UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Term 3 2019

MECH4900

MECHANICS OF FRACTURE AND FATIGUE

Contents

1. Staff contact details

Contact details for course convenor

Name: Professor Jay Kruzic
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Contact details for additional lecturers

Name: Dr. Bernd Gludovatz
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Contact details for demonstrators will be provided on Moodle before the start of semester.

Please see the course Moodle. Consultation concerning this course is available during the tutorial sessions. You may make an appointment by email for additional consultations.

2. Important links

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

3. Course details

Credit points

This is a 6 unit-of-credit (UoC) course and involves 4 hours per week (h/w) of face-to-face contact.

The normal workload expectations of a student are approximately 25 hours per term for each

UOC, including class contact hours, other learning activities, preparation and time spent on all assessable work.

You should aim to spend about 12 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

Contact hours

	Day	**Time**	**Location**	**Weeks**
Lectures	Mondays	10:00 – 12:00	CLB 8	1 – 3 5 – 11
Demonstrations	Tuesdays Thursdays	10:00-11:00 11:00-12:00 12:00-13:00 12:00-13:00 13:00-14:00 14:00-15:00	Elec Eng G17-G10 Elec Eng G17-G10 Ainswth J17-G01 Ainswth J17-202 Ainswth J17-202 Ainswth J17-202	1 – 3 5 – 10
Lab	Thursday	9:00 – 12:00 13:00 – 16:00	J18 - UTL	4*
* Each student will be assigned a lab group, and each lab group will be assigned a specific time for their lab experiments. This will be posted on Moodle during the semester.				

Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes.

Summary and Aims of the course

Handbook Description

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.

Detailed 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 to learn how to quantitatively predict and prevent the failure of materials that contain cracks or flaws.

Student learning outcomes

This course is designed to address the learning outcomes below and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

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	PE 1.1, 1.2, 1.3, 2.1, 2.2
2.	Identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis	PE 1.1, 1.3, 2.1, 2.2
3.	Correctly determine the linear elastic fracture toughness, K_{IC}, of a material from experimental data	PE 1.1, 1.2, 1.3, 2.1, 2.2
4.	Correctly predict lifetimes for fatigue and environmentally assisted cracking	PE 1.1, 1.2, 1.3, 2.1, 2.2

4. Teaching strategies

Component	**Expectations**
Lectures	• Find out what you must learn • Learn information that is not in the textbook • Observe alternative presentations of textbook topics • Follow worked examples • Learn about course updates and changes
Tutorials	• Ask questions • Work example problems • Be guided by demonstrators • Work with fellow students
Laboratories	• Observe physical experiments • Analyse data • Produce complete and accurate report on the data analysis
Private Study	• Read assigned textbook chapters • Review lecture material • Complete problem sets, assignments, and Moodle quizzes • Monitor notices and download course materials from Moodle

5. Course schedule

The below course schedule is tentative and subject to change. Please do each reading prior to the lecture.

Week	Tentative Lecture Topics	Readings Due	Tutorial 1	Tutorial 2	Assessments
1	Introduction, Solid Mechanics Review, Elastic Stress Concentrations,	Book: Ch1; 2.0-2.2			
2	Griffith's Theory of Fracture, Strain Energy Release Rate Stress Analysis of Cracks, Fracture Toughness, Superposition, Connecting the fracture theories, Critical Crack Sizes (NDE, Ductile vs. Brittle)	Book: 2.3-2.4; 2.6-2.7	Problem set 1	Fracture & Leak before Break Examples	
3	Crack Tip Plasticity, Plane Stress vs. Strain, Plastic Constraint, K_{Ic} testing	Book: 2.8-2.10; 7.0-7.2; ASTM Standard E399 (on Moodle)	Problem set 2	Lab Preparation + Q&A	Moodle Quiz 1 Open: T*BD*
4	Labour Day – Public Holiday	Book: 2.5; 2.11; 3.1	Labs	Labs	
5	CTODs, Mixed-mode fracture, R-curves, R-curve testing, R-curves, R-curve testing, Elastic-plastic fracture mechanics (EPFM),	Book: CH3.0-3.5; 7.3-7.4; 5.0-5.1; 6.1	Problem set 3 & Lab Assignment Questions	Problem set 4 & Lab Assignment Questions	Lab Assignment due Moodle
6	J-integral, J_{Ic} testing, Ductile Fracture Mechanisms	Book: 5.2-5.4; 6.2	Problem set 5	TBD + Q&A	Moodle Quiz 2 Open: TBD
7	Brittle Fracture Mechanisms, Ductile to Brittle Transition, Scanning Electron Microscopy Toughening Mechanisms	Book: 6.1-6.2; 11.0-11.4; 11.6	Problem set 6	Fracture Surface Identification	
8	Toughening Mechanisms Cont'd, Embrittlement Mechanisms Environmentally Assisted Crack Growth, Damage Tolerant Lifetime Predictions, EAC Test Methods	PDF file of notes	Problem Set 7	EAC Lifetime Example	
9	EAC Case Studies, Fatigue, Fatigue Life Analysis	Book: 10.0-10.3*; 10.8-10.10*	Problem Set 8	Comet Case Study	Moodle Quiz 3 Open: TBD
10	Fatigue Crack Initiation, Damage Tolerant Lifetime Predictions, Fatigue Crack Growth Testing, Fatigue Crack Growth Mechanisms	Book: 10.4-10.5*; 11.5	Problem Set 9	Open Q&A for final assignment	Final Assignment due Moodle
11	Crack Closure Effects, Corrosion Fatigue, Fatigue Failure Analysis, Fatigue Fractography Case Studies				
TBC					Final Exam

