MECH4900

MECHANICS OF FRACTURE AND FATIGUE
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1. Staff contact details

Contact details for course convenor

Name: Professor Jay Kruzic
Office location: Ainsworth Building (J17), Level 3, Room 311F
Tel: (02) 9385 4017
Email: j.kruzic@unsw.edu.au

Contact details for additional lecturers

Name: Dr. Bernd Gludovatz
Office location: Ainsworth Building (J17), Level 3, Room 311G
Tel: (02) 9385 4006
Email: b.gludovatz@unsw.edu.au

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**

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
<th>Location</th>
<th>Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures</td>
<td>Mondays</td>
<td>10:00 – 12:00</td>
<td>CLB 8</td>
</tr>
<tr>
<td></td>
<td>Tuesdays</td>
<td>10:00-11:00</td>
<td>Elec Eng G17-G10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11:00-12:00</td>
<td>Elec Eng G17-G10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12:00-13:00</td>
<td>Ainswth J17-G01</td>
</tr>
<tr>
<td>Demonstrations</td>
<td>Thursdays</td>
<td>12:00-13:00</td>
<td>Ainswth J17-202</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13:00-14:00</td>
<td>Ainswth J17-202</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14:00-15:00</td>
<td>Ainswth J17-202</td>
</tr>
<tr>
<td>Lab</td>
<td>Thursday</td>
<td>9:00 – 12:00</td>
<td>J18 - UTL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13:00 – 16:00</td>
<td></td>
</tr>
</tbody>
</table>

* 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*


*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:

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>EA Stage 1 Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Correctly apply linear elastic fracture mechanics (LEFM) to predict material failure</td>
<td>PE 1.1, 1.2, 1.3, 2.1, 2.2</td>
</tr>
<tr>
<td>2. Identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis</td>
<td>PE 1.1, 1.3, 2.1, 2.2</td>
</tr>
<tr>
<td>3. Correctly determine the linear elastic fracture toughness, $K_{IC}$, of a material from experimental data</td>
<td>PE 1.1, 1.2, 1.3, 2.1, 2.2</td>
</tr>
<tr>
<td>4. Correctly predict lifetimes for fatigue and environmentally assisted cracking</td>
<td>PE 1.1, 1.2, 1.3, 2.1, 2.2</td>
</tr>
</tbody>
</table>

**4. Teaching strategies**

<table>
<thead>
<tr>
<th>Component</th>
<th>Expectations</th>
</tr>
</thead>
</table>
| 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.

<table>
<thead>
<tr>
<th>Week</th>
<th>Tentative Lecture Topics</th>
<th>Readings Due</th>
<th>Tutorial 1</th>
<th>Tutorial 2</th>
<th>Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction, Solid Mechanics Review, Elastic Stress Concentrations,</td>
<td>Book: Ch1; 2.0-2.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>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)</td>
<td>Book: 2.3-2.4; 2.6-2.7</td>
<td>Problem set 1</td>
<td></td>
<td>Fracture &amp; Leak before Break Examples</td>
</tr>
<tr>
<td>3</td>
<td>Crack Tip Plasticity, Plane Stress vs. Strain, Plastic Constraint, K/&lt;span style='font-variant: normal;'&gt;C&lt;/span&gt; testing</td>
<td>Book: 2.8-2.10; 7.0-7.2; ASTM Standard E399 (on Moodle)</td>
<td>Problem set 2</td>
<td></td>
<td>Lab Preparation + Q&amp;A Moodle Quiz 1 Open: TBD</td>
</tr>
<tr>
<td>4</td>
<td>Labour Day – Public Holiday</td>
<td>Book: 2.5; 2.11; 3.1</td>
<td>Labs</td>
<td>Labs</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>CTODs, Mixed-mode fracture, R-curves, R-curve testing, R-curves, R-curve testing, Elastic-plastic fracture mechanics (EPFM),</td>
<td>Book: CH3.0-3.5; 7.3-7.4; 5.0-5.1; 6.1</td>
<td>Problem set 3 &amp; Lab Assignment Questions</td>
<td>Problem set 4 &amp; Lab Assignment Questions</td>
<td>Lab Assignment due Moodle</td>
</tr>
<tr>
<td>6</td>
<td>J-integral, K/&lt;span style='font-variant: normal;'&gt;C&lt;/span&gt; testing, Ductile Fracture Mechanisms</td>
<td>Book: 5.2-5.4; 6.2</td>
<td>Problem set 5</td>
<td>TBD + Q&amp;A</td>
<td>Moodle Quiz 2 Open: TBD</td>
</tr>
<tr>
<td>7</td>
<td>Brittle Fracture Mechanisms, Ductile to Brittle Transition, Scanning Electron Microscopy Toughening Mechanisms</td>
<td>Book: 6.1-6.2; 11.0-11.4; 11.6</td>
<td>Problem set 6</td>
<td></td>
<td>Fracture Surface Identification</td>
</tr>
<tr>
<td>8</td>
<td>Toughening Mechanisms Cont’d, Embrittlement Mechanisms Environmentally Assisted Crack Growth, Damage Tolerant Lifetime Predictions, EAC Test Methods</td>
<td>PDF file of notes</td>
<td>Problem Set 7</td>
<td></td>
<td>EAC Lifetime Example</td>
</tr>
<tr>
<td>9</td>
<td>EAC Case Studies, Fatigue, Fatigue Life Analysis</td>
<td>Book: 10.0-10.3*; 10.8-10.10*</td>
<td>Problem Set 8</td>
<td></td>
<td>Comet Case Study Moodle Quiz 3 Open: TBD</td>
</tr>
<tr>
<td>10</td>
<td>Fatigue Crack Initiation, Damage Tolerant Lifetime Predictions, Fatigue Crack Growth Testing, Fatigue Crack Growth Mechanisms</td>
<td>Book: 10.4-10.5*; 11.5</td>
<td>Problem Set 9</td>
<td></td>
<td>Open Q&amp;A for final assignment Final Assignment due Moodle</td>
</tr>
<tr>
<td>11</td>
<td>Crack Closure Effects, Corrosion Fatigue, Fatigue Failure Analysis, Fatigue Fractography Case Studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Final Exam</td>
</tr>
</tbody>
</table>

