University of Manitoba | Price Faculty of Engineering
Department of Biosystems Engineering

Course Outline

Instruction Team

- Dr. Song Liu, P.Eng. (he/him)
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- Lab Instructor: Derek Inglis (he/him)
  A206 AEB
  (204)474-7964
  Derek.Inglis@umanitoba.ca

Student Hours

- Dr. Liu will be present during lectures
- Individual assistance is always available by appointment: talk to me.

Teaching Assistant

- Quintin Litke, (he/him)
  W512 Duff Roblin
  litkeq@myumanitoba.ca

- Meetings can be set up via email.

Locations

- Lectures: **Buller 527**
- Labs: **Human Ecology 322**

Contact Hours

- 4 credit hours
- Lectures:
  MWF 10:30-11:20 am
  3 hours x 12 weeks = 36 hours
- Lab Time:
  Tuesdays at 11:30 am – 2:25 pm or 2:30 pm – 5:30 pm
  3 hours x 11 weeks = 33 hours

Prerequisites:

MATH 2130 and [BIOE 2800 or CIVL 2800 or MECH 2222 (or the former MECH 2220)]

Course Website:

http://umanitoba.ca/umlearn

Traditional Territories Acknowledgement

The University of Manitoba campuses are located on the original lands of the Anishinaabeg, Cree, Oji-Cree, Dakota, and Dene peoples, and on the homeland of the Métis Nation.

We respect the Treaties that were made on these territories, we acknowledge the harms and mistakes of the past, and we dedicate ourselves to move forward in partnership with Indigenous communities in a spirit of reconciliation and collaboration.

BIOE 3320 Engineering Properties of Biological Materials
Winter 2024

Course Objectives

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 the 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 the 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.

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Course Content

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.

Course Delivery

Lectures and Lab Time will proceed as listed on the left and this time will be used to deliver course content and provide time for hands-on activities.

Considering the ongoing pandemic please note:

The Department of Biosystems Engineering has devised a plan so that there is minimal impact on the delivery and content of the course, should the instructor fall sick and be unable to continue lectures in person. Please be assured that the alternative plan outlining any deviation from the normal mode of instruction will be communicated to you as quickly as possible if/when the need arises.

Recommended Reading

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 (www.umlearn.com).
3. Instructional materials for labs and assignments will be posted on UM Learn

Accreditation Details

Accreditation Units

- Mathematics: 15%
- Natural Science: 10%
- Complementary Studies: 0%
- Engineering Science: 75%
- Engineering Design: 0%

Graduate Attributes

KB: A knowledge base for engineering
PA: Problem analysis
IN: Investigation
DE: Design
ET: Use of engineering tools
IT: Individual and team-work
CS: Communication skills
PR: Professionalism
IE: Impact of engineering on society/environment
EE: Ethics and equity
EP: Economics and project management
LL: Life-long learning

Competency Levels

1 - Knowledge (Able to recall information)
2 - Comprehension (Ability to rephrase information)
3 - Application (Ability to apply knowledge in a new situation)
4 - Analysis (Able to break problem into its components and establish relationships.)
5 - Synthesis (Able to combine separate elements into a whole)
6 - Evaluation (Able to judge the worth of something)

Grading Scale

Letter	Mark
A+	92–100
A	85–91
B+	78–84
B	72–77
C+	66–71
C	60–65
D	51-59
F	< 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 year-to-year grading consistency.

Learning Outcomes

By the end of this course, you will be able to:

No.	Learning Outcome
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.
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	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	Analyze, 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.

Graduate Attribute Competency Levels Developed

Outcome	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
1	4											3
2	3		4									
3	4		3									3
4	3											
5	3		4									3
6			4									3
7	3											

CEA

KB.1 – Comprehends and applies information and concepts in mathematics
KB.2 – Recalls and defines information, first principles and concepts in the natural sciences
KB.3 – Comprehends and applies information and concepts in fundamental engineering science
IN. 2 – Devises and/or implements an appropriate plan/methodology for gathering information required to solve a complex engineering problem
IN. 3 – Interprets results and reaches appropriate conclusions
IN. 4 – Understands appropriate safe work procedures during experiments or laboratory exercises
LL.2 – Engages in activities to advance knowledge and understands the role of on-going professional development

Important Dates

- **Louis Riel Day**
  Mon. Feb. 19, 2024
  No classes or examinations
- **Winter Term Break**
  Feb. 19-23, 2024
  No classes or examinations
- **Mid-term Exam**
  Feb. 27th, 2024 @ 6:00 – 8:00 pm
  Room: TBD
- **Voluntary Withdrawal Deadline**
  March 20, 2024
- **Good Friday**
  Fri. Mar. 29, 2024
- **Last Day of Classes**
  Wed. Apr. 10, 2024

Evaluation

Late assignments will be assessed a penalty of 10% per day or part thereof (including weekends).

Component	Value (%)	Method of Feedback*	Learning Outcomes Evaluated	I/T**
Assignments	10	S	1-5,7	I
Lab Reports	25	S, F	6	T
Mid-term Exam	25	S, F	1-7	I
Final Exam	40	S	1-7	I

* Method of Feedback: **F** - Formative (written comments / oral discussion), **S** - summative (numerical grade)

** I/T: **I** – Individual effort, **T** – A team effort

Academic Integrity

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the *General Academic Regulations* on *Academic Integrity*, students are reminded that plagiarism or any other form of cheating in examinations, term tests, assignments, projects, or laboratory reports is subject to serious academic penalty (e.g., suspension or expulsion from the faculty or university). A student found guilty of contributing to cheating by another student is also subject to serious academic penalties.

