



ENGG*3170 Biomaterials

01

Winter 2024

Section(s): 01

School of Engineering

Credit Weight: 0.50

Version 1.00 - January 04, 2024

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. Non-BENG students may take a maximum of 4.00 ENGG credits.

1.2 Timetable

Lectures and Laboratory Sessions will be delivered (in class).

Lectures (synchronous):	THRN 1307	
Monday, Wednesday, Friday	All Sections	2:30 PM - 3:20 PM
Laboratory (synchronous):	THRN 1104	
Monday	Section 0101	11:30 AM - 1:20 PM

Monday	Section 0102	11:30 AM - 1:20 PM
Thursday	Section 0103	9:30 AM - 11:20 AM
Thursday	Section 0104	9:30 PM - 11:20 PM
Friday	Section 0105	8:30 AM - 10:20 AM
Friday	Section 0106	8:30 PM - 10:20 PM

1.3 Final Exam

Tuesday, April 16, 11:30 AM - 1:30 PM.

See WebAdvisor for the exam location

2 Instructional Support

2.1 Instructional Support Team

Instructor: Karen Gordon
Email: kgordon@uoguelph.ca
Telephone: ext 52435
Office: RICH 2517
Office Hours: By appointment

Lab Technician: Jacqueline Fountain
Email: fountain@uoguelph.ca
Telephone: +1-519-823-1268 x57237
Office: THRN 1104

2.2 Teaching Assistants

Teaching Assistant (GTA): Celina Kuczynski
Email: ckuczyns@uoguelph.ca
Office Hours: During scheduled laboratory sessions and by appointment

Teaching Assistant (GTA): Nicola Billings
Email: billingn@uoguelph.ca
Office Hours: During scheduled laboratory sessions and by appointment.

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

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.

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.*

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.

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

#	Outcome	Learning Outcome
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.

5 Teaching and Learning Activities

5.1 Lecture

Topics:

Tentative Schedule (in class)

Week (Start date)	Lecture Topics	Assessment
1 (Jan 8)	Intro & Review • Biomaterials overview, Atomic structure, Mechanical properties	
2 (Jan 15)	Material Characterization	Quiz 1 (in class Friday, Friday Jan.

	<ul style="list-style-type: none"> • Fracture, Fatigue, Thermal properties, Surface properties 	19)
3 (Jan 22)	<p>Polymers</p> <ul style="list-style-type: none"> • Structure, Synthesis, Properties • Testing and Applications 	
4 (Jan 29)	<p>Metals and Metal Alloys</p> <ul style="list-style-type: none"> • Structure and forming, Stainless Steel • Cobalt-Chromium • Titanium, Tantalum, Magnesium, Nitinol • Structure, Properties, Mechanical Testing 	Quiz 2 (in class Friday, Feb. 2)
5 (Feb 5)	<p>Ceramics</p> <ul style="list-style-type: none"> • Structure, Properties, Mechanical Testing • Biocompatibility, Proof testing 	
6 (Feb 12)	<p>Composites</p> <ul style="list-style-type: none"> • Structure, combined mechanical properties 	Quiz 3 (in class Friday, Feb 16)
WINTER BREAK		
7 (Feb 26)	<p>Viscoelasticity</p> <ul style="list-style-type: none"> • Principles; Kelvin-Voigt, Maxwell, Standard linear solid 	Midterm (in class Fri. Mar 1)
8 (Mar 4)	<p>Viscoelasticity (ctd)</p> <p>Natural Materials</p>	

	<ul style="list-style-type: none"> • Collagen; Elastin; Proteoglycan; Bone 	
9 (Mar 11)	<p>Natural Materials</p> <ul style="list-style-type: none"> • Cartilage, Ligament & Tendon 	Quiz 4 (in class, Friday, March 15)
10 (Mar 18)	<p>Cell/Immune Response</p> <ul style="list-style-type: none"> • Host response; Surface colonization, Sterilization 	
11 (Mar 25)	<p>Testing/Standards</p> <ul style="list-style-type: none"> • Cytotoxicity <p>Corrosion & Wear</p> <ul style="list-style-type: none"> • Electrochemistry 	
12 (Apr 1)	<p>Corrosion & Wear</p> <ul style="list-style-type: none"> • Hydrolysis <p>Course Review Monday April 8th (last day of class)</p>	Quiz 5 (in class, Wednesday April 3)

5.2 Lab

Topics: Weekly Lab Schedule

Each lab section will follow the schedule outlined below. Lab groups (3-4 students per group) will be formed and posted on CourseLink.