*For CH10 chapter numbers are different for 3<sup>rd</sup> and 4<sup>th</sup> editions of the textbook. For 3<sup>rd</sup> edition, read CH10.0-10.4 and 10.7-10.9
## 6. Assessment

### Assessment overview

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

  - (Online version of 3rd edition is available on the UNSW Library Website and that edition is fine too)
  - (Available on Moodle)

Additional Suggested Readings

  - (Online version is available on the UNSW Library Website)
  - (1st – 3rd editions available at UNSW Library)
  - (1st – 2nd editions available at UNSW Library)
  - (Available at UNSW Library)
  - (Available at UNSW Library)

UNSW Library website: [https://www.library.unsw.edu.au/](https://www.library.unsw.edu.au/)

### 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](http://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 policies. 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

<table>
<thead>
<tr>
<th>PE1: Knowledge and Skill Base</th>
<th>Program Intended Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE1.1</td>
<td>Comprehensive, theory-based understanding of underpinning fundamentals</td>
</tr>
<tr>
<td>PE1.2</td>
<td>Conceptual understanding of underpinning maths, analysis, statistics, computing</td>
</tr>
<tr>
<td>PE1.3</td>
<td>In-depth understanding of specialist bodies of knowledge</td>
</tr>
<tr>
<td>PE1.4</td>
<td>Discernment of knowledge development and research directions</td>
</tr>
<tr>
<td>PE1.5</td>
<td>Knowledge of engineering design practice</td>
</tr>
<tr>
<td>PE1.6</td>
<td>Understanding of scope, principles, norms, accountabilities of sustainable engineering practice</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PE2: Engineering Application Ability</th>
<th>Program Intended Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE2.1</td>
<td>Application of established engineering methods to complex problem solving</td>
</tr>
<tr>
<td>PE2.2</td>
<td>Fluent application of engineering techniques, tools and resources</td>
</tr>
<tr>
<td>PE2.3</td>
<td>Application of systematic engineering synthesis and design processes</td>
</tr>
<tr>
<td>PE2.4</td>
<td>Application of systematic approaches to the conduct and management of engineering projects</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PE3: Professional and Personal Attributes</th>
<th>Program Intended Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE3.1</td>
<td>Ethical conduct and professional accountability</td>
</tr>
<tr>
<td>PE3.2</td>
<td>Effective oral and written communication (professional and lay domains)</td>
</tr>
<tr>
<td>PE3.3</td>
<td>Creative, innovative and pro-active demeanour</td>
</tr>
<tr>
<td>PE3.4</td>
<td>Professional use and management of information</td>
</tr>
<tr>
<td>PE3.5</td>
<td>Orderly management of self, and professional conduct</td>
</tr>
<tr>
<td>PE3.6</td>
<td>Effective team membership and team leadership</td>
</tr>
</tbody>
</table>