ENGG*3170 Biomaterials

01

Winter 2022
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 2.00 - January 12, 2022

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1 Course Details

1.1 Calendar Description

Physical properties of natural and synthetic (e.g. stainless steel, polymers) materials used in biological engineering applications are presented in this course. Topics will include microstructure and mechanical properties of typical biomaterials, quantification of advanced material properties and behaviours, fabrication, compatibility, biodegradation and mechanical failure. Typical applications will include processing of biomaterials as well as equipment and implant design.

Pre-Requisites: ENGG*2120
Restrictions: This is a Priority Access Course. Enrolment may be restricted to the BIOE and BME specializations in the BENG and BENG:C programs. See department for more information.

1.2 Timetable

Lectures and Laboratory Sessions will be delivered synchronously via Zoom from Week 1 (January 10) until face to face instruction resumes.

Lectures (synchronous):	Zoom or MCKN 120	
Tuesday, Thursday	All Sections	2:30 PM - 3:50 PM
Laboratory (synchronous):	Zoom or THRN 1104	

Tuesday	Section 0101	11:30 AM - 1:20 PM
Wednesday	Section 0102	8:30 AM - 10:20 AM
Monday	Section 0103	8:30 AM - 10:20 AM
Tuesday	Section 0104	8:30 AM - 10:20 AM
Wednesday	Section 0105	3:30 PM - 5:20 PM
Wednesday	Section 0106	12:30 PM - 2:20 PM
Friday	Section 0107	8:30 AM - 10:20 AM
Monday	Section 0108	12:30 PM - 2:20 PM

1.3 Final Exam

Thursday, April 14, 7:00 PM - 9:00 PM.

By default, the exam will be face-to-face. Otherwise (e.g. due to pandemic restrictions) the exam will use Zoom for synchronous invigilation during a written OR online test.

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2 Instructional Support

2.1 Instructional Support Team

Instructor: Scott Brandon PhD, P.ENG
Email: bscott10@uoguelph.ca
Telephone: +1-519-824-4120 x52875
Office: THRN 2415
Office Hours: By appointment

Lab Technician: Kitson Morden
Email: mordenk@uoguelph.ca
Telephone: +1-519-823-1268 x57237

Office: 95 Stone Rd. W

2.2 Teaching Assistants

Teaching Assistant (GTA): Akash Shashikant Tiwari
Email: tiwaria@uoguelph.ca
Office Hours: During scheduled laboratory sessions and by appointment

Teaching Assistant (GTA): Ahmad Naser
Email: anaser@uoguelph.ca
Office Hours: During scheduled laboratory sessions and by appointment.

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3 Learning Resources

3.1 Required Resources

Course Website (Website)
https://courselink.uoguelph.ca
Course material including lecture notes, news, announcements, and grades will be regularly posted to the ENGG*3170 Courselink site. You are responsible for checking the site regularly.

3.2 Recommended Resources

Biomaterials Science: An Introduction to Materials in Medicine (Textbook)
Ratner, B. D. 3rd Edition. Amsterdam: Academic Press. 2013. *Available Online through U of Guelph Library.*

Materials Science and Engineering: An Introduction (Textbook)
D. Callister and D.G. Rethwisch, 8th Edition, John Wiley & Sons, Inc., 2010.

The Intersection of Biology and Materials Science, Pearson Prentice Hall Bioengineering (Textbook)
S. Temenoff. And A.G. Mikos, Biomaterials, 2008.

3.3 Additional Resources

Lecture Information (Notes)
All the lecture notes will be posted on the course website.

Lab Information (Lab Manual)
The lab manual will also be posted on the course website.

Miscellaneous Information (Other)
Other information related to Biomaterials may also be posted on the course website.

3.4 Communication and Email Policy

Please use lectures and lab help sessions as your main opportunity to ask questions about the course. Major announcements will be posted to the course website. **It is your responsibility to check the course website regularly.** As per university regulations, all students are required to check their <@uoguelph.ca> e-mail account regularly: e-mail is the official route of communication between the University and its students.

