Course Details

Course Title & Number: BIOE 4414 IMAGING AND SPECTROSCOPY FOR BIOSYSTEMS

Number of Credit Hours: 4

Class Times & Days of Week: Lectures: TR 8:30-9:45 AM

Location for classes/labs: Classes: E2-310 Engineering & Information Technology Complex (EITC)
Labs: E2-164 EITC

Pre-Requisites: BIOE 3270

Course Description:
BIOE 3270 provides students with the basic knowledge of electrical components, circuits and measurement of parameters involved in electrical engineering. BIOE 4414 builds upon this knowledge and delves into design and analysis of opto-electronic instruments.

Instructor Information

Instructor(s) Name: Dr. Jitendra Paliwal, Professor
I prefer to be addressed as Dr. Paliwal.
Dr. Chyngyz Erkinbaev
I prefer to be addressed as Dr. Erkinbaev

Office Location: E1-342 Engineering & Information Technology Complex (EITC) Dr. Paliwal
A203 Agricultural Engineering Building (AEB) Dr. Erkinbaev

Office Hours or Availability: Please make an appointment if you wish to meet outside of class hours.

Office Phone No. 204-474-8429 (Paliwal); 204-474-7966 (Erkinbaev)

Email: J.Paliwal@UManitoba.ca; Chyngyz.Erkinbaev@umanitoba.ca

Contact: You may contact us by phone, by email, or in person. Emails sent after business hours will not likely be answered until the next day.

Teaching Assistant: Mr Sandeep Thakur
Office location: TBA
Office phone No.: TBA
Email: umthakus@myumanitoba.ca
General Course Information

Why is this course useful?
The purpose of this course is to familiarize senior Biosystems Engineering students with the fundamentals of imaging and spectroscopy for biosystems. Techniques of image acquisition, storage, processing, and pattern recognition will be taught. Various spectroscopy techniques and their applicability to biological materials will be discussed. Analysis of data using statistical, artificial neural networks and chemometric methods will be covered.

How does this course fit into the curriculum?
It is intended that students take this course during the third year of the program or later. As mentioned above, this course introduces the student to several fundamental principles of optics instruments associated with it. The skills obtained in this course will come in handy when doing the undergraduate thesis, post-graduate research, and doing on-site measurements in the industry (upon graduation or during co-op).

Course Goals
The intent of this course is to:

- provide students with an understanding of the fundamentals of the techniques and instrumentation of imaging and spectroscopy as it pertains to the biological world.
- provide students with an opportunity to use imaging and spectroscopic instruments for non-destructive assessment of biological materials
- provide students with opportunities to effectively communicate experimental procedures, data and results
- students will gain knowledge of the hardware components of the imaging and spectroscopy systems and the principles on which these instruments are based.
- teach various image enhancement, image manipulation, feature extraction, pattern recognition, and data analysis techniques.

Intended Learning Outcomes
At the conclusion of the course, the student should be able to:

1. Understand the theory and principles involved in measurement of
   - Visible light and spectral data
2. Gather hands-on experience in
   - Measurement and quantification of light using various modalities
3. Collaborate equitably with group members in a team setting to manage lab exercises
4. Communicate the results of lab exercises
   - Implement effective writing techniques to prepare a written lab report

Textbook, Readings, Materials

1. Textbook:

2. Journals
4. Computer Vision and Image Understanding.
5. Applied Spectroscopy.
6. Analytica Chimica Acta.
8. Cereal Chemistry.

3. Lecture materials: A set of class presentations in pdf format will be available on UM Learn
4. Instructional materials for labs will be posted on UM Learn
5. Assignments will be posted on UM Learn

Using Copyrighted Material
Please respect copyright. We will use copyrighted content in this course. The content used is appropriately acknowledged and is copied in accordance with copyright laws and University guidelines. Copyrighted works, including those created by us, are made available for private study and research and must not be distributed in any format without permission.

Recording Class Lectures
Drs. Jitendra Paliwal and Chyngyz Erkinbaev and the University of Manitoba hold copyright over the course materials, presentations and lectures that form part of this course. No audio or video recording of lectures or presentations is allowed in any format, openly or surreptitiously, in whole or in part without permission from Drs. Paliwal and Erkinbaev. Course materials (both paper and digital) are for the participant’s private study and research.

Course Technology
As a courtesy to both the instructors and your classmates, use of cell phones is not permitted during class time. Please remember to switch your cell phone to vibrate mode to avoid interruptions. Laptop or tablet computers may be used during lectures only for the purpose of taking notes. Some course materials will be available through UM Learn.

Class Communication
The University requires all students to activate an official University email account. For full details of the Electronic Communication with Students please visit:
http://umanitoba.ca/admin/governance/media/Electronic_Communication_with_Students_Policy_-_2014_06_05.pdf

Please note that all communication between you as a student and your instructors/TAs must comply with the electronic communication with student policy
(http://umanitoba.ca/admin/governance/governing_documents/community/electronic_communication_wi
Expectations: You Can Expect Us To

Learning is most effective when both the teacher and the student are engaged in the subject material. The role of the teacher, therefore, is to create an environment that facilitates student engagement and learning. Lectures will be mainly delivered using a tablet computer supported by PowerPoint presentations. Students will have access to a PDF format of the lecture material at the end of each lecture week. Laboratory work will be conducted in a group of two or three students. Instructional materials for each laboratory exercise will be provided on UM Learn a day before the lab. Assignments will be posted on UM Learn. Lab reports and assignments will be marked by a Teaching Assistant who will be available for consultations or additional clarifications of the evaluation of assignments and lab reports. The instructor(s) will be available for individual student consultation by appointment and try to answer short (2-3 min) questions at any time. The instructor(s) will endeavour to create an active learning environment.

Expectations: We Expect You To

I expect you to be in attendance, and on time, for all scheduled lectures. If you must be absent, please be courteous and send an e-mail notifying me of your absence. Laboratory work will require students to conduct experiments and to present written reports outlining the results. All labs need to be attended. Each student is obligated to perform their own tests and write a report based on their own data. No “borrowing” data is expected in this course. All e-mail communication needs to be done through the students’ university e-mail addresses and must have in subject: "BIOE4414". To benefit the most from this class, you will be expected to prepare for class by reading the assigned materials.

Academic Integrity:
Plagiarism or any other form of cheating in examinations, term tests or academic work is subject to serious academic penalty. Cheating in examinations or tests may take the form of copying from another student or bringing unauthorized materials into the exam room. Exam cheating can also include exam impersonation. A student found guilty of contributing to cheating in examinations or term assignments is also subject to serious academic penalty. Students should acquaint themselves with the University’s policy on plagiarism, cheating, exam impersonation and duplicate submission. Electronic detection tools may be used to screen assignments in cases of suspected plagiarism.

Referencing Style
Students are expected to follow the Canadian Biosystems Engineering (CBE) journal reference style when citing references in course assignments. The Instructions for preparing a paper for CBE is available through UM Learn. Please refer to this guide to ensure that you follow the correct referencing style.

Students Accessibility Services (SAS)

If you are a student with a disability, please contact SAS for academic accommodation supports and services such as note-taking, interpreting, assistive technology and exam accommodations. Students who have, or think they may have, a disability (e.g. mental illness, learning, medical, hearing, injury-related, visual) are invited to contact SAS to arrange a confidential consultation. 

Student Accessibility Services  http://umanitoba.ca/student/saa/accessibility/
520 University Centre
204 474 7423
Student_accessibility@umanitoba.ca
Class & Lab Schedule

LECTURES  Three hours per week for one term (14 weeks, E2-350 EITC)

Week (Jan. 1)  Introduction to Light
Week (Jan. 8)  Light, Human visual system
Week (Jan. 15)  Vision, Colour
Week (Jan. 22)  Colour, Digital Image
Week (Jan. 29)  Image, Imaging techniques
Week (Feb. 5)  Imaging techniques, Digital file formats
Week (Feb. 12)  Image sensors, X-rays & Computed tomography
Week (Feb. 19)  Reading Week
Week (Feb. 26)  Introduction to spectroscopy
Week (Mar. 5)  Hyperspectral imaging, Mid-term exam (March 8, 2017)
Week (Mar. 12)  Raman spectroscopy, Guest lecture (Microwave imaging)
Week (Mar. 19)  Mass spectrometry, Guest lecture (Biophotonics)
Week (Mar. 26)  Guest lecture (OCT), Data processing (Artificial neural networks)
Week (Apr. 2)  Chemometrics

March 8, 2018: Midterm Examination (during lecture class)
March 16, 2018: Voluntary Withdrawal Deadline

LABORATORIES (E2-164, EITC)

One three-hour period per week. Labs will be conducted on Fridays at 2:30 PM. Laboratory work will require students to conduct experiments and prepare written reports outlining the results.

