MECH4900

Mechanics of Fracture and Fatigue

Term 3, 2021

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Jay Kruzic	j.kruzic@unsw.edu.au	All course material questions should be directed to the Moodle Q & A forum. Confidential questions (e.g., marks) can use email or MS Teams private chat.	Ainsworth Building (J17), level 3, room 311F	02 9385 4017

Demonstrators

Name	Email	Availability	Location	Phone
Moses James Paul	moses.jamespaul@unsw.edu.au	All course material questions should be directed to the Moodle Q & A forum. Confidential questions (e.g., marks) can use email or MS Teams private chat.		
Qian Liu	qian.liu@unsw.edu.au	All course material questions should be directed to the Moodle Q & A forum. Confidential questions (e.g., marks) can use email or MS Teams private chat.		

School Contact Information

Location

UNSW Mechanical and Manufacturing Engineering

Ainsworth building J17, Level 1

Above Coffee on Campus

Hours

9:00–5:00pm, Monday–Friday*

*Closed on public holidays, School scheduled events and University Shutdown

Web

School of Mechanical and Manufacturing Engineering

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

(+61 2) 9385 4097 – School Office**

**Please note that the School Office will not know when/if your course convenor is on campus or available

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries

- e.g. admissions, fees, programs, credit transfer

School Office – School general office administration enquiries

- NB: the relevant teams listed above must be contacted for all student enquiries. The School will only be able to refer students on to the relevant team if contacted

Important Links

- Student Wellbeing
- Urgent Mental Health & Support
- Equitable Learning Services
- Faculty Transitional Arrangements for COVID-19
- Moodle
- Lab Access
- Computing Facilities
- Student Resources
- Course Outlines
- Makerspace
- UNSW Timetable
- UNSW Handbook

Course Details

Units of Credit 6

Summary of the Course

Topics

Theories of fracture; failure modes. Ductile, brittle fracture. Mechanics of crack propagation, arrest. Measurement of static fracture properties. Fatigue crack initiation, propagation. Engineering aspects of fatigue.

Summary

This course is an advanced course in the mechanics of solids. The course introduces the students to the terminology, principles, methods and practice used to safeguard structures against fracture and fatigue failures. In particular, the course teaches students to perform “damage tolerance analysis” of structures that are pertinent in design of advanced structures such as aerospace, naval, automobile structural components.

Aims

The first aim of this course is to develop an understanding of the influence of cracks and flaws on the performance of structural materials subject to mechanical loads. The second aim of this course is learn how to quantitatively predict and prevent the failure of materials that contain cracks or flaws.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Correctly apply linear elastic fracture mechanics (LEFM) to predict material failure	PE1.1, PE1.2, PE1.3, PE2.1, PE2.2
2. Identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis	PE1.1, PE1.3, PE2.1, PE2.2
3. Correctly determine the linear elastic fracture toughness, KIc, of a material from experimental data	PE1.1, PE1.2, PE1.3, PE2.1, PE2.2
4. Correctly predict lifetimes for fatigue and environmentally assisted cracking	PE1.1, PE1.2, PE1.3, PE2.1, PE2.2

Teaching Strategies

Please refer to the information in Moodle

Assessment

Please refer to Moodle for the assignments and the relevant templates to complete them.

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. KIc Assignment	15%	Friday 23:59 Week 5	1, 2, 3, 4
2. Final Examination	45%	TBD	1, 2, 3, 4
3. Final Assignment	16%	Friday 23:59 Week 10	1, 2, 4
4. Quizzes	24%	Friday 23:59 Week 3; Monday 23:59 Week 7; Friday 23:59 Week 9	1, 2, 3, 4

Assessment 1: KIc Assignment

Assessment length: 2 weeks to complete
Due date: Friday 23:59 Week 5
Deadline for absolute fail: 96 hours after due date
Marks returned: Two weeks after submission

Students will follow the ASTM standard E399 to determine KIc using real experimental data.

Assessment criteria

Students will be assessed on their answers they provide to a problem set related to calculating KIc and following the ASTM standard E399.

Assessment 2: Final Examination

Start date: TBD
Assessment length: 2 hours to complete the exam
Due date: TBD

Comprehensive final examination

Assessment criteria

Students will be assess based on their answers to a mixture of True-False questions, short answer questions, and several calculation questions.