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4 Learning Outcomes

4.1 Course Learning Outcomes

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

1. Analyze materials engineering problems specific to biomedical applications using a balance of mathematics, physics, chemistry, and physiologic considerations.
2. Demonstrate a working knowledge of general properties (mechanical, chemical, physiological) of both synthetic and natural materials used in biomedical and biological engineering applications.
3. Predict the stress/strain/time response of biological materials using mathematical equations.
4. Demonstrate competency in using materials testing equipment to obtain mechanical properties of biological materials.
5. Appraise and critique current methods of testing/standards required for the development of biomaterials in medical applications, including ethical issues involved.
6. Communicate effectively in a professional environment through technical reports and presentations.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1, 2, 3
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 3
1.4	Recall, describe and apply program-specific engineering principles and concepts	1, 2
5	Use of Engineering Tools	4

#	Outcome	Learning Outcome
5.2	Demonstrate proficiency in the application of selected engineering tools	4
7	Communication Skills	6
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	6
8	Professionalism	5
8.1	Demonstrate an understanding of what it means to be a professional engineer and distinguish between legislated and non-legislated professions	5
10	Ethics & Equity	5
10.1	Summarize ethical theories and equity, diversity, and inclusivity principles	5

4.3 Relationships with other Courses & Labs

Previous Courses:

- **ENGG*2120 Materials Science.** Fundamentals of materials science are reviewed in this class, and built upon with biomedical applications in mind.

Follow-on Courses:

- **ENGG*4400 Biomechanical Engineering Design.** Design projects and case studies will integrate materials science principles with biomechanical applications.
- **ENGG*41X Fourth year engineering design IV.** Design projects will integrate materials science principles.

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5 Teaching and Learning Activities

5.1 Lecture

Topics: Tentative Schedule

Lectures will be held synchronously via Zoom from Week 1 (week of January 10) until face-to-face instruction resumes (if it does). A Zoom link for each lecture will be provided on Courselink.

Week (Start date)	Lecture Topics	Assessment
1 (Jan 10)	Intro & Review • Biomaterials overview, Atomic structure, Mechanical properties	
2 (Jan 17)	Material Characterization • Fracture, Fatigue, Thermal properties, Surface properties	
3 (Jan 24)	Metals and Metal Alloys • Structure and forming, Stainless Steel • Cobalt-Chromium	Quiz 1 (CourseLink, due by end-of-week)
4 (Jan 31)	Metals and Metal Alloys • Titanium, Tantalum, Magnesium, Nitinol Ceramics • Structure, Properties, Mechanical Testing	
5 (Feb 7)	Ceramics	

	• Biocompatibility, Proof testing Polymers • Structure, Synthesis, Properties	
6 (Feb 14)	Polymers • Testing & Applications Composites • Structure, combined mechanical properties	Quiz 2 (CourseLink, due by end-of-week)
	WINTER BREAK	
7 (Feb 28)	Viscoelasticity • Principles; Kelvin-Voigt, Maxwell, Standard linear solid	Midterm (in class Mar 3)
8 (Mar 7)	Viscoelasticity (ctd) Natural Materials • Collagen; Elastin; Proteoglycan; Bone	
9 (Mar 14)	Natural Materials • Cartilage, Ligament & Tendon	Quiz 3 (CourseLink, due by end-of-week)

	Biomaterials Ethics	
10 (Mar 21)	Cell/Immune Response • Host response; Surface colonization, Sterilization	
11 (Mar 28)	Testing/Standards • Cytotoxicity Corrosion & Wear • Electrochemistry	
12 (Apr 4)	Corrosion & Wear • Hydrolysis Course Review	Quiz 4 (CourseLink, due by end-of-week)

5.2 Lab

Topics: Weekly Lab Schedule

Each lab section will follow the schedule outlined below. Lab groups (2-4 students per group) will be formed and posted on Courselink.

- Written reports are due on CourseLink before the start of your next lab experiment (i.e. 2 weeks later)
  - Instructions for the written reports are given in the lab manual
- You are encouraged to visit the lab during your “off” weeks (labelled Q&A

below) to meet with your TA's and the lab technician to:
    - discuss any questions about the experiments, data analysis, lab reports, or grades.
    - <if face-to-face is permitted> gain additional hands-on experience with materials testing equipment (requires appointment with GTA).
- Lab 1 will be delivered via synchronous Zoom instruction, and distribution of pre-collected data and an instructional video.
- Labs 2-4 are tentatively scheduled for face-to-face delivery. However, these labs will pivot to Zoom + pre-recorded data and instructional videos as required.
- The Oral Debate is tentatively scheduled for face-to-face delivery. However, this debate will pivot to Zoom and/or pre-recorded presentation submissions as required.

