Instructor: Brian Smith  
Office: 262 Willamette Hall  
Phone: +1 541 346 5790  
Email: bjsmith@uoregon.edu  
Office hours: T 15:00-16:00, W 10:00-11:00, or by appointment

Teaching Assistant: Abigail Pauls  
Office: 242 Willamette Hall  
Email: aapauls@uoregon.edu  
Office hours: M 10:00-11:00  
Held in 240D Willamette Hall

Laboratory Instructor: Nima Dinyari  
Office: 412 Lewis Integrative Sciences Building (LISB)  
Phone: +1 541 346 7578

Meeting times and locations:  
Lectures: M, W 14:00-15:50, 318 Willamette Hall  
Laboratory: W 14:00-15:50 as listed in schedule below, B004 LISB  
Credits: 4  
Prerequisites: PHYS 424 Classical Optics (or by prior approval of instructor)  
Communication: The best form of communication between students and the teaching team will be via email. You must use your uoregon.edu email address. Please mention PHYS 425 in the subject line. Email will be checked only during normal work hours.

Course Synopsis: This course builds upon the material introduced in PHYS 424, further developing the methods to describe the basic properties of light, its propagation and simple techniques to characterize these properties. We will begin with a review of the wave equation and polarization, extending our treatment to discuss optical activity, and the polarization effects at an interface of two dielectric media. This will then be followed by a review of Fourier analysis as applied to the electromagnetic field, which is an essential tool of a branch of optics known as Fourier optics. We then discuss the diffraction of light and how light propagates after it is incident on an aperture. The Fraunhofer and Fresnel regimes of diffraction will be covered. The spectral properties of light will then be introduced. Simple optical instruments used to characterize the spectral properties of light will be discussed including the Fabry-Perot interferometer and a diffraction-based spectrometer. If time permits we will examine the slowly-varying envelope approximation, which leads to optical pulses, dispersion, phase, and group velocity, and the Lorentz model of light-matter interaction that leads to a useful description of dispersion. See the tentative course schedule below for further details of what aspects we shall cover during the autumn term.

Course learning objectives: The aim of this course is to provide students with a quantitative understanding of and ability to describe modern optical phenomena as well as provide an introduction to modern optical laboratory equipment, techniques and methods. Topics covered during the course will include

- Polarization:
  - Birefringence and susceptibility tensor – polarizability of dielectric media
    (electromagnetic fields inside media – constitutive relations)
  - Optical activity
- Polarization of light at an interface (Fresnel coefficients)
- Faraday effect
- Optical isolators

**Fourier optics and diffraction:**
- Periodic functions and Fourier series
- Non-periodic functions and the Fourier transformation
- Dirac delta function
- Convolution and Parseval theorems
- Near (Fresnel) and far (Fraunhofer) field diffraction patterns
- Fourier transform properties of a lens
- Diffraction from a hard aperture
- Apodization
- Spatial resolution (Rayleigh criteria)
- Babinet's principle
- Spatial filtering

**Coherence and spectral properties of light:**
- Time-varying electric field and its Fourier representation
- Spectral measurements and resolving power:
  - Imaging spectrometer: Grating and prism
  - Fabry-Perot interferometer
  - Michelson interferometer
- Slowly-varying envelope approximation, optical pulses and wave packets*
- Dispersion, Kramers-Kronig relation, group and phase velocity*
- Coherence theory*
  - Coherence time, coherence length*
  - Wiener-Khinchin theorem*
  - Interference between partially coherent source*

**Light-matter interactions:***
- Polarizability*
- Lorentz model*
- Rayleigh scattering*

* Time permitting

Learning will take place through a variety of methods including lectures, assigned reading, homework exercises, laboratory sessions and class discussions.

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**Course resources**

**Course website:** Canvas ([https://canvas.uoregon.edu/](https://canvas.uoregon.edu/)) will be used in this course as an online resource for the syllabus, course materials, and homework assignments. Please frequently check Canvas to stay up to date on the course materials that are posted between class meetings. Important announcements will also be sent via email, so it is best to get into the habit of checking your email daily.

**Textbook:** Although no textbook is required there are many excellent standard optics texts that you may find useful for this course. I suggest *Introduction to Optics* by Pedrotti, Pedrotti, and Pedrotti as a good introductory level. Another useful resource are the optics notes by Prof. Daniel Steck available at [http://atomoptics-nas.uoregon.edu/~dsteck/teaching/optics/](http://atomoptics-nas.uoregon.edu/~dsteck/teaching/optics/).
In addition, I recommend the following books that provide alternative approaches to the subject:

- Brooker, Modern Classical Optics
- Fowles, Introduction to Modern Optics
- Goodman, Fourier Optics
- Guenther, Modern Optics
- Hecht, Optics
- Saleh and Teich, Fundamentals of Photonics

Course assessment: Assessment of student learning will be based on homework, laboratory work, a mid-term exam, and a final exam. The relative weights will be as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>25%</td>
</tr>
<tr>
<td>Laboratory work</td>
<td>25%</td>
</tr>
<tr>
<td>Midterm exam</td>
<td>20%</td>
</tr>
<tr>
<td>Final exam</td>
<td>30%</td>
</tr>
</tbody>
</table>

In class, 11 February 2019

Grading Scale: The expected grading scale for this course is 100-85 = A(+/-), 85-75 = B(+/-), 75-65 = C(+/-), 65-50 = D, <50 : in danger of F. If necessary, a curve may be applied to achieve a higher average final grade. However, you are guaranteed at least the grade listed here based on your course average. Pass/fail grading option: A passing grade requires at least the equivalent of a C-grade.

Expectations

Attendance / punctuality: Class attendance is mandatory and credit will be given to students who attend all classes. With prior notification you may miss up to two classes with no loss of attendance points. You can also miss up to one day without prior notification with no loss of attendance points. Furthermore, you are expected to arrive in class on time – late arrivals are disruptive and disrespectful to other students’ learning.

Course participation: Learning is an active process and the classroom and office meetings should be places to exchange ideas. You will be expected to actively prepare for class through reading and homework exercises, and engage in class discussions and activities. If you have questions or are unsure of material, you should seek assistance in class or during office hours. It is your responsibility to ask questions and seek clarification, direction and guidance to any assignments.

Homework: Homework is to be submitted in the appropriate assignment box in the basement of Willamette hall near the teaching laboratories. Assignments are due by 5pm on the dates specified on the problem set (this will usually be Thursday). Thereafter, late homework will only be accepted no more than 24 hours after the deadline with a 20% penalty. Partial assignments may be turned in on time, and only the late portion will be penalized. The relative contribution of each homework assignment to the final grade will depend on its difficulty. Late homework should be handed into the optics box and an email sent to both the instructor and TA to notify it has been completed. Homework may be turned in late with no penalty under extenuating circumstances only by pre-arrangement with at least 24-hours notice before the normal deadline.

Note: There will be a homework assignment due during Dead Week.

Course reading: Reading from Prof. Daniel Steck’s optics notes are given in the course schedule below. You are expected to have done this reading prior to attending class.
Laboratory: Labs will be held on Wednesday from 14:00 PM to 15:50 in B004 in the Lewis Integrative Science Building (LISB). Lab handouts will be posted on the Canvas page of this course each week of a new lab. People will work in groups of two but each individual is responsible for the completion of their own work. Students will keep a detailed account of their work in a laboratory notebook provide to them by the instructor. The lab notebook should be uploaded electronically to Canvas as indicated on the course schedule below. Prior to each new laboratory session a pre-lab section should be completed in your notebook before the lab session which consists of an introduction and overview of the lab being done that day. This ensures that you will utilize the time most efficiently during the lab time. Also please dress accordingly for the laboratory sessions, e.g. do not wear open-toe shoes to lab.

Examinations: The exams are pre-scheduled (see above and below) so you can avoid conflicts. **Thus, there will be no makeup exams for this course, so please check the dates now.** If you have a serious and documented reason for missing the Midterm Exam (e.g. death in the family, serious illness), your final-exam score will count in place of the missed midterm exam score. That is, your final-exam score will count for more than it would otherwise.

Calculators: Calculators will be allowed on examinations, but the use of mobile phones, tablets, computers, etc. is not acceptable.

Course feedback: If you have suggestions for improving anything about how the course is going, please drop a note (this can be unsigned) in the assignment box.

Academic honesty: Students have the responsibility to behave honorably in an academic environment. The University Student Conduct Code ([http://dos.uoregon.edu/conduct](http://dos.uoregon.edu/conduct)) defines academic misconduct. Academic dishonesty, including cheating, fabrication, facilitating academic dishonesty, and plagiarism, devalues the reputation of our institution, its faculty, its students, and the degrees we offer. Moreover, academic misconduct is particularly unfair for the students who do their work with integrity and honor. All incidences of suspected academic misconduct will be reported to the Office of Student Conduct and Community Standards. The procedures for handling academic misconduct cases are outlined in Oregon Administrative Rule OAR517-021-0215.

Creating an inclusive learning environment: Students are expected to conduct themselves in a manner that contributes to a positive learning environment for all within the classroom.