Assessment 3: Final Assignment

Assessment length: Two weeks to complete
Due date: Friday 23:59 Week 10
Deadline for absolute fail: 96 hours after due date
Marks returned: Two weeks after submission

Problem set based on literature readings and case studies

Assessment criteria

Students will be assessed on their answers they provide to a problem set related to independent readings and based on a short Moodle quiz on the readings.

Assessment 4: Quizzes

Assessment length: 30 minutes to complete each quiz
Due date: Friday 23:59 Week 3; Monday 23:59 Week 7; Friday 23:59 Week 9
Deadline for absolute fail: After quiz closes
Marks returned: Within one week of quiz close

3 Moodle Quizzes

Assessment criteria

Students will be assess based on their answers to 10 True-False questions, several multiple choice questions, and a calculation question.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 13 September - 17 September	Lecture	Introduction, Solid Mechanics Review, Elastic Stress Concentrations, Griffith's Theory of Fracture, Strain Energy Release Rate
	Reading	Book: Chapters 1; 2.0-2.4
	Workshop	**Workshop 1:** None **Workshop 2:** None
Week 2: 20 September - 24 September	Lecture	Stress Analysis of Cracks, Fracture Toughness, Superposition, Connecting the fracture theories, Critical Crack Sizes (NDE, Ductile vs. Brittle), Crack Tip Plasticity
	Reading	Book: Chapters 2.6-2.9
	Workshop	**Workshop 1:** Problem set 1 **Workshop 2:** Examples: Fracture, Leak before Break
Week 3: 27 September - 1 October	Lecture	Crack Tip Plasticity Example, Plane Stress vs. Strain, Plastic Constraint, CTODs, KIc Testing
	Reading	Book: Chapters 2.10; 3.1; 7.0-7.2; ASTM Standard E399 (on Moodle)
	Workshop	**Workshop 1:** Problem set 2 **Workshop 2:** KIc Testing Video + Assignment and Quiz Preparation Q&A
	Assessment	Quiz 1 (Moodle) **Friday 1 October, 6:00 - 23:59**
Week 4: 4 October - 8 October	Lecture	Mixed-mode fracture, R-curves, R-curve testing, Elastic-plastic fracture mechanics (EPFM), J-integral, JIc testing

	Reading	Book: Chapters 2.5; 2.11 3.0-3.5; 7.3-7.4
	Workshop	**Workshop 1:** Problem set 3 **Workshop 2:** Composite fracture
Week 5: 11 October - 15 October	Lecture	JIc testing, JIc vs. KIc, Ductile Fracture Mechanisms, Brittle Fracture Mechanisms
	Reading	Book: Chapters 5.0-5.2, 5.4; 6.1
	Workshop	**Workshop 1:** Problem set 4 **Workshop 2:** KIc Assignment Q&A; Quiz Preparation Q&A
	Assessment	KIc Assignment due Friday 23:59 in Moodle
Week 6: 18 October - 22 October	Lecture	None – Flexibility Week
	Reading	None – Flexibility Week
	Workshop	None – Flexibility Week
Week 7: 25 October - 29 October	Lecture	Brittle Fracture Mechanisms, Ductile to Brittle Transition, Toughening Mechanisms for Ductile and Brittle Materials. Embrittlement Mechanisms
	Reading	Book: Chapters 5.3; 6.2
	Workshop	**Workshop 1:** Problem set 5 **Workshop 2:** Fracture Surface Identification
	Assessment	Quiz 2 (Moodle) **Monday 25 October, 6:00 - 23:59**
Week 8: 1 November - 5 November	Lecture	Embrittlement Mechanisms, Environmentally Assisted Crack Growth, Damage Tolerant Lifetime Predictions, EAC Test Methods, EAC Case Studies, Fatigue, Fatigue Life Analysis
	Reading	Book: Chapters 11.0-11.4; 11.6 PDF file of notes (on Moodle)
	Workshop	**Workshop 1:** Problem Set 6 **Workshop 2:** EAC Lifetime Example
Week 9: 8 November - 12 November	Lecture	Fatigue Life Analysis, Fatigue Crack Initiation, Damage Tolerant Lifetime Predictions, Fatigue Crack Growth Testing

