Medical Biophysics 3645A (9645A) – Introduction to Biomedical Optics

1. Course Information

Medical Biophysics 3645A (9645A): Introduction to Biomedical Optics

Fall Term 2021

An introduction to the physical and biophysical principles underlying the methodology and technology for the medical uses of light including diagnostic, monitoring and therapeutic applications. Specific areas will include: instrumentation which involves light detection and analysis, light spectroscopy which involves photodynamic therapy and diffuse optical tomography and optical imaging.

Lectures:
Mondays and Wednesdays 13:30-14:30 in MSB-190

Laboratories:
None

Tutorials:
None

Assignments:
4 take-home assignments

Exams:
Mid-term test and Final Exam

Prerequisite(s):
One of Calculus 1000A/B, Calculus 1500A/B, Numerical and Mathematical Methods 1412A/B or the former Applied Mathematics 1412A/B, plus one of Calculus 1301A/B, Calculus 1501A/B, Numerical and Mathematical Methods 1414A/B and or the former Applied Mathematics 1414A/B, or the former Applied Mathematics 1413; one of Physics 1201A/B, Physics 1401A/B, Physics 1501A/B, the former Physics 1028A/B, the former Physics 1301A/B; plus one of Physics 1202A/B, Physics 1402A/B, Physics 1502A/B, the former Physics 1029A/B, the
former Physics 1302A/B. Integrated Science 1001X can be used as a prerequisite in place Calculus 1301A/B and Physics 1202A/B.

Although typically taken in third year, this course is open to second-year students with a minimum average of 75% in first year.

Corequisites:
None

Antirequisites:
None

Senate regulation regarding the student’s responsibility regarding requisites:
Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

Accessibility Statement

*Please contact the course instructor if you require material in an alternate format or if you require any other arrangements to make this course more accessible to you. You may also wish to contact Student Accessibility Services at 661-2111 x 82147 for any specific question regarding an accommodation.*

2. Instructor Information

<table>
<thead>
<tr>
<th>Instructors</th>
<th>Email</th>
<th>Office</th>
<th>Phone</th>
<th>Office Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Jeffrey Carson (Course Coordinator)</td>
<td><a href="mailto:jcarson@lawsonimaging.ca">jcarson@lawsonimaging.ca</a></td>
<td>Lawson</td>
<td>64767</td>
<td>Email for appointment</td>
</tr>
<tr>
<td>Dr. Mamadou Diop</td>
<td><a href="mailto:mdiop@uwo.ca">mdiop@uwo.ca</a></td>
<td>UWO</td>
<td>80284</td>
<td>Email for appointment</td>
</tr>
<tr>
<td>Dr. Timothy Scholl</td>
<td><a href="mailto:scholl@uwo.ca">scholl@uwo.ca</a></td>
<td>Robarts</td>
<td>20019</td>
<td>Email for appointment</td>
</tr>
<tr>
<td>Dr. Kevin Jordan</td>
<td><a href="mailto:kevin.jordan@lhsc.on.ca">kevin.jordan@lhsc.on.ca</a></td>
<td>LRCP</td>
<td>53145</td>
<td>Email for appointment</td>
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Course Website:
Please access the course website through OWL at https://owl.uwo.ca/portal

3. Course Syllabus

General Overview:
Optical methods for diagnosis and treatment of disease have been in use for more than 100 years. Recent developments in optical technology have brought about a revolution in the use of light for preclinical drug testing, the treatment of eye and skin disorders, intra-operative evaluation during surgery, and the detection of cancer. The field of biomedical optics is growing at a rapid pace world-wide with innovative contributions from academic research groups and the biophotonics industry.

Course Objectives:
The course will serve as an introduction to the physical and biophysical principles underlying the methodology and technology for the medical use of light. Upon successful completion, students will have an understanding of the physics of light and the physics of the interaction of light with matter. Students will be able to use mathematical and computational tools to solve problems relevant to biomedical optical practice and research. Furthermore, students will be able to assess the advantages and limitations of current optical methods for detection and treatment of disease and evaluate the suitability of new optical technologies for medical research using established physical and biophysical principles.