**Accessible Education:** The University of Oregon is working to create inclusive learning environments. Please notify us if aspects of the instruction or course design result in barriers to your participation. You are also encouraged to contact Accessible Education Center in 164 Oregon Hall at 346-1155.

If you have a documented need for accommodations in this course, please meet with the instructor in the first week of term so that we can design a plan for you. Also please request that the Accessible Education Center (AEC) send a letter verifying your documented needs for accommodations. [http://aec.uoregon.edu](http://aec.uoregon.edu) If you have a disability, but have not registered with AEC, you should contact them as soon as possible. It is more likely that adequate special accommodation can be made if organized through AEC.
<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topics to be covered</th>
<th>HW</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7-Jan-19</td>
<td>Overview of course, Polarization review: birefringence, optical activity</td>
<td></td>
<td>Steck 4.3, 4.4, 8, 9</td>
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<tr>
<td></td>
<td>9-Jan-19</td>
<td>Polarization: optical activity, Faraday effect, and Fresnel coefficients (polarization at an interface)</td>
<td></td>
<td>Steck 4.3, 4.4, 8, 9</td>
</tr>
<tr>
<td>2</td>
<td>14-Jan-19</td>
<td>Fourier analysis: Periodic functions and Fourier series</td>
<td></td>
<td>Steck 3, 11.2, 11.3</td>
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<tr>
<td></td>
<td>16-Jan-19</td>
<td>Fourier analysis: Non-periodic functions and the Fourier transformation, Dirac delta function, Parseval and convolution theorems</td>
<td>PS1</td>
<td>Steck 3, 11.2, 11.3</td>
</tr>
<tr>
<td>3</td>
<td>21-Jan-19</td>
<td>No class: MLK day</td>
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<td></td>
<td>23-Jan-19</td>
<td>Lab 1: Polarization</td>
<td>PS2</td>
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<td>4</td>
<td>28-Jan-19</td>
<td>Diffraction: Single slit diffraction pattern in the far field – definitions, general approach to diffraction and examples</td>
<td></td>
<td>Steck 12</td>
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<tr>
<td></td>
<td>30-Jan-19</td>
<td>Lab 1: Polarization</td>
<td>PS3</td>
<td></td>
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<tr>
<td>5</td>
<td>4-Feb-19</td>
<td>Diffraction: Spatial resolution of a lens / imaging system</td>
<td>Lab1</td>
<td>Steck 12</td>
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<tr>
<td></td>
<td>6-Feb-19</td>
<td>Diffraction: Spatial resolution of a lens / imaging system</td>
<td>PS4</td>
<td>Steck 12</td>
</tr>
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<td>6</td>
<td>11-Feb-19</td>
<td><strong>Midterm</strong></td>
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<tr>
<td></td>
<td>13-Feb-19</td>
<td>Spectral properties of light: Temporal coherence</td>
<td></td>
<td>Steck 7</td>
</tr>
<tr>
<td>7</td>
<td>18-Feb-19</td>
<td>Optical grating and resolving power of spectrometer</td>
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<td>Steck 7</td>
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<tr>
<td></td>
<td>20-Feb-19</td>
<td>Lab 2: Fourier optics and diffraction</td>
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<tr>
<td>8</td>
<td>25-Feb-19</td>
<td>Fabry-Perot interferometer and spectrum analyzer <strong>SNOW DAY</strong></td>
<td></td>
<td>Steck 7</td>
</tr>
<tr>
<td></td>
<td>27-Feb-19</td>
<td>Lab 2: Fourier optics and diffraction <strong>SNOW DAY</strong></td>
<td></td>
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<tr>
<td>9</td>
<td>4-Mar-19</td>
<td>Optical grating and resolving power of spectrometer</td>
<td></td>
<td>Steck 7</td>
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<tr>
<td></td>
<td>6-Mar-19</td>
<td>Lab 2: Fourier optics and diffraction</td>
<td>PS5</td>
<td>Steck 7</td>
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<tr>
<td>10</td>
<td>11-Mar-19</td>
<td>Fabry-Perot interferometer and spectrum analyzer</td>
<td>Lab2</td>
<td>Steck 7</td>
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<tr>
<td></td>
<td>13-Mar-19</td>
<td>Fabry-Perot interferometer and spectrum analyzer</td>
<td>PS6</td>
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<tr>
<td>11</td>
<td>21-Mar-18</td>
<td>Final Exam: <strong>14:45-16:45</strong></td>
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**Other important dates:**

- Last day to drop without a W: 14 January 2019
- Last day to register: 16 January 2019
- Last day to withdraw: 24 February 2019