PHYS430/530: Optics

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CATALOGUE DESCRIPTION

Course Summary: Geometrical, physical, quantum, and experimental optics with emphasis on topics of current interest. ~~Three lectures plus a 3-hour laboratory weekly~~.

Prerequisites: PHYS 370, or consent of department.

CONTACT

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CLASS MEETINGS

Weekly on Tuesdays and Thursdays from 9:00 to 10:15 am.

COURSE DESCRIPTION & OUTCOME

This course provides students with a contemporary approach to optical phenomena at the senior undergraduate level. Students will develop problem-solving techniques and acquire mathematical skills necessary to apply various descriptions of optical phenomena (geometric optics, wave optics, and quantum nature of light) to practical applications. The lectures incorporate discussion/solving sessions and practical applications of optics in various branches of Physics. The course also includes laboratory experiments where students will familiarize themselves with optical components, light sources (including lasers) and learn how to analyze and present their findings. In additions students enrolled in the PHYS530 are expected to complete a small research project on a topic to be mutually agreed on.

TEXTBOOK

Required textbook: J. Peatross and M. Ware, *Physics of Light and Optics*, 2015 edition, available at http://optics.byu.edu/ .

COURSE MATERIALS

The lesson plan will closely follow the text except for a few lessons where some lecture notes will be provided. Supplemental material, slides, and lecture note will be available on the class website at http://nicadd.niu.edu/ piot/phys_430-530/index.html

HOMEWORK

Homework will be distributed every 10 days approximately (there will be 7-8 sets of homework over the semester depending on time and progress). The homework will be posted on the course website and an e-mail notifying it has been distributed sent to all students. You are welcome to work together in solving the problems. However, your homework solution should be your own work. Please credit work you might have used (textbook, paper, web pages) when solving the problems. Make sure you explain your derivations and write neatly.

Late-homework policy: Late homeworks are accepted up to the end of the week's due date (i.e. up to 11:59 pm on the Friday of that week). If you return your homework late I expect you to send me a scan version by the Friday deadline and provide me with a paper copy of the homework in my mailbox the next business day (ask the Physics front office to time stamp your homework). If you do not return your scanned homework by the Friday deadline at the latest it will not be graded (you will get a zero). Although I accept late homeworks, I keep track of them and you will eventually be penalized (e.g. no get extra credit point when curving grades at the end of the school).

LABORATORY [SILL SOME OPEN QUESTIONS]

This course enables students to learn about the various aspects of optics by performing experiments. The lab sessions provide students with an opportunities to develop experimental skills, learn how to use basic laboratory equipment, and gain experience with writing scientific reports summarizing experiments. The labs are self-directed, before each lab, we will have a 30 mins session (on Thursdays) to introduce the lab. You can check-out the laboratory key from the department front office to freely access the lab and perform your experiment during normal business hours of the department (8:30 am to 4:30 pm from Monday to Friday). If you need help you can ask the instructor to help you or make an appointment.

This course includes 8-9 laboratory experiments. The labs will be posted on the class website at the appropriate time. During the laboratory experiments, you will be working in small groups to perform the relevant experiments and acquire the associated data. Subsequent to the laboratory session, each student is expected to analyze alone the acquired data, performed the relevant analysis, and write his/her own report. **the teamwork, if any, should be limited to performing the experiment and acquiring the data only**.

Each student is expected to write an individual formal report due within the deadline given at the time the lab is distributed. The report should be typed, plots should be properly labeled and data should have error bars. When analyzing/reporting your data

you should always make an effort to quantify error bars.

Lab safety

The main safety hazard is associated with the HeNe lasers. HeNe lasers in the 0.5-mW to 5.0-mW range are common tools for alignment and science laboratories. Although these devices are safe if handled properly, they can cause injury if employed improperly. The following procedures will ensure the safe operation of a HeNe laser. These rules are essentially identical to rules for using low power laser diodes.

1. DO NOT LOOK DIRECTLY INTO THE LASER BEAM.

   The low-power HeNe laser is little more than a coherent, monochromatic light bulb. The HeNe laser described here is not capable of burning or drilling holes in most materials; and accidental, momentary eye exposure will not normally cause eye damage. Nevertheless, the highly-directional, intense beam of light should be treated with caution, care and respect. Common sense dictates that one must not look directly into any bright light source such as the sun, carbon arc, or an arc lamp projector, and particularly a laser beam. The lens of the eye can focus the beam from even a low-powered (1-5 mW) HeNe laser to a small spot on the retina and cause thermal damage to retinal tissue.

2. DO NOT LOOK AT SPECULAR REFLECTIONS OF THE LASER BEAM.

   Specular reflections are those from mirrors, watch crystals, polished metal surfaces (painted and unpainted), or any other highly-reflective surface. Specular reflections of a laser beam are considered secondary laser sources and, as such, are treated with the same caution as is the direct laser beam. (See Laser Safety Precaution 1.)

