



# ENGG\*3170 Biomaterials

Winter 2018

Section(s): C01

School of Engineering

Credit Weight: 0.50

Version 1.00 - January 05, 2018

## 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

<b>Lectures (RICH 2529):</b>		
Monday, Wednesday, Friday		12:30 – 1:20 PM
<b>Laboratory (THRN 1104):</b>		
Thursday	Section 01	3:30-5:20 PM
Monday	Section 03	2:30 - 4:20 PM
Thursday	Section 04	9:30-11:20 AM
Tuesday	Section 06	1:30 - 3:20 PM

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## 1.3 Final Exam

Wednesday, April 18, 11:30-1:30 pm, Room TBA on Webadvisor

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## 2 Instructional Support

### 2.1 Instructor(s)

**Scott Brandon PhD, EIT**

**Email:** scott.brandon@uoguelph.ca  
**Telephone:** +1-519-824-4120 x52875  
**Office:** THRN 2415  
**Office Hours:** By appointment

### 2.2 Instructional Support Team

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

### 2.3 Teaching Assistant(s)

**Teaching Assistant:** Connor Davies  
**Email:** cdavie05@uoguelph.ca  
**Office Hours:** During your scheduled lab time in THORN 1104 (Weeks 2-12)

**Teaching Assistant:** Calvin Young  
**Email:** cyoung02@uoguelph.ca  
**Office Hours:** During your scheduled lab time in THORN 1104 (Weeks 2-12)

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## 3 Learning Resources

### 3.1 Required Resources(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 Resources(s)

**Materials Science and Engineering: An Introduction (Textbook)**

D. Callister and D.G. Rethwisch, 8<sup>th</sup> 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(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

Successfully completing this course will contribute to the following:

#	Outcome Set Name	Course Learning Outcome
1	Knowledge base	1, 2, 3, 4, 5, 6

#	Outcome Set Name	Course Learning Outcome
1.1	Recall, describe and apply fundamental mathematical principles and concepts	1, 2, 3, 4, 5, 6
1.2	Recall, describe and apply fundamental concepts and principles in natural sciences	1, 2, 3, 4, 5, 6
1.3	Comprehend and apply fundamental engineering concepts	1, 2, 3, 4, 5, 6
1.4	Comprehend and apply program-specific engineering concepts	1, 2, 3, 4, 5, 6
2	Problem analysis	1, 2, 3, 4
2.1	Formulate a problem statement in engineering and nonengineering terminology	1, 2, 3, 4
2.2	Construct a conceptual framework	1, 2, 3, 4
2.3	Identify, organize and justify appropriate information	1, 2, 3, 4
2.4	Execute an engineering solution	1, 2, 3, 4
2.5	Critique and appraise results	1, 2, 3, 4
3	Investigation	4
3.1	Propose and test working hypotheses	4
3.2	Design and apply an investigation plan	4
3.3	Analyze and interpret experimental data	4
3.4	Assess validity of conclusions within limitations of data and methodologies	4
5	Use of engineering tools	2, 4, 5
5.1	Select appropriate engineering tools from various alternatives	2, 4, 5
5.2	Apply selected engineering tools	2, 4, 5
5.3	Recognize limitations of selected engineering tools	2, 4, 5
6	Individual and team work	4, 6
6.1	Act as an individual team member to promote team success	4, 6
6.2	Demonstrate leadership through team building, providing feedback and positive attitude	4, 6
7	Communication skills	6
7.1	Develop and deliver clear, key concepts using methods appropriate for the intended audience	6
7.2	Critically evaluate received information	6

#	Outcome Set Name	Course Learning Outcome
7.3	Demonstrate active listening and follow instructions	6
8	Professionalism	5
8.1	Identify what it means to be a professional and distinguish between legislated and non-legislated based professions	5
8.2	Perform in a professional manner	5
8.3	Effectively describe engineering law and its impact on professional engineering practice	5
9	Impact of engineering on society and environment	5
9.1	Analyze the social, environmental and legal aspects of engineering activity	5
9.2	Summarize the common sources of uncertainty and risk in their engineering field	5
9.3	Identify the impact of introducing innovative technologies to solve engineering problems	5
10	Ethics and equity	5
10.1	Describe Ethical and Equity based Principles and Theory	5
10.2	Summarize the similarities and differences in the ethical roles and principles in Canada and in the international context	5
10.3	Demonstrate honesty, trustworthiness and academic Integrity	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)	Topics
1 (Jan 8)	Intro & Review <ul style="list-style-type: none"><li>• Biomaterials overview, Atomic structure, Mechanical properties</li></ul>
2 (Jan 15)	Intro & Review <ul style="list-style-type: none"><li>• Fracture, Fatigue, Thermal properties, Surface properties</li></ul>
3 (Jan 22)	Metals and Metal Alloys <ul style="list-style-type: none"><li>• Structure and forming, Stainless Steel, Cobalt-Chromium</li></ul>
4 (Jan 29)	Metals and Metal Alloys <ul style="list-style-type: none"><li>• Titanium, Tantalum, Magnesium, Nitinol</li></ul> Ceramics <ul style="list-style-type: none"><li>• Structure &amp; testing</li></ul>
5 (Feb 5)	Ceramics <ul style="list-style-type: none"><li>• Degradation, examples</li></ul> Polymers <ul style="list-style-type: none"><li>• Structure, synthesis, applications</li></ul>
6 (Feb 12)	Composites <ul style="list-style-type: none"><li>• Structure, combined mechanical properties</li><li>• Applications and examples</li></ul>

