# PHO 102 Applied Optics
**4 credits (5 hours)**

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**Office: C272**
**Office Hours: MTW 11-12**

**<u>Prerequisites</u>:** 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.

Classroom demonstrations, Internet web sites, and in-class mini labs and team projects will be used extensively. You may work in the lab or on projects during one or both of the scheduled classes each week.

## References:
The course will be taught mainly from instructor notes and hands-on experiments. You need to have a binder. 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
***Because the course involves ongoing projects and experiments, you must be in class on time and every time. If you need to miss a class for a legitimate reason, please contact me (885-2353) and your team mates beforehand.***

## Course Topics with Approximate Hours

**LENSES**

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|---|---|
| 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 |
| Lens application | 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**

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

**TEST:** (In class/take home)

| | |
|---|---|
| Coherence | 1.5 |
| Diffraction | 3 |
| Scattering | 1.5 |
| Polarization | 4.5 |

**FINAL: (in class/take home)**

**SOME TENTATIVE LAB EXPERIMENTS and/or PROJECTS**

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

**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.***

**Reports**

Each lab or project 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% (-1 each unexcused absence, +1 volunteer activity) |
| Tests: | 50% |
| Labs and projects: | 40% |

*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 participation in outreach activities may contribute positively to this category.

## PHO 102 Course Objectives

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

1. Interpret catalog specifications for lenses such as front, back and equivalent focal length
2. Sketch a lens system showing the principle planes and applicable focal lengths.
3. Explain the effects of third order and chromatic aberrations on an image, and specify the correction of at least one lens aberration, using algebraic formulas
4. Define and calculate f/# and explain its importance in photography and how f/# is used in the description of a lens
5. Explain the importance of pupils, stops and windows
6. Explain the operation of a simple camera, the human eye, Newtonian and Galilean telescopes and other optical systems
7. Distinguish among forms of interferometer (Michelson, Mach Zender, Fabry Perot, others) and explain the salient features and main uses of each. Build and/or use at least two types of interferometers.
8. Explain the importance of spatial and longitudinal coherence to specific experiments or technologies.
9. 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. Identify filter types by their transmission graphs from a catalog such as Edmund Optics. Specify filters for given applications using manufacturer’s catalogs.
10. Explain the importance of Rayleigh’s criterion in imaging systems and its application to art and technology
11. Explain the importance of resolvance and free spectral range to spectroscopy.
12. Explain Rayleigh scattering. Use the explanation to answer practical questions such as why is the sky blue?
13. Explain the effect of quarter and half wave plates on light of various polarizations and give examples from laser technology.
14. Explain the operation of devices employing polarization, such as an LCD display.
15. Feel confident working around and with optical components in an optical laboratory and in teams.
16. Develop critical thinking and problem solving skills and practice the use of the problem solving cycle.