*For CH10 chapter numbers are different for 3rd and 4th editions of the textbook. For 3rd edition, read CH10.0-10.4 and 10.7-10.9

6. Assessment

Assessment overview

Assessment	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Moodle Quizzes (3x)	30 Minutes	3 x 10% = 30%	1, 2, 4	All class material prior to the quiz	Weeks 3, 6,9 via Moodle, 1 attempt allowed	After quiz closes	After quiz closes
Laboratory Assignment	Format will be posted on Moodle	15%	3	All class material regarding K_{IC} testing	Week 5, upload to Moodle	96 hours after deadline	Two weeks after submission
Final Assignment	Format will be posted on Moodle	10%	1, 2, 4	All course content	Week 10 Friday, upload to Moodle	96 hours after deadline	Two weeks after submission
Final exam	2 hours	45%	1, 2, 4	All course content	Exam period, date TBC	N/A	Upon release of final results

Assignments

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

Laboratory Assignment

You will not be allowed to complete the laboratory assignment if you do not attend your assigned laboratory preparation tutorial and assigned experiment session without advance arrangements.

Presentation

All non-electronic submissions should have a standard School cover sheet, which is available from this course's Moodle page.

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.

Submission

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.

Examinations

You must be available for all tests and examinations. Final examinations for each course are held during the University examination periods: November/December for T3.

Please visit myUNSW for Provisional Examination timetable publish dates.

For further information on exams, please see the Exams webpage.

Calculators

You will need to provide your own calculator of a make and model approved by UNSW for the examinations. The list of approved calculators is available at student.unsw.edu.au/exam-approved-calculators-and-computers

It is your responsibility to ensure that your calculator is of an approved make and model, and to obtain an "Approved" sticker for it from the Engineering Student Supper Services Centre prior to the examination. Calculators not bearing an "Approved" sticker will not be allowed into the examination room.

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 submitting an assessment or sitting an exam.

Please note that UNSW now has a Fit to Sit / Submit rule, which means that if you sit 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.

7. Expected resources for students

Required Readings

- Anderson T L, "Fracture Mechanics: Fundamentals and Applications", 4th Edition, CRC Press, 2017.
    - (Online version of 3rd edition is available on the UNSW Library Website and that edition is fine too)
- ASTM Standard E399, "Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness K_{Ic} of Metallic Materials," ASTM International.
    - (Available on Moodle)

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

8. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience process, informal discussion in the final class for the course, and the School’s Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

This is an adaptation of a course I developed and improved with student feedback over 12 years in the USA, and 2 years at UNSW. I look forward to your feedback and I strive for continued improvement here at UNSW.

9. 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

10. 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
- Computing Facilities
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Disability Support Services
- Health and Safety
- Lab Access

Appendix A: Engineers Australia (EA) Competencies

Stage 1 Competencies for Professional Engineers

	Program Intended Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
	PE1.3 In-depth understanding of specialist bodies of knowledge
	PE1.4 Discernment of knowledge development and research directions
	PE1.5 Knowledge of engineering design practice
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex 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
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability
	PE3.2 Effective oral and written communication (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