Fall Semester 2018: Physics 606: Nonlinear Optics

Instructor: Lloyd M. Davis
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Course Objectives:
Develop an in-depth understanding and knowledge of the fundamental principles and applications of nonlinear optics. Learn how to look up needed information and equations and understand how to extend and apply them to new experimental set-ups.

Course Content and Texts:
In this course, we will mostly follow "Nonlinear Optics", Third Edition, by Robert Boyd. You will need to have access to the text and should read the pages indicated in the class schedule before and/or after class to more easily follow the lecture. http://www.amazon.com/Nonlinear-Optics-Third-Edition-Robert/dp/0123694701

Other recommended references:
(1) http://www.amazon.com/Modern-Optics-B-D-Guenther/dp/0471605387
(2) http://www.amazon.com/Nonlinear-Optics-Quantum-Electronics-Applied/dp/0471088072
(3) http://www.amazon.com/Fundamentals-Photonics-Bahaa-E-Saleh/dp/0471358320
(4) http://www.amazon.com/The-Principles-Nonlinear-Optics-Shen/dp/0471430803

Recommended prerequisite courses/background:
There are no required pre-requisite courses enforced by the course registration system, but it is recommended that you have taken previous courses covering the following subjects: Quantum Mechanics, Maths Methods, Electrodynamics, Classical Optics. In addition, Quantum Optics would be helpful, but is not required.

Format: This course is available to students at any location, including UTSI, UT-Knoxville, ORNL, or off-campus. We will use Zoom https://oit.utk.edu/teachingtools/liveonline/zoom-getting-started/, which enables students to attend class from any location with open internet access, e.g., home, office, or lab. However, in order to attend interactively, to ask questions, etc., you will need a PC with a microphone (e.g., a laptop with a webcam and microphone), or a telephone/cell phone. On the other hand, each class will be recorded: I do not require that you attend every class interactively—if needed, you can watch the recording at a later time. Even if you have attended interactively, the recordings may be replayed for later study.

Class times: Tuesdays and Thursdays : May be changed
Central Time: 10:10–11:25 a.m.
Eastern Time: 11:10–12:25 a.m.

Required Instructional Technology:
You will require access to a computer (laptop, tablet or smartphone may also work). If you are connecting by computer to Zoom, your computer will need a microphone and speakers. A calculator is required for homework and exams. The take-home exam will be open-book and may require use of a

calculator. You will require a scanner to submit homework problems by e-mail, or you may take a photograph with your cell phone camera and e-mail that to me, provided it is legible.

Contact Information & Office Hours:

There are no formal office hours scheduled for this course. You may contact me at any time by e-mail ldavis@utsi.edu, telephone 931-393-7335, or in person regarding questions about the coursework, homework, or project. My office is room 143 in the Center for Laser Applications lab building at UTSI. Students who are not at UTSI may request to meet me via Zoom at any time. After each class, it takes me about 10 minutes to record and upload the Zoom session. After this is a good time to reinitiate a Zoom session upon request to answer questions or discuss the coursework or homework.

Course Schedule: (As of August 20, 2018)

Lec.	Date	Topics	Boyd pages; Sections	Homework Problems*	HW Due
1	Thursday Aug 23	Units, susceptibility, Non-linear processes	1-17; App. A, B, §1.1, 1.2	1.1,1.2,1.3	8/27
2	Tuesday Aug 28	Nonlinear Susceptibility (nls)	17-33; §1.3, 1.4	1.4	9/3
3	Thursday Aug 30	Properties of nls	33-52; §1.5	#1	9/3
4	Tuesday Sep 4	Time domain, Kramers-Kronig	52-63; §1.6, 1.7	1.11	9/10
5	Thursday Sep 6	Wave equation, Phase matching	69-88; §2.1-2.4	2.1	9/10
6	Tuesday Sep 11	Manley-Rowe, Frequency mixing, OPOs	88-116; §2.5-2.9	2.5, 2.8, #2,	9/17
7	Thursday Sep 13	NLO with Gaussian beams, interfaces	105-128; §2.10-2.11	2.10, 2.18	9/17
8	Tuesday Sep 18	Quantum mechanics theory of susceptibilities	135-169; §3.1-3.5	3.1	9/24
9	Thursday Sep 20	QM theory of nonlinear susceptibilities	170-201; §3.6-3.9	3.4, 3.5 (part)	9/24
10	Tuesday Sep 25	Intensity dependent refractive index	207-228; §4.1-4.3	4.2	10/1
11	Thursday Sep 27	Molecular reorientation, thermal & semiconductor	228-249; §4.4-4.7	4.11	10/1
12	Tuesday Oct 2	Molecular origin of nonlinear response	253-273; §5.1-5.6	5.2	10/15
	Thursday Oct 4	No class: Fall break			
13	Tuesday Oct 9	No class: Lloyd away			
14	Thursday Oct 11	No class: Lloyd away			

15	Tuesday Oct 16	Two-level approximation	277-293; §6.1-6.3	#3 (saturation),	10/22
16	Thursday Oct 18	Rabi oscillations, dressed atoms, Wave mixing in 2-level systems	293-327; §6.4-6.6	6.3	10/22
17	Tuesday Oct 23	Self-focusing, Optical phase conjugation	329-359; §7.1, 7.2	7.3	10/29
18	Thursday Oct 25	Optical bistability, two-beam coupling, temporal solitons	359-383; §7.3-7.5	7.13	10/29
19	Tuesday Oct 30	Spontaneous light scattering, Acoustooptics	391-427; §8.1-8.4	8.1, 8.2, 8.7	11/5
20	Thursday Nov 1	Stimulated Brillouin & Raman scatter *Discuss possible project topics; Students must choose a topic by 11/7*	429-468; §9.1-9.6	9.1,9.6	11/5
21	Tuesday Nov 6	Stimulated Raman scattering; CARS, Stimulated Rayleigh wing scattering	473-508 §10.1-10.6	10.1, #4 (CARS microscopy)	11/12
	Thursday Nov 8	Electro-optics, photorefractive	511-540; §11.1-11.6	#5, #6	11/12
	Tuesday Nov 13	Optical breakdown	543-559; §12.1-12.5	#7	11/14
	Thursday Nov 15	Ultrafast nonlinear optics *Distribute take-home exam (covers sections 1.1-12.5; due 11/21)*	561-571; §13.1-13.3	#8	11/26
22	Tuesday Nov 20	No class, time to do take-home exam			
	Thursday Nov 22	No class: Thanksgiving			
23	Tuesday Nov 27	Relativistic nonlinear optics *Discuss projects; written part due 12/2*	571-585; §13.4-13.8	#9	12/3
24	Thursday Nov 29	Nonlinear optics in microscopy	Literature	#10	12/3
25	Tuesday Dec 4	Final Project Presentations; 20-30 minutes each; ~5 mins questions	Written reports posted on 12/3	Last day of classes	
	Thursday Dec 6	No Final Exam		Exam period	

*Homework problems are from Boyd, except for additional set problems, which are numbered #1 to #10

Grading:

Homework assignments:	35 %	(35 problems in total, each worth 1%)
Take-home exam:	40 %	(covers Chapters 1-12)
Final project:	25 %	(discussed below)

Each homework assignment (1-3 problems, mostly from Boyd) should be scanned and e-mailed to me by the due date posted in the schedule above, which is usually by 11:59 p.m. on the following Monday. I will post model answers and grade the assignments, which may be discussed during the beginning of the Thursday class. There is a 25% penalty for late assignments turned in after the Monday midnight

deadline but before the Thursday class. Late assignments will not be accepted after the model answer is posted and/or reviewed. (However, if you have conference travel or similar extenuating circumstance, contact me at least one week beforehand for a replacement assignment with adjusted due date.) Homework problems must be worked independently (never worked out together with another student) but the lecture notes and the principles needed for working problems may be discussed with other class members or me. Partial credit will be given for partial steps towards completion. The take home exam must be worked independently, and without discussion with others.

(See pages 16-18 of http://dos.utk.edu/files/Hilltopics2012-2013.pdf for UT policies on plagiarism, receiving or giving assistance, collaborating, etc.)

Final Project:

Research a contemporary topic in non-linear optics of interest to you; make a tutorial written report on your chosen topic to present to your classmates; also prepare a 12-15 minute PowerPoint presentation, which you will present during one of the two last class meetings. Your written report should be about 3 or 4 pages long of text/ bullet notes/equations, and must be less than 10 pages long, for example in a double-spaced word document. You should include references (not included in the page limit). You may insert figures taken from the literature if you provide the references. You must discuss your proposed topic with me by e-mail between 11/1 and 11/26. Your written report is due by midnight on 12/3. I will upload all written reports to the class website on 12/4. Your presentation will be on 12/4. Please notify me by 11/26 if you have a schedule conflict on 12/4 and require an alternate date.

Your 25% grade assessment for the project will be either (15% for the report + 10% for the presentation) or (20% for the report + 5% for the presentation), whichever is more favorable. You will be assessed largely on the basis of your conveyed understanding of the topic, although thoroughness of your references, and keeping within your allotted time limit will also be considered. You are encouraged to provide reference to the relevant sections or equations from Boyd's text, wherever possible. Be prepared for questions following your presentation.

Grade allocation scale:

A	91–100
A–	86–90
B+	81–85
B	76–80
B–	71–74
C+	66–70
C	61–65
C–	56–60
D	51–55
F	≤ 50