MECH9420

Composite Materials and Mechanics

Term One // 2021

School of Mechanical and Manufacturing Engineering // UNSW Engineering

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Gangadhara Prusty	G.Prusty@unsw.edu.au	Friday 12-1 p.m. in-person and Via Moodle	208F	0293855939

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

Course Details

Credit Points 6

Summary of the Course

Using a unified and integrated approach, this course will give you a solid grounding in:

- The properties of composite materials;
- Processing and manufacturing methods;
- Micromechanics and lamination theory;
- The analysis and manufacture of light weight composite structures;
- The design of a composite structures;
- Test methods to confirm mechanical properties.

The course will cater to the specific challenge of materials engineers across all engineering disciplines:

- Aerospace
- Manufacturing
- Civil & Mechanical Engineering
- Mechatronics
- Naval Architecture
- Architecture
- Industrial Design

Course Aims

To provide an understanding of the advanced composite materials, micro-mechanical analysis of composite strength and stiffness, and be able to manufacture of macro level specimens for structural applications.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Upon completion of this course the student is expected to be familiar with the use of advanced composite materials such as glass and carbon fibre epoxy for design and manufacture of composite structures.	PE1.1, PE1.3, PE1.6, PE1.5
2. Develop the basic understanding to use the composite materials, micromechanics of layered composites, Analysis and design of composite structures and Failure analysis of laminated panels.	PE2.1, PE2.2, PE2.3, PE2.4

Teaching Strategies

This course includes two teaching methods:

1. Lectures to introduce properties of composite materials, micro and macro-mechanical studies
2. Hands-on laboratory and team-work to apply fundamental concepts in in understanding the material properties and their use in engineering applications.

Assessment

Assessment Tasks

Assessment task	Weight	Due Date	Student Learning Outcomes Assessed
Assignment 1	15%	05/03/2021 05:00 PM	1, 2
Assignment 2	25%	02/04/2021 05:00 PM	2
Assignment 3 (Hands on)	20%	16/04/2021 05:00 PM	1
Test 1	20%	08/03/2021 07:00 PM	2
Test 2	20%	19/04/2021 07:00 PM	1, 2

Assessment Details

Assessment 1: Assignment 1

Start date: 15/02/2021 10:59 AM

Length: 10 pages

Details:*Understanding of industry specific applications of composites and critical views on the published literature*

Additional details:

Essential checklist for a good literature review

Overall presentation	
Is the literature review sensibly sectioned? Is each section organised using subheadings, providing a logical flow to aid transitional phrases throughout the review?	
Was the literature review formatted in accordance with instructions given in the assignment? (i.e. font type and size, a page limit and the number of articles)	
What is the overall quality of English Expression (clear and concise)? - The overall quality of English expression also includes use of relevant verbs in places when incorporating references and quotations. Are there any spelling and/or punctuation errors? Is technical jargon correctly used throughout the literature review?	
Do the references cited properly conform to APA style? Is the reference list properly formatted using APA style for each type of references?	
Contents	
Introduction	How well have the context and aims of a literature review been introduced?
	Is the overview statement of the literature clearly and succinctly presented?
	Does the author clearly describe the significance of a topic and
	Is the appropriate inquiry question established as a scholarly article?
	Are the findings and results of reviewed articles judiciously compared,

	contrasted and connected to each other?
Main text	Are the chosen articles closely pertinent to the initial inquiry question described in the introduction?
	Has the author successfully managed to deliver the main argument and meaningful findings of articles reviewed?
	Are arguments and analyses from multiple sources in the literature coherently integrated to link author's main topic and argument together?
	Are all arguments and contents evidenced using correct references for the academic integrity?
	Are all similarities and differences of ideas and research outcomes related to the topic of a literature review correctly identified and demonstrated from a reference to a reference?
	Has the author successfully verified through evidence and facts? You must remain objective through scientific facts or evidence and statistics.
Conclusions	Does the conclusion of the review summarise knowledge acquired from the review well in context of the specific focus described in the introduction?
	Are the obvious gaps and methodological flaws in research of the area identified explicitly? - The conclusions must briefly evaluate 'state-of-the-art' for the literature reviewed, indicating major gaps in research, inconsistencies in theory and findings and current issues pertinent to the topic of interest.
	Has a proper closing remark been provided at the conclusion of a literature review? – The conclusions sometimes need to finish by providing author's overall perspective and insight into the topic and outline of what the obvious next stage of research would be.

The total of 100 marks will be scaled back to 15 basic marks allocated to this assignment.

Submission notes: Submission via Moodle only

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

Assessment 2: Assignment 2

Start date: 08/03/2021 09:00 AM

Length: 15 pages + Additional 5 pages for graphs/plots and discussions

Details:*Experimental methods for characterisation of composite material under tension, compression and shear loadings. Report writing, communication skills and understanding of experimental procedures.*

Additional details:

Assignments must be submitted to Turnitin (see https://student.unsw.edu.au/how-use-turnitin-within-moodle) in softcopy. **Your report is limited to 15 1.5-spaced pages, not including the references page, with Times New Roman at 12 pts and the standard margins (3 cm for the top and 2.54 cm for the rest)**.

Assessment

Your task will be graded out of 100 based on the following guideline:

1. **Introduction: (Mark: 10)**

1. **Description of the experiment: (Mark: 30)**

-Including manufacturing process of the panel, the influences of the ply stacking in each type of forces that are involved, and the setup of experimental tests.

1. **Result analysis and mechanical characterisation with discussions: (Mark: 40)**
    1. **Carbon/Epoxy**
        1. *Tensile test results: Draw Stress vs Strain and calculate Strength (σ) and Modulus (E)*
        2. *Compressive test results: Draw Stress vs Strain and calculate Strength (σ) and Modulus (E)*
        3. *Shear test results: Draw Stress vs Strain and calculate Strength (σ) and Modulus (E)*
    2. **E-glass/Epoxy**
        1. *Tensile test results: Draw Stress vs Strain and calculate Strength (σ) and Modulus (E)*
        2. *Compressive test results: Draw Stress vs Strain and calculate Strength (σ) and Modulus (E)*
        3. *Shear test results: Draw Stress vs Strain and calculate Strength (σ) and Modulus (E)*
    3. **Kevlar/Epoxy**
        1. *Tensile test results: Draw Stress vs Strain and calculate Strength (σ) and Modulus (E)*
        2. *Compressive test results: Draw Stress vs Strain and calculate Strength (σ) and Modulus (E)*

Compare the tensile, compression and shear test results of Carbon/Epoxy, E□glass/Epoxy and Kevlar/Epoxy composite

1. **Conclusion and comments based on the results obtained (Mark: 15)**

5. Reflection: (Mark: 5)

Submission notes: Submission Moodle only

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

Assessment 3: Assignment 3 (Hands on)

Start date: 22/03/2021 09:00 AM

Length: 12 pages + Additional 5 pages for graphs/plots and discussions

Details:*Hands-on manufacture of large composite panels, experiments on coupons, report writing and communication skills*

Additional details:

Question 1 – 20 marks

(1□2 pages as a guide)

Assume the following fibre, laminate ply and core data:

g/m2		Wf%	pF (10EE3kg/m3)
200	Woven carbon	60	1.81
612	DB E-glass	65	2.55

1. Calculate the areal mass in kg/m2 of the **cured** laminate for the single skin portion of the panel on page 1and 2.
2. Calculate the areal mass in kg/m2 of the sandwich portion of the panel.
3. Show *full workings for each entry*, then complete the following table for the 200g/m2 woven carbon ply (refer to the *MECH9420_Fibre Fraction Interpolator*.xlsx spreadsheet on the Course Moodle):

1. Using the spreadsheet *MECH9420_Fibre Fraction Interpolator*.xlsx, perform the same calculations as in (c) above for the 612g/m2 DB E-glass ply. Do *not* show full workings. Just provide a copy of the completed spreadsheet for these two cases.
2. Complete the grey-shaded cells in the following table to **2 decimal** places:

