

MATLS 3M03: MECHANICAL BEHAVIOUR OF MATERIALS**Instructor**

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Teaching assistants

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Course description

This course will examine how the microstructure of a material determines its mechanical behaviour. The topics covered will include elastic and plastic deformation, creep, fatigue and fracture of engineering materials. Materials selection will also be discussed.

Learning Outcomes

- Gain practical experience in measurement and quantification of mechanical properties.
- Understand the physical and microstructure basis of mechanical properties.
- Become familiar with failure mechanisms of structural materials.
- Develop ability to predict the useful lifetime of a material under specific load conditions.
- Knowledge of how to incorporate material strength limitations into engineering design.

Course structure

12 weeks: lectures 3 hrs/week, 4 virtual lab demonstrations

Module 1 (week 1–3): Elasticity

- stress and strain tensors
- generalized Hooke's law
- nature and types of chemical bonding
- atomic structure of solids
- microscopic insight to elasticity
- modulus limited design
- Demonstration 1: Elastic modulus of composite materials *or* Chance fracture, bone

as a composite material

Module 2 (week 4-5,7): Plasticity

- tensile testing
- perfect strength, dislocations, yielding
- mechanics of plastic flow
- strengthening mechanisms
- yielding under combined stress
- yield-limited design
- Demonstration 2: Effect of microstructure on the strength of an aluminum alloy *or* Anterior cruciate ligament injury

Module 3 (week 8–9): Fracture mechanics

- energetics of fracture growth
- plasticity at the fracture tip
- measurement of fracture toughness
- damage tolerance design
- elements of fractography
- Demonstration 3: Measuring the toughness of low carbon steels

Module 4 (week 10–11): Creep

- stress-strain-time relationship
- creep testing
- physical mechanism of creep
- diffusion
- creep-resistant materials
- Demonstration 4: Creep and high temperature deformation of aluminum

Module 5 (week 12–13): Fatigue

- low- and high-cycle fatigue
- laboratory testing in fatigue
- residual stress, surface and environmental effects
- fatigue of cracked components
- designing out fatigue failure

Evaluation

Activities	Contribution to the final grade (%)
Assignments (5 in total)	15
Lab demonstration reports (4 in total)	20
Midterm exam (modules 1 & 2)	25
Final exam (modules 3, 4, & 5)	40

Overdue submissions are accepted until the feedback is released to the class, but there is a penalty factor

$$(1 - 0.1 \times \text{number of full days overdue}) .$$

For example, the assignment graded as 80% with 2 days overdue will receive

$$80\% \times (1 - 0.1 \times 2) = 64\% .$$

Due dates can be extended by 72 hrs in addition to the original due date (without penalties), provided MSAF form is submitted.

Prerequisites and relevance to other courses

The course builds on MATLS 1M03 “Structure and Properties of Materials” with an emphasis on applications to engineering design. ENGINEER 2P04 “Engineering Mechanics A” course provides knowledge of mechanics, which is required to solve design-related problems. It is expected that students are familiar with the structure of crystalline solids (Chapter 3 in “Materials Science and Engineering” by W. D. Callister).

Recommended texts

- Thomas H. Courtney, *Mechanical Behavior of Materials*, 2nd ed., (Waveland Press, 2000). ISBN: 978-1-57766-425-3 (our main text)
- Norman E. Dowling, *Mechanical behavior of materials: Engineering methods for deformation, fracture, and fatigue*, 4th ed., (Pearson Education). ISBN: 978-0131395060 (it is a more design-oriented text)
- Michael F. Ashby and David R. H. Jones, *Engineering materials 1: an introduction to properties, applications and design*, 4th ed., (Elsevier, 2011). ISBN: 978-0080966656 (it is less advanced in theoretical background, but contains good engineering/practical examples of design problems)

COVID-related changes

Live lectures will take place online (Zoom, not pre-recorded) where students can ask questions directly during the lecture. If missed, students will have access to recorded lectures and notes. In-person demonstration labs are substituted with virtual ones, which include a

video of tests performed. Students will be provided with raw data collected during experiments for further processing and preparation of lab reports. Both midterm and final exams will take place online, most likely, via Avenue to learn platform (details will follow). The instructor will be available for online consultations.

COURSE OUTLINE – APPROVED ADVISORY STATEMENTS

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the [Academic Integrity Policy](https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/), located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

ONLINE PROCTORING

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the [Code of Student Rights & Responsibilities](#) (the “Code”). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students’ access to these platforms.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact [Student Accessibility Services](#) (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University’s [Academic Accommodation of Students with Disabilities](#) policy.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC TERM WORK

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar “Requests for Relief for Missed Academic Term Work”.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the [RISO](#) policy. Students should submit their request to their Faculty Office **normally within 10 working days** of the beginning of term in which they anticipate a need for accommodation or to the Registrar’s Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.