MECH9400

MECHANICS OF FRACTURE AND FATIGUE
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MECH9400 MECHANICS OF FRACTURE AND FATIGUE

COURSE OUTLINE

1. STAFF CONTACT DETAILS

Contact details and consultation times for course convener

Dr Kana Kanapathipillai
Room G17/467
School of Mechanical and Manufacturing Engineering
Tel (02) 9385 4251
Fax (02) 9663 1222
Email s.kanapathipillai@unsw.edu.au

Consultation concerning this course is available during the problem solving guidance sessions. You may contact the lecturers to make appointment for consultation by email.

Lecturers

Dr Kana Kanapathipillai
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2. COURSE DETAILS

Units of credit

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.”

For a standard 24 UoC in the semester, this means 600 hours, spread over an effective 15 weeks of the semester (thirteen weeks plus stuvac plus one effective exam week), or 40 hours per week, for an average student aiming for a credit grade
Various factors, such as your own ability, your target grade, etc., will influence the time needed in your case

Some students spend much more than 40 h/w, but you should aim for not less than 40 h/w on coursework for 24 UoC.

This means that you should aim to spend not less than about 10 h/w on this course, i.e. an additional 4 h/w of your own time. This should be spent in making sure that you understand the lecture material, completing the set assignments, further reading about the course material, and revising and learning for the examination.

There is no parallel teaching in this course.

Course aims

Fracture is a problem that society has faced from beginning. The problem is actually worse today than previous centuries because more can go wrong in our complex technological society. It is imperative for graduates in a number of engineering disciplines including mechanical engineering to be familiar with the concept of fracture and fatigue. In this course, the students learn about the fundamental of mechanics of fracture and fatigue and the concept of damage tolerance analysis that is used in design of industrial components to avoid fracture and fatigue failures.

How the course relates to other course offerings and overall program(s) in the discipline

This course is an advanced course in the field of 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.

Students have learned about basic stress analysis in MMAN2400 and have been introduced to elementary concepts in the area of fracture mechanics and fatigue in MMAN2400 and MMAN3400. These concepts will be used in this course and further extended so that students develop capabilities of performing “damage tolerance analysis” of industrial structures and machinery components.

Student learning outcomes

On completion of this course, you will be expected to have learnt the following topics:

- various modes of fracture;
- plastic collapse;
- crack-tip stresses and displacements;
- fracture criterion;
- fracture toughness and its evaluation;
- various methods of obtaining stress intensity factor;
- crack-tip plasticity corrections;
• residual strength diagram;
• crack growth and fatigue;
• damage tolerance analysis;
• applying the finite element method to fracture analysis.

Graduate attributes

UNSW’s graduate attributes are shown at https://my.unsw.edu.au/student/atoz/GraduateAttributes.html

UNSW aspires to develop graduates who are rigorous scholars, capable of leadership and professional practice in a global community. The university has, thus, articulated the following Graduate Attributes as desired learning outcomes for ALL UNSW students.

UNSW graduates will be

1. Scholars who are:
   (a) understanding of their discipline in its interdisciplinary context ✓
   (b) capable of independent and collaborative enquiry
   (c) rigorous in their analysis, critique, and reflection
   (d) able to apply their knowledge and skills to solving problems ✓
   (e) ethical practitioners
   (f) capable of effective communication ✓
   (g) information literate ✓
   (h) digitally literate

2. Leaders who are:
   (a) enterprising, innovative and creative
   (b) capable of initiating as well as embracing change
   (c) collaborative team workers

3. Professionals who are:
   (a) capable of independent, self-directed practice ✓
   (b) capable of lifelong learning
   (c) capable of operating within an agreed Code of Practice

4. Global Citizens who are:
   (a) capable of applying their discipline in local, national and international contexts ✓
   (b) culturally aware and capable of respecting diversity and acting in socially just/responsible ways
   (c) capable of environmental responsibility

✓ = Developed in this course

In this course, you will be encouraged to develop Graduate Attributes 1(a), 1(d), 1(f), 1(g), 3(a), and 4(a) by undertaking the selected activities and knowledge content. These attributes will be assessed within the prescribed assessment tasks, as shown in the assessment table on Page 8.
3. RATIONALE FOR INCLUSION OF CONTENT AND TEACHING APPROACH

