ELECTROMAGNETIC WAVES AND OPTICS

PHY 411 Instructor: Dr. Romulo Ochoa Office: SC-P132 Phone: 771-3162

e-mail:ochoa@tcnj.edu

Text: "Optics," E. Hecht (4th Ed.) website: <u>www.tcnj.edu/~ochoa/courses/optics</u>

I. Course Description

Properties of electromagnetic waves are studied, with a focus on visible light. Topics include wave motion, interaction of electromagnetic waves with matter, geometrical and physical optics, polarization, optical instruments, holography, laser physics and quantum optics at an intermediate level. Laboratory work involves designing experiments to verify physical models and use of photonics research equipment. The course provides the foundation for imaging, laser physics and optical spectroscopy techniques.

II. Course Outline

1. Geometrical optics.- (Ch. 5)

Lenses. Mirrors. Prisms. Fiberoptics. Aberrations. Homework problems: 12, 13, 14, 19, 24, 27, 33, 36, 38, 53, 54, 58, 63, 65, A1, A2, A3, A4, A5, A16, A7.

2. Wave motion.- (Ch. 2)

One-dimensional waves. Harmonic waves. Phase and phase velocity. The superposition principle. The complex representation. Plane waves. Three-dimensional waves.

Homework problems: 16, 17, 22, 30, 32, 35, 36, 41, A8, A9, A10.

3. Electromagnetic theory, photons and light.- (Ch. 3)

Basic laws of electromagnetic theory. Electromagnetic waves. Energy and momentum. Radiation. Light and matter. The electromagnetic-photon spectrum. Homework problems: 2, 5, 7, 15, 16, 17, 18, 24, 30, 31, 36, 46.

4. The propagation of light.- (Ch. 4)

Rayleigh scattering. Reflection. Refraction. Fermat's principle. The electromagnetic approach. Total internal reflection. Optical properties of metals. Homework problems: 4, 6, 7, 12, 13, 14, 20, 24, 25, 38, 60, A11.

Test 1 (TBA)

5. Superposition of waves.- (Ch. 7)

Addition of waves of the same frequency. Standing waves. The addition of waves of different frequency. Beats. Group velocity. Fourier analysis of anharmonic

waves. Fourier integrals of nonperiodic waves. Pulses and wavepackets. Coherence length. Fourier Optics. Homework problems: 5, 6, 10, 13, 14, 18, 19, 28, 29, 44, A12.

6. Polarization.- (Ch. 8)

Polarized light. Polarizers. Dichroism. Birefringence. Scattering and polarization. Polarization by reflection. Retarders. Circular polarizers. Optical activity. A mathematical description of polarization.

Homework problems: 1, 4, 5, 10, 12, 16, 18, 21, 29, 32, A13, A14, A15.

Test 2 (TBA)

7. Interference.- (Ch. 9)

Conditions for interference. Interferometers. Multiple-beam interference. Homework problems: 6, 7, 8, 9, 10, 16, 26, 35, 37.

8. Diffraction.- (Ch. 10)

Fraunhofer diffraction. Fresnel diffraction. The diffraction grating. Homework problems: 8, 9, 29, 31, 32, 33, 35.

 Modern optics: lasers and other topics.- (Ch. 11) Lasers and laser light. Raman effect. Imagery - the spatial distribution of optical information. Holography.

Final Exam (TBA)

III. Laboratory

- Lab. 1. Snell's Law.
- Lab. 2. Geometrical Optics I
- Lab. 3. Geometrical Optics II
- Lab. 4. Microwaves Optics.
- Lab. 5. Interferometers. Mirrored and multiple beam.
- Lab. 6. Reflectance Curves.
- Lab. 7 Polarization I. Malus's Law. Optical Activity.
- Lab. 8. Discussion of Advanced topics in photonics
- Lab. 9. Diffraction: Multiple slits, circular slits, and gratings.
- Lab. 10. Fiber Optics
- Lab. 11. Holography I. Single beam reflection holograms.
- Lab. 12. Holography II. Single beam transmission holograms.

IV. Assessment of Student Performance

- 1. tests (30 points)
- 2. final exam (30 points)
- 3. homework problems (10 points)
- 4. lab. grade (20 points)
- 5. Presentation of advanced topics in photonics (10 points)

For the laboratory grade students must prepare two formal reports, have at all times in lab a lab notebook in which they must write all calculations, observations and procedures performed during the experiments. Students are expected to be in the lab on time, points will be deducted for tardiness. Lab reports represent 2 points each towards your final grade, lab participation and performance are 14 points, and the lab notebook is 2 points. Homework is due one week after the corresponding chapter has been completed in the lectures unless otherwise noted. Late homework will not be accepted.

Grading Scale	
Final Score	Letter Grade
92.5 - 100	А
89.5 - 92.4	A-
86.5 - 89.4	B+
82.5 - 86.4	В
79.5 - 82.4	В-
76.5 - 79.4	C+
72.5-76.4	С
69.5 - 72.4	C-
66.5 - 69.4	D+
59.5 - 66.4	D
0-59.4	F

Fourth Hour:

In this class, the deep learning outcomes associated with TCNJ's 4th hour are accomplished through laboratory experiments.

V. SELECTED TCNJ POLICIES

Final Examinations

The final exam is not scheduled until the middle of the semester. Therefore do not plan on any travel until after the last day of the exam period. TCNJ's final examination policy is available on the web:

http://academicaffairs.pages.tcnj.edu/college-governance/policies/finalexamevaluationreading-days-policy/

Attendance

Every student is expected to participate in each of his/her courses through regular attendance at all class sessions. It is further expected that every student will be present, on time, and prepared to participate when scheduled class sessions begin. While attendance itself is not used as a criterion for academic evaluations, grading in this course is based on participation in quizzes to be given at the beginning of several classes. No make-ups or extensions will be given unless a student has a genuine emergency. If a student misses an exam or assignment deadline they must contact the instructor within 36 hours to explain the situation; otherwise the student will earn a zero for that exam or assignment. Students who must miss classes due to participation in a field trip, athletic event, or other official college function or for a religious holiday should arrange with their instructors for such class absences well in advance. In every instance, however, the student has the responsibility to initiate arrangements for make-up work.

TCNJ's full attendance policy is available at:

http://policies.tcnj.edu/policies/digest.php?docId=9134

Academic Integrity Policy

Academic dishonesty is any attempt by the student to gain academic advantage through dishonest means, to submit, as his or her own, work which has not been done by him/her or to give improper aid to another student in the completion of an assignment. Such dishonesty would include, but is not limited to: submitting as his/her own a project, paper, problem set, report, test, or speech copied from, partially copied, or paraphrased from the work of another (whether the source is printed, under copyright, or in manuscript form). Credit must be given for words quoted or paraphrased. The rules apply to any academic dishonesty, whether the work is graded or ungraded, group or individual, written or oral.

TCNJ's academic integrity policy is available at:

http://policies.tcnj.edu/policies/viewPolicy.php?docId=7642

Americans with Disabilities Act (ADA) Policy

Any student who has a documented disability and is in need of academic accommodations should notify the professor of this course and contact the Office of Differing Abilities Services (609-771-2571). Accommodations are individualized and in accordance with Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1992. TCNJ's Americans with Disabilities Act (ADA) policy is available at: <u>http://affirm.pages.tcnj.edu/key-documents</u>

VI. Bibliography

Guenther, R., <u>Modern Optics</u>, J. Wiley & Sons, 1990.
Halliday, Resnick and Walker, <u>Fundamentals of Physics</u>, 8th Ed., Wiley & Sons, 2005.
Hecht, E., <u>Optics</u>, Shaum's Outline Series, McGraw-Hill, 1975.
Klein, M.V. and Furtak, T.E. <u>Optics</u>, 2nd Ed., J. Wiley & Sons, 1986.
Pedrotti, F. L., Pedrotti, L. S., and Pedrotti, L. M., <u>Introduction to Optics</u>, 3rd Ed., Pearson-Prentice Hall, 2007.
Serway, R. and Jewett, J., <u>Principles of Physics</u>, 4th Ed., Thomson-Brooks/Cole Publishers, 2006.
Young, H.D. and Freedman, <u>University Physics</u>, 11th Ed., Addison-Wesley, 2003.