ENG PHYS 4SO4/6S04
The Introduction to Lasers and Electro-Optics
Winter 2025
Course Outline

CALENDAR/COURSE DESCRIPTION

The material covered in this course includes the basic description of light in terms of electro-magnetic fields. Relevant aspects of geometric and physical optics as well as physics of radiation will be reviewed. The propagation of light through materials and the optical response of materials are used to introduce non-linear optical phenomena, including optical amplification. The properties of resonators and the basic operation of lasers are discussed, and the unique properties of laser radiation are described. These topics are described in the context of representative laser systems and their industrial applications as well as optical mirrors, detectors, modulators, optical fibers, etc.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): One of ENGPHYS 3E03 or 3E04, PHYSICS 3N03 or 3N04, or ELECENG 4EM4 or 3FK4
Antirequisite(s): NA

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Chang-qing Xu
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Office Hours:
By appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

Yiru Huo

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Office Hours:
By appointment

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

http://avenue.mcmaster.ca/

- Email, Microsoft Teams and Avenue to Learn will be used in communications with/between students;
- Note that email messages sent out are deemed to have been read by the students.

COURSE OBJECTIVES

By the end of this course, students should be able to:

- Understand optical processes and physics behind lasing phenomenon;
- Understand the concept, properties, and physics of optical resonators, and their linkage with laser performance;
- Understand laser oscillation mathematically and physically, and its impact on laser performance;
- Understand physics and applications of lasers and other electro-optic devices;
- Be able to understand engineering design process and follow engineering design process.

MATERIALS AND FEES

Recommended Textbook:

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Lecture notes:

- posted on Avenue to Learn

References:

- Karl F. Renk, "Basics of Laser Physics", 2nd Edition, Springer International Publishing AG 2017;
- Kelin J. Kuhn, "laser engineering", Prentice-Hall, 1998;
- Frank L. Pedrotti, S. J. Leno S. Pedrotti, "Introduction to Optics", Pretice Hall, 1993;
- Richard Syms and John Cozens, "Optical Guided Waves and Devices", McGraw Hill, 1993;
- Amnon Yariv, "Optical Electronics in Modern Communications", New York, Oxford, Oxford University Press, 1997.

Calculator:

- Only the McMaster Standard Calculator will be permitted in tests and examinations. This is available at the Campus Store.

COURSE FORMAT AND EXPECTATIONS

The course is organized as follows:

- 3 lectures and 1 tutorial per week
- Practice questions (for each Chapter)
  - Solutions to the selected questions will be discussed and provided in tutorials.
- Tutorial Presentations
  - Preparing and presenting solutions of the selected practice questions and/or important concepts/phenomena learnt in the classes.
  - Need to inform and discuss with Dr. Xu on the first day of the class if you have preferred dates for the presentation.
  - The presentation schedule will be posted to Avenue to Learn.
- 4 labs
  - Labs will be done in-person (lab schedule will be posted on Avenue to Learn)
  - Lab will be graded based on lab performance and lab report
  - Submission deadline of lab report will be posted on Avenue to Learn
  - Late submission of lab reports will not be marked and a grade of ZERO will be assigned.
- 1 assignment (including reports and presentations)
  - Assignment report submission deadline to be posted on Avenue to Learn
  - Assignment presentation schedule to be posted on Avenue to Learn

  - Late submission of assignment reports will not be marked and a grade of ZERO will be assigned.
- 1 midterm in-class test
  - Check the Schedule on Avenue to Learn for the date of test.
  - 50 min. in-class
- Final exam

COURSE OVERVIEW

Date/Week	Topic	Readings (lecture notes – sections; textbook – chapters)
Week 1	Overview and optical process	Section 1, 2; Chapter 1, 2
Week 2	Amplification and optical resonator	Section 2, 4; Chapter 4, 5
Week 3	Longitudinal and transverse modes	Section 3, 4; Chapter 3, 4
Week 4	Laser performance	Section 4; Chapter 5
Week 5	Types of lasers	Section 5; Chapter 9, 10
Week 6	Optical amplifiers	Section 6; Chapter 12
Week 7	No class	
Week 8	Plan wave, reflection and refraction – review	Sections 7, 10
Week 9	Interference, refractive index, light propagation in a medium	Sections 11, 8, 9
Week 10	Index ellipsoid, Pockel's effect, modulators	Sections 9, 12
Week 11	Modulators, nonlinear effect	Sections 12, 9
Week 12	Applications (presentation)	
Week 13	Applications (presentation)	

ASSESSMENT*

Component	Weight
Labs (4)	30%
Assignment (1)	20%
Tutorial presentations	10%
Midterm in-class test (1)	10%
Final exam	30%
Total	100%

*To obtain credit for 600 Level, additional work must be done. Please contact with Dr. Xu for details.

