ENGG*2120 Material Science

Fall 2019
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - September 04, 2019

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1 Course Details

1.1 Calendar Description

Study of the mechanical, electrical, magnetic, optical and thermal properties of solids. Atomic order and disorder in solids, single-phase metals, and multiphase materials (their equilibria and micro-structure) are examined as a basis for understanding the causes of material properties. Interwoven throughout the course is an introduction to materials selection and design considerations.

Pre-Requisites: CHEM*1040, PHYS*1130

1.2 Timetable

Lectures:

Section 1

Tuesday & Thursday	4:00 PM – 5:20 PM	ROZH 102

Section 2

Tuesday & Thursday	10:00 AM – 11:20 AM	MACN 113

Laboratory: Materials Science Lab (THRN 1008)

Sec 1	Monday	8:30 AM - 10:20 AM	THRN 1008
Sec 2	Wednesday	8:30 AM - 10:20 AM	THRN 1008
Sec 3	Friday	8:30 AM - 10:20 AM	THRN 1008
Sec 4	Monday	10:30 AM - 12:20 PM	THRN 1008
Sec 5	Wednesday	10:30 AM - 12:20 PM	THRN 1008
Sec 6	Friday	10:30 AM - 12:20 PM	THRN 1008
Sec 7	Monday	2:30 PM - 4:20 PM	THRN 1008
Sec 8	Tuesday	7:00 PM - 8:50 PM	THRN 1008
Sec 9	Friday	2:30 PM - 4:20 PM	THRN 1008

1.3 Final Exam

Tuesday, December 3rd, 2019 2:30 PM - 4:30 PM

Final exam date, time and location is set by the University Registrar.

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2 Instructional Support

2.1 Instructional Support Team

Instructor: Ryan Clemmer Ph.D P.Eng
Email: rclemmer@uoguelph.ca
Telephone: +1-519-824-4120 x52132
Office: THRN 1337
Office Hours: Tuesday and Thursday 2:00 PM – 3:00 PM, or via email or by appointment

Lab Technician: Barry Verspagen
Email: baverspa@uoguelph.ca
Telephone: +1-519-824-4120 x58821
Office: THRN 1138

2.2 Teaching Assistants

Teaching Assistant: Fatima Haque
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Teaching Assistant: Arku Precious
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Telephone: +1-519-824-4120 x58047
Office: THRN 3106
Office Hours: By appointment

Teaching Assistant: Iftekhar Hussain Chowdhury
Email: iftekhar@uoguelph.ca
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Teaching Assistant: Miguel Vigil Fuentes
Email: mvigilfu@uoguelph.ca
Office Hours: By appointment

Teaching Assistant: Maisyn Picard
Email: maisyn@uoguelph.ca
Office Hours: By appointment

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3 Learning Resources

3.1 Required Resources

D.R. Askeland and W.J. Wright, The Science and Engineering of Materials, 7th Edition, SI, Cengage Learning, 2016 (Textbook)

Iclickers for quizzes (Equipment)
> Iclickers required for in-class quizzes

3.2 Recommended Resources

W.D. Callister and D.G. Rethwisch, Materials Science and Engineering: An Introduction, 9th Edition, John Wiley & Sons, Inc., 2014. (Textbook)

3.3 Additional Resources

Lecture Information: An incomplete set of lecture notes will be posted on Courselink prior to lecture. During lecture, additional notes and examples will be provided. It is expected that you will have a copy of the posted lecture notes for each class.

Lab Information: The lab manual and schedule for the laboratory exercises are posted on Courselink. Be sure to read the appropriate lab instructions prior to attending the lab.

Assignments: Study assignments will be posted at the end of a chapter or a group of

chapters, with the solutions to follow about one week later. Assignments will not be marked. It is strongly recommended that you work through these assignments as they are valuable study aids and similar to the types of questions that may be asked on an exam.

Exams: Sample exam questions from previous years are posted. The solutions will also be posted for your convenience.

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4 Learning Outcomes

There are two main aspects to design: physical structure and material selection. Each material has its own unique properties and characteristics. Understanding how the material properties can change with the environment and how the properties can be manipulated will provide more informed material selection choices. A properly selected material can enhance a design through structural changes and a greater performance, while an improperly selected material can lead to complete design failure.

This course is an introductory course in materials science. The student will be introduced to the atomic or molecular structure of metals, polymers, ceramics, and composite materials and learn how these different structures influence their mechanical, electrical, and thermal behaviour. Many of the differences between properties of classes of materials are related to the atomic structure of the material.

The mechanical properties of a material are influenced by the atomic arrangement and presence of crystallographic defects. In addition, methods of controlling the atomic arrangement of a material such as heat treating and strain hardening will be investigated. Finally, common service failures due to creep, fatigue, or fast fracture will be examined in light of the atomic structure of the different materials.

