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## **IPT5110 Nonlinear Optics Spring, 2022**

國立清華大學 光電光程研究所/電機工程學系

Prof. 黃衍介

class schedule: R2R3R4

Class location: HOPE516

Head TA: 陳文祺 [wenchi1130@gapp.nthu.edu.tw](mailto:wenchi1130@gapp.nthu.edu.tw), Course assistant: Alexey

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### 一、課程說明

The scope of this course covers most nonlinear optical phenomena associated with the 2<sup>nd</sup> and 3<sup>rd</sup> order optical nonlinearities. Near the end of the semester, high harmonic generation and plasma nonlinearity in the relativistic regime will also be introduced. To assist learning, this course begins with some review on the linear electromagnetic theory and then gradually moves into the nonlinear regime. This approach is to accommodate more and more undergraduate students taking this course.

Student's participation plays a key role in this course. All students are required to give a few presentations to earn their grades during the whole semester.

### 二 指定用書

1. Class handouts (available at 利捷影印店 on the NTHU campus or <http://www.hope.nthu.edu.tw> during the 1<sup>st</sup> week of the class)

### 三、參考書籍

0. David K. Cheng, Field and Wave Electromagnetics 2<sup>nd</sup> Ed., Addison Wesley, 1989.
1. 近代實驗光學，東華書局，黃衍介 著。
2. Nonlinear Optics by E.G. Sauter, John Wiley & Sons, 1996.
2. Fundamental of Photonics by Saleh & Teich, John Wiley & Sons, Inc.
3. Nonlinear Optics by R.W. Boyd, Academic Press.
4. Optical Waves in Crystals by Yariv and Yeh, John Wiley & Sons, Inc.
5. Quantum Electronics, by Yariv, John Wiley and Sons, Inc.

### 四、教學方式

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## Homework assignment

Doing homework is a team work in this course.

- (1) Each 2-3 students form a study group. **Your group members could be different every week. We will draw lottery to determine your group members after every weekly class.**
- (2) Each week, members in a study group are required to work together on a set of ~30 slides, approximately 1 slide for 1 page of the course reader.
- (3) Each student is then responsible for working out ~10 slides. For the ~10 slides, design 5 questions relevant to the content of the slide. Answer 10 questions not designed by you on a separate page (QA sheet) and email it to the TA (Wenchih, [wenchi1130@gapp.nthu.edu.tw](mailto:wenchi1130@gapp.nthu.edu.tw)) and Prof. Huang at 5 pm of each Thursday. Provide necessary information on the filename, such as QA\_N\_your\_name.pdf, for the N<sup>th</sup> submission.
- (4) Before the class, all students have to email their slides + 5 designed questions in the pdf format to the TA (Wenchih, [wenchi1130@gapp.nthu.edu.tw](mailto:wenchi1130@gapp.nthu.edu.tw)) and Prof. Huang. The file size can't exceed 1 Mb. Provide necessary information on the filename, such as slide\_N\_your\_name.pdf, for the N<sup>th</sup> submission.
- (5) Each student has to bring a memory stick to the class and get ready for a presentation.
- (6) My slides are available on the course website for your reference only. Design your own slides. **Don't copy my slides directly into your homework. In case your group member(s) can't provide you the slides or can't provide you the slides on time for your presentation, you can use my slides or the other group's slides for your presentation. You simply have to study the course materials well before the class.**

## Presentation

In each class, I **randomly** draw 3-4 students, each giving half an hour presentation **and hosting a Q&A session** by using approximately 10 slides. *Note that you could have to use the other member's slides in your group for your presentation. This means you do have to work together with your team members on ALL the slides.* A presenter's performance will be graded by both the professor and the fellow students in the audience. **Each student is expected to give >10 presentations in a semester.**

## Exams

There will be some quiz, a mid-term exam, and a final exam. All exams are open books/notes. Details of the exams will be announced later.