<table>
<thead>
<tr>
<th>Lab#</th>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab.1</td>
<td>Jan. 12</td>
<td>Photography</td>
</tr>
<tr>
<td>Lab.2</td>
<td>Jan. 19</td>
<td>Visual illusions</td>
</tr>
<tr>
<td>Lab.3</td>
<td>Jan. 26</td>
<td>Photography presentations</td>
</tr>
<tr>
<td>Lab.4</td>
<td>Feb. 2</td>
<td>Problem solving (diffraction)</td>
</tr>
<tr>
<td>Lab.5</td>
<td>Feb. 9</td>
<td>Image processing 1</td>
</tr>
<tr>
<td>Lab.6</td>
<td>Feb. 16</td>
<td>Image processing 2</td>
</tr>
<tr>
<td>Reading Week</td>
<td>Feb. 23</td>
<td></td>
</tr>
<tr>
<td>No lab</td>
<td>Mar. 2</td>
<td></td>
</tr>
<tr>
<td>Lab. 7/8</td>
<td>Mar. 9</td>
<td>Thermal imaging/Light scattering</td>
</tr>
<tr>
<td>Lab. 7/8</td>
<td>Mar. 16</td>
<td>Thermal imaging/Light scattering</td>
</tr>
<tr>
<td>Lab. 9</td>
<td>Mar. 23</td>
<td>PCA analysis</td>
</tr>
<tr>
<td>Lab. 10</td>
<td>Mar. 30</td>
<td>Project presentations</td>
</tr>
</tbody>
</table>
Course Evaluation Methods

Final letter grades will be assigned on the basis of the overall performance of the class, and the spread of the numerical marks.

Assignments and Lab Reports 30%
Mid-term Exam 20%
Group project 20%
Final Exam 30%

All assignments need to be submitted on the deadline by 4:30 PM. Late submissions will not be accepted. Lab reports and assignments must be uploaded as (MS Word file) on UM Learn Dropbox (no exceptions, no submissions after the deadline). Submitted file must be named as “Lab#1 Family name Given name” (i.e. Lab#1 Erkinbaev Chyngyz). Submitted file must be named as “Lab# Group number” (i.e. Lab#7 Group3).

If you miss the mid-term exam, the marks for it will be rolled over to the final (there will be no ‘make-up’ mid-term). There will be a few guest lectures. Material covered during guest lectures, could be asked in the exams. For group project, students will be assigned a topic, research it, prepare a report and make a presentation.

Grading

The grading scale used for this course is shown below.

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>Percentage out of 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>92-100</td>
</tr>
<tr>
<td>A</td>
<td>85-91</td>
</tr>
<tr>
<td>B+</td>
<td>78-84</td>
</tr>
<tr>
<td>B</td>
<td>72-77</td>
</tr>
<tr>
<td>C+</td>
<td>66-71</td>
</tr>
<tr>
<td>C</td>
<td>60-65</td>
</tr>
<tr>
<td>D</td>
<td>50-59</td>
</tr>
<tr>
<td>F</td>
<td>Less than 50</td>
</tr>
</tbody>
</table>

Assignment Grading Times

The last date for Voluntary Withdrawal (VW) from the course is March 16, 2018. Students can expect to receive grades for several of the assignments and the lab reports, and the midterm prior to the VW date. The evaluation feedback (Mid-term Examination) will be given to the students prior to the VW deadline. Grades for the remaining course assignments and lab reports will be available prior to the end of the term.

Assignment Extension and Late Submission Policy

Deadlines are a reality in the world of engineering; we expect assignments to be completed on time. All assignments need to be submitted during class. Late submissions will not be accepted; any assignment missed for an appropriate, documented reason will have the final exam mark instead. If you miss the midterm exam for a legitimate reason, the marks for it will be rolled over to the final (there will be no ‘make-up’ midterm).
Supplemental Course Information for BIOE 4414

All courses in the Biosystems Engineering program are expected to contribute, in some way, to the development of one or more of the 12 graduate attributes that have been identified by the Canadian Engineering Accreditation Board. The 12 graduate attributes have been defined below for your information.