Question 2 – 20 marks

(1□2 pages as a guide)

Given the following data:

Transform the section according 446.5=6.77

Carbon ply thickness 0.22mm and Glass ply thickness 0.51mm

And observing the XX- and YY- axes convention shown on the drawing on page 1;

1. Calculate the moment of inertia, Ixx of the sandwich laminate in mm4/(mm width).

2. Calculate the section modulus, Zxx of the sandwich laminate in mm3/(mm width).
3. Calculate the moment of inertia, Ixx of the single skin in mm4/(mm width).
4. Calculate the section modulus, Zxx of the single skin in mm3/(mm width).

HINT: To complete (a) to (d) successfully, you must firstly perform a **transformed "equivalent section"** of the laminate cross-section as the plies of the laminate do not have the same Young's elastic modulus in the x-x direction (Eb xx [GPa]). Refer to *Design_multilayer laminates in flexure*.pdf in Assignment 3 section of Course Moodle for help with the method.

1. Calculate the bending stiffness (laminate flexural rigidity Elam•Ixx) of the laminate. What can be said about the bending stiffness of the single skin region compared to the bending stiffness of the sandwich laminate region in the x-x direction? What is the main reason for the difference?

Question 3 – 20 marks

(1□2 pages as a guide)

Vacuum resin infusion is a widely-adopted composites processing method.

1. List **four advantages and disadvantages** of the method.
2. Write approximately **150 words describing the method, as found in one existing application** that you have researched and found interesting. Include a photograph and/or diagram including reference in APA style.
3. Suggest a *novel* application of the vacuum resin infusion processing method for a composite component that you can think of, as opposed to an established method. Briefly explain what advantages the use of the method would bring to the application in approx.150 words.

Question 4 – 20 marks

Write a report ***(3□4 pages as a guide)*** on the mechanical testing that **you participated** (**Own group results)** in during the period Week 4-10. Your report *must* include the following elements identified in **bold**:

1. Write the experimental **Aims** in bullet-point form.
2. Two test methods are used—ASTM D3039 for tensile properties and ASTM D790 Procedure A for flexural properties. Provide full citations for the two **Test Methods** using APA style (*see Instruction 5 below). Copies of the two test methods are on the Course Moodle site in the Assignment 3 section.
3. Provide **photos** of the specimen you tested; before, during and after failure. Clearly label each photo with a **caption** identifying the laminate type, test method (abbreviated) and before/during/after failure.
4. A **Results section** according to both of the test methods. Each **must include**:

- Date and location of test. Test machine name and model.
- Your name and Group Number.
- One specimen per group is to be tested. Label each specimen with Group Number.
- The specimen length, width and thickness in mm. For ASTM D790 specimen, state the support span length.
- A Chart or Graph (Curve) for both sets of test results as produced by the Instron machine

software output (**Own group results)**.

- Can you attempt a calculation of the tensile stress, tensile strain and tensile chord modulus (see ASTM D3039 at 13.1, 13.2 and 13.3.1/13.3.1.1 respectively) **of your own group results**? If so, please include your attempt.
- Can you attempt a calculation of modulus in bending (see ASTM D790 at 13.1.12 (tangent modulus only) and flexural stress at break in 13.1.15)? If so, please include your attempt.

1. Summarise the key **Observations** you made.
2. Write up a **Discussion of Results**.
3. State your **Conclusions**.
4. Write a **Statement** explaining what you have learned about the nature of typical **failure modes** in composites compared with, for example, metals. [Hint: Consider the use of such terms as *brittle* and *ductile*].

Question 5 – 20 marks

(1 page as a guide)

Write a brief reflection on what you see as the learning outcomes of this assignment (in bullet-point form; **max. 500 words**).