Week	Lab
1 - January 10	No labs
2 - January 17	Lab 1 - Metal Fatigue
3 - January 24	Q&A
4 - January 31	Lab 2 - Surface Tension & Contact Angle
5 - February 7	Q&A
6 - February 14	Lab 3 - Tendon Tensile Testing
Reading Week	
7 - February 28	Q&A
8 - March 7	Lab 4 - Cartilage Relaxation
9 - March 14	Q&A
10 - March 21	Demo: Bone Compression Testing
11 - March 28	Oral Debate (all students participate)
12 - April 4	Q&A

5.3 Other Important Dates

Monday, January 10: First day of classes
Monday, February 21- Friday, February 25: Winter Break – NO CLASS
Friday, April 8: Last day of classes

6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Quizzes (Individual)	10
Lab Reports (Group)	25
Debate (Group)	15
Midterm Test (Individual)	20
Final Exam (Individual)	30
Total	100

6.2 Assessment Details

Quizzes (Individual) (10%)
Date: , Courselink
Learning Outcome: 1, 2, 3, 5

- Quiz Weeks (due Fridays at 11:59 pm):
  - Weeks 3, 6, 9, and 12
- Best 3 of 4 (i.e. drop your lowest grade, each quiz is worth 3.33%)
- Each quiz will be approximately 15 minutes in length

Lab Reports (Group) (25%)
Date: , Upload to CourseLink
Learning Outcome: 1, 2, 3, 4, 6
Written lab reports are due two weeks after you complete the experiment. See section 5.2 for the complete lab schedule, and section 6.3 for grading polices.

Debate (Group) (15%)
Date: , Virtual
Learning Outcome: 5, 6
Debates will take place during week 11 lab sessions (week of Mar. 28). See CourseLink for detailed information. Assessment will be divided into two parts, both due on the day of the debate:

- Written: Evidence and research (5%) - upload to CourseLink
- Oral: Final Debate (10%)

Midterm Test (Individual) (20%)

Date: Thu, Mar 3, In class
Learning Outcome: 1, 2, 3, 5
Covers material up to and including week 6 (i.e. all material prior to the Winter Break).
Closed book.

Final Exam (Individual) (30%)
Date: , TBA
Learning Outcome: 1, 2, 3, 5
Covers all course material, with emphasis on material introduced after the midterm exam.
Closed book.

6.3 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing grade: The passing grade in this course is 50%.

Quizzes: There will be four quizzes throughout the semester as scheduled above. These quizzes are intended to help you better understand the course content.

- Quizzes account for 10% of your final mark.
- Your worst (lowest grade) quiz will be automatically dropped without penalty, and all remaining quizzes (3/4) will be equally weighted.
- If you miss 1 or more quizzes due to grounds for granting academic consideration or religious accommodation, the following policies will apply:
    - 1-3 missed quizzes: The missed quizzes will be dropped and the weight of missed quizzes will be added to the remaining quizzes. Note that you will not be able to drop any of the quizzes that you complete.
    - 4 missed quizzes (all): The weight of the missed quizzes (10%) will be added to the final exam.

Missed midterm tests: If you miss a test due to grounds for granting academic consideration or religious accommodation, the weight of the missed test will be added to the final exam. There will be no makeup midterm test.

Lab Work: It is recommended that you attend all lab sessions, particularly when the lab is introduced/taught. Attendance will not be taken. Instructional lab videos will be available on Courselink after the lab session is over.

Late Lab Reports: Lab reports are due at the start of your next scheduled lab session, two weeks after the experiment was introduced. For example, if the experiment was taught on Wednesday at 11am-1pm, your lab report will be due two weeks later on Wednesday at 11am. Late submissions of written lab reports (submission times recorded by Courselink) will be subject to penalties of:

- 10% penalty if the report is less than 1 hour late
- 40% penalty if the report is between 1 hour and 24 hours late
- 80% penalty if the report is between 24 and 48 hours late
- 100% penalty (i.e., zero) if the report is more than 48 hours late

Debate: You must attend and participate in the debate. If you miss the debate due to grounds for granting academic consideration or religious accommodation, arrangements will be made at the instructor's discretion to participate in an alternate section and/or to submit a written position statement.

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7 School of Engineering Statements

7.1 Instructor's Role and Responsibility to Students

The instructor’s role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

7.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

7.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

8 University Statements

8.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

8.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

8.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses

https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

8.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

8.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

8.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct

https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

8.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

8.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars

8.9 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via CourseLink and/or class email.

This includes on-campus scheduling during the semester, mid-terms and final examination schedules. All University-wide decisions will be posted on the COVID-19 website (https://news.uoguelph.ca/2019-novel-coronavirus-information/) and circulated by email.

8.10 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).

8.11 Covid-19 Safety Protocols

For information on current safety protocols, follow these links:

- https://news.uoguelph.ca/return-to-campuses/how-u-of-g-is-preparing-for-your-safe-return/
- https://news.uoguelph.ca/return-to-campuses/spaces/#ClassroomSpaces

Please note, these guidelines may be updated as required in response to evolving University, Public Health or government directives.
