practice and then demonstrate that you have learned 1) how to determine the fundamental physical principles that are involved in a described situation and 2) how to apply those principles in a disciplined and orderly fashion. Of course, if you have learned how to do these things, you should expect to get the right answer too, but that is - really - of secondary importance. You will find - indeed, you probably have found - that, given time, an open book, lots of worked examples, and knowledge of the correct answer, it is very often possible to "get the answer" without the slightest understanding of what you are doing. Please guard against this; it is a complete waste of your time because it does not prepare you for, and it obviously will not work on, exams.

Accordingly, we are not - and you should not be - satisfied with problem "solutions" that simply consist of a series of mathematical manipulations leading to a result. Instead, the problem solutions you submit are to be "presented." By this we mean that they should be readable by someone who does not have access to the problem statement; should include written explanations and thoughtful comments about what you are doing and, especially, why; should use well-defined and consistent notation (employing unique and meaningful subscripts and superscripts as necessary); should be accompanied by neatly drawn and carefully labeled diagrams; and should flow in a logical and orderly progression down the page. They should use more space for the written explanatory information than for the mathematics! They should ***not*** include lengthy, multiple-step, purely mathematical manipulations because it only serves to obscure the physics. Do this kind of work on scratch paper and simply say something like "Solving equations 1, 2, and 3 for x, y, and z, we obtain ..." and give the result.

I will not "check" your homework solutions in any serious fashion; it is up to *you* to check them against the solutions that I will hand out and to get answers—from me or others in the class—to any remaining questions you have. I will look over your work only casually and assign a holistic score of 1 to 10. See the Homework Rubric for more information, but briefly: a 9 or 10 point assignment work shows a correct understanding of the concepts and explains them clearly to a new learner. A 7 or 8 point assignment is generally correct but not clearly explained, or contains misunderstandings but is clearly written. A 5 or 6 point assignment demonstrates little understanding of the concepts or is so poorly written (or absent) that the reader can't understand. Unsubmitted problem sets will receive a 0.

I *strongly* encourage you to form study groups and to discuss with others your readings, questions that come up in and out of class, and how to go about solving problems. The work ***you*** turn in, however, must be ***yours***, based on the understanding ***you*** have acquired. When faced with two write-ups that show any signs of copying, I conclude that at least one person hasn't done the work. In such cases both papers will receive no credit.

I do not accept late Homework Assignments, but, in order to allow for extraordinary circumstances (*including* absence for *any* reason), I will throw out your two lowest scores.

Midterms and Final: We will have two in-class exams, both open-note exams. Of course, I trust you will do all your own work on the exams. If you are caught cheating on an exam you will receive an F for the exam for the first offense; for a second offense, an F for the entire course.

Grading: Your overall "Course Score" will be calculated using the following relative weights:

Participation	10%
Reading Memos	10%
All Labs	30%
Homework	20%
Exams	30%

Academic Integrity: Please make sure that you have read and fully understood Westminster's Policy on Academic Honesty (and Dishonesty) that appears in the Academic Catalog. My sincere desire is to act as facilitator—not an enforcer—for your studies in physics. Accordingly, I operate on the assumption that all of our interactions are based on openness, honesty, and good faith. I expect all of us to be honest and to treat each other fairly and with respect. Because our trust in each other is absolutely *crucial* to the effectiveness of our relationship, I take an uncompromising stance, as should you, on the necessity for sanctions when it is violated.

ADA Statement: Westminster College seeks to provide equal access in higher education to academically qualified students with physical, learning, and psychiatric disabilities. If you need disability-related accommodations in this class, have emergency medical information you wish to share with me, or need special arrangements in case the building must be evacuated, please inform me immediately. Please see me privately after class or in my office. Disability Services authorizes disability-related academic accommodations in cooperation with the students themselves and their instructors. Students who need academic accommodations or have questions about their eligibility should contact Karen Hicks, Director of *Disability Services* & *Testing Center*, in the basement of Giovale Library (801-832-2272) or email *disabilityservices@westminstercollege.edu*.

Title IX: Title IX of the Education Amendments of 1972 prohibits sex discrimination against any participant in an educational program or activity that receives federal funds. Westminster is committed to providing a safe and non-discriminatory learning, living, and working environment to all members of the Westminster community and does not discriminate on the basis of sex. This includes on the basis of gender, gender identity, gender expression, or sexual orientation. The College's Title IX policy strictly prohibits sexual assault, sexual harassment, gender-based harassment, gender-based discrimination, sexual exploitation, interpersonal violence (dating violence, domestic violence, stalking), and retaliation for making a good faith report of prohibited conduct or participating in any proceeding under the policy. The policy and accompanying procedures are available at *www.westminstercollege.edu/titleix* and discuss prohibited conduct, resources, reporting, supportive measures, rights, investigations, and sanctions for violations of the policy.

If you want to make a report of prohibited conduct, you may contact Westminster's Title IX Coordinator, Kat Thomas, or report an incident *online*. Kat can be reached at *kthomas@westminstercollege.edu*, 801-832-2262, or in Malouf 107. You can also contact Deputy Coordinator Traci Siriprathane at *tsiriprathane@westminstercollege.edu*, 801-832-2862, or in HWAC 210. Please note that to the extent permitted by law, the College aims to protect the privacy of all parties involved in the investigation and resolution of reported violations of the Policy. However, the College has a duty to investigate and take actions in response to reports and cannot guarantee confidentiality or that an investigation will not be pursued. The *Counseling Center* is a confidential resource, and by law the counselors who work there cannot reveal confidential information to any third party unless there is an imminent threat of harm to self or others.

As a professor, I am a responsible employee and am required to report any information I obtain regarding conduct that may violate the policy to the Title IX Coordinator, so that students can receive supportive measures and referrals to resources, they are aware of their options, and the safety of the campus community can be ensured. If you begin to disclose an incident of prohibited conduct, I may interrupt you because I want to make sure that you have had the opportunity to discuss the incident with confidential resources on and off campus first. If you need supportive measures inside or outside the classroom because of an incident of prohibited conduct, please reach out to the Title IX Coordinator for assistance.

Title VI: Title VI of the Civil Rights Act of 1964 prohibits discrimination based on race, color, or national origin in any program or activity receiving federal financial assistance. In addition to these, Westminster policy prohibits discrimination or harassment based on ethnicity, age, religion, veteran status, or genetic information in any of its programs or activities. If you encounter this type of discrimination or harassment, or feel that you have been retaliated against for reporting prohibited conduct or participating in any related proceeding, you should contact the Equal Opportunity Administrator, Kat Thomas. She can be reached at *kthomas@westminstercollege.edu*, 801-832-2262, or in Malouf 107. The equal opportunity policy and procedures can be accessed from the *Student Life webpage*.

As a professor, just as with Title IX, I am a responsible employee and am required to report any information I obtain regarding discrimination or harassment to the Equal Opportunity Officer for further review.