UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Term 1 2019

MECH9420

COMPOSITE MATERIALS AND MECHANICS

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Professor Gangadhara Prusty
Office location: Ainsworth Building (J17), Room 208F
Tel: (02) 9385 5939
Email: g.prusty@unsw.edu.au

Contact details and consultation times for additional lecturers/demonstrators/lab staff

Name: Mr. David Lyons
Office location: Ainsworth Building (J17), Room 208D
Tel: (02) 9385 6120
Email: david.lyons@unsw.edu.au

Contact details for other demonstrators will be available on Moodle.

Consultation

Consultation concerning this course is available during the lectures and problem-solving sessions. Outside of these hours, the convenor and demonstrators can be contacted through the Moodle platform; either via a forum or through direct messaging. Any questions about course content and assessment that are not of a private nature should be directed to the appropriate Moodle forum. Any personal queries about course administration can be directed to the course convenor via direct email or Moodle direct message

2. Important links

- Moodle
- Lab Access
- Computing Facilities
- Student Resources
- Course Outlines
- Engineering Student Support Services Centre

3. Course details

Credit Points

This is a HYBRID course offered to final year undergraduate and postgraduate students. This is a 6 unit-of-credit (UoC) course, and involves 3 or 4 hours per week (h/w) of face-to-face contact.

Contact hours

	Day	Time	Location
Lectures (Weeks 1 – 10)	Wednesday (PG +UG)	12pm – 2pm	Colombo Theatre A
Problem Solving Sessions (Weeks 3 – 8)	Tuesday (PG)	10am – 12pm	Electrical ENG G03 (G17)
	Tuesday (UG)	4pm – 6pm	Red Centre Central Wing 1040 (H13)
	Wednesday (UG)	2pm – 4pm	Ainsworth 201 (J17)
	Wednesday (PG)	2pm – 4pm	OMB G32 (K15)
	Wednesday (PG)	4pm – 6pm	Ainsworth 201 (J17)
Laboratory	**(See Below)**		
Weeks 4 – 8, 10	Friday	9am – 11am	Willis Annexe J18 / Automated Composite Lab
	Friday	11am – 1pm	Willis Annexe J18 / Automated Composite Lab
	Friday	1pm – 3pm	Willis Annexe J18 / Automated Composite Lab
Weeks 4 – 9	Thursday	3pm – 5pm	Willis Annexe J18 / Automated Composite Lab

Lectures commence in week 1 and run until week 10. Problem Solving Sessions / Laboratory commence in week 2 and run until week 10. 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

(a) Composite material constituents and their properties

(b) Manufacturing methods and processes

(c) Micromechanical analysis of composite strength and stiffness:
- Assumptions and limitations
- Longitudinal strength and stiffness
- In-plane shear modulus and Poisson's ratio

(d) Elastic properties of the unidirectional lamina:
- Engineering constants
- Stress-strain relationship of a thin lamina
- Transformation of stress and strain and elastic constants
- Typical elastic properties of a unidirectional lamina

(e) Analysis of laminated composites:
- Basic assumptions
- Strain-displacement relationship
- Laminate stiffness
- Determination of lamina stress and strain
- Types of laminate configuration

(f) Failure theories and strength of unidirectional lamina:
- Micro-mechanics of failure of unidirectional lamina

- Failure theories
- Importance of shear stress
- Choice of failure criteria
- Typical strength properties

(g) Design of components:
- International standards for tests and certification

(h) Structural health monitoring and non-destructive testing methods

* Topics during the weekly teaching format might be varied or changed

On successful completion of this course, students should be able to: (a) Understand the use of fibre-reinforced composites in structural applications and (b) Develop a basic understanding of the use of composite materials, micromechanics of layered composites, analysis and design of composite structures and failure analysis of laminated panels.

Composite Materials and Mechanics takes the themes of the fundamentals of material science and engineering and applies them in an engineering context.

The objective of this course is to develop a solid understanding of the properties of composite materials, micromechanics and lamination theory, together with the analysis and manufacture of lightweight composite structures in a unified and integrated manner for an undergraduate/postgraduate student. These are fundamental to mechanical, civil and material science engineering and related programs such as mechatronic engineering, naval architecture, aerospace engineering and biomedical engineering as well as manufacturing and industrial design.