Graduate Attributes

1. **A Knowledge Base for Engineering:** Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

2. **Problem Analysis:** An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

3. **Investigation:** An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.

4. **Design:** An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

5. **Use of Engineering Tools:** An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

6. **Individual and Team Work:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

7. **Communication Skills:** An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

8. **Professionalism:** An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

9. **Impact of Engineering on Society and the Environment:** An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

10. **Ethics and Equity:** An ability to apply professional ethics, accountability, and equity.

11. **Economics and Project Management:** An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

12. **Life-long Learning:** An ability to identify and address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

While there are likely some aspects of many of these attributes that can be found in this course, the attributes being emphasized in this course are: 1) *A Knowledge Base for Engineering*, 2) *Problem Analysis*, 5) *Use of Engineering Tools*, 6) *Individual and Teamwork* and 8) *Professionalism*. 
# Mapping of Course Evaluation to Graduate Attributes & Indicators

To maintain the accreditation of our Biosystems Engineering program, it is a requirement that student competency with respect to the 12 graduate attributes be assessed. To enable such assessment to occur in a meaningful manner, the Faculty of Engineering and representatives from industry developed a comprehensive list of indicators for each of the 12 graduate attributes. The indicators being formally assessed in BIOE 4414 are shown in the table below.

<table>
<thead>
<tr>
<th>Grade Component</th>
<th>Specific Evaluation Point</th>
<th>Graduate Attribute</th>
<th>Indicators Being Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Base for Engineering</td>
<td>Lab report</td>
<td>Comprehends and applies information in engineering problems</td>
<td>Various indicators related to the ability to carry out measurements, understand errors associated with these measurements, present and interpret results and see limitations</td>
</tr>
<tr>
<td>Midterm Examination</td>
<td></td>
<td>Demonstrates competence in specialized engineering problems</td>
<td>Various indicators related to the ability to understand and apply theory in engineering problems.</td>
</tr>
<tr>
<td>Final Examination</td>
<td></td>
<td>Comprehends and applies information and in specialized engineering problems</td>
<td>Various indicators related to the ability to understand and apply theory to engineering problems.</td>
</tr>
<tr>
<td>Problem Analysis</td>
<td>Lab report</td>
<td>Identify problem, select and implement solutions</td>
<td>Various indicators related to the ability to interpret results, identify limitations and implications.</td>
</tr>
<tr>
<td>Mid-term and final examination</td>
<td>Contextualize problems, formulate strategies and implement solutions</td>
<td>Various indicators related to the ability to identify multiple strategies to solve a problem, demonstrate skilful ability to analyze, evaluate and select optimal/practical solution.</td>
<td></td>
</tr>
<tr>
<td>Group Project Report</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of Engineering Tools</td>
<td>Lab Reports</td>
<td>Evaluate and select tools to complete engineering activities</td>
<td>Two indicators are used: ability to explain principles behind applicability of engineering tools. Ability to understand the limitations of tools and the ability to discuss the assumptions.</td>
</tr>
<tr>
<td>Individual and Team work</td>
<td>Assignments</td>
<td>Evaluate individual work contribution and time management</td>
<td>Ability to carry out individual responsibilities, manage time and complete jobs carefully, meticulously and punctually.</td>
</tr>
<tr>
<td></td>
<td>Lab work and Lab Reports</td>
<td>Individual contribution to teamwork, working with others, promoting positive team atmosphere</td>
<td>Ability to work in team and share responsibility</td>
</tr>
<tr>
<td>Group project report</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication Skills</td>
<td>Lab Work, Lab Reports, Group Project Report</td>
<td>Exhibit behaviour expected from a professional engineer</td>
<td></td>
</tr>
</tbody>
</table>
improvement can occur. Data generated from this course will be compiled with data collected from other sources (i.e., other courses, SEEQ surveys, exit surveys, co-op surveys) to facilitate on-going review and improvement of the Biosystems Engineering curriculum.