Requirements/Regulations

- Please copy the Instruction Team in all emails (Instructors and Teaching Assistants). All email communication must conform to the Communicating with Students university policy.

  Communicating with Students

- As the Instruction Team, we will do our best to respond to all emails **within 48 hours during working hours** (8:30 AM – 5:30 PM Monday through Friday). Ex. A Friday night email may not be responded to until the following Tuesday.
- Self-declaration forms may be completed for missed tests, exams, or assignments during short-term absences (≤72 hours) for extenuating circumstances. This form cannot be used for planned absences like vacations. It is also not to be used for longer-term absences, or ongoing circumstances (e.g., Authorized Withdrawals, Leaves of Absence, or other accommodations), which will still require additional documentation.

  Self-Declaration Form for Brief or Temporary Absence

  Self-Declaration Policy for Brief or Temporary Absences

- It is the responsibility of each student to contact the instructor in a timely manner if he or she is uncertain about his or her standing in the course and about his or her potential for receiving a failing grade. Students should familiarize themselves with the University's *General Academic Regulations*.

  General Academic Regulations

  Engineering Academic Regulations

- Students should be aware that they have access to an extensive range of resources and support organizations. These include Academic Resources, Counselling, Advocacy and Accessibility Offices as well as documentation of key University policies e.g., Academic Integrity, Respectful Behaviour, Examinations, and related matters.

  Supplemental Resources

Deferred Final Examinations

Students who miss the regularly scheduled writing of a final examination for valid medical or compassionate reasons will only be allowed to write a deferred exam if the Associate Dean (Undergraduate) approves the request. All requests for a deferred examination *must* be made within 48 hours of the missed exam and follow the procedure described on the Faculty website without exception. Course Instructors *do not have the discretion* to grant deferred final examinations.

Deferred Exam Policy (student experience website)

Retention of Student Work

Students are advised that copies of their work submitted in completing course requirements (i.e. assignments, laboratory reports, project reports, test papers, examination papers, etc.) may be retained by the Instructor and the Department for the purpose of student assessment and grading, and to support the ongoing accreditation of each Engineering program. This material shall be handled in accordance with the University's *Intellectual Property Policy* and the protection of privacy provisions of *The Freedom of Information and Protection of Privacy Act (Manitoba)*. Students who do not wish to have their work retained must inform the Head of Department, in writing, at their earliest opportunity.

Copyright Notice

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. 8) Importance of properties of biological materials in design of engineered systems
L2. (Jan. 10) Physical attributes: separation, sizing, orientation
L3. (Jan. 12) Physical attributes: volume, surface, density, porosity
L4. (Jan. 15) Regression relationship among physical attributes
L5. (Jan. 17) Precision vs accuracy, criteria for describing shape and size
L6. (Jan. 19) Machine vision
L7. (Jan. 22) The basics of color
L8. (Jan. 24) Color in engineering and research
L9. (Jan. 26) Structure and composition of biological materials
L10. (Jan. 29) Surface tension, theoretical estimation of water activity
L11. (Jan. 31) Retention of water in biological materials
L12. (Feb. 2) Water adsorption equation, measuring techniques for water activity
L13. (Feb. 5) Basic concept of rheology
L14. (Feb. 7) Modulus of elasticity in biomaterials, apparent modulus, true stress and strain
L15. (Feb. 9) Viscoelasticity and basic mechanical models
L16. (Feb. 12) Stress relaxation, retardation and 4-element model
L17. (Feb. 14) Creep-recovery behavior
L18. (Feb. 16) Dynamic tests

Feb. 19-23, 2024: Reading Week

L18. (Feb. 26) Review before the Midterm Exam

Feb. 27th, 2024 @ 6:00 – 8:00 pm: Midterm Examination, Room to be determined.

L19. (Feb. 28) Dynamic tests
L20. (Mar. 1) Resonant method and free vibration tests
L21. (Mar. 4) Contact stress.
L22. (Mar. 6) Parallel plate contact, die loading.
L23. (Mar. 8) Mechanical damage.
L24. (Mar. 11) Concept of impulse momentum.

L25. (Mar. 13) Non-Newtonian fluids.
L26. (Mar. 15) Type of flow curves.
L27. (Mar. 18) Tube and capillary viscometer
L28. (Mar. 20) Rotational viscometers
L29. (Mar. 22) Plastic flow
L30. (Mar. 25) Pseudoplastic flow
L31. (Mar. 27) Viscometry of dough

Mar. 29 Good Friday (University closed)

L32. (Apr. 1) Thermal properties of biological materials
L33. (Apr. 3) Specific heat of food materials
L34. (Apr. 5) Thermal conductivity of grain and food products
L35. (Apr. 8) Convective heat transfer coefficient
L36. (Apr. 10) 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. 9, T) Lab safety issues and a case study
Lab. 2 (Jan. 16) Determination of the surface area, volume, and density of biological materials
Lab. 3 (Jan. 23) Physical attributes determination
Lab. 4 (Jan. 30) Moisture determination and water activity measurements
Lab. 5 (Feb. 6) Construction of Sorption Isotherms
Lab. 6 (Feb. 13) Elasto-plastic behaviour of biological materials

Feb. 19-23, 2024 Reading Week

Feb. 27th, 2024 Midterm Examination at 6:00-8:00 pm **, room to be determined.**

Lab. 7 (Mar. 6) Stress relaxation tests
Lab. 8 (Mar. 13) Creep and recovery test for biological product
Lab. 9 (Mar. 20) Contact stress, impact damage tests for apples
Lab. 10 (Mar. 27) Determination of flow behaviour index and viscosity of a non-Newtonian fluid
Lab. 11 (Apr. 3) 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 forward.