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

Course Details

Course Title & Number:	BIOE 3320 ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS
Number of Credit Hours:	4
Class Times & Days of Week:	Lectures: MWF 10:30-11:20 am
Location for classes/labs:	EITC E2 304/Human Ecology Building 322
Pre-Requisites:	MATH 2130 and [BIOE 2800 or CIVL 2800 or MECH 2222 (or the former MECH 2220)]

Course Description:
This course emphasizes the importance of understanding the properties of biological materials in the design of engineered systems. The discussion focuses on the definition and measurement of mechanical, optical, water-retaining, rheological, and thermal properties of biological materials. Lab activities involve measuring these properties and using them in engineering calculations.

Instructor Information

Instructor(s) Name:	Dr. Song Liu, E.I.T, Professor I prefer to be addressed as Dr. Liu.
Office Location:	W581 Duff Roblin Building
Office Hours or Availability:	Please make an appointment if you wish to meet with me outside of class hours.
Office Phone No.	204-474-9616
Email:	Song.Liu@umanitoba.ca
Contact:	You may contact me by phone, by email, or in person. Emails sent after business hours will not likely be answered until the next day.

Teaching Assistant:	Mr. Quintin Litke
Office location:	
Office phone No.:	
Email:	litkeq@myumanitoba.ca

General Course Information

Why is this course useful?

The properties of biological materials are important in relation to processing and their role in the development of new products and processes. Physico-chemical characteristics of biological materials have influence on their processing and design of material processing equipment. Knowledge of engineering properties is useful in process development and operation of equipment and structures associated with handling, processing and storage of raw as well as processed food products.

How does this course fit into the curriculum?

This is an engineering core course in the Biosystems Engineering program. It is intended that students take this course during the third year in the program of Department of Biosystems Engineering.

Course Goals

The intent of this course is:

- To provide students with an understanding of engineering properties of biological and interacting materials within the system.
- To assist students in gaining an understanding of strength of materials as it applies to biological materials, and to understand the relationship between composition, structure, and properties of plant, animal, and human tissues.
- To introduce students to definition and measurement of electromagnetic, mechanical, thermal, rheological, chemical and biological properties and their variability.
- To familiarize students with the use of these properties in engineering calculations.

Intended Learning Outcomes

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

1 Measure and determine physical attributes of various biological materials including: size, shape, volume, surface area, solid density, bulk density, porosity, color and textural features, water activity, and moisture relationships.
2 Understand definitions related to mechanical properties of biological materials and measure rheological properties of solids and non-Newtonian liquids
3 Understand the concept of dynamic tests, contact stress, and impact loading.
4 Be able to measure and determine basic thermal properties such as specific heat, thermal conductivity, thermal and mass diffusivity.
5 Determine errors associated with measurements of attributes
6 Analyse, present, and communicate experimental results obtained during laboratory exercises.
7 Understand the response of biological materials to various thermo-hydro-physical conditions and solve numerical problems associated with such conditions

Textbook, Readings, Materials

1. Textbook: Cenkowski, S. 2020. “Engineering Properties of Biological Materials.” The textbook is available at the University Bookstore.
2. Lecture materials: A set of class presentations in pdf format will be available on UM Learn
3. Instructional materials for labs and 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. Song Liu, Stefan Cenkowski and the University of Manitoba hold copyright over the course materials, presentations and lectures that form part of this course. I will record online lectures. All Course materials (including the recorded lectures) 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. Laptops 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:
https://umanitoba.ca/admin/governance/media/Electronic_Communication_with_Students_Policy_-_2013_09_01_RF.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 partially delivered in a traditional format using PowerPoint presentations supported by video clips showing industrial applications of engineering properties. Students will have access to a pdf format of slides prior to lectures. Also, numerical problems will be solved during lectures. 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 together with lab instructional materials. 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. I will be available for individual student consultation by appointment. Also, we will be available to answer short (2-3 min) questions at any time. You can expect us to endeavour to create an active learning environment.

Expectations: We Expect You To

We expect you to be in attendance, and on time, for all scheduled lectures and labs. If you must be absent, please show us the courtesy of sending an e-mail notifying us 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. 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)

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)
(L# = Lecture number)

L1. (Jan. 9) Importance of properties of biological materials in design of engineered systems
L2. (Jan. 11) Physical attributes: separation, sizing, orientation
L3. (Jan. 13) Physical attributes: volume, surface, density, porosity
L4. (Jan. 16) Regression relationship among physical attributes
L5. (Jan. 18) Precision vs accuracy, criteria for describing shape and size
L6. (Jan. 20) Machine vision
L7. (Jan. 23) The basics of color
L8. (Jan. 25) Color in engineering and research
L9. (Jan. 27) Structure and composition of biological materials
L10. (Feb. 1) Surface tension, theoretical estimation of water activity
L11. (Feb. 3) Retention of water in biological materials
L12. (Feb. 6) Water adsorption equation, measuring techniques for water activity
L13. (Feb. 8) Basic concept of rheology
L14. (Feb. 10) Modulus of elasticity in biomaterials, apparent modulus, true stress and strain
L15. (Feb. 13) Viscoelasticity and basic mechanical models
L16. (Feb. 15) Stress relaxation, retardation and 4-element model
L17. (Feb. 17) Creep-recovery behavior

Feb. *20-24*, 2023: Reading Week

L18. (Feb. 27) Review before the Midterm Exam

Feb. 28th, 2023 @ 6:00 – 8:00 pm: Midterm Examination, Room to be determined.