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.	Recognise the fundamentals of orthotropic materials and mechanics of materials	1.1, 1.3, 1.6
2.	Demonstrate the fundamentals of directional stresses and strains	1.1, 1.3, 1.6
3.	Develop a solid understanding in the properties of composite materials	1.3, 1.5, 2.1
4.	Develop an understanding of micromechanics and lamination theory together with the analysis and manufacture of lightweight composite structures in a unified and integrated manner	2.1, 2.2, 2.3
5.	Learn how to design a composite structure and be able to test and confirm its mechanical properties	2.2, 2.3, 2.4

4. Teaching strategies

Component	Activities
Lectures	• Find out what you must learn. • See methods that are not in the textbook. • Follow worked examples. • Hear announcements on course changes.
Laboratory/Problem solving class	• Be guided by course notes and demonstrators. • Ask questions. • Do problems, as set out in the course notes. • Work with colleagues.
Private study (including Moodle)	• Review lecture material and textbook. • Do set problems and assignments. • Discuss with fellow students. • Join Moodle discussions of problems. • Download materials from Moodle. • Keep up with notices and find out marks via Moodle.
Assessments (assignments, laboratories and final exam)	• Demonstrate your basic knowledge and skills. • Learn from feedback. • Demonstrate higher understanding and problem solving.

5. Course schedule

Lecture/Problem Solving Session Topic Schedule

Composites 3M: Materials, Mechanics and Manufacturing		
Week	**Lecture (2 hr) – Colombo Theatre A**	**Problem Solving Session/Laboratory (2 hr) – (as allocated to you)**
1	Introduction to Composite Materials	
2	Materials and processing of fibre-reinforced composites (DL)	Lab tour -Explanation of materials and demonstration of equipment. -One hour consultation for Assignment 1 *Assignment 1 issued-a review document on composite materials-applications, relevant to your degree program. Submission due in Wk 3 (15%)*
3	Composite Strength and Stiffness	- Sample problem solving class *Assignment 1 due*
4	Micro-mechanical Analysis, Elastic properties of uni-directional lamina	- Sample problem solving class *Assignment 2 issued- report on the materials, manufacturing method and characterisation. Submission due in Wk 7 (20%)*
5	Laminated Composites	- Sample problem solving class
6	Analysis of laminated composites and composite beams	- Sample problem solving class
7	Failure Theories	- Large sample manufacture- Make, bake and break /discussion (Wk 7-9) *Assignment 3 issued- report on the large test article manufactured and tested. Submission due in Wk 10 (20%)* *Assignment 2 due*
8	(a) Strength of UD lamina (b) First-ply and Ultimate failure	- Large sample manufacture and test
9	Design of laminates, Standards and Codes for FRP and discuss Assignment 3 (DL)	-Large sample manufacture and test
10	Structural Health Monitoring and NDT methods	- Sample problem solving class *Assignment 3 due*

PSS and Laboratory Schedule

	PSS			Automated Composites Lab (ACL)				
Week	Day	Time	Location	Day	Time	Location	Task	
2				Wed	12-1 pm 1-2 pm	L102 & 103, Willis Annexe	Composites lab tour and demonstration will happen during 12-2 p.m. (Lecture time of this week only)	
3	Tues	10am-12pm	Elec ENG G03					
	Tues	4pm-6pm	Red Centre 1040					
	Wed	2pm-4pm	Ainsworth 201 / OMB G32					
	Wed	4pm-6pm	Ainsworth 201					
4	Tues	10am-12pm	Elec ENG G03	TBA	TBA	TBA	ACL, Willis Annexe (L102-103)	Assignment 2: Instron
	Tues	4pm-6pm	Red Centre 1040					
	Wed	2pm-4pm	Ainsworth 201 / OMB G32					
	Wed	4pm-6pm	Ainsworth 201					
5	Tues	10am-12pm	Elec ENG G03	TBA	TBA	TBA	ACL, Willis Annexe (L102-103)	Assignment 2: Instron
	Tues	4pm-6pm	Red Centre 1040					
	Wed	2pm-4pm	Ainsworth 201 / OMB G32					
	Wed	4pm-6pm	Ainsworth 201					
6	Tues	10am-12pm	Elec ENG G03	TBA	TBA	TBA	ACL, Willis Annexe (L102-103)	Assignment 2: Instron
	Tues	4pm-6pm	Red Centre 1040					
	Wed	2pm-4pm	Ainsworth 201 / OMB G32					
	Wed	4pm-6pm	Ainsworth 201					