4.1 Course Learning Outcomes

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

1. Describe the general properties of key engineering materials: metals, semiconductors, ceramics, polymers, and composites through a material identification project
2. Recognize the link between atomic structure of a material and its macroscopic properties through testing of material properties such as strength, stiffness, and impact behaviour
3. Explain how the microstructure of a material can be manipulated by altering the operating environment, strain hardening, and heat treatment through lab report discussion questions
4. Compare measured material properties such as compressive strength, tensile strength, and elastic modulus with the expected theoretical results and explain discrepancies through lab report discussions
5. Determine the phases present, the compositions of the phases, and the mass fractions of

the phases for some given phase diagrams through practice problems, quizzes, and exams

6. Create simple lab experiments to measure material properties and evaluate the effectiveness of the experiment in measuring those properties through a material identification project
7. Select an appropriate material for a given application based on knowledge of material properties through class examples, exams, and lab reports
8. Present, analyze, and discuss experimental data through well written lab reports

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, 4, 5, 7
1.2	Recall, describe and apply fundamental principles and concepts in natural science	1, 2, 3, 4, 5, 7
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 2, 3, 4, 5, 7
3	Investigation	4, 6, 8
3.1	Propose a working hypothesis	6, 8
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	6, 8
3.3	Analyze and interpret experimental data	4, 6, 8
3.4	Assess validity of conclusions within limitations of data and methodologies	4, 6, 8
5	Use of Engineering Tools	4, 6
5.1	Select appropriate engineering tools from various alternatives	6
5.2	Demonstrate proficiency in the application of selected engineering tools	6
5.3	Recognize limitations of selected engineering tools	4, 6
7	Communication Skills	6, 8
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	8
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	8

#	Outcome	Learning Outcome
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
7.4	Substantiate claims by building evidence-based arguments and integrating effective figures, tables, equations, and/or references	6, 8
7.5	Demonstrate ability to process oral and written communication by following instructions, actively listening, incorporating feedback, and formulating meaningful questions	8

5 Teaching and Learning Activities

Please note that the topic order is approximate and the schedule may be altered.

5.1 Lecture

Topics: Introduction
References: Chapter 1

Topics: Mechanical Properties
References: Chapter 6

Topics: Failure Mechanisms
References: Chapter 7

Topics: Atomic Structure
References: Chapter 2

Topics: Ferrous & Non-Ferrous Alloys
References: Chapter 13, 14

Topics: Ceramics
References: Chapter 15

Topics: Polymers
References: Chapter 16

Topics: Composites
References: Chapter 17

Topics: Atomic Arrangement
References: Chapter 3

Topics: Imperfections in Atomic Arrangement
References: Chapter 4

Topics:	Strain Hardening
References:	Chapter 8
Topics:	Solid Solutions
References:	Chapter 10
Topics:	Dispersion Strengthening - Phase Diagrams
References:	Chapter 11
Topics:	Dispersion Strengthening - Phase Transformations
References:	Chapter 12
Topics:	Heat Treating of Steel
References:	Chapter 13
Topics:	Semiconductors
References:	Chapter 19

5.2 Lab Schedule

A detailed lab schedule is posted on Courselink. The schedule provides information on groups, experiments and project. All lab reports must be submitted electronically in the dropbox on Courselink for marking by 4:00 PM **two weeks** after the laboratory is performed (unless indicated otherwise). For the weeks students are not in the lab, they are expected to be writing their lab report, or preparing for their next lab exercise. GTAs will be available during the lab time to answer questions.

You must attend the lab section you are registered in.

Lab Activity	Groups (All Sections)	Lab Performed	Report Due Date
Lab Safety and Project Introduction	1 - 4	Sep 9 - Sep 13	
	5 - 8	Sep 9 - Sep 13	
Project Testing	1 - 4	Sep 16 - Sep 20	Sep 30 - Oct 4
	5 - 8	Sep 16 - Sep 20	Sep 30 - Oct 4
Compressive Testing of Materials	1 - 4	Sep 23 - Sep 27	Oct 7 - Oct 11
	5 - 8	Sep 23 - Sep 27	Oct 7 - Oct 11

Tensile Testing of Materials	1 - 4	Sep 30 - Oct 4	Oct 21 - Oct 25
	5 - 8	Oct 7 - Oct 11	Oct 28 - Nov 1
Midterm Review	1 - 4	Oct 16 - Oct 18	
	5 - 8	Oct 16 - Oct 18	
Impact Testing of Materials	1 - 4	Oct 21 - Oct 25	Nov 4 - Nov 8
	5 - 8	Oct 21 - Oct 25	Nov 4 - Nov 8
Heat Treating of Metals	1 - 4	Nov 4 - Nov 8	Nov 18 - Nov 22
	5 - 8	Nov 11 - Nov 15	Nov 25 - Nov 29

