MODERN OPTICS

Phys 473 Fall 2015

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Office Hours: M 1 –2 pm, T 11am – noon, R 9– 11am, F 2 –3pm

Class Meetings: MWF 11:00am-11:50am, WS 366

Course Website: http://www.coloradomesa.edu/~dacollin/teaching/2015Fall/Phys473/index.html

Required Text: C. A. Bennett, *Principles of Physical Optics,* Wiley (2008).

Prerequisites: Phys 311

Overview

Optics is the study of the vast array of phenomena associated with light. While certain properties of light were well understood much earlier, it was only after the development of electromagnetism in the 19^{th} century that the a comprehensive theory of light could be developed. This classical theory of optics, describing light via waves, successfully explains phenomena as diverse as reflection, refraction, interference and diffraction.

The classical theory is poor for describing effects in which there are very low levels of light or for certain phenomena involving the interaction of light with matter. These can be explained by adapting quantum theory to describe light; understanding the operation of lasers is an example.

While the theories of optics arise from general curiosity about the world, the resulting ideas have have found widespread practical use. Lenses, mirrors, fiber optics, and lasers are used throughout our daily lives. Many measurements and sensing tools throughout the sciences use light as a probe and this has yielded some of the most precise scientific measurements.

Phys 473 will introduce you to the classical theory of optics, concentrating on wave descriptions, as well as many applications of wave and geometrical optics. The course will also offer a brief overview of the operation of lasers.

The course covers:

1. Electromagnetic waves.
2. Reflection and refraction.
3. Geometric optics.

4. Interference and diffraction.
5. Lasers.

Assignments

An undergraduate student should expect to spend on this course a minimum of two hours outside the classroom for every hour in the classroom. The outside hours may vary depending on the number of credit hours or type of course. More details are available from the faculty member or department office and in CMUs Curriculum Policies and Procedures Manual.

1. **Homework:** There will typically be one homework assignment per class meeting. This will be due by 5pm on the date indicated on the assignment. Late homework will be subject to a penalty of at least a 1% reduction in maximum grade for each hour that the work is late. It is in your best interests to work by yourself on the homework problems but collaboration is acceptable. You can discuss the broad outlines of problem solutions with your colleagues but must write your final solutions independently. You are also encouraged to consult me for help with homework problems.

Exams and Quizzes

1. **Class Exams:** There will be two exams during class on the following days:

   Exam 1: 21 September 2015
   Exam 2: 9 November 2015

   Exams will be closed book and closed notes although you will be able to bring a formula sheet. Calculators will be allowed.

2. **Final Exam:** There will be a final exam at **10:00 am on Wednesday 9 December 2015**. The final will last one hour and 50 minutes and be comprehensive and closed book although a formula sheet will be allowed. Calculators will be allowed.

Grades

Individual assignments and exams will be graded using suitable scales. In general, to get full credit (100%) for a problem your solution must be correct and well justified. Partial credit will be given for incomplete or partly correct solutions. No credit (0%) will be given for problems not attempted, assignments not turned in or quizzes and exams missed without good reason.

The numerical grades for each component will be totaled and a final numerical grade will be computed according to the following distribution.

Homework	40%
Class Exams	30%
Final Exam	30%

The following final numerical scores will guarantee letter grades:

90%	A
80%	B
70%	C
60%	D

Policies

1. **Helpful Resources:** The Tutorial Learning Center (TLC) is a *free* academic service for all CMU students. Tutors are available in Houston Hall 113 on a walk-in basis for many courses. More information is available at www.coloradomesa.edu/tutoring or 248-1392.

   In coordination with Educational Access Services, reasonable accommodations will be provided for qualified students with disabilities. Students must register with the EAS office to receive assistance. Please meet with the instructor the first week of class for information and/or contact Dana VandeBurgt, the Coordinator of Educational Access Services, directly by phone at 248-1801, or in person in Houston Hall, Suite 108.

2. **Withdrawals:** There are several ways to drop this course. The deadline for dropping without penalty is **1 September 2015.** Please consult the MSC academic calendar and catalog for more details about adding and dropping courses.

3. **Attendance:** Attendance policies are described in the CMU catalog. You are expected to attend all the class meetings. In case of illness or other emergencies you must be able to produce the appropriate documentation. There are other circumstances under which you can be excused but you must discuss these with me in advance. If you miss a class or lab for a valid reason, turn in any assignments due before the start of the next class. Assignments turned in beyond your return to class will not be accepted.

   If there is an unavoidable conflict with one of the class exams or the final exam, please discuss it with me as soon as possible. In general I will assume that the final exam will have priority, since you know the dates of the exam.

4. **Academic integrity:** You are expected to present your own work in assignments, exams and quizzes. Fabrication of data, plagiarism, and copying from anyone else, particularly in closed book exams, are serious violation of academic norms. CMU has extensive policies on these matters and penalties for infringement can be severe. For more details, consult the academic integrity policies in the CMU catalog.

Objectives

A student who has taken this course will demonstrate the ability to:

1. Use various standard mathematical representations for describing electromagnetic waves.
2. Analyze reflection and refraction at an interface using electromagnetic waves and geometrical optics.
3. Construct ray diagrams for an optical system to analyze and describe the formation of the resulting image.
4. Apply the concept of the superposition of harmonic waves to analyze assorted electromagnetic wave phenomena.
5. Use the wave picture of light to describe the properties of and propagation of light in various physical situations, including interference and diffraction phenomena.

This course contributes to the fulfillment the following program learning objectives for the BS in Physics degree. A student will have demonstrated the ability to:

1. Show fluency with the major fields of physics (classical mechanics, electromagnetism, statistical physics and quantum theory).
2. Use mathematical representations to analyze physical scenarios. This requires translating back and forth between physical and mathematical problems and using appropriate mathematics to aid in the analysis of the scenario.

Schedule

The following schedule is tentative, except for the dates of the class exams.

Week	Dates	Topic
1	8/17 – 8/21	Waves (Ch 1).
2	8/24 – 8/29	Electromagnetic waves (Ch 2.1 – 2.3, 2.5).
3	8/31 – 9/4	Reflection and refraction, Fermat's principle (Ch 3.1 – 3.2).
4	9/7 – 9/11	Electromagnetic waves at interfaces, Fresnel equations (Ch 3.3 - 3.5).
5	9/14 – 9/18	Fresnel equations, reflectivity and transmissivity (Ch 3.5 –3.6).
6	9/21	**Exam I**.
6	9/23 – 25	Geometric optics: general reflection and refraction (Ch 4.1 – 4.2).
7	9/30 – 10/2	Geometric optics: spherical surfaces, thin lenses (Ch 4.3 – 4.4).
8	10/5 – 10/7	Superposition, interference (Ch 5.1 – 5.3)
8	10/9	Fall break (no classes)
9	10/12 – 10/16	Interference, Fourier analysis (Ch 5.3 – 5.4)
10	10/19 – 10/23	Fourier analysis, wavepackets (Ch 5.4 – 5.7).
11	10/26 – 10/30	Interferometry, coherence (Ch 5.8 , 5.10, 5.12).
12	11/2 – 11/6	Coherence, diffraction (Ch 5.12, 6.1 –6.2).
13	11/9	**Exam II**.
13	11/11 – 11/13	Diffraction, Fraunhofer diffraction (Ch 6.1 – 6.3)
14	11/16 – 11/20	Fraunhofer diffraction (Ch 6.3)
15	11/23 - 11/27	Thanksgiving (no classes).
16	5/5 – 5/7	Lasers (Ch 7.1 – 7.4).