Course Structure:
The course consists of video-based lectures, tutorials, and problem assignments. It will cover four topics within the discipline of biomedical optics.

Topic 1: Instrumentation
Instructor: Dr. Tim Scholl
   a. Introduction to Light
   b. Light generation
   c. Light transportation and manipulation
   d. Light detection and Analysis
   e. Assignment #1
Topic 2: Introduction to light spectroscopy
Instructor: Dr. Kevin Jordan
a. Spectroscopy overview: classifications, acquisition methods, applications
b. Fluorescence spectroscopy of solutions and tissue
c. Spectral effects as local probes (temperature, pH, oxygen, viscosity)
d. Applications in medicine: photodynamic therapy
e. Tour: London Regional Cancer Program
f. Assignment #2

Mid-term Test (Scholl/Jordan) – TBD

Topic 3: Near infrared spectroscopy
Instructor: Dr. Mamadou Diop
a. Introduction
b. Light Scattering by Tissue
c. Modeling Light transport in Tissue
d. Application: Pulse Oximetry
e. Special Topic: Diffuse Optical Spectroscopy
f. Assignment #3

Topic 4: Optical Imaging
Instructor: Dr. Jeffrey Carson
a. Methods for optical imaging tissue
b. Optical coherence tomography (OCT)
c. Photoacoustic tomography (PAT)
d. Assignment #4

Final Exam (Diop/Carson) - TBD

4. Learning Objectives
1. Knowledge
Students will be able to explain the motivation, instrumentation, methods, and practical uses of biomedical optics. Students will be able to analyze and solve problems related to biomedical optics.

2. Literacies and Interdisciplinarity
Students will be able to understand and use technical language, theory, and numerical methods. Students will be able to use knowledge to answer questions related to biomedical optics. They will be able to describe limitations of the sources and methods they use.
3. Communication
Students will be able to communicate academic work through written means.

4. Resilience and Life-long Learning
Students will be able to adapt to biomedical optics challenges by being self-aware, resilient, and self-reflexive. In addition to their mastery of discipline specific knowledge and methods, students will be able to articulate a clear understanding of their own interests and goals as well as the limitations of their own knowledge.

5. Global and Community Engagement
Students will be able to interact ethically, compassionately, and thoughtfully with peers and instructors.

6. Critical Inquiry and Creative Thinking
Students will have developed habits of constructive skepticism, differentiation and intellectual adaptability in their approaches to biomedical optics. They will be able to identify underlying assumptions and evidence thereby arriving at conclusions about reliability. They will bring habits of careful judgment, an appetite for further refinement, and highly developed problem-solving skills to biomedical optics problems.

7. Professionalism and Ethical Conduct
Students will be able to recognize the ways in which their conduct affects others. They will be able to work effectively with others practically (e.g. time management, conflict resolution); ethically (e.g. division of intellectual responsibility and credit) and socially (e.g. respecting cultural differences, work preferences).

5. Course Materials

Course Website:
The course website can be accessed on OWL at https://owl.uwo.ca/portal

Textbook:
There is no single text which encompasses the material in the course. Students are directed to the following texts for supplementary information:


Contact with Instructors regarding course materials:

We encourage students to approach and discuss any course-related problems with the relevant instructor. Please make an appointment (preferably via email) utilizing the contact information provided above.

Collaborative work:

Students are encouraged to work together, but each student must take total responsibility for their submitted work. Note on Plagiarism: “Students must write their essays and assignments in their own words. Whenever students take an idea, or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence” (see Scholastic Offence Policy in the Western Academic Calendar).

6. Evaluation

The final grade will be based on a 25% contribution from each of the four topics (see “Course Syllabus” section above). The mark for each topic will be obtained from problem assignments, the mid-term test and the final exam. Note that each midterm test will have two equal sections related to topics 1 and 2. The final exam will have two equal sections related to topics 3 and 4.

Final grade breakdown:

Assignments: 60%
Mid-term Test: 20%
Final Exam: 20%
The midterm test and final exam will be in hand-written format. Questions will include problems to be solved and may also include short answer questions as well
as short “essay” questions. The only electronic devices permitted for use during the exams are standard (not programmable) calculators.
Assignments that are submitted late will receive a penalty of 10% per day. For example, an assignment which is 3 days late will receive a penalty of $3 \times 10\% = 30\%$. An extension for assignment submission, which is delayed due to medical reasons can only be granted by the Academic Counseling Office. Students are advised to inform the instructor as soon as possible regarding such delays.

**Assignment Schedule:**

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Topic</th>
<th>Handed Out</th>
<th>Due Date</th>
<th>Returned</th>
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</thead>
<tbody>
<tr>
<td>Assignment 1</td>
<td>Instrumentation</td>
<td>Late Sept</td>
<td>Early Oct</td>
<td>Mid Oct</td>
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<tr>
<td>Assignment 2</td>
<td>Spectroscopy</td>
<td>Mid Oct</td>
<td>Mid-Late Oct.</td>
<td>Late Oct</td>
</tr>
<tr>
<td>Assignment 3</td>
<td>Spectroscopy Applications</td>
<td>Early Nov</td>
<td>Mid Nov</td>
<td>Late Nov</td>
</tr>
<tr>
<td>Assignment 4</td>
<td>Imaging</td>
<td>Late Nov</td>
<td>Early Dec</td>
<td>Early Dec</td>
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</tbody>
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7. **Additional Information/Statements**

**Statement on Academic Offences:**

“Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following website:  
https://www.uwo.ca/univsec/appeals_discipline.html

**Absence from course commitments:**

**A. Absence for medical illness:**

Students must familiarize themselves with the Policy on Accommodation for Medical Illness: student.uwo.ca

**Statement from the Dean’s Office, Faculty of Science:**

If you are unable to meet a course requirement due to illness or other serious circumstances, you must provide valid medical or other supporting documentation to the Dean's office as soon as possible and contact your instructor immediately. It is the student's responsibility to make alternative arrangements with their instructor once the accommodation has been approved and the instructor has been informed.
In the event of a missed final exam, a "Recommendation of Special Examination" form must be obtained from the Dean's Office immediately.

A student requiring academic accommodation due to illness, should use the Student Medical Certificate when visiting an off-campus medical facility or request a Record's Release Form (located in the Dean's Office) for visits to Student Health Services.

B. Absence for non-medical reasons:

If you are unable to meet a course requirement due to non-medical reasons, then please contact the instructor and the course coordinator. Accommodation will only be granted in cases where there are extraordinary circumstances.

C. Special Examinations:

A Special Examination is any examination other than the regular examination, and it may be offered only with the permission of the Dean of the Faculty in which the student is registered, in consultation with the instructor and Department Chair. Permission to write a Special Examination may be given on the basis of compassionate or medical grounds with appropriate supporting documents. A Special Examination must be written at the University or an Affiliated University College no later than 30 days after the end of the examination period involved. To accommodate unusual circumstances, a date later than this may be arranged at the time permission is first given by the Dean of the Faculty. The Dean will consult with the instructor and Department Chair and, if a later date is arranged, will communicate this to Registrarial Services. If a student fails to write a scheduled Special Examination, permission to write another Special Examination will be granted only with the permission of the Dean in exceptional circumstances and with appropriate supporting documents. In such a case, the date of this Special Examination normally will be the scheduled date for the final exam the next time the course is offered.

Support Services:

Office of the Registrar: http://www.registrar.uwo.ca
Accessibility: http://accessibility.uwo.ca/resources/support_services.html
Student Center: http://student.uwo.ca
Student Development Centre: http://www.sdc.uwo.ca
Student Health Services: http://www.shs.uwo.ca/
Students that are in emotional/mental distress should refer to Mental Health@Western [http://www.uwo.ca/uwocom/mentalhealth/] for a complete list of options about how to obtain help.