L19. (Mar. 1) Dynamic tests
L20. (Mar. 3) Resonant method and free vibration tests
L21. (Mar. 6) Contact stress.
L22. (Mar. 8) Parallel plate contact, die loading.
L23. (Mar. 10) Mechanical damage.
L24. (Mar. 13) Concept of impulse momentum.
L25. (Mar. 15) Non-Newtonian fluids.
L26. (Mar. 17) Type of flow curves.
L27. (Mar. 20) Tube and capillary viscometer
L28. (Mar. 22) Rotational viscometers
L29. (Mar. 24) Plastic flow
L30. (Mar. 27) Pseudoplastic flow
L31. (Mar. 29) Viscometry of dough
L32. (Mar. 31) Thermal properties of biological materials
L33. (Apr. 3) Specific heat of food materials
L34. (Apr. 5) Thermal conductivity of grain and food products

Apr. 7 Good Friday (University closed)

L35. (Apr. 10) Convective heat transfer coefficient
L36. (Apr. 12) Review before the Final Exam

LABORATORIES: Human Ecology Building 322

One three-hour period per week. Labs will be conducted on Tuesdays for Group A at 11:30 am – 2:25 pm and for Group B at 2:30 pm – 5:30 pm, or for both groups from 11:30 am to 1: 30 pm. Laboratory work will require students to conduct experiments and to present written reports outlining the results.

Lab. 1 (Jan. 10, T) Lab safety issues and a case study
Lab. 2 (Jan. 17) Determination of the surface area, volume, density of biological materials
Lab. 3 (Jan. 24) Physical attributes determination
Lab. 4 (Jan. 31) Moisture determination and water activity measurements
Lab. 5 (Feb. 7) Construction of Sorption Isotherms
Lab. 6 (Feb. 14) Elasto-plastic behaviour of biological materials

Feb. 20-24, 2023 Reading Week

Feb. 28th, 2023 Midterm Examination at 6:00-8:00 pm **, room to be dertermined.**

Lab. 7 (Mar. 7) Stress relaxation tests
Lab. 8 (Mar. 14) Creep and recovery test for biological product
Lab. 9 (Mar. 21) Contact stress, impact damage tests for apples
Lab. 10 (Mar. 28) Determination of flow behaviour index and viscosity of a non-Newtonian fluid
Lab. 11 (Apr. 4) Determination of moisture diffusivity for granular materials

Lab Attendance IS REQUIRED AND THERE ARE NO MAKE-UP LABS FOR UNEXCUSED ABSENCES. A missed lab will count as zero unless you have a valid medical or legal excuse (this is at the discretion of the instructor). You should be prepared to provide documentation to substantiate your emergency (note from your physician, police report, etc.) An e-mail explaining your absence must be received within two days of you missing lab or the lab will be counted as a missed lab. Being on time to lab class is mandatory. Late arrivals will be noted and on the third late arrival there will be a 10% penalty from your lab that day, and every time you are late going forwards.

Course Evaluation Methods

The course introduces fundamental subjects on biological materials that are important to the design of engineered systems. Such properties as physical attributes, effect of moisture, mechanical stresses, non-Newtonian behavior and thermal properties are covered in weekly assignments and are studied through laboratory exercises. Evaluation of weekly assignments will be based on individual work. Laboratory experiments and laboratory reports will be assessed based on a team work of two or three students.

Final letter grades will be based on 11 assignments/lab reports, one mid-term and a final exam. The specific distribution is shown below:

Assignments	10%
Lab Reports	25%
Mid-term Exam	25%
Final Exam	40%

Grading

The grading scale used for this course is shown below.

Letter Grade	Percentage out of 100
A+	92-100
A	85-91
B+	78-84
B	72-77
C+	66-71
C	60-65
D	50-59
F	Less than 50

Assignment Grading Times

The last date for Voluntary Withdrawal (VW) from the course is March 22, 2023. 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 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. Assignments submitted after the due date will be docked 10% per day. All assignments must be submitted to pass the course. There will be no “make-up” midterms; students who miss a midterm with a reasonable explanation will have the value of the final examination increased by 25% to 65%.

Supplemental Course Information for BIOE 3320

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, 3) Investigation, 12) Life-long Learning.*

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 3320 are shown in the table below.

Graduate Attributes	Grade Components	Specific Evaluation Points	Indicators Being Assessed
Knowledge base for Engineering	Assignments	Demonstrates competence in engineering fundamentals and engineering properties of biological materials	KB 1, 2, 3
	Lab Reports	Comprehends and applies information in engineering problems	
	Midterm Examination	Demonstrates competence in specialized engineering problems	
	Final Examination	Comprehends and applies information and in specialized engineering problems	
Investigation	Assignments	Gathering information and analysis	IN 1, 3
	Lab reports	Ability to conduct investigations and interpret results	
Life-Long Learning	Lab reports	Explores a subject/topic in the pursuit of knowledge	LL. 2
Use of Engineering Tools	Not evaluated but marks will be deducted if these attributes are ignored by students.		
Individual and Team work			
Professionalism			

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.