Teaching ranks amongst the nation's top prestigious professions where one is involved in shaping the future of the country. Understanding how students learn is one of the significant aspects of teaching. This is linked to their knowledge, background and maturity. The key is to relate to the students by starting from what they know in elementary courses in the area of solid mechanics and building upon it. Damage tolerance analysis that is based on concepts of mechanics of fracture and fatigue is an applied field where students constantly apply the fundamental concepts and theory learned in the classroom to integrity assessment and design of industrial components. The main goal is to encourage independent thinking and analytical reasoning to augment students’ problem solving skills. During the lectures, I prompt you to question at every stage: ‘why’, ‘how’ the problem at hand should be tackled. My favourite approach is: “If you don't have any question I have some for you”. This may lead to classroom discussions and/or several intellectually stimulating questions/arguments which are not easy to answer.

While a set of comprehensive notes, prepared by the course convenor, is available for this course on the Moodle, I believe that there should be enough room for flexibility and I tend to adapt to the students' requirements as the course proceeds. Therefore, additional materials to those described in the notes may be covered in the lectures or alternatively not all materials described in the notes may be referred to in the lectures.

The format employed in this course combines face-to-face lectures, laboratory experimentation and interactive problem solving guidance sessions.

4. TEACHING STRATEGIES

The teaching strategies that will be used include:

- Presentation of the material in weekly lectures so that the students develop understanding of the underlying concepts of the various topics covered in the course.
- Provision of weekly supervised problem solving guidance sessions where students can obtain assistance and develop their skill in solving technical problems.
- Provision of laboratory classes where (postgraduate) students work in teams to perform physical experiments, analyse data and produce pertinent reports about which students will receive feedbacks.

Suggested approaches to learning in the course

- Regular attendance and participation in lectures, problem solving guidance sessions and laboratory classes.
- Diligence in working through the set problems in preparation for examinations.
- Effectively utilising the lecturer and demonstrator.
- Additional reading on, and about the material presented in lectures to broaden the students understanding.
• Practicing demonstrated problems and past examination questions in preparation for examinations.
• Working effectively with other students in carrying out the laboratory experiments.

5. ASSESSMENT

Overall rationale for assessment components and their relationship with specific student learning outcomes
This course will be assessed by a laboratory test/report, an in-semester quiz, an assignment and a final formal examination.

Details of each assessment component, the marks assigned to it, and the dates of submission:

Undergraduate students:

<table>
<thead>
<tr>
<th>Assessment Component</th>
<th>Mark</th>
<th>Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-semester Quiz</td>
<td>20%</td>
<td>5</td>
</tr>
<tr>
<td>Fracture Toughness Laboratory Report</td>
<td>15%</td>
<td>10</td>
</tr>
<tr>
<td>FEA Assignment</td>
<td>5%</td>
<td>11</td>
</tr>
<tr>
<td>Final Formal Examination</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>

Postgraduate students:

<table>
<thead>
<tr>
<th>Assessment Component</th>
<th>Mark</th>
<th>Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-semester Quiz</td>
<td>20%</td>
<td>5</td>
</tr>
<tr>
<td>Fracture Toughness Laboratory Report</td>
<td>15%</td>
<td>10</td>
</tr>
<tr>
<td>FEA Assignment</td>
<td>5%</td>
<td>11</td>
</tr>
<tr>
<td>Major Assignment</td>
<td>15%</td>
<td>12</td>
</tr>
<tr>
<td>Final Formal Examination</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>

The assignment listed above is to develop learning outcome of fracture mechanics properties such as fracture toughness with the aim to develop Graduate Attributes 1(a), 1(d), 1(f), 1(g), 3(a), and 4(a) listed in page 6.

The above-mentioned dates are indicative depending on progress in lectures. If so, the new dates for the tests and lab will be announced during the lectures. Postgraduate students may be required to answer extra questions in the final examination. In order to pass the course, you must achieve a total mark of 50% or higher.
Submission of Assignments and lab reports

The assignments and the lab report will be submitted electronically through a drop box in Moodle by 11 pm, Friday in the weeks indicated in the course schedule.