	<p>Biomaterials Regulation &amp; Ethics</p> <ul style="list-style-type: none"> <li>• Case studies</li> </ul>
7 (Feb 19)	WINTER BREAK
8 (Feb 26)	<p>Viscoelasticity</p> <ul style="list-style-type: none"> <li>• Kelvin-Voigt, Maxwell, Standard linear solid</li> </ul>
9 (Mar 5)	<p>Natural Materials</p> <ul style="list-style-type: none"> <li>• Collagen &amp; Elastin, Bone</li> </ul>
10 (Mar 12)	<p>Natural Materials</p> <ul style="list-style-type: none"> <li>• Cartilage, Ligament &amp; Tendon</li> </ul>
11 (Mar 19)	<p>Cell/Immune Response</p> <ul style="list-style-type: none"> <li>• Surface colonization, sterilization, injury mechanisms</li> </ul> <p>Testing/Standards</p> <ul style="list-style-type: none"> <li>• Cytotoxicity</li> </ul>
12 (Mar 26)	<p>Testing/Standards</p> <ul style="list-style-type: none"> <li>• Sensitization</li> </ul> <p>Corrosion &amp; Wear</p> <ul style="list-style-type: none"> <li>• Definitions and types</li> </ul>
13 (Apr 2)	<p>Corrosion &amp; Wear</p> <ul style="list-style-type: none"> <li>• Pourbaix diagram, protection, examples</li> </ul> <p>Review</p>

## 5.2 Lab

**Topic(s):** Bi-weekly laboratory schedule

Each lab section has been subdivided into 6 sub-schedules (A-F). Lab schedules and groups are automatically assigned on CourseLink.

- Students on schedules A, B, & C will perform laboratory experiments during weeks 2, 4, 6, 9, and 11.
- Students on schedules D, E, and F will perform laboratory experiments during weeks 3, 5, 8, 10, and 12.
- Written reports are due on CourseLink within 1 week after your lab experiment.

	<b>Lab Experiment Schedules</b>					
Week	A	B	C	D	E	F
1 (Jan 8)	-	-	-	-	-	-
2 (Jan 15)	Lab 1	Lab 1	Lab 1	-	-	-
3 (Jan 22)	-	-	-	Lab 1	Lab 1	Lab 1
4 (Jan 29)	Lab 2	Lab 3	Labs 4&5	-	-	-
5 (Feb 5)	-	-	-	Lab 2	Lab 3	Labs 4&5
6 (Feb 12)	Lab 3	Labs 4&5	Lab 2	-	-	-
7 (Feb 19)	WINTER BREAK					
8 (Feb 26)	-	-	-	Lab 3	Labs 4&5	Lab 2
9 (Mar 5)	Labs 4&5	Lab 2	Lab 3	-	-	-
10 (Mar12)	-	-	-	Labs 4&5	Lab 2	Lab 3
11 (Mar 19)	Debate			-	-	-
12 (Mar 26)	-	-	-	Debate		
13 (Apr 2)	-	-	-	-	-	-

### 5.3 Other Important Dates

**Monday, January 8, 2018:** First day of class



**Monday, February 19 - Friday, February 23, 2018:** Winter Break – NO CLASS

**Friday, March 9, 2018:** 40th class day, last day to drop

**Friday, March 30, 2018:** Holiday - NO CLASS

**Friday, April 6, 2018:** Last day of class

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## 6 Assessments

### 6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Quizzes (Individual)	10.00
Labs	25.00
Debate	15.00
Midterm Test	20.00
Final Exam	30.00
Total	100.00

### 6.2 Assessment Details

#### Quizzes (Individual) (10.00%)

**Date:** In class

- Dates: Jan 26, Feb 16, Mar 16, April 18
- 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

#### Labs (25.00%)

**Date:** Upload to CourseLink

Written lab reports are due one week after you complete the experiment. See section 5.2 for the complete lab schedule, and section 6.3 for grading policies.

#### Debate (15.00%)

**Date:** THRN 1104

Debates will take place during week 11 and 12 lab sessions (weeks of Mar. 19 and Mar. 26). Consult the lab schedule (section 5.2) and CourseLink group assignments for detailed schedule 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 (20.00%)

**Date:** Wed, Feb 28, In class

Covers material up to and including week 6 (i.e. all material prior to the Winter Break)

#### Final Exam (30.00%)

**Date:** Wed, Apr 18, 11:30 AM - 1:30 PM, TBA

Covers all course material

## 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 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/lhci/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 1-3 quizzes due to grounds for granting academic consideration or religious accommodation, the missed quiz(zes) will be dropped and the weight of missed quizzes will be added to the remaining quizzes.
- If you miss all 4 quizzes due to grounds for granting academic consideration or religious accommodation, 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 scheduled lab session, one week after your experiment. For example, if you complete a lab on Wednesday at 11am-1pm, your lab report will be due on the following Wednesday at 11am. Late submissions of written lab reports will be subject to penalties of:

- 10% penalty if the report is less than 1 hour late (as denoted by Courselink).
- 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.

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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 regulations and procedures for [Academic Consideration](#) are detailed in the Undergraduate Calendar.

### **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 [Dropping Courses](#) are available in the Undergraduate Calendar.

### **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: [www.uoguelph.ca/sas](http://www.uoguelph.ca/sas)

### **8.6 Academic Misconduct**

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 discourages misconduct. 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.

The [Academic Misconduct Policy](#) is detailed in the Undergraduate Calendar.

### **8.7 Recording of Materials**

Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, a classmate

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 which apply to undergraduate, graduate and diploma programs.

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