University of Manitoba
Faculty of Agricultural & Food Sciences
Department of Biosystems Engineering

Course Details

Course Title & Number:	BIOE 4414 IMAGING AND SPECTROSCOPY FOR BIOSYSTEMS
Number of Credit Hours:	4
Class Times & Days of Week:	Lectures: TR, 8:30-9:45AM Labs: M, 2:30 PM-5:15 PM
Location for classes/labs:	Remote learning via UM Learn/Cisco WebEx (until end of February) Labs: On-line UM Learn/Cisco WebEx (until end of February) Classes: E2-304 Engineering & Information Technology Complex (EITC) Labs: 222 Education bldg.
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. Chyngyz Erkinbaev I prefer to be addressed as Dr. Erkinbaev
Office Location:	E1-344 Engineering & Information Technology Complex (EITC) Dr. Erkinbaev
Office Hours or Availability:	Please make an appointment if you wish to meet outside of class hours.
Office Phone No.	204-474-6977 (Erkinbaev)
Email:	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. Jean-Christophe Habeck
Office location:	
Office phone No.:	
Email:	umhabeck@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:
   1. Digital Image Processing by R.C. Gonzalez and R.E. Woods. 2008 (3rd Edition). Prentice Hall.
   2. Imaging in Biological Research by Michael Conn. 2004. Elsevier Academic Press.

3. Image Retrieval: Theory and Research by Corinne Jorgensen. 2003. Scarecrow Press.
4. Image Processing for the Food Industry by E.R. Davies. 2000. World Scientific.
5. Digital Image Processing by Kenneth R. Castleman. 1979. Prentice-Hall.
6. Handbook of Spectroscopy by G. Gauglitz and T. Vo-Dinh. 2003. Wiley-VCH.
7. Handbook of Vibrational Spectroscopy by John M. Chalmers and Peter R. Griffiths. 2002. John Wiley & Sons
8. Near-Infrared Technology: in the Agricultural and Food Industries by Phil Williams and Karl Norris. 2001. American Association of Cereal Chemists.
9. Practical NIR Spectroscopy: with Applications in Food and Beverage Analysis by B.G. Osborne, T. Fearn, and P.H. Hindle. 1993. Longman Scientific & Technical.

2. Journals
    1. Journal of the Optical Society of America.
    2. International Journal of Computer Vision.
    3. Journal of Digital Imaging.
    4. Computer Vision and Image Understanding.
    5. Applied Spectroscopy.
    6. Analytica Chimica Acta.
    7. Canadian Journal of Spectroscopy.
    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

Dr. 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 Dr. 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_with_students_policy.html). You are required to obtain and use your U of M email account for all communication between yourself and the university.

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 portable 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 four or six 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 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: "BIOE 4414". 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 Enginering (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)

Student Accessibility Services

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 (13 weeks, E2-304 EITC)

Week (Jan. 24) Introduction
Week (Jan. 31) Light
Week (Feb. 7) Human visual system, Colour
Week (Feb. 21)Reading Week
Week (Feb. 28) Digital Image
Week (Mar. 7) Image, Imaging techniques
Week (Mar. 14) Image sensors, Digital file formats **Mid-term exam (March 22, 2022)**
Week (Mar. 21) Introduction to spectroscopy
Week (Mar. 28) Hyperspectral imaging, Guest lecture 1 (Hyperspectral imaging)
Week (Apr. 4) X-rays & Computed tomography, Guest lecture 2 (Microwave imaging)
Week (Apr. 11) Raman Spectroscopy, Guest lecture 3 (Biophotonics)
Week (Apr. 18) Guest lecture 4 (OCT), Data processing, Chemometrics

March 22, 2022: Midterm Examination (during lecture class)
April 25, 2022 Voluntary Withdrawal Deadline

LABORATORIES (222 EDUCATION)

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

Lab#	Date	Topic
No Lab	Jan. 24	
Project discussion	Jan. 31	Project topics
Lab 1	Feb.7	Image processing 1
Lab 2	Feb. 14	Image processing 2
No Lab	**Feb. 21**	**Reading week**
No Lab	Feb. 28	
Lab 3	Mar. 7	Thermal imaging
Lab 4	Mar. 14	Light scattering
Lab 5	Mar. 21	Spectra analysis/Grain analysis
Lab 6	Mar. 28	**TBD**
	Apr. 4	Project presentations
	Apr. 11	Project presentations
No Lab	Apr. 25	

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	25%
Mid-term Exam	20%
Group project	20%
Final Exam	35%

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.

Letter Grade	Percentage out of 100
A+	95-100
A	87-94
B+	78-86
B	72-77
C+	66-71
C	60-65
D	50-59
F	Less than 50

Note: These boundaries represent a guide for the instructor and class alike. Provided that no individual student is disadvantaged, the instructor may vary any of these boundaries to ensure consistency of grading from year-to-year.

Assignment Grading Times

The last date for Voluntary Withdrawal (VW) from the course is April 25, 2022. 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 mid-term 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.

Grade Component	Specific Evaluation Point	Graduate Attribute	Indicators Being Assessed
Knowledge Base for Engineering	Lab report	Comprehends and applies information in engineering problems	Various indicators related to the ability to carry out measurements, process and analyze the data (spectra, images, etc.); present and interpret results
	Midterm Examination	Demonstrates competence in specialized engineering problems	Various indicators related to the ability to understand and apply theory in engineering problems.
	Final Examination	Comprehends and applies information and in specialized engineering problems	Various indicators related to the ability to understand and apply theory to engineering problems.
Problem Analysis	Lab report	Identify problem, select and implement solutions	Various indicators related to the ability to interpret results, identify limitations and implications.
	Mid-term and final examination	Contextualize problems, formulate strategies and implement solutions	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.
	Group Project Report	Evaluate individual and team work contribution and time management	Ability to carry out individual responsibilities, manage time and complete jobs carefully, meticulously and punctually. Ability to work in a team.
Use of Engineering Tools	Lab Reports	Evaluate and select tools to complete engineering activities	Ability to explain principles behind applicability of engineering tools. Ability to understand the limitations of tools and the ability to discuss the assumptions.
Individual and Team work	Assignments	Evaluate individual work contribution and time management	Ability to carry out individual responsibilities, manage time and complete jobs carefully, meticulously and punctually.
	Lab work and Lab Reports	Individual contribution to teamwork, working with others, promoting positive team atmosphere	Ability to work in team and share responsibility
	Group project report	Evaluate individual and team work contribution and time management	Ability to carry out individual responsibilities, manage time and complete jobs carefully, meticulously

			and punctually. Ability to work in a team.
Communication Skills	Lab Work, Lab Reports, Group Project Report	Exhibit behaviour expected from a professional engineer	Ability to present project work, answer the questions, demonstrate effective communication skills.

The ultimate goal of mapping the course evaluation in specific courses to graduate attributes and indicators is the identification of potential deficiencies in the Biosystems Engineering program so that continuous 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.