ENGG*3170 Biomaterials

Winter 2019
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 05, 2019

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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-Requisite(s): ENGG*2120

1.2 Timetable

Lectures (ANNU 156):		
Tuesday, Thursday		4:00 - 5:20 PM
Laboratory (THRN 1104):		
Tuesday	Sections 01 & 02	8:30 - 10:20 AM
Friday	Sections 03 & 04	11:30 AM - 1:20 PM
Wednesday	Sections 05 & 06	8:30-10:20 AM
Tuesday	Sections 07 & 08	10:30 AM - 12:20 PM

1.3 Final Exam

Monday, April 8, 11:30-1:30 pm, Room TBA on Webadvisor

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2 Instructional Support

2.1 Instructional Support Team

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

Lab Technician: Nick Vanstone
Email: vanstonn@uoguelph.ca
Telephone: +1-519-824-4120 x56676
Office: THRN 1102

2.2 Teaching Assistant(s)

Teaching Assistant: Mateo Gonzalez de Gortari
Email: mgonza07@uoguelph.ca
Office Hours: During your scheduled lab time in THORN 1104 (Weeks 1-12), and by appointment

Teaching Assistant: Bruno Bottega Pergher
Email: bbottega@uoguelph.ca
Office Hours: During your scheduled lab time in THORN 1104 (Weeks 1-12), and by appointment

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3 Learning Resources

3.1 Required Resource(s)

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.

iClicker (Equipment)
i>clickers are required for quizzes. There is not a required text book for this course.

3.2 Recommended Resource(s)

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 Resource(s)

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(s)
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

Topic(s): Tentative Schedule

Week (Start date)	Lecture Topics	Assessment
1 (Jan 7)	Intro & Review • Biomaterials overview, Atomic structure, Mechanical properties	
2 (Jan 14)	Material Characterization • Fracture, Fatigue, Thermal properties, Surface properties	
3 (Jan 21)	Metals and Metal Alloys • Structure and forming, Stainless Steel	Quiz 1 (i-clicker)
4 (Jan 28)	Metals and Metal Alloys • Cobalt-Chromium, Titanium, Tantalum, Magnesium, Nitinol	

	Ceramics • Structure, Properties, Mechanical Testing	
5 (Feb 4)	Ceramics • Biocompatibility, Proof testing Polymers • Structure, Synthesis, Properties	
6 (Feb 11)	Polymers • Testing, Applications Composites • Structure, combined mechanical properties	Quiz 2 (i-clicker)
7 (Feb 18)	WINTER BREAK	
8 (Feb 25)	Viscoelasticity • Principles; Kelvin-Voigt, Maxwell, Standard linear solid	Midterm (in class)
9 (Mar 4)	Viscoelasticity (ctd) Natural Materials • Collagen; Elastin; Proteoglycan; Bone	
10 (Mar	Natural Materials	Quiz 3 (i-clicker)

11)	• Cartilage, Ligament & Tendon Biomaterials Ethics	
11 (Mar 18)	Cell/Immune Response • Host response; Surface colonization, Sterilization Testing/Standards • Cytotoxicity	
12 (Mar 25)	Guest Lectures (TBD)	
13 (Apr 1)	Corrosion & Wear • Electrochemistry; Pourbaix diagram, Hydrolysis; Course Review	Quiz 4 (i-clicker)

5.2 Lab

Topic(s): Bi-weekly laboratory schedule

Each lab section has been subdivided into 4 sub-schedules (A-D). Lab schedules and groups are automatically assigned on Courselink.

