UNSW Course Outline

MECH4900 Mechanics of Fracture and Fatigue - 2024

Published on the 20 May 2024

General Course Information

Course Code : MECH4900
Year : 2024
Term : Term 2
Teaching Period : T2
Is a multi-term course? : No
Faculty : Faculty of Engineering
Academic Unit : School of Mechanical and Manufacturing Engineering
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Postgraduate, Undergraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

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.

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.

Course Aims

This course aims to develop the students' understanding of the influence of cracks and flaws on the performance of structural materials subject to mechanical loads and how to quantitatively predict and prevent the failure of materials that contain cracks or flaws.

This course builds on the students' understanding of mechanics of materials.

This course teaches students how to analyze mechanical engineering problems to ensure safety and reliability against fracture and fatigue.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Apply linear elastic fracture mechanics (LEFM) to predict material failure
CLO2 : Identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis
CLO3 : Determine the linear elastic fracture toughness, KIC, of a material from experimental data
CLO4 : Predict lifetimes for fatigue and environmentally assisted cracking

Course Learning Outcomes	Assessment Item
CLO1 : Apply linear elastic fracture mechanics (LEFM) to predict material failure	• Quizes • KIC Assignment • Final Assignment • Final Examination
CLO2 : Identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis	• Quizes • KIC Assignment • Final Assignment • Final Examination
CLO3 : Determine the linear elastic fracture toughness, KIC, of a material from experimental data	• Quizes • KIC Assignment • Final Examination
CLO4 : Predict lifetimes for fatigue and environmentally assisted cracking	• Final Assignment • Quizes • KIC Assignment • Final Examination

Learning and Teaching Technologies

Moodle - Learning Management System | Microsoft Teams | Echo 360

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Quizes Assessment Format: Individual	24%	Start Date: Various Due Date: Various
KIC Assignment Assessment Format: Individual	15%	Start Date: 14/06/2024 11:59 PM Due Date: 28/06/2024 11:59 PM
Final Assignment Assessment Format: Individual	16%	Start Date: 19/07/2024 11:59 PM Due Date: 02/08/2024 11:59 PM
Final Examination Assessment Format: Individual	45%	Start Date: Not Applicable Due Date: Not Applicable

Assessment Details

Quizes

Assessment Overview

3 Moodle Quizes

Students will be assessed on their ability to answer true-false questions, multiple choice questions, and one calculation problem on each quiz.

Marks will be returned after LMS grading is checked and verified as accurate, within one week or sooner. Quiz solution review will be open for one week after marks are released.

Course Learning Outcomes

- CLO1 : Apply linear elastic fracture mechanics (LEFM) to predict material failure
- CLO2 : Identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis
- CLO3 : Determine the linear elastic fracture toughness, KIC, of a material from experimental data
- CLO4 : Predict lifetimes for fatigue and environmentally assisted cracking

Detailed Assessment Description

Purpose: To test knowledge of class content, to test problem solving ability, and to prepare for the final exam format.

Assessment Length

30 minutes to complete each quiz on specified day

Submission notes

Mark of zero will be assigned if quiz is not completed on the specified date. Supplementary quiz can only be given if a special consideration is granted.

Assessment information

Marks will be returned after Moodle grading is checked and verified as accurate, within one week or sooner. Quiz solution review will be open for one week after marks are released.

Assignment submission Turnitin type

Not Applicable

KIC Assignment

Assessment Overview

Students will complete an assignment based on data from a laboratory demonstration. Students will be assessed on their ability to answer both quantitative and qualitative questions. Feedback will be provided via comments on the marked assignment.

Course Learning Outcomes

- CLO1 : Apply linear elastic fracture mechanics (LEFM) to predict material failure
- CLO2 : Identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis
- CLO3 : Determine the linear elastic fracture toughness, KIC, of a material from experimental data
- CLO4 : Predict lifetimes for fatigue and environmentally assisted cracking

Detailed Assessment Description

Purpose: To test the ability of the students to apply their class knowledge to real world data analysis.

Assessment Length

2 weeks to complete

Submission notes

Standard late submission policy will apply.

Assessment information

Marks will be returned within two weeks of submission deadline.

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students do not see Turnitin similarity

reports.

Final Assignment

Assessment Overview

Problem set based on literature readings and case studies. Students will be assessed on their ability to answer both quantitative and qualitative questions. Feedback will be provided via comments on the marked assignment.

Course Learning Outcomes

- CLO1 : Apply linear elastic fracture mechanics (LEFM) to predict material failure
- CLO2 : Identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis
- CLO4 : Predict lifetimes for fatigue and environmentally assisted cracking

Detailed Assessment Description

Purpose: To test the ability of the students to apply their class knowledge to understand real world issues regarding the fracture and fatigue of materials based on published literature case studies and examples.

Assessment Length

Two weeks to complete

Submission notes

Standard late submission policy will apply.

Assessment information

Marks will be returned within two weeks of submission deadline.

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Final Examination

Assessment Overview

Comprehensive final examination, Students will be assessed on their ability to answer true-false questions, multiple choice questions, short answer questions, and calculation problems.

2 hours to complete the exam. Final exam marking review is available by submitting an application for review of results.

Course Learning Outcomes

- CLO1 : Apply linear elastic fracture mechanics (LEFM) to predict material failure
- CLO2 : Identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis
- CLO3 : Determine the linear elastic fracture toughness, KIC, of a material from experimental data
- CLO4 : Predict lifetimes for fatigue and environmentally assisted cracking

Detailed Assessment Description

Purpose: To test knowledge of class content and problem solving ability.

Assessment Length

2 hours to complete the exam

Submission notes

Mark of zero will be assigned if exam is not completed at the specified date/time.

Supplementary exam can only be given if a special consideration is granted.