Submission notes: Submission via Moodle only

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

Assessment 4: Test 1

Start date: 08/03/2021 06:00 PM

Details: Online test (one hour duration) covering the lecture materials during Wk 1-3

Additional details:

Online test (one hour duration) covering the lecture materials during Wk 1-3.

Formula sheet will be provided.

Submission notes: Moodle on-line test

Turnitin setting: This is not a Turnitin assignment

Assessment 5: Test 2

Start date: 19/04/2021 06:00 PM

Details: Online test (one hour duration) covering the lecture materials during Wk 4-9

Additional details:

Online test (one hour duration) covering the lecture materials during Wk 4-9

Turnitin setting: This is not a Turnitin assignment

Resources

Recommended Resources

Reference Texts

1. Isaac M. Daniel and Ori Ishai, Engineering Mechanics of Composite Materials, Oxford University Press, 1994.
2. R. A. Shenoi and J. F. Wellicome, Composite Materials in Maritime Structures, Vol 1&2, Cambridge University Press, U.K., 1993.

UNSW Library website: https://www.library.unsw.edu.au/

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

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.

Feedback from a previous instance of the course suggested that a large number of small assessment tasks were conducive to continued online learning and this has been maintained. Prior to that, improvements included moving to a single platform for online content delivery and assessment.

Laboratory Workshop Information

The laboratory component of this course will be held in Automated Composite Laboratory (L102 & 103 of Willis Annexe) of the MECHENG School.

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
- UNSW Email Address
- Computing Facilities
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Lab Access
- Makerspace
- UNSW Timetable
- UNSW Handbook
- UNSW Mechanical and Manufacturing Engineering

Submission of Assessment Tasks

Assessment submission and marking criteria

Should the course have any non-electronic assessment submission, these should have a standard School cover sheet.

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.

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.

Late policy

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. Examples include:

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

Examinations

You must be available for all quizzes, tests and examinations. For courses that have final examinations, these are held during the University examination periods: February for Summer Term, May for T1, August for T2, and November/December for T3.

Please visit myUNSW for Provisional Examination timetable publish dates. For further information on exams, please see the Exams webpage.

Special Consideration

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.

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

Please note that students will **not** be required to provide **any** documentary evidence to support absences from any classes missed **because of COVID-19 public health measures such as isolation**. UNSW will **not** be insisting on medical certificates from anyone deemed to be a positive case, or when they have recovered. Such certificates are difficult to obtain and put an unnecessary strain on students and medical staff.

Applications for special consideration **will** be required for assessment and participation absences – but no documentary evidence **for COVID 19 illness or isolation** will be required.

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

Academic Information

Credit points

Course credit is calculated in Units-Of-Credit (UOC). The normal workload expectation for one UOC is approximately 25 hours per term. This includes class contact hours, private study, other learning activities, preparation and time spent on all assessable work.

Most coursework courses at UNSW are 6 UOC and involve an estimated 150 hours to complete, for both regular and intensive terms. Each course includes a prescribed number of hours per week (h/w) of scheduled face-to-face and/or online contact. Any additional time beyond the prescribed contact hours should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

On-campus class attendance

Public distancing conditions must be followed for all face-to-face classes. To ensure this, only students enrolled in those classes will be allowed in the room. Class rosters will be attached to corresponding rooms and circulated among lab demonstrators. No over-enrolment is allowed in face-to-face class. Students enrolled in online classes can swap their enrolment from online to a **limited** number of on-campus classes by Sunday, Week 1. Please refer to your course's Microsoft Teams and Moodle sites for more information about class attendance for in-person and online class sections/activities.

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate.** We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed. Further information is available on any course Moodle or Teams site.

In certain classroom and laboratory situations where physical distancing cannot be maintained or there is a high risk that it cannot be maintained, face masks will be considered **mandatory PPE** for students and staff.

For more information, please refer to the
FAQs: https://www.covid-19.unsw.edu.au/safe-return-campus-faqs

Guidelines

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

Important Links

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

Image Credit

Synergies in Sound 2016

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	✓
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	✓
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in 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	