5.3 Other Important Dates

- **Monday, October 14, 2019:** Thanksgiving Day, No Classes
- **Tuesday, October 15, 2019:** Study Day, No Classes
- **Thursday, November 28, 2019:** Make up for Study Day (Tuesday Schedule)
- **Friday, November 29, 2019:** Make up for Thanksgiving Day (Monday Schedule) and Last Day to Drop Fall Courses Without Academic Penalty

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6 Assessments

Passing grade: Students must achieve at least 50% of the marks assigned to the midterm and final exams in order for the labs and quizzes to be counted in the final grade. If you do not achieve at least 50% of the marks assigned to the midterm and final exams, the weighting of the lab reports and quizzes in your final grade will be zero. An overall final grade of 50% is required to pass the course.

6.1 Marking Schemes & Distributions

The final grade will be the better of Marking Scheme A or Marking Scheme B.

Name	Scheme A (%)	Scheme B (%)
Quizzes	10	0
Project	5	5
Lab Reports	20	20
Midterm(s)	25	30
Final Exam	40	45
Total	100	100

6.2 Assessment Details

Quizzes (10%)
Date: In-class
Learning Outcome: 1, 2, 3, 5, 7
The best 5 of 7 quizzes will be used to calculate the overall Quizzes grade.

Quiz1 Sep. 19th

Quiz 2 Oct. 1st

Quiz 3 Oct. 17th

Quiz 4 Oct. 31st

Quiz 5 Nov. 12th

Quiz 6 Nov. 21st

Quiz 7 Nov. 28th

Project (5%)
Learning Outcome: 1, 2, 3, 4, 6, 7, 8
For project report due dates, please refer to the activities schedule section of the course outline.

Lab Reports (20%)
Date: THRN 1008
Learning Outcome: 2, 3, 4, 7, 8

For lab report due dates, please refer to the activities schedule section of the course outline.

Midterm(s) (25%)
Date: Sat, Oct 26, 6:30 PM - 8:30 PM, MACN 105
Learning Outcome: 1, 2, 7
Each student is allowed one **single-sided** 8.5" x 11" note sheet for the exam. Each note sheet must be prepared by you (typed or handwritten) and be your own original work (i.e., not a copy).

Final Exam (40%)
Date: Tue, Dec 3, 2:30 PM - 4:30 PM, Room TBD
Learning Outcome: 1, 2, 3, 5, 7
Final Exam date, time and location is set by the University Registrar.

Each student is allowed one **double-sided** 8.5" x 11" note sheet for the exam. Each note sheet must be prepared by you (typed or handwritten) and be your own original work (i.e., not a copy).

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7 Course Statements

7.1 Introduction

1. Sharing of iclicker, calculators, formula sheets, if applicable, or use of smart phones as calculators is not allowed.
2. Grading is based on the procedure, correctness of numerical calculations and final answer.
3. Check your lab section. <u>You are only allowed to attended the section you are registered in.</u>

7.2 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 at 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: Students must achieve at least 50% of the marks assigned to the midterm and final exams in order for the labs and quizzes to be counted in the final grade. If you do not achieve at least 50% of the marks assigned to the midterm and final exams, the weighting of the lab reports and quizzes in your final grade will be zero. An overall final grade of 50% is required to pass the course.

Missed midterm exams: 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 exams.

Lab Work: You must attend and complete all labs. Doors to the lab will be closed 15 minutes after the scheduled lab time. **Students arriving after the lab doors are closed are considered absent.** If you miss a lab due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the teaching assistant to complete a makeup lab. Unless academic consideration is granted, failure to complete a lab will result in a mark of zero for that lab report.

The laboratory work is group based. Check course link for your group. **You will not be allowed to conduct the project or labs unless you attend the safety session and sign a form indicating that you have done so.**

Each group will be responsible for conducting the labs and writing a single report for each lab. You will be equally responsible for your group's laboratory reports. Each group member must make a significant contribution to the writing of the lab report and sign the lab report cover page in order to receive a lab report mark. Lab reports will be marked and the marks posted on Courselink. **Note that up to 20% of the lab mark may be deducted for poor lab report format, poor graph or table format, or poor English (spelling, grammar, etc.).** Any reports judged to be entirely unacceptable will be returned without marking for rewriting. If you have questions about your mark, see the GTA responsible for that lab and they will discuss it with you.

Late Lab Reports: There will be a late penalty of 20%/day or part thereof for any late lab reports. That is, reports submitted within 24 hours after the initial due date will lose 20%, reports submitted between 24 and 48 hours after the initial due date will lose 40%, and so on. Lab reports are considered late if they are submitted after the specified time they are due.

8 School of Engineering Statements

8.1 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.

8.2 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.

8.3 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.

9 University Statements

9.1 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.

9.2 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

9.3 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

9.4 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.

9.5 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

9.6 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

9.7 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.

9.8 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