	Reading	Book: Chapters 10.0-10.3*; 10.9-10.10* *For CH10 chapter numbers are different for 3rd and 4th editions of the textbook. For 3rd edition, read 10.0-10.5; 10.7-10.9
	Workshop	**Workshop 1:** Problem Set 7 **Workshop 2:** Aero Case Studies; Quiz Preparation Q&A
	Assessment	Quiz 3 (Moodle) **Friday 12 November, 6:00 - 23:59**
Week 10: 15 November - 19 November	Lecture	*Fatigue Crack Growth Mechanisms,* Polymer Fatigue, Brittle Fatigue, Crack Closure, Corrosion Fatigue, Fatigue Fractography
	Reading	Book: Chapters 10.4-10.6*; 10.8*, 11.5 *For CH10 chapter numbers are different for 3rd and 4th editions of the textbook. For 3rd edition, read 10.0-10.5; 10.7-10.9
	Workshop	**Workshop 1:** Problem Set 8 **Workshop 2:** Final Assignment Q&A
	Assessment	Final Assignment due Friday 23:59 in Moodle

Resources

Prescribed Resources

Required Readings:

1. Textbook: Anderson T L, “Fracture Mechanics: Fundamentals and Applications”, 4th Edition, CRC Press, 2017. Note: Online version of 3rd edition is available on the UNSW Library Website and that edition is fine too.
2. ASTM Standard E399, “Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness *K*Ic of Metallic Materials,” ASTM International, will be available on Moodle
3. PDF File of Notes will be available on Moodle

UNSW Library website: https://www.library.unsw.edu.au/

Moodle: https://moodle.telt.unsw.edu.au/login/index.php

Recommended Resources

Additional Suggested Readings:

- Robert P. Wei, “Fracture Mechanics: Integration of Mechanics, Materials Science and Chemistry,” 1st Edition, Cambridge University Press, 2010. Online version is available on the UNSW Library Website
- Richard Hertzberg, “Deformation and Fracture Mechanics of Engineering Materials,” John Wiley and Sons. 1st – 3rd editions available at UNSW Library
- Subra Suresh, “Fatigue of Materials,” Cambridge University Press. 1st – 2nd editions available at UNSW Library
- Murakami Y, “Stress Intensity Factors Handbook”, Vols 1&2, Pergamon Press, 1987. Available at UNSW Library
- Aliabadi M H, “Database of Stress Intensity Factors”, UK (1996). Available at UNSW Library

UNSW Library website: https://www.library.unsw.edu.au/

Course Evaluation and Development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience process, informal feedback from students given to lecturers and demonstrators, and the School’s Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based on such feedback.

This is a course I developed and improved with over 12 years of student feedback in the USA, and 4 years of student feedback at UNSW. I look forward to your feedback and I strive for continued improvement here at UNSW.

Submission of Assessment Tasks

Assessment submission and marking criteria

Should the course have any non-electronic assessment submission, these should have a standard School cover sheet.

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work and should be treated with due respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

Marking guidelines for assignment submissions will be provided at the same time as assignment details to assist with meeting assessable requirements. Submissions will be marked according to the marking guidelines provided.

Late policy

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of 20 percent (20%) of the maximum mark possible for that assessment item, per calendar day, for a minimum of zero marks.

The late penalty is applied per calendar day (or part thereof), including weekends and public holidays, that the assessment is overdue.

Work submitted after the ‘deadline for absolute fail’ is not accepted and a mark of zero will be awarded for that assessment item. For example:

- Your course has an assessment task worth a total of **30 marks (Max Possible Mark)**
- You submit the assessment **2 days after the due date**
- The assessment is marked as usual and achieves a score of **20 marks (Awarded Mark)**
- The late policy is applied using **Late Mark = Awarded Mark - (Days*Penalty per Day)*Max Possible Mark**. Your adjusted final score is **8 marks** (20 - ((2*0.2)*30)).

For some assessment items, a late penalty may not be appropriate. These are clearly indicated in the course outline, and such assessments receive a mark of zero if not completed by the specified date. Examples include:

1. Weekly online tests or laboratory work worth a small proportion of the subject mark, or
2. Online quizzes where answers are released to students on completion, or
3. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
4. Pass/Fail assessment tasks.

Examinations

You must be available for all quizzes, tests and examinations. For courses that have final examinations, these are held during the University examination periods: February for Summer Term, May for T1, August for T2, and November/December for T3.

Please visit myUNSW for Provisional Examination timetable publish dates. For further information on

exams, please see the Exams webpage.

Special Consideration

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to submitting an assessment or sitting an exam.

UNSW now has a Fit to Sit / Submit rule, which means that if you attempt an exam or submit a piece of assessment, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's Special Consideration page.

Please note that students will **not** be required to provide **any** documentary evidence to support absences from any classes missed **because of COVID-19 public health measures such as isolation**. UNSW will **not** be insisting on medical certificates from anyone deemed to be a positive case, or when they have recovered. Such certificates are difficult to obtain and put an unnecessary strain on students and medical staff.

Applications for special consideration **will** be required for assessment and participation absences – but no documentary evidence **for COVID-19 illness or isolation** will be required.

Special Consideration Outcomes

Assessments have default Special Consideration outcomes. The default outcome for the assessment will be advised when you apply for Special Consideration. Below is the list of possible outcomes:

Outcome	Explanation	Example
Time extension	Student provided more time to submit the assessment	e.g. 1 more week of time granted to submit a report
Supplementary assessment	Student provided an alternate assessment at a later date/time	e.g. a supplementary exam is scheduled during the supplementary exam period of the term
Substitute item	The mark for the missed assessment is substituted with the mark of another assessment	e.g. mark for Quiz 1 applied also applied as mark for Quiz 2, meaning if a student achieved a mark of 20/30 for Quiz 1 and was granted Special Consideration for Quiz 2, a mark of 20/30 would be applied for Quiz 2, etc
Exemption	All course marks are recalculated excluding this assessment and its weighting	e.g. The course has an assessment structure of: - Assignments 30%, - Lab report 30%, - Final Exam 40%. If the Lab report is missed and student is granted Special Consideration, then the assessment structure may be reweighted as follows: - Assignments 50% - Final Exam 50% as though the Lab report did not exist
Non-standard	Course Coordinator is contacted for the outcome when special consideration is granted as the outcome differs on a case-by-case basis	e.g. typical for group assessments where time extension supplementary assessment could be granted to the group member, time extension could be granted to the whole group, etc. Clarify with your Course Convenor for

Academic Honesty and Plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism, visit: student.unsw.edu.au/plagiarism. The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

If plagiarism is found in your work when you are in first year, your lecturer will offer you assistance to improve your academic skills. They may ask you to look at some online resources, attend the Learning Centre, or sometimes resubmit your work with the problem fixed. However more serious instances in first year, such as stealing another student's work or paying someone to do your work, may be investigated under the Student Misconduct Procedures.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Academic Information

Credit points

Course credit is calculated in Units-Of-Credit (UOC). The normal workload expectation for one UOC is approximately 25 hours per term. This includes class contact hours, private study, other learning activities, preparation and time spent on all assessable work.

Most coursework courses at UNSW are 6 UOC and involve an estimated 150 hours to complete, for both regular and intensive terms. Each course includes a prescribed number of hours per week (h/w) of scheduled face-to-face and/or online contact. Any additional time beyond the prescribed contact hours should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

On-campus class attendance

****T3-2021 UPDATE****
Classes will be entirely ONLINE until at least Week 6, after which we will receive further advice from UNSW about the return of face-to-face classes. Students who are enrolled in face-to-face classes will have access to the course's online content but NO classes will be changed to reflect online delivery until Week 6 due to uncertainty regarding delivery mode for the rest of the term. Please go to your course's Moodle modules and MS Teams sites for further information about accessing course resources and content.

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Public distancing conditions must be followed for all face-to-face classes. To ensure this, only students enrolled in those classes will be allowed in the room. No over-enrolment is allowed in face-to-face classes. Students enrolled in online classes can swap their enrolment from online to a **limited** number of on-campus classes by Sunday, Week 1. Please refer to your course's Microsoft Teams and Moodle sites for more information about class attendance for in-person and online class sections/activities.

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate.** We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed. Further information is available on any course Moodle or Teams site.

In certain classroom and laboratory situations where physical distancing cannot be maintained or there is a high risk that it cannot be maintained, face masks will be considered **mandatory PPE** for students and staff.

For more information, please refer to the
FAQs: https://www.covid-19.unsw.edu.au/safe-return-campus-faqs

Guidelines

All students are expected to read and be familiar with UNSW guidelines and polices. In particular,

students should be familiar with the following:

- Attendance
- UNSW Email Address
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism

Image Credit

Photo by Stephen Blake March 2017, Willis Annexe (J18) Thermofluids lab

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering problem solving	✓
PE2.2 Fluent application of engineering techniques, tools and resources	✓
PE2.3 Application of systematic engineering synthesis and design processes	
PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in professional and lay domains	
PE3.3 Creative, innovative and pro-active demeanour	
PE3.4 Professional use and management of information	
PE3.5 Orderly management of self, and professional conduct	
PE3.6 Effective team membership and team leadership	