	PSS (Cont'd)			Automated Composites Lab (ACL) (Cont'd)				
7	Tues	10am-12pm	Elec ENG G03	TBA	TBA	TBA	ACL, Willis Annexe (L102-103)	Assignment 3: Composite manufacturing (VRI)
	Tues	4pm-6pm	Red Centre 1040					
	Wed	2pm-4pm	Ainsworth 201 / OMB G32					
	Wed	4pm-6pm	Ainsworth 201					
8	Tues	10am-12pm	Elec ENG G03	TBA	TBA	TBA	ACL, Willis Annexe (L102-103)	Assignment 3: Composite manufacturing (VRI) & Tensile/3PB test
	Tues	4pm-6pm	Red Centre 1040					
	Wed	2pm-4pm	Ainsworth 201 / OMB G32					
	Wed	4pm-6pm	Ainsworth 201					
9				TBA	TBA	TBA	ACL, Willis Annexe (L102-103)	Assignment 3: Tensile/3PB test
10				TBA	TBA	TBA	ACL, Willis Annexe (L102-103)	

6. Assessment

Assessment overview

Assessment	Group Project?	If Group, number of Students per group	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Assignment 1	No	N/A	5000 words (10 pages)	15%	1, 2, 3	Understanding of industry specific applications of composites and critical views on the published literature	5 pm Friday in week 3 (8th March 2019)	Week 3	Two weeks after the submission day
Assignment 2	Yes	12	15 pages	20%	1, 2, 5	Use of experiment and Simulation technology for composites. Report writing, communication skills and understanding of experimental procedures	5 pm Friday in week 7 (5th April 2019)	Week 7	Two weeks after the submission day
Assignment 3	Yes	19	10 pages + 500 words discussion	20%	1, 4, 5	Hands-on sample manufacture, experiments, report writing and communication skills	5 pm Friday in week 10 (26th April 2019)	Week 10	Two weeks after the submission day
Final exam	No	N/A	2 Hours Examination	45%	1, 2, 4	Understanding of all course content	Exam period, date TBA.	NA	Upon release of final results

Assignments

Purpose

We need to find out how well you have:

- grasped the fundamentals of micro-mechanics of composites
- become proficient in developing your understanding for engineering applications
- become proficient in calculation layout and development
- developed correct, professional technique
- become proficient in using composite materials fundamentals to solve practical problems and apply
- come to see the world through “engineers’ eyes”
- prepared yourself for your future career

Scheme

The final grade in MECH9420 will be based on the sum of the scores from each of the assessment components.

- Final grades may be adjusted by scaling with the approval of the appropriate departmental meeting.
- A pass in this course requires a mark of 50% in assessments and final examination.

Presentation

All submissions should have a standard School cover sheet, available on 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. In the event of incorrect answers, marks are awarded for method and understanding.

Further details of individual assessment tasks will be provided on Moodle, including submission procedures and the criteria by which grades will be assigned.

The preferred set-out of any numerical calculation is similar to the following:

$A_{bow} = 0.0035AmfV$	(Equation in symbols)
$= 0.0035 \times 480 \times 0.95 \times 1.0 \times 18.00$	(Numbers substituted)
$= 28.7\ m^2$	(Answer with units)

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. 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.

Assessment Criteria

Assignment/ Laboratory Reports

- Interpretation of the experimental results for the required information described in the handout for each experiment.
- Understanding the relationship between the theory covered during the lectures and experimental results in the laboratory.
- Presentation of the report in accordance with the MECHENG guidelines.
- Attendance and participation during the laboratory experiments.

Final examination

- Use the basic concepts of micro- and macro-mechanics of structures.
- Systematic approach to outline the steps for a problem and use the necessary fundamental concepts covered in the lectures and problem solving classes.
- Correctness of the solution with the aid of necessary diagrams/sketches and the use of appropriate units.

Examinations

You must be available for all tests and examinations. Final examinations for each course 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.

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 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 has interfered with your assessment performance, you are eligible to 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

Reference Texts

1. Isaac M. Daniel and Ori Ishai, Engineering Mechanics of Composite Materials, Oxford University Press, 1994.
2. Mel M. Schwartz, Composite Materials, Vol 2, Prentice Hall, New Jersey, 1997.
3. 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

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.

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.

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

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
- 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

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