UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Semester 2 2018

MECH4900

MECHANICS OF FRACTURE AND FATIGUE

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Professor Jay Kruzic
Office location: J17/311f
Tel: (02) 9385 4017
Email: j.kruzic@unsw.edu.au
Moodle: https://moodle.telt.unsw.edu.au/login/index.php

Contact details and consultation times for demonstrators will be provided on Moodle before the start of semester.

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

Please see the course Moodle.

2. Important links

- Moodle
- UNSW Mechanical and Manufacturing Engineering
- Course Outlines
- Student intranet
- UNSW Mechanical and Manufacturing Engineering Facebook
- UNSW Handbook

3. Course details

Credit Points

This is a 6 unit-of-credit (UoC) course, and involves 3 hours per week (h/w) of face-to-face contact.

The UNSW website states “The normal workload expectations of a student are approximately 25 hours per semester for each UoC, including class contact hours, other learning activities, preparation and time spent on all assessable work. Thus, for a full-time enrolled student, the normal workload, averaged across the 16 weeks of teaching, study and examination periods, is about 37.5 hours per week.”

This means that you should aim to spend about 9 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	Tuesdays	14:00 – 16:00	CLB 8	1 – 12
Demonstrations	Thursdays	14:00-15:00 15:00-16:00 16:00-17:00	Ainswth201 Ainswth201 Ainswth201	2 – 13
	Fridays	12:00-13:00 13:00-14:00 14:00-15:00	Ainswth201 Ainswth201 RedC M010	
Lab	Monday	9:00 – 12:00 13:00 – 16:00	UTL	Week 8*
* 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	Assessments
1	Introduction, Solid Mechanics Review, Elastic Stress Concentrations, Griffith's Theory of Fracture, Strain Energy Release Rate,	Book: CH1, 2.0-2.2-2.4		
2	Stress Analysis of Cracks, Fracture Toughness, Fracture Problem Example 1, Leak before Break Example, Superposition, Connecting the fracture theories, Critical Crack Sizes & NDE	Book: 2.6-2.7	Y	
3	Critical Crack Sizes (Ductile vs. Brittle), Crack Tip Plasticity, Plane Stress/Strain, Plastic Constraint, CTODs	Book: CH2.8-2.10, 3.1	Y	
4	Mixed-mode fracture, K_{Ic} testing, R-curves, R-curve testing	Book: CH 2.5, 2.11, 7.0-7.2 ASTM Standard E399 (on Moodle)	Y	Moodle Quiz 1 Open: Friday – Sunday
5	Elastic-plastic fracture mechanics (EPFM), J-integral, J_{Ic} testing, Application Case Studies	Book: CH3.0-3.5, 7.3-7.4	Y	
6	Ductile and Brittle Fracture Mechanisms, Ductile to Brittle Transition	Book: CH5.0-5.4, 6.1	Y	
7	Scanning Electron Microscopy, Fractography Case Studies, Toughening Mechanisms	Book: CH6.1-6.2	Y	Moodle Quiz 2 Open: Friday – Sunday
8	Embrittlement Mechanisms, Environmentally Assisted Crack Growth, Damage Tolerant Lifetime Predictions, Example Problem, Test Methods, EAC Failure Case Studies	Book: CH11.0-11.4, 11.6	Y + Lab (UTL)	
9	Fatigue, Fatigue Life Analysis	PDF file of class notes	Y	Lab Assignment due Friday on Moodle
10	Fatigue Crack Initiation, Damage Tolerant Lifetime Predictions	PDF file of class notes, Book:	Y	

Week	Tentative Lecture Topics	Readings Due	Tutorial	Assessments
	Example Problem, Fatigue Crack Growth Testing, Fatigue Crack Growth Mechanisms	CH10.0-10.3*, 10.8-10.10*		
11	Crack Closure Effects, Corrosion Fatigue, Failure Analysis, Fatigue Fractography Case Studies	10.4-10.5*, 11.5	Y	
12	Catch up on Previous Topics, Special Topics (TBD)	TBD	Y	Moodle Quiz 3 Open: Friday – Sunday
13	-		Y	PG Assignment
TBD				Final Exam

**For CH10 there are differences in the chapter numbers 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

Undergraduate Students:

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, 7,12 via Moodle, 1 attempt allowed. Open 0:00 Friday to 23:59 Sunday	After quiz closes	After quiz closes and results have been reviewed by course convener
Laboratory Assignment	Format will be posted on Moodle	15%	3	All class material regarding K_{IC} testing	Week 9 Friday 23:59, upload to Moodle	72 Hours After Deadline	Two weeks after deadline
Final exam	2 hours	55%	1, 2, 4	All course content	Exam period, date TBC	N/A	Upon release of final results

Postgraduate Students:

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, 7,12 via Moodle, 1 attempt allowed, Open 0:00 Friday to 23:59 Sunday	After quiz closes	After quiz closes and results have been reviewed by course convener
Laboratory Assignment	Format will be posted on Moodle	15%	3	All class material regarding K_{IC} testing	Week 9 Friday 23:59, upload to Moodle	72 Hours After Deadline	Two weeks after deadline
Postgraduate Assignment	Format will be posted on Moodle	15%	1, 2, 4	All course content	Week 13 Friday 23:59, upload to Moodle	72 Hours After Deadline	Two weeks after deadline
Final exam	2 hours	40%	1, 2, 4	All course content	Exam period, date TBC	N/A	Upon release of final results

Assignments

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 per cent (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:

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

Marking

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.

Examinations

You must be available for all quizzes and examinations. Final examinations for each course are held during the University examination periods, which are June for Semester 1 and November for Semester 2.

Provisional Examination timetables are generally published on myUNSW in May for

Semester 1 and September for Semester 2

For further information on exams, please see the Exams section on the intranet.

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 shown 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 School Office or the Engineering Student Centre prior to the examination. Calculators not bearing an "Approved" sticker will not be allowed into the examination room.

Special consideration and supplementary assessment

For details of applying for special consideration and conditions for the award of supplementary assessment, 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, 2005.
    - (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 one year here 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: 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

Further information on School policy and procedures in the event of plagiarism is available on the intranet.

10. Administrative matters and links

All students are expected to read and be familiar with School guidelines and polices, available on the intranet. In particular, students should be familiar with the following:

- Attendance, Participation and Class Etiquette
- UNSW Email Address
- Computing Facilities
- Assessment Matters (including guidelines for assignments, exams and special consideration)
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Student Support Services

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