- Written reports are due on CourseLink according to the due dates given in the lab manual.
 - Labs 1 and 2 are due February 18, 5 pm (all groups)
 - Labs 3 and 4 are due April 7, 5pm (all groups)
 - Instructions for the written reports are given in the lab manual
- You are encouraged to visit the lab during "off" weeks to meet with your TA's and the lab technician to:
 - discuss any questions about the experiments, data analysis, lab reports, or grades.
- Lab and Oral Debate schedules are as follows (see the Table)

Lab Experiments and Debate Schedules								
	ODD Sections (01, 03, 05)				EVEN Sections (02, 04, 06)			
Week/Group	A	B	C	D	A	B	C	D
1 (Jan 8)	No Lab							
2 (Jan 15)	Lab1	Lab1	Lab2	Lab2	-	-	-	-
3 (Jan 22)	-	-	-	-	Lab1	Lab1	Lab2	Lab2
4 (Jan 29)	Lab2	Lab2	Lab1	Lab1				
5 (Feb 5)	-	-	-	-	Lab2	Lab2	Lab1	Lab1
6 (Feb 12)	Catch-up Lab 1 and 2 (Reports are due by February 18th, 5 pm)							
(Feb 19)	Winter Break							
7 (Feb 26)	Lab 3	Lab 3	Lab 4	Lab 4	-	-	-	-
8 (Mar 4)	-	-	-	-	Lab 3	Lab 3	Lab 4	Lab 4
9 (Mar 11)	Lab 4	Lab 4	Lab 3	Lab 3	-	-	-	-
10 (Mar	-	-	-	-	Lab 4	Lab 4	Lab 3	Lab 3
11 (Mar 25)	Catch up for Lab 3 and 4 (reports are due April 7, 5 pm)							
12 (April 1)	Debate (Mon. April 1 sections 0101 and 0102, Thurs. April 4 sections 0103 and 01014, Mon. April 8 sections 0105 and 0106)							

5.3 Other Important Dates

Monday, January 8: First day of classes

Monday, February 19- Friday, February 23: Winter Break – NO CLASS

Monday, April 8: Last day of classes

6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Quizzes (Individual)	15
Lab Reports (Group)	20
Midterm Test (Individual)	15
Debate (Group)	15
Final Exam (Individual)	35
Total	100

6.2 Assessment Details

Quizzes (Individual) (15%)

Date: , In class

Learning Outcome: 1, 2, 3, 5

- Quiz Dates Jan 19, Feb 2, Feb 16, Mar 15, April 3.
- Best 4 of 5 (i.e. drop your lowest grade, each quiz is worth 3.75%)
- Each quiz will be approximately 30 minutes in length.

Lab Reports (Group) (20%)

Date: , Upload to CourseLink Dropbox

Learning Outcome: 1, 2, 3, 4, 6

Written lab reports are due according to the lab schedule.

Midterm Test (Individual) (15%)

Date: Mon, Feb 26, 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.

Debate (Group) (15%)

Date: , Lab (THRN 1104)

Learning Outcome: 5, 6

Debates will take place during week 12 lab sessions (week of April 1). See CourseLink for detailed information.

Final Exam (Individual) (35%)

Date: , TBA

Learning Outcome: 1, 2, 3, 5

Tuesday April 16, 11:30-1:30. 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 five quizzes throughout the semester as scheduled above. These quizzes are intended to help you better understand the course content.

- Quizzes account for 15% of your final mark.
- Your worst (lowest grade) quiz will be automatically dropped without penalty, and all remaining quizzes (4/5) 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:
 - 1-2 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.
 - 3 or more missed quizzes: The weight of the missed quizzes 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 1 and 2 are due February 18th by 5 pm. Lab reports 3 and 4 are due April 7 by 5 pm. Late lab reports will not be accepted.

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 submit a written position statement.

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 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).