Late submissions attract a penalty of ten percent per day, unless prior dispensation has been given; i.e. see the lecturer before the due date to avoid penalty.

Marking criteria

Quiz and Exam: In marking the quiz and the exam the major portion of the marks will be allocated to correct drawing of any pertinent free-body diagrams and correct method of solution.

Laboratory Report: In marking the laboratory report, particular attention will be paid to correct and neat presentation of the data, calculations and comprehensive discussion and conclusions. The reports are expected to be typed but equations may be hand-written.

Examination

There will be one two-hour examination at the end of the semester, based on all material covered during the whole semester.

You will need to provide your own calculator, of a make and model approved by UNSW, for the examination. The list of approved calculators is shown at https://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 Administrative Matters for All Courses, available from the School website.

6. ACADEMIC HONESTY AND PLAGIARISM

Plagiarism is using the words or ideas of others and presenting them 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 booklet which provides essential information for avoiding plagiarism: https://my.unsw.edu.au/student/academiclife/Plagiarism.pdf

There is a range of resources to support students to avoid 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. Information is available on the dedicated website Plagiarism and Academic Integrity website:
http://www.lc.unsw.edu.au/plagiarism/index.html

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

Further information on School policy and procedures in the event of plagiarism is presented in a School handout, Administrative Matters for All Courses, available on the School website.

7. COURSE SCHEDULE

The following table shows the time table of lecture topics and problem solving guidance sessions times.

<table>
<thead>
<tr>
<th>Date</th>
<th>Week</th>
<th>Lecture Topic</th>
<th>Friday 2 – 4 pm CLB06</th>
<th>Friday 4 – 5 pm CLB06</th>
<th>Due</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 August</td>
<td>1</td>
<td>Introduction to damage tolerance analysis and fracture mechanics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 August</td>
<td>2</td>
<td>Plastic collapse</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>15 August</td>
<td>3</td>
<td>Modes of fracture, crack-tip stresses and displacements, stress intensity factor.</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 August</td>
<td>4</td>
<td>Fracture criterion</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 August</td>
<td>5</td>
<td>Various methods of determining stress intensity factor Fracture toughness</td>
<td>✓</td>
<td></td>
<td>Quiz</td>
<td></td>
</tr>
<tr>
<td>05 Sept</td>
<td>6</td>
<td>Crack-tip plasticity &amp; Description of Major Assignment</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Week</td>
<td>Activity</td>
<td></td>
<td></td>
<td></td>
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<td>---------------------------------------------------------------------------</td>
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<td></td>
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<tr>
<td>12 Sept</td>
<td>7</td>
<td>Fracture toughness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 Sept</td>
<td>8</td>
<td>Residual Strength Diagram</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 Sept</td>
<td>9</td>
<td>Laboratory – Fracture toughness testing &amp; Description of FEA Assignment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Semester break</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Oct</td>
<td>10</td>
<td>Crack growth and fatigue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 Oct</td>
<td>11</td>
<td>Crack growth diagram</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 Oct</td>
<td>12</td>
<td>Damage tolerance analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 Oct</td>
<td>13</td>
<td>No lecture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The timing of the above schedule is indicative and minor adjustments may occur.

8. **RESOURCES FOR STUDENTS**

**Textbook & notes details**


**List of required and suggested additional readings**


Copies of the above reference books are kept in the Main Library. One starting point for assistance is: [http://info.library.unsw.edu.au/web/services/services.html](http://info.library.unsw.edu.au/web/services/services.html).
9. CONTINUAL EVALUATION AND DEVELOPMENT

We are particularly interested in your feedback. We want your suggestions of what is good and should be retained, and what is not so good and should be improved (with ideas on how to do it). In addition to the standard UNSW Course and Teaching Evaluation and Improvement (CATEI) surveys we will be asking for your feedback in other ways during your studies. The assessment has been adjusted based on previous student feedback.

10. ADMINISTRATIVE MATTERS

You are expected to have read and be familiar with Administrative Matters for All Courses, available on the School website. This document contains important information on student responsibilities and support, including special consideration, assessment, health and safety, and student equity and diversity.

Dr Kana Kanapathipillai  
11th July 2014