ENGG*3170 Biomaterials

01

Winter 2021
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 2.00 - January 10, 2021

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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 (synchronous via Zoom):		
Tuesday, Thursday		11:30 AM - 12:50 PM
Laboratory (synchronous via Zoom):		
Wednesday	Sections 0101	3:30 - 5:20 PM

Tuesday	Sections 0102	1:30 - 3:20 PM
Monday	Sections 0103	2:30-4:20 PM

1.3 Final Exam

Monday, April 24, 8:30 - 10:30 AM, more details to follow.

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2 Instructional Support

2.1 Instructional Support Team

Instructor: Karen Gordon PhD, PEng.
Email: kgordon@uoguelph.ca
Telephone: +1-519-824-4120 x52435
Office Hours: By appointment

Lab Technician: Jacqueline Fountain
Email: fountain@uoguelph.ca
Telephone: +1-519-824-4120 x56676
Office: THRN 1102

2.2 Teaching Assistants

Teaching Assistant: Emily Deignan
Email: edeignan@uoguelph.ca
Office Hours: During your scheduled lab time or by appointment.

Teaching Assistant: Venkata Bompalli
Email: vbompall@uoguelph.ca
Office Hours: During your scheduled lab time or by appointment

Teaching Assistant: Abdullah Al-Hayali
Email: aalhayal@uoguelph.ca
Office Hours: During your scheduled lab time or 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. 2nd Edition. Amsterdam: Academic Press. 2004. *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
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. A Zoom link for each lecture will be provided in Courselink.

Week (Start date)	Lecture Topics	Assessment
1 (Jan 11)	Intro & Review • Biomaterials overview, Atomic structure, Mechanical properties	
2 (Jan 18)	Material Characterization • Fracture, Fatigue, Thermal properties, Surface properties	
3 (Jan 25)	Metals and Metal Alloys	Quiz 1 (in class

	• Structure and forming, Stainless Steel	Jan 26)
4 (Feb 1)	Metals and Metal Alloys • Cobalt-Chromium, Titanium, Tantalum, Magnesium, Nitinol Ceramics • Structure, Properties, Mechanical Testing	
5 (Feb 8)	Ceramics • Biocompatibility, Proof testing Polymers • Structure, Synthesis, Properties	Quiz 2 (In class February 11)
	WINTER BREAK	
6 (Feb 22)	Composites • Structure, combined mechanical properties	Midterm (in class Feb 25)
7 (Mar 1)	Viscoelasticity • Principles; Kelvin-Voigt, Maxwell, Standard linear solid	

8 (Mar 2)	Viscoelasticity (ctd) Natural Materials • Collagen; Elastin; Proteoglycan; Bone	Quiz 3 (in class March 9)
9 (Mar 15)	Natural Materials • Cartilage, Ligament & Tendon Biomaterials Ethics	
10 (Mar 22)	Cell/Immune Response • Host response; Surface colonization, Sterilization	
11 (Mar 29)	Testing/Standards • Cytotoxicity Corrosion & Wear • Electrochemistry	Quiz 4 (in class March 30)
12 (Apr 5)	Corrosion & Wear • Hydrolysis Course Review	

5.2 Lab

Topics: Weekly Lab Schedule

Each lab section will follow the schedule outlined below. Lab groups will be posted to 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 lab reports or data analysis.

Week	Lab
1 - January 11	No labs
2 - January 18	Lab 1 (instructional video and data distribution)
3 - January 25	Lab 1 (Q&A)
4 - February 1	Lab 2 (instructional video and data distribution)
5 - February 8	Lab 2 (Q&A)
Reading Week	
6 - February 22	Lab 3 (instructional video and data distribution)
7 - March 1	Lab 3 (Q&A)
8 - March 8	Lab 4 (instructional video and data distribution)
9 - March 15	Lab 4 (Q&A)
10 - March 22	Oral Lab test (each student allocated a 10 minute time slot)
11 - March 29	Debate (all students participate)
12 - April 5	Make-up (if needed)

5.3 Other Important Dates

Monday, January 11: First day of classes
Monday, February 15 - Friday, February 19: Winter Break – NO CLASS

Monday, April 12: Last day of classes

6 Assessments

6.1 Marking Schemes & Distributions

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

6.2 Assessment Details

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

- Dates: Jan 26, Feb 11, March 9, March 30
- 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) (20%)
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 and 12 lab sessions (weeks of Mar. 29 and April 5). Consult the lab schedule and 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%)

Oral Lab Test (Individual) (10%)
Learning Outcome: 2, 4, 6
A ten minute individual oral lab test will take place during the lab sections in week 10. Each student will be asked to respond to 2-3 questions concerning the four lab experimental labs.

Midterm Test (Individual) (15%)
Date: Thu, Feb 25, In class
Learning Outcome: 1, 2, 3, 5
Covers material up to and including week 5 (i.e. all material prior to the Winter Break)

Final Exam (Individual) (30%)
Date: Sat, Apr 24, 8:30 AM - 10:30 AM, TBA
Learning Outcome: 1, 2, 3, 5
Covers all course material, with emphasis on material introduced after the midterm exam.

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 during the lectures 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 book their exams at least 7 days in advance and not later than the 40th Class Day.

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 and academic schedules. Any such changes will be announced via CourseLink and/or class email. 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

The University will not normally require verification of illness (doctor's notes) for fall 2020 or winter 2021 semester courses. However, requests for Academic Consideration may still require medical documentation as appropriate.