- **ODD** lab sections (01, 03, 05, 07) will perform lab experiments during odd weeks, beginning in week 1
- **EVEN** lab sections (02, 04, 06, 08) will perform lab experiments during even weeks, beginning in week 2
- Written reports are due on CourseLink before the start of your next lab

experiment (i.e. 2 weeks after you perform the experiment)
    - Labs 1-4 require full lab reports
    - Labs 5&6 only require short answers to discussion questions
- You are encouraged to visit the lab during your “off” weeks to meet with your TA’s and discuss any questions about lab reports or data analysis.
    - e.g. a student in **odd** section 01-A could visit the lab during an even week

	Lab Experiment Schedules							
	ODD sections (01, 03, 05, 07)				**EVEN** sections (02, 04, 06, 08)			
Week	A	B	C	D	A	B	C	D
1 (Jan 7)	Lab 1	Lab 1	Lab 1	Lab 1	-	-	-	-
2 (Jan 14)	-	-	-	-	Lab 1	Lab 1	Lab 1	Lab 1
3 (Jan 21)	Lab 2	Lab 3	Lab 4	Labs 5&6	-	-	-	-
4 (Jan 28)	-	-	-	-	Lab 2	Lab 3	Lab 4	Labs 5&6
5 (Feb 4)	Lab 3	Lab 4	Labs 5&6	Lab 2	-	-	-	-
6 (Feb 11)	-	-	-	-	Lab 3	Lab 4	Labs 5&6	Lab 2
7 (Feb 18)	WINTER BREAK							
8 (Feb 25)	Lab 4	Labs 5&6	Lab 2	Lab 3	-	-	-	-
9 (Mar 4)	-	-	-	-	Lab 4	Labs 5&6	Lab 2	Lab 3
10 (Mar 11)	Labs 5&6	Lab 2	Lab 3	Lab 4	-	-	-	-

11 (Mar 18)	-	-	-	-	Labs 5&6	Lab 2	Lab 3	Lab 4
12 (Mar 25)	Debate				-	-	-	-
13 (Apr 1)	-	-	-	-	Debate			

5.3 Other Important Dates

Monday, January 7, 2019: First day of classes
Monday, February 18 - Friday, February 22, 2019: Winter Break – NO CLASS
Friday, March 8, 2019: 40th class day, last day to drop
Friday, April 5, 2019: Last day of classes

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6 Assessments

6.1 Marking Schemes & Distributions

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

6.2 Assessment Details

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

- Dates: Jan 24, Feb 14, Mar 14, April 4
- Best 3 of 4 (i.e. drop your lowest grade, each quiz is worth 3.33%)
- Each quiz will be approximately 20 minutes in length
- Discussion is encouraged, but each student will receive an individual grade

Lab Reports (Group) (25%)
Date: , Upload to CourseLink
Learning Outcome(s): 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: , THRN 1104
Learning Outcome(s): 5,6
Debates will take place during week 12 and 13 lab sessions (weeks of Mar. 25 and Apr. 1). Consult the lab schedule (section 5.2) 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%)

Midterm Test (Individual) (20%)
Date: Thu, Feb 28, In class
Learning Outcome(s): 1,2,3,5
Covers material up to and including week 6 (i.e. all material prior to the Winter Break)

Final Exam (Individual) (30%)
Date: Mon, Apr 8, 11:30 AM - 1:30 PM, TBA
Learning Outcome(s): 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%. Additionally, the average of your Midterm + Final exam grades (i.e. [Midterm % + Final %] / 2) must be greater than 50%. If your average exam grade is less than 50%, an overall grade of 49% will be assigned for the course.

Quizzes: There will be four i>clicker quizzes during the lectures throughout the semester as scheduled above. These quizzes are intended to help you better understand the course content. Students are expected to be present and use their own i>clicker during these

quizzes. Prior to the first quiz, you must register your i>clicker serial number by clicking on the *"Student i>clicker Registration"* link on the webpage:
http://www.tss.uoguelph.ca/ltci/clickers/index.cfm

- 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: You must attend and complete all laboratory experiments. If you miss an experiment due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the teaching assistant to complete a make-up lab.

Late Lab Reports: Lab reports are due at the start of your next scheduled lab session, two weeks after your experiment. For example, if you complete a lab 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.

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.

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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

8.3 Drop Date

Courses that are one semester long must be dropped by the end of the fortieth class day; two-semester courses must be dropped by the last day of the add period in the second semester. The regulations and procedures for course registration are available in the Undergraduate and Graduate 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

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.

More information can be found on the SAS website
https://www.uoguelph.ca/sas

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