PHO 102 Applied Optics
4 credits (3 hour lecture, 2 hour lab)

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Office Hours: MTW 11-12

Prerequisites: PHO K105 and PHO K101; or permission of the instructor

This course is the second semester in a sequence to introduce optics and its applications. Building on the foundations of PHO 101 Introduction to Photonics, you will study more involved systems of lenses, including stops, pupils and windows and aberrations. Matrix methods will be introduced. Topics from wave optics include coherence, types of interferometers and their applications, thin films, Fresnel and Fraunhofer diffraction, scattering, production and modification of polarized light. Natural and technical applications of optical phenomena will be emphasized.

The laboratory parallels the classroom lectures. You will construct and evaluate multiple lens systems and various interferometers using both rail and breadboard systems. Classroom demonstrations, Internet web sites, and in-class mini labs and team projects will be used extensively.

References:

The course will be taught mainly from instructor notes. You need to have a binder for organizing them. We will also use the text from PHO 101, LIGHT-Introduction to Photonics. Other useful books are:

J.R. Meyer-Arendt, *Introduction to Classical and Modern Optics, Fourth Edition*; Prentice Hall. This book is out of print, copies are available in the lab and from used book sellers such as Alibris.

Pedrotti and Pedrotti, *Introduction to Optics, Ed 4*, Prentice Hall 1993
This is an advanced text, available in the TRCC library and the lab library.

Hecht, *Optics, Ed 4*, Addision Wesley, 2002.
This is also an advanced text, with beautiful photos of optical phenomena. It is also in the TRCC library and the lab library.

Attendance Policy

Students are expected to attend all classes, to be on time and to be prepared. Since the course is based on instructor notes, you need to be in class!

Homework

Homework will be assigned for every class. You are expected to make a good effort to solve the homework problems- if you get stuck, send me an email or talk with other students. You learn by trying. Be sure you understand each problem that is assigned- if you don't, ask in class or come to office hours for help.

Course Topics with Approximate Hours

LENSES

Review of basic optics (PHO 101)	1.5
Review of thin lenses, mirrors and imaging	4.5
Thick Lenses: principle planes, equivalent power front and back vertex power	6.0
Matrix methods: matrix algebra, refraction, translation and thin lens matrix, system matrix	1.5

TEST: (In class/take home)

Aberrations: description of 3rd order; calculation of correction for selected aberrations	4.5
Apertures, stops and pupils	4.5

LAB TEST: telescope design (Meyer-Arendt)

WAVE OPTICS

Review of interference	1.5
Diffraction gratings and interferometers	6
Thin films and air wedges	3

TEST:

Coherence	1.5
Diffraction	3
Scattering	1.5
Polarization	4.5

FINAL: (in class/take home)

SOME TENTATIVE LAB EXPERIMENTS

Two thin lenses
Negative lens focal length
Spherical mirrors
Equivalent lenses
Matrix Methods
Aberrations
Lens design
Interferometer construction
Telescope design
Filter characterization
Air wedge
n for air- Michelson interferometer
single slit diffraction
Malus' law
Identification of polarization state

Exam Policy

Several exams are scheduled- some in class and some take home. Teamwork is not discouraged on take home tests- in fact, it is encouraged as long as all members of the team are equally involved. For in class exams, a sheet of equations will be allowed.

Makeup exams will only be given in the case of serious illness or other bona-fide excuse. Students will be expected to have appropriate documentation to schedule a make-up exam.

If it becomes evident that good effort is not being expended on homework, there will be pop quizzes as well. These will be open book but time limited.

Laboratory Reports

Each lab will have specific items that need to be handed in. Be sure to find out what is expected of you before leaving the lab for the day. Most labs will be graded on the basis of 10 points, but some may only be checked off that they were completed.

ALL labs are expected to be neat and complete. Incomplete labs will not be graded.

No lab reports will be accepted more than 2 weeks after the experiment is completed, or after the graded lab is returned to the class.

Grade Determination

The final grade will consist of:

Class participation*	10%	
Tests:	65%	
Lab:	25%	(You must pass the lab to pass the course)

*Class Participation: The class participation grade will depend first and foremost on attendance, being on time and prepared with completed homework. Occasional assignments such as research on companies or participation in outreach activities (field trips, volunteer activities such as Tech Night or Laser Camp), may contribute positively to this category.

PHO 102 Course Objectives

Upon successful completion of this course you will be able to:

1. Solve for front, back and equivalent focal of a lens or lens system
2. Sketch a lens system showing the principle planes and applicable focal lengths.
3. Explain how matrices may be used to solve for lens parameters.
4. Explain the effects of third order aberrations, and algebraically correct a lens for spherical aberration, using the shape and position factors
5. Explain the effect of chromatic aberration, and correct a lens for chromatic aberration in a simple case
6. Define and calculate f/# and explain its importance in photography and how f/# is used in the description of a lens
7. Explain the importance of pupils, stops and windows
8. Explain the operation of a simple camera, the human eye, and Newtonian and Galilean telescopes
9. Distinguish among forms of interferometer (Michelson, Mach Zender, Fabry Perot, others) and explain the salient features and main uses of each.
10. Explain the importance of spatial and longitudinal coherence to specific experiments or technologies.
11. Calculate the required thickness of a simple thin film for reflectance and transmission at a given wavelength and explain the advantages of thin films over colored filters
12. Identify filter types by their transmission graphs from a catalog such as Edmund Optics
13. Calculate the “just resolvable” spacing of two points using Rayleigh’s criterion. Explain the importance of Rayleigh’s criterion in imaging systems and its application to art.
14. Predict the spacing of orders for a diffraction grating. Explain the importance of resolvance and free spectral range to spectroscopy.
15. Explain Rayleigh scattering. Use the explanation to answer practical questions: why is the sky blue?
16. Explain the effect of quarter and half wave plates on light of various polarization and give examples from laser technology.
17. Explain the operation of devices employing polarization, such as an LCD display.
18. Feel confident working around and with optical components in an optical laboratory