PHYS 434 – OPTICS SYLLABUS

General Information:

TERM: Winter, 2019 – January 7 to April 12
LECTURE TIME: Monday and Wednesday, 2:35pm to 3:55pm
LOCATION: Rutherford RPHYS 115
CREDITS: 3

INSTRUCTOR INFORMATION:

Name: Dr. Vanessa Graber
Contact: vanessa.graber@mcgill.ca
Office: MSI 207 ('The Space Shack', 3550 McGill University)
Office hours: *TBD (doodle poll in week 1)*

TEACHING ASSISTANT INFORMATION:

Name: Rigel Zifkin
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Name: Ziggy Pleunis
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Office hours: *TBD (doodle poll in week 1)*
Weekly tutorial: *TBD (doodle poll in week 1)*

HANDS-ON DEMONSTRATIONS COORDINATOR:

Name: Dr. Kelly Lepo
Contact: kelly.lepo@mcgill.ca
Office: WONG 0160

OFFICE HOURS / TUTORIAL:

The Optics *TAs* will hold a *regular tutorial* and *office hours* (times TBD) to support students who are working through homework assignments and preparing for course examinations. The TAs will offer help with questions, working through derivations and reviewing material.

COMMUNICATION:

Please contact me via email or drop by during the office hours (time TBD). The TA responsible for grading a specific homework assignment will vary from week to week (as indicated on the problem sets), so please make sure to contact the appropriate TA. Course announcements will be sent to registered students at their mcgill.ca email address and further be posted to the MyCourses website. *All registered students are responsible for knowing the content of email announcements within one weekday of receiving them*. Lecture notes, homework problems, exam review, and supplementary materials will also be posted on the MyCourses website.

Course Overview:

PREREQUISITES:

Prerequisites for PHYS 434 are *PHYS 342 Majors EM Waves* or *PHYS 352 Honours EM Waves*. You should be comfortable with the mathematical techniques used to describe waves, including the wave equation (especially related to electromagnetic waves), complex numbers, multivariate calculus, and Fourier methods. Please ask if you have any questions or concerns – it is your responsibility to make sure you are properly equipped to take this class. *Note: This course is typically taken by U3 students in Physics (Majors or Honours)*.

COURSE CONTENT:

PHYS 434 will introduce fundamental concepts of optics, the mechanisms behind optical devices and applications, and give some insight into modern developments. The course consists of four main parts and will cover ***topics*** such as:

- **PART I – Review of Electromagnetism and Light Propagation:** index of refraction, scattering, light propagation in media, reflection, refraction **(2 weeks)**
- **PART II – Geometric Optics:** mirrors and lenses, optical systems, aberrations **(2 – 3 weeks)**
- **PART III – Superposition, Polarisation and Interference:** coherence properties of light, polarisation, scattering, optical activity, interference and interferometers **(3 – 4 weeks)**
- **PART IV – Diffraction, Fourier Optics and Modern Optics:** diffraction and its applications, Fourier methods, Gaussian beams, holography **(5 weeks)**

Where appropriate, we will discuss numerical approaches and use hands-on demonstrations. Note further that as time allows, we may delve into additional topics in modern optics.

LEARNING OUTCOMES:

By the *end of the course*, students should be able to

- explain the microscopic picture of light propagation through media, including scattering, reflection and refraction, group velocity, and dispersion.
- use principles of geometric optics to predict image formation and understand image planes, magnification, resolution and aberration.
- understand the polarisation of light and how birefringent and optically active materials are used to manipulate and exploit polarisation for applications.
- calculate interference effects and apply this knowledge to diverse instruments and optical elements such as thin film coatings and photonic crystals.
- use physical optics to predict diffraction patterns and apply these principles to determine the spatial and spectral resolution of optical instruments.
- derive beam propagation from the paraxial wave equation, predict beam propagation through optical elements, and relate beam propagation to physical and geometric optics.

EVALUATION:

Your ***grade*** will be determined by *homework assignments* (regular problem sets plus hands-on demonstrations) (50%), a *midterm exam* (20%) and the *final exam* (30%). In addition, there will be an opportunity (optional) to write a short paper to replace half of your midterm grade. Please note that

- McGill University values academic integrity. All students must understand the meaning and consequences of cheating, plagiarism and other academic offenses under the *Code of Student Conduct and Disciplinary Procedures* (www.mcgill.ca/students/srr/honest/).
- in accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in *English* or in *French* any written work that is to be graded.
- to support academic integrity, students' assignments may be submitted to text-matching or other appropriate *software* (e.g., formula-, equation-, and graph-matching).

Problem sets will be posted on the MyCourses website approximately every two weeks. The *due date*, which will be specified for each problem set, will typically be at the *beginning of class* one week after posting. Occasional in-class quizzes may also be assigned. Note that

- problem sets will include *exercises* (questions, which you should work through but do not need to be handed in) and *problems* (these will be graded and must be handed in). To encourage you to work through the exercises, one question on each of the two exams will be very closely related to an assigned problem or exercise.
- you are encouraged to *collaborate* with other students on the problem sets. However, the solutions that you hand in at the end must reflect your own work.
- use of solution sets in graded homework is ***plagiarism*** and will be treated accordingly. This includes consulting previous years' solution sets, instructor solution manuals, or similar documents (e.g., solutions obtained from the internet).
- ***late problem sets*** will not be accepted unless an extension has been approved by me or one of the TAs prior to the due date. To compensate for this, the *lowest* problem set *grade* will be *dropped*, if it helps your final grade.

In addition to the problem sets, students have to carry out three ***hands-on demonstrations*** in groups of three (where possible). We will schedule approximately one demo per month. The demos will include preparing the material beforehand, performing the experiments and writing a final report for each of them. Group compositions will be randomly assigned and changed for each demo. The demos will be run by *Dr. Kelly Lepo* and each group will have to *schedule a 90min slot* (outside of class time) for each experiment with her. Slots are on a first come, first served basis, so you are encouraged to book a time as early as possible. More details on the demonstrations will be provided in the first week of class.

There will be one closed-book 80 minute ***midterm exam*** (Wednesday, February 20) during regularly scheduled class time. You will be permitted to use an 8x11" equation sheet (one side), a dictionary, and a calculator. Further note that

- if you have to *miss the midterm* because of a documented medical emergency or other serious reason (please contact me as much in advance as possible), your midterm grade will be replaced by the average of your homework and final exam grades.
- if you *cannot provide a serious, documented reason* for missing the midterm, your grade for it will be 0. (Note that doctors' notes will be accepted at my discretion.)
- following the midterm, you will have the opportunity to write a *research paper* to replace half of your midterm grade. There will be two required components: a proposal (to be submitted shortly after the midterm) and a short article (approx. 3 pages) discussing a research topic in modern optics. Further details on the project requirements will be provided shortly after the midterm exam.

There will be a closed-book 3hour **final exam** (date to be determined). You will be permitted to use an 8x11" equation sheet (two sides), a dictionary, and a calculator. If you are unable to write your final exam due to a serious, documented reason (e.g., illness), you may *apply for a deferral*. If your application is accepted, you will be permitted to write the final exam during the next deferred exam period. A deferred or supplemental exam will count toward your final grade in exactly the same manner as the regular final exam. Otherwise, the grade for your final exam will be 0.

READING MATERIALS:

The *required text* for the course is *´Optics`* by Eugene *Hecht*. I am using the 5th edition, but earlier editions also cover the course material in an acceptable manner. The 5th edition is available at bookstores or can be purchased online but is not cheap (note that the digital version is however much cheaper than the printed one), so you may wish to look for used copies (which can be found at a considerable discount online) or take advantage of copies available in the *library*. This text can be quite wordy, but it does contain a lot of detail and background material, as well as providing many problems with solutions that you may find helpful during the course. Moreover, there are many other optics textbooks which may prove helpful to you. ´The Light Fantastic – A Modern Introduction to Classical and Quantum Optics` by Ian Kenyon, for example, was formerly used as the primary text in this course.

Note that Hecht and Kenyon will be placed on reserve in the *Schulich library*. Please let me know ASAP if you have trouble accessing the books.

IMPORTANT DATES:

The *first lecture* will take place on Monday, January 7.
The *midterm* will be held during class on Wednesday, February 20.
No lectures will take place during the *reading week*, March 4 to 8.
The *final exam period* will begin on Monday, April 15 and end on Tuesday, April 30.

ADDITIONAL INFORMATION:

- Additional policies governing academic issues, which affect students can be found in the *McGill Charter of Students' Rights*.
- In the event of *extraordinary circumstances* beyond the University's control, the content and/or evaluation scheme in this course is subject to change.
- The *University Student Assessment Policy* exists to ensure fair and equitable academic assessment for all students and to protect students from excessive workloads. All students and instructors are encouraged to review this Policy, which addresses multiple aspects and methods of student assessment, e.g. the timing of evaluation due dates and weighting of final examinations (https://mcgill.ca/secretariat/files/secretariat/2016-04_student_assessment_policy.pdf).
- Instructor-generated *course materials* (e.g., handouts, notes, summaries, exam questions, etc.) are protected by law and may not be copied or distributed in any form or in any medium without explicit permission of the instructor. Note that infringements of *copyright* can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures.
- As the instructor of this course I aim to provide an *inclusive learning environment*. However, if you experience barriers to learning in this course, do not hesitate to discuss them with me and/or the Office for Students with Disabilities, https://mcgill.ca/osd/.
- McGill University is on land which has long served as a site of meeting and exchange amongst *Indigenous peoples*, including the Haudenosaunee and Anishinabeg nations. We acknowledge and thank the diverse Indigenous people, whose footsteps have marked this territory on which peoples of the world now gather.