ACCREDITATION LEARNING OUTCOMES

The Learning Outcomes defined in this section are measured for Accreditation purposes only and will not be directly taken into consideration in determining a student's actual grade in the course.

Outcomes	Indicators
Able to describe optical processes and explain physics behind laser operation; Able to describe optical resonators and apply to laser principles; Understanding of laser oscillation and application to operation; Understanding of optical modulators and ability to apply to engineering example; Demonstrate knowledge of widely used lasers and ability to apply taught theory to real device; Understanding of plane waves and ability to apply mathematics; Knowledge of the interaction between light and materials	1.4
Demonstrates an ability to identify reasonable assumptions (including identification of uncertainties and imprecise information) that could or should be made before a solution path is proposed; Demonstrates an ability to identify a range of suitable engineering fundamentals (including mathematical techniques) that would be potentially useful for analyzing a technical problem; Obtains substantiated conclusions as a result of a problem solution including recognizing the limitations of the solutions	2.1, 2.2, 2.3
Recognizes and discusses applicable theory knowledge base; Selects appropriate model and methods and identifies assumptions and constraints; Estimates outcomes, uncertainties and determines appropriate data to collect	3.1, 3.2, 3.3
Recognizes and follows an engineering design process. (This means an iterative activity that might include recognizing the goal, specifying the constraints and desired outcomes, proposing solutions, evaluating alternatives, deciding on a solution, and implementing); Recognizes and follows engineering design principles including appropriate consideration of environmental, social and economic aspects as well as health and safety issues; Proposes solutions to open-ended problems; Includes appropriate health and safety considerations	4.1, 4.2, 4.3, 4.5
Demonstrates an ability to respond to technical and non-technical instructions and questions; Presents instructions and information clearly and concisely as appropriate to the audience; Constructs effective oral or written arguments as appropriate to the circumstances	7.1, 7.2, 7.3
Critically evaluates and applies knowledge, methods and skills procured through self directed and self identified sources, including those that lie outside the nominal course curriculum; Shows an awareness of the wide range of engineering societies, literature, conferences, and other information sources	12.1, 12.2

For more information on Accreditation, please visit: https://www.engineerscanada.ca

EQUITY, DIVERSITY, AND INCLUSION

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you.

The Department of Engineering Physics is committed to creating an environment in which students of all genders, cultures, ethnicities, races, sexual orientations, abilities, and socioeconomic backgrounds have equal access to education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Undergraduate Chair, Academic Advisor or to contact the Equity and Inclusion Office.

PHYSICAL AND MENTAL HEALTH

For a list of McMaster University's resources, please refer to the Student Wellness Centre.

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the *Academic Integrity Policy*, located at https://secretariat.mcmaster.ca/university-policies-procedures- guidelines/

The following illustrates only three forms of academic dishonesty:
1. plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. improper collaboration in group work.
3. copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

McMaster is committed to an inclusive and respectful community. These principles and expectations extend to online activities including electronic chat groups, video calls and other learning platforms.

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the

technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's *Academic Accommodation of Students with Disabilities* policy.

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

1. It is the students' responsibility to regularly check the course webpage (i.e. Avenue to Learn) for updates and announcements.
2. Late submission of homework, assignment report, mid-terms and final exam will not be accepted and marked, and a grade of ZERO will be assigned.

SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

1. **Relief for missed academic work worth less than 25% of the final grade resulting from medical or personal situations lasting up to three calendar days:**

    - Use the McMaster Student Absence Form (MSAF) on-line self-reporting tool. No further documentation is required.
    - Students may submit requests for relief using the MSAF once per term.
    - An automated email will be sent to the course instructor, who will determine the appropriate relief. Students must immediately follow up with their instructors. Failure to do so may negate the opportunity for relief.
    - The MSAF cannot be used to meet a religious obligation or to celebrate an important religious holiday.
    - The MSAF cannot be used for academic work that has already been completed attempted.
    - An MSAF applies only to work that is due within the period for which the MSAF applies, i.e. the 3-day period that is specified in the MSAF; however, all work due in that period can be covered by one MSAF.
    - The MSAF cannot be used to apply for relief for any final examination or its equivalent. See *Petitions for Special Consideration* above.

2. **For medical or personal situations lasting more than three calendar days, and/or for missed academic work worth 25% or more of the final grade, and/or for any request for relief in a term where the MSAF has been used previously in that term:**

   - Students must report to their Faculty Office to discuss their situation and will be required to provide appropriate **supporting documentation**.
   - If warranted, the Faculty Office will approve the absence, and the instructor will determine appropriate relief.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.