Assignment submission Turnitin type

Not Applicable

General Assessment Information

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

Grading Basis

Standard

Requirements to pass course

Achieve a composite mark of at least 50 out of 100.

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 27 May - 2 June	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 : 3 June - 9 June	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 Problem, Leak Before Break Problem
Week 3 : 10 June - 16 June	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 (links available on MS Teams and Moodle)
	Workshop	Workshop 1: Problem set 2
	Laboratory	KIc Testing Demonstration: In small groups, you will observe a KIc fracture toughness testing demonstration and take post-test sample measurments to create the data set for your KIc assignment. You will only attend the laboratory during your group's assinged timeslot. (You will not need to attend the full 3 hours.)
	Assessment	Quiz 1 (30 minute duration, in Moodle, link will be provided on MS Teams) Quiz open during Friday 14 June, 12:00 - 23:59
Week 4 : 17 June - 23 June	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, KIc Assignment Q&A
Week 5 : 24 June - 30 June	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 via Turnitin/Moodle (link will be provided on MS Teams)
Week 6 : 1 July - 7 July	Lecture	None – Flexibility Week
	Reading	None – Flexibility Week
	Workshop	None – Flexibility Week
Week 7 : 8 July - 14 July	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 (30 minute duration, in Moodle, link will be provided on MS Teams) Quiz open during Monday 8 July, 12:00 - 23:59
Week 8 : 15 July - 21 July	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 fatigue (links available on MS Teams and Moodle)
	Workshop	Workshop 1: Explanation of common KIc assignment mistakes with Q&A, Problem Set 6 Workshop 2: EAC Lifetime Example
Week 9 : 22 July - 28 July	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 PDF file of notes on fatigue (links available on MS Teams and Moodle)
	Workshop	Workshop 1: Problem Set 7 Workshop 2: Problem Set 7 cont'd, Quiz Preparation Q&A, Final Assignment Q&A
	Assessment	Quiz 3 (30 minute duration, in Moodle, link will be provided on MS Teams)

		Quiz open during Friday 26 July, 12:00 - 23:59
Week 10 : 29 July - 4 August	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: Problem Set 8 cont'd, Final Assignment Q&A
	Assessment	Final Assignment due Friday 23:59 in Turnitin/Moodle, link will be provided on MS Teams

Attendance Requirements

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

Course 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.

- Print: https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781498728133
- Digital: https://unswbookshop.vitalsource.com/products/-v9781498728140
- A free online version of 3rd edition is available at this Link through the UNSW Library Website. It is fine to use this edition also.

2) ASTM Standard E399, “Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness KIc of Metallic Materials,” ASTM International, will be available as a PDF file with links on Moodle and MS Teams

3) PDF file of notes on Fatigue will be available with links on Moodle and MS Teams

MS Teams: You will be automatically added to the MECH4900 T3 2023 Team

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 7 years of student feedback at UNSW. I look forward to your feedback and I strive for continued improvement here at UNSW.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Jay Kruzic		Ainsworth Building (J17), level 3, room 311F	02 9385 4017	All course material questions should be directed to the MS Teams Q & A forums. Confidential questions (e.g., marks) can use email or MS Teams private chat.	No	Yes
Demonstrator	Qian Liu				All course material questions should be directed to the MS Teams Q & A forums. Confidential questions (e.g., marks) can use email or MS Teams private chat.	No	No
	Yuwan Huang				All course material questions should be directed to the MS Teams Q & A forums. Confidential questions (e.g., marks) can use email or MS Teams private chat.	No	No
	Harvey Ling				All course material questions should be directed to the MS Teams Q & A forums. Confidential questions (e.g., marks) can use email or MS Teams private chat.	No	No
	Rais Alfiansyah Taufiq				All course material questions should be directed to the MS Teams Q & A forums. Confidential questions (e.g., marks) can use email or MS Teams private chat.	No	No

Other Useful Information

Academic Information

I. Special consideration and supplementary assessment

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, or within 3 working days of, submitting an assessment or sitting an exam.

Please note that UNSW has a Fit to Sit rule, which means that if you sit an exam, 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.

II. Administrative matters and links

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
- Equitable Learning Services

III. Equity and diversity

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equitable Learning Services. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

IV. Professional Outcomes and Program Design

Students are able to review the relevant professional outcomes and program designs for their streams by going to the following link: https://www.unsw.edu.au/engineering/student-life/student-resources/program-design.

Note: This course outline sets out the description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle or your primary learning management system (LMS) should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline/Moodle/LMS, the description in the Course Outline/Moodle/LMS applies.

Academic Honesty and Plagarism

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.

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 or contract cheating) even suspension from the university. The Student Misconduct Procedures are available here:

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

Submission of Assessment Tasks

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of five percent (5%) 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. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be 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 will be clearly indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

- Weekly online tests or laboratory work worth a small proportion of the subject mark;
- Exams, peer feedback and team evaluation surveys;
- Online quizzes where answers are released to students on completion;

- Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date; and,
- Pass/Fail assessment tasks.

Faculty-specific Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, 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

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)

School-specific Information

Short Extensions

Short extensions are not currently applicable to Mechanical and Manufacturing Engineering Courses.

Review of Results

The purpose of a review of results is if there was a marking error. Review of results is for when you have cause to believe that there is a marking error. Review of Results cannot be used to get feedback. If you would like feedback for assessments prior to the final exam, you are welcome to contact the course convenor directly. No feedback will be provided on final exams.

Use of AI

The use of AI is prohibited unless explicitly permitted by the course convenor. Please respect this and be aware that penalties will apply when unauthorised use is detected, such as through Turnitin. If the use of generative AI, such as ChatGPT, is allowed in a specific assessment, they must be properly credited, and your submissions must be substantially your own work.

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