3. TAKE CARE WHEN MOVING THE LASER OR WHEN MOVING OBJECTS IN THE BEAM PATH OF THE LASER.

   Most low-power HeNe lasers are small enough to be moved about easily. If the laser must be moved during its operation, care must be taken to direct the beam carefully in order that it will not shine into anyone's eyes. For the reasons outlined in Laser Safety Precaution 2, caution also must be taken not to direct the beam upon a specular reflector when the laser is moved.

   If an object must be moved into the beam of a laser, movement should be deliberate, with due consideration given to where the reflections will be directed. Usually, a laser should be turned off before it is moved.

4. BEWARE OF HIGH VOLTAGE WHEN THE CASE OR ENCLOSURE OF AN OPERATING LASER IS OPEN.

   The HeNe laser described here contains a high-voltage power supply. This unit should not be disassembled, demonstrated, or serviced by anyone unfamiliar with such devices. Most lasers contain either high-voltage or high-current power supplies that should be treated with caution. Each year more people in the laser industry are injured by electrical hazards than by exposure to laser beams.

5. OPERATE THE LASER IN AN AREA DESIGNED FOR LASER OPERATION.

   If possible, the laser should be operated with the beam horizontal and below eye level to prevent eye damage. All potential specular reflectors should be removed from the beam area. Adequate provision for all support equipment should be made prior to the operation of the laser. The number of persons working around the laser should be kept to a minimum, and the area at which the laser is being operated should be illuminated as much as possible. Access to the operation area should be limited and appropriate warning signs exhibited.

   Most low-power HeNe lasers are designed to operate with 110/120 volts, single phase, 50-60 Hz ac power. Some may operate with 220/240 volts, single- or three-phase 50-60 Hz ac power. Prior to the operation of any laser, the correct power requirements for that laser should be determined from the laser specification. The power cord attached to the laser should be examined. For most low-power HeNe lasers, the unit is equipped with a power cord consisting of a three-wire, grounded plug. The third-wire, grounded terminal must not be bypassed.

6. DO NOT INTENTIONALLY OR INADVERTENTLY TRACK VEHICLES OR AIRCRAFT WITH HE LASER BEAM.

   Federal laws prohibit the tracking of vehicles or aircraft with laser beams. Such actions could cause considerable property damage, loss of eyesight, or even loss of lives.

7. DO NOT LEAVE AN OPERATING LASER UNATTENDED. ALWAYS UNPLUG IT WHEN IT IS NOT BEING USED.

   When not in use, the laser should be turned off to prevent accidental exposure to the beam by unqualified persons.

PROJECT FOR PHYS530 STUDENTS

Student in PHYS530 are also expected to work on an experimental project. The topic will be discussed and agreed with each of the students. In essence the project will consist in putting together a new lab and reporting on the work and experiment in an oral presentation the last week of classes.

ASSESSMENT & GRADING

The assessment will consist of homework, labs, a midterm and final exams (and a project for PHYS530). The grading will be as follows:

	PHYS430	PHYS530
Homework	30% of overall grade	20% of overall grade
Laboratory	30% of overall grade	30% of overall grade
Project.	N/A	10% of overall grade
MidTerm	20% of overall grade	20% of overall grade
Final.	20% of overall grade	20% of overall grade

The numeric averaged grade will be computed given the above Table and a letter grade will be assigned following the table below.

Letter grade	Percentage points.
A	$\geq 90\%$
A-	$\geq 85\%$
B+	$\geq 80\%$
B	$\geq 75\%$
B-	$\geq 70\%$
C+	$\geq 65\%$
C	$\geq 60\%$
D	$\geq 50\%$
F	$< 50\%$

Further information on NIU grading system can be found at:
http://www.niu.edu/regrec/grading/gradingfaqs.shtml

STUDENT RESPONSIBILITIES

The students are expected to be engaged researchers carrying their work safely and with highest integrity.

ACCESSIBILITY

If you need an accommodation for this class, please contact the Disability Resource Center (RDC) as soon as possible. The DRC coordinates accommodations for students with disabilities. It is located on the 4th floor of the Health Services Building, and can be reached at 815-753-1303 (V) or drc@niu.edu. Also, please contact me privately as soon as possible so we can discuss your accommodations. The sooner you let us know your needs, the sooner we can assist you in achieving your learning goals in this course.

SYLLABUS

- Week 1: E.M. phenomena and plane wave solution of wave equation, complex representation
- Week 2: Index of refraction, dielectric matter
- Week 3: Reflection & Refraction
- Week 4: Interface phenomena
- Week 5: Propagation in anisotropic media
- Week 6: Polarization of light
- Week 7: Superimposition of Waves

- Week 8: Coherence
- Week 9: mid-term exam [will cover up to Coherence, wk 10/14 included], Geometric optics
- Week 10: Geometric Optics
- Week 11: Optical beams (notes to be provided)
- Week 12: Diffraction & Application
- Week 13: Introduction to nonlinear optics (notes to be provided)
- Week 14: Quantum aspects of light (notes to be provided, class on Tuesday only)
- Week 15: project presentation (PHYS530) and class review