## 五、教學進度

1. Electromagnetic waves in the linear regime (D. K. Cheng, Huang)

2. Electromagnetic Wave in Anisotropic Media (Ch. 2 by Sauter, Ch. 6 by S&T, Ch. 4 by Y&Y)
3. Acousto-optics (Ch. 20 by S&T, Ch. 9 by Y&Y, Ch. 7 by Boyd)
4. Nonlinear Susceptibility (Ch. 1 by Boyd, Ch. 1 by Sauter)
5. Electro-optics (Ch. 3 by Sauter, Ch. 18 by S&T, Ch. 7 by Y&Y, Ch. 10 by Boyd )
6. Second harmonic generation (Ch. 2, 4 by Sauter, Ch. 19 by S&T)
7. Other Frequency Conversions using 2nd-order Nonlinearity (Ch. 4&5 by Sauter, Ch. 2 by Boyd, Ch. 19 by S&T, Ch. 12 by Y&Y)
8. Quasi-phase-matching nonlinear optics (handout)
9. Third-order Nonlinear Processes: third-harmonic generation, conjugate waves, Brillouin scattering, and Raman Scattering (Ch. 6 by Sauter, Ch. 18 by Yariv, Ch. 19 by S&T)
10. DC and AC Kerr Effect (Ch. 7 by Sauter, Ch. 19 by S&T)
11. High harmonic generation and plasma nonlinear optics

Week 1 (Feb. 14<sup>th</sup>) Introduction

Week 2 (Feb. 21<sup>st</sup>) up to page 28 of the course reader

Week 3 (Feb. 28<sup>th</sup>): up to page 57 of the course reader

Week 4 (March 7<sup>th</sup>): up to page 84

Week 5 (March 14<sup>th</sup>): up to page 112

Week 6 (March 21<sup>st</sup>): up to page 140

Week 7 (March 28<sup>th</sup>): up to page 168

Week 8 (April 4<sup>th</sup>) : up to page 196,

Week 9 (April 11<sup>th</sup>): up to page 224

Week 10 (April 18<sup>th</sup>): **midterm exam**

Week 11 (April 25<sup>th</sup>): up to page 252

Week 12 (May 2<sup>nd</sup>): up to page 280

Week 13 (May 9<sup>th</sup>): up to page 308

Week 14 (May 16<sup>th</sup>) : up to page 336

Week 15 (May 23<sup>th</sup>): up to page 364

Week 16 (May 30<sup>th</sup>): up to page 383

Week 17 (June 6<sup>th</sup>): Review

Week 18 (June 13<sup>nd</sup>): **Final exam week**

## 六、成績考核

Homework (slide+QA) & Quiz

40%

presentation

20% (10% graded by peers)

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midterm exam 20%

Final exam 20%

Q&A – reference for score adjustment (Prof. Huang will keep a record of questions asked by you during and off the class)

七、講義位址 chapter files available at <http://www.hope.nthu.edu.tw> bound copies available at the on-campus 利捷影印店 during the week of Feb 22<sup>nd</sup>.

### Presentation Grading Sheet

Grader's name: \_\_\_\_\_ Grader's ID #: \_\_\_\_\_

Date (mm/dd/yyyy): \_\_\_\_\_

1<sup>st</sup> presenter's name:

A+	A	A-	B+	B	B-	C	D	X
(90-100)	(85-89)	(80-84)	(77-79)	(73-76)	(70-72)	(60-69)	(1-59)	(0)

2<sup>nd</sup> presenter's name:

A+	A	A-	B+	B	B-	C	D	X
(90-100)	(85-89)	(80-84)	(77-79)	(73-76)	(70-72)	(60-69)	(1-59)	(0)

3<sup>rd</sup> presenter's name:

A+	A	A-	B+	B	B-	C	D	X
(90-100)	(85-89)	(80-84)	(77-79)	(73-76)	(70-72)	(60-69)	(1-59)	(0)

4<sup>th</sup> presenter's name:

A+	A	A-	B+	B	B-	C	D	X
(90-100)	(85-89)	(80-84)	(77-79)	(73-76)	(70-72)	(60-69)	(1-59)	(0)

5<sup>th</sup> presenter's name:

A+	A	A-	B+	B	B-	C	D	X
(90-100)	(85-89)	(80-84)	(77-79)	(73-76)	(70-72)	(60-69)	(1-59)	(0)

6<sup>th</sup> presenter's name:

A+	A	A-	B+	B	B-	C	D	X
(90-100)	(85-89)	(80-84)	(77-79)	(73-76)	(70-72)	(60-69)	(1-59)	(0)