

CARLETON UNIVERSITY
Department of Mechanical & Aerospace Engineering
Course Outline - MECH 4103
Fatigue and Fracture Analysis

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1) Learning Outcomes

Students will be able to:

- explain different design approaches to ensure safe operation of components and structures
- perform basic fatigue life estimation for metallic and ceramic materials subjected to constant or variable amplitude loading
- identify the basic mechanisms of fatigue crack nucleation and crack growth in metals and composites
- estimate the life of components based on crack propagation analysis
- explain the effect of design decisions on fatigue life

2) Texts

Required textbook:

- Schijve, J *Fatigue of Structures and Materials*, 2nd ed., Springer, 2009.

Other recommended resources include:

- Pook, LP *Metal Fatigue – What it is and Why it Matters*, Springer, 2007 [eBook]
- Hertzberg, RW *Deformation and Fracture Mechanics of Engineering Materials*, 3rd ed., Wiley, 1989.
- Schultz, W. "[History of Fatigue](#)", *Engineering Fracture Mechanics*, 54(2), pp. 263-300, 1996.
- Anderson, TL *Fracture Mechanics – Fundamentals and Applications*, 2nd ed., CRC Press, 1995.

3) Course Outline

Section 1 Design Approaches (notes)

- Safe life, fail-safe, damage tolerance

Section 2 Material failure (Schijve Chapter 2)

- Overview: initiation vs growth
- Factors affecting failure, engineering parameters (K_t vs K)

Section 3 Basic fatigue and fracture mechanics (Schijve, Chapters 2-8)

- Stress life, S-N, mean stress effects, stress amplitude/range, strain life
- Notches
- Stress intensity, crack growth, da/dN
- Linear elastic fracture mechanics (LEFM)
- Elastic-plastic fracture mechanics (EPFM)

Section 4 Load spectra

- Spectra (Schijve Chapter 9)
- Damage accumulation (Schijve Chapters 10 and 11)

Section 5 Fatigue testing

- Basic setup
- Uncertainties (Schijve Chapter 13)
- Scatter (Schijve Chapter 12)

Section 6 Conditions affecting fatigue

- Surface treatments (Schijve Chapter 14)
- Corrosion (Schijve Chapters 15 and 16)
- Temperature (Schijve Chapter 17)

Section 7 Joints

- Assembled joints (Schijve Chapter 18)
- Welded joints (Schijve Chapter 19)

Section 8 (time permitting) Non-metallic materials

- Ceramics (notes)

4) Evaluation and Marking Scheme

Case study	20%
Quizzes (x2)	20%
Final Exam	60%

a) Term work

Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3) days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. Consult section 4.4 of the University Calendar:

<https://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/examinations/#deferred-term-work>

b) Final Examination

i) Final exams are for evaluation purpose and will not be returned to students.

ii) Students who are unable to write the final examination because of a serious illness/emergency or other circumstances beyond their control may apply for accommodation by contacting the Registrar's office. Consult the Section 4.3 of the University Calendar:

<https://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/examinations/>

5) Academic dates

Students should be aware of the academic dates (eg. last day for academic withdrawal) posted on the Registrar's office web site <https://carleton.ca/registrar/registration/dates/academic-dates/>

6) Academic Integrity and Plagiarism

a) Please consult the Faculty of Engineering and Design information page about the Academic Integrity policy and our procedures: <https://carleton.ca/engineering-design/current-students/fed-academic-integrity> Violations of the Academic Integrity Policy will result in the assignment of a penalty such as reduced grades, the assignment of an F in a course, a suspension or, expulsion.

b) One of the main objectives of the Academic Integrity Policy is to ensure that **the work you submit is your own**. As a result, it is important to write your own solutions when studying and preparing with other students and to avoid plagiarism in your submissions. The University Academic Integrity Policy defines plagiarism as “presenting,

whether intentionally or not, the ideas, expression of ideas or work of others as one's own." This includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source.

Examples of violations of the policy include, but are not limited to:

- any submission prepared in whole or in part, by someone else;
- using another's data or research findings without appropriate acknowledgement;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own; and
- failing to acknowledge sources of information through the use of proper citations when using another's work and/or failing to use quotations marks.

7) Copyright

The materials (including the course outline and any slides, posted notes, videos, labs, project, assignments, quizzes, exams and solutions) created for this course and posted on this web site are intended for personal use and may not be reproduced or redistributed or posted on any web site without prior written permission from the author(s).

8) Academic Accommodations

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Pregnancy obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For accommodation regarding a formally-scheduled final exam, you must complete the Pregnancy Accommodation Form ([click here](#)).

Religious obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details [click here](#).

Academic Accommodations for Students with Disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities

(LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable).

Survivors of Sexual Violence: As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: <https://carleton.ca/equity/sexual-assault-support-services>

Accommodation for Student Activities: Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation will be provided to students who compete or perform at the national or international level. Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. <https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf>

9) Student Mental Health Services

As a University student you may experience a range of mental health challenges that significantly impact your academic success and overall well-being. Carleton's Wellness Services Navigator <https://wellness.carleton.ca/navigator/> is designed to help students connect with mental health and wellness resources. If you need to talk to someone, please reach out for assistance: <https://carleton.ca/health/emergencies-and-crisis/>.

10) Special Information for Pandemic measures

It is important to remember that COVID is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. There are [a number of actions you can take](#) to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you're sick, washing your hands and maintaining proper respiratory and cough etiquette.

Feeling sick? Remaining vigilant and not attending work or school when sick or with symptoms is critically important. If you feel ill or exhibit COVID-19 symptoms do not come to class or campus. If you feel ill or exhibit symptoms while on campus or in class, please leave campus immediately. In all situations, you must follow Carleton's [symptom reporting protocols](#).

Masks: Carleton has paused the [COVID-19 Mask Policy](#), but continues to strongly recommend masking when indoors, particularly if physical distancing cannot be maintained. It may become necessary to quickly reinstate the mask requirement if pandemic circumstances were to change.

Vaccines: Further, while proof of vaccination is no longer required as of May 1 to attend campus or in-person activity, it may become necessary for the University to bring back proof of vaccination requirements on short notice if the situation and public health advice changes. Students are strongly encouraged to get a full course of vaccination, including booster doses as soon as they are eligible, and submit their booster dose information in [cuScreen](#) as soon as possible. Please note that Carleton cannot guarantee that it will be able to offer virtual or hybrid learning options for those who are unable to attend the campus.

All members of the Carleton community are required to follow requirements and guidelines regarding health and safety which may change from time to time. For the most recent information about Carleton's COVID-19 response and health and safety requirements please see the [University's COVID-19 website](#) and review the [Frequently Asked Questions \(FAQs\)](#). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca.