MECH4900

Mechanics of Fracture and Fatigue

Term Three // 2020

School of Mechanical and Manufacturing Engineering // UNSW Engineering

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Jay Kruzic	j.kruzic@unsw.edu.au	MS Teams is best forum for Q&A	Ainsworth Building (J17), level 3, room 311F	02 9385 4017

Demonstrators

Name	Email	Availability	Location	Phone
Halsey Ostergaard	h.ostergaard@unsw.edu.au	MS Teams is best forum for Q&A		
Moses James Paul	moses.jamespaul@unsw.edu.au	MS Teams is best forum for Q&A		
Yuwan Huang	yuwan.huang@unsw.edu.au	MS Teams is best forum for Q&A		

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

Course Details

Credit Points 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.

Course 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

Component	Expectations
Lectures	• Find out what you must learn • Observe alternative presentations of textbook topics and learn

	about their significance • Learn information that is not in the textbook • Learn about course updates and changes
Tutorials	• Ask questions • Learn information that is not in the textbook • Learn from worked examples • Work through problems guided by demonstrators • Work with fellow students
Private Study	• Read assigned textbook chapters and digital files • Review lecture and tutorial materials • Complete problem sets, assignments, and Moodle quizzes • Monitor notices and download course materials from Teams/Moodle

Assessment

Assessment Tasks

Assessment task	Weight	Due Date	Student Learning Outcomes Assessed
Quizzes	24%	Weeks 3, 7, 9	1, 2, 3, 4
KIC Assignment	15%	16/10/2020 11:59 PM	1, 2, 3, 4
Final Examination	45%	TBD	1, 2, 3, 4
Final Assignment	16%	20/11/2020 11:59 PM	1, 2, 4

Assessment Details

Assessment 1: Quizzes

Start date: Weeks 3, 7, 9

Details:

3 Moodle Quizzes

Assessment 2: KIC Assignment

Start date: Week 4

Details:

Students will complete an assignment based on actual fracture toughness test data.

Assessment 3: Final Examination

Start date: TBD

Details:

Comprehensive final examination

Assessment 4: Final Assignment

Start date: TBD

Details:

Problem set based on literature readings and/or case studies

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: 14 September - 18 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
	Tutorial	**Tutorial 1:** None **Tutorial 2:** Week 1 Problem Set
Week 2: 21 September - 25 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
	Tutorial	**Tutorial 1:** Example Problems: Fracture and Leak Before Break **Tutorial 2:** Week 2 Problem Set
Week 3: 28 September - 2 October	Lecture	Plane Stress vs. Strain, Plastic Constraint, CTODs, Mixed-Mode Fracture, R-curves
	Reading	Book: Chapters 2.5; 2.10 - 2.11; 3.1; 7.0 - 7.2 ASTM Standard E399 "Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness of Metallic Materials"
	Tutorial	**Tutorial 1:** Example Problem on Crack Tip Plasticity, KIc Testing Overview **Tutorial 2:** Week 3 Problem Set
	Assessment	Quiz 1 (Moodle)
Week 4: 5 October - 9 October	Lecture	None: Public Holiday – Labour Day
	Reading	ASTM Standard E399 "Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness of Metallic Materials"
	Tutorial	**Tutorial 1:** KIc Testing Video + Assignment **Tutorial 2:** Week 4 Problem Set
Week 5: 12 October - 16 October	Lecture	Elastic-plastic fracture mechanics (EPFM), J-integral, Ductile Fracture Mechanisms, Brittle Fracture Mechanisms

	Reading	Book: Chapters 3.0 - 3.5; 7.3 - 7.4; 5.0 - 5.1; 5.4; 6.1
	Tutorial	**Tutorial 1:** R-curve & JIc Testing Overview, KIc Assignment Q&A **Tutorial 2:** Week 5 Problem Set; KIc Assignment Q&A
	Assessment	KIc assignment is due Friday at 23:59.
Week 6: 19 October - 23 October	Lecture	None – Flexibility Week
	Reading	None – Flexibility Week
	Tutorial	None – Flexibility Week
Week 7: 26 October - 30 October	Lecture	Brittle Fracture Mechanisms, Ductile to Brittle Transition, Toughening Mechanisms for Brittle Materials
	Reading	Book: Chapters 5.2 - 5.3; 6.2
	Tutorial	**Tutorial 1:** Fracture Surface Identification **Tutorial 2:** Week 7 Problem Set
	Assessment	Quiz 2 (Moodle)
Week 8: 2 November - 6 November	Lecture	Toughening Metals, Embrittlement Mechanisms, Environmentally Assisted Crack Growth (EAC), Damage Tolerant Lifetime Predictions, EAC Test Methods, EAC Case Studies
	Reading	Book: Chapters 11.0 - 11.4; 11.6
	Tutorial	**Tutorial 1:** Example Problem on EAC Lifetime Prediction **Tutorial 2:** Week 8 Problem Set
Week 9: 9 November - 13 November	Lecture	Fatigue, Fatigue Life Analysis, Fatigue Crack Initiation
	Reading	PDF File of Notes
	Tutorial	**Tutorial 1:** Composite Fracture **Tutorial 2:** Week 9 Problem Set
	Assessment	Quiz 3 (Moodle)
Week 10: 16 November - 20 November	Lecture	Damage Tolerant Lifetime Predictions, Fatigue Crack Growth Testing, Fatigue Crack Growth Mechanisms, Fatigue Fractography
	Reading	Book: Chapters 10.0 - 10.3*; 10.5 - 10.6*; 10.8 - 10.10* *Note: For chapter 10, the chapter numbers are different for 3rd and 4th editions of the textbook. If you are using the 3rd edition, read chapters 10.0-10.2; 10.4-10.5; 10.7-10.9
	Tutorial	**Tutorial 1:** Aero Case Studies **Tutorial 2:** Week 10 Problem Set

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.
3. PDF File of Notes

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 3 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.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day.

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

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 in T3.

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. 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

Public distancing conditions must be followed for all T3 face-to-face classes. To ensure this, only students enrolled in those classes will be allowed in the room. Class rosters will be attached to corresponding rooms and circulated among lab demonstrators. No over-enrolment is allowed in face-to-face class. Students enrolled in online classes can swap their enrolment from online to other additional, **but 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 1.5 metres 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

Other Matters

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

Important Links

- Moodle
- Lab Access
- Health and Safety
- Computing Facilities
- Student Resources
- Course Outlines
- Engineering Student Support Services Centre
- Makerspace
- UNSW Timetable
- UNSW Handbook
- UNSW Mechanical and Manufacturing Engineering
- Equitable Learning Services

Image Credit

Synergies in Sound 2016

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	