Mechanical and Manufacturing Engineering

Course Outline

Term 2 2019

MECH4320

ENGINEERING MECHANICS 3

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Dr. David C. Kellermann
Office location: Ainsworth 208J
Tel: (02) 91619714
Email: d.kellermann@unsw.edu.au

Consultation time can be arranged via email. Step 1 is to talk to your peers or post on Teams, step 2 is to discuss with your demonstrator, step 3 is to message your lecturer on Teams or email with your question, and only after all those steps have been exhausted should you attempt to arrange a meeting.

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

Name: Michael Ling, Head Demonstrator
Email: m.z.ling@unsw.edu.au
Contact Michael via Teams chat (Search Michael Ling)

Please see the course Moodle.

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 4-5 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

	Day	Time	Location
Lectures	Monday	3pm – 5pm	Ainsworth Building G02 (K-J17-G02)
Problem Solving Sessions (PSS)	Wednesday	3pm – 5pm	Ainsworth Building 201 (K-J17-201)
Block Test (Weeks 4, 7, 10)	Friday	1pm – 2pm	Ainsworth Building 201 (K-J17-201)

Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes.

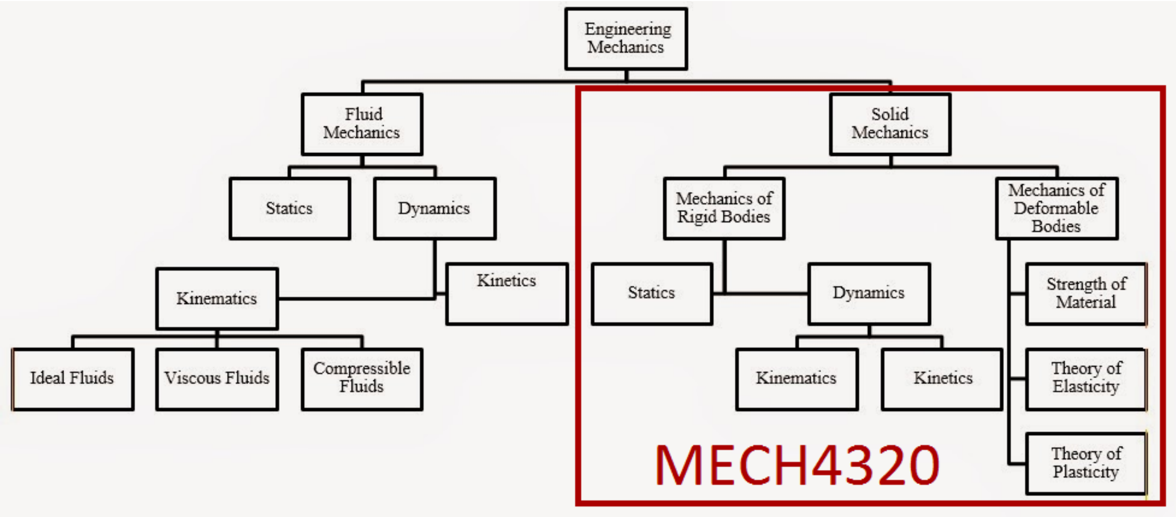
Summary and Aims of the course

This course is a sequel to courses in Engineering Mechanics (MMAN1300 and MMAN2300) where you will have studied the dynamics of particles, rigid bodies and mechanisms under a number of simplifying assumptions – chiefly that motion occurs in the plane. Although not a prerequisite, it also follows on from the concepts learnt in Solid Mechanics (MMAN2400 and MMAN3400). However, we will introduce new absolute tensor notation, which is essentially like starting from scratch. In this course, you will examine particle and rigid body systems that move and rotate in all three dimensions. You will also be presented with some instruction in the appropriate background mathematics necessary for the above. We will introduce students to the modern formulation of continuum mechanics, which is a basis-free formalization of elasticity theory. This will ultimately extend to hyperelastic theory.

Aims of the course

In this course, we will be looking at advanced topics within the Solid Mechanics (rather than Fluid Mechanics) stream of Engineering Mechanics. The aims of this course are split between the two major disciplines of Solid Mechanics, namely the *Mechanics of Rigid Bodies* and the *Mechanics of Deformable Bodies*:

1. You will gain new ways of seeing, explaining and predicting the behaviour of dynamic engineering systems in a generalised three-dimensional formulation.
2. You will gain basic familiarity with some advanced tensor representations of elasticity theory in its more modern form known as "continuum mechanics" that will allow you to formulate large deformation solutions in solid mechanics.



You will be developing an advanced body of knowledge in engineering mechanics, enhancing your conceptual understanding of the fundamentals of analytical dynamics and nonlinear continuum mechanics - some of the research directions therein as well as your ability to communicate this new understanding to your peers and lay people. This course would be a complement to a Finite Element Methods or Composite Mechanics course.

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.	Explain and describe principles and components of Rigid Body Dynamics, the Mechanics of Deformable Bodies and their inter-relationships formally and informally, in writing and verbally, to technical experts, peers and lay people.	1.1, 1.3 3.2, 3.4
2.	Model, approximate, analyse and simulate the kinematics of rigid bodies in three dimensions using appropriate computational tools as necessary. Model materials using modern continuum mechanics formulations	1.1, 1.2, 1.3 2.1, 2.2 3.2, 3.4
3.	Model, approximate, analyse and simulate the mechanics of rigid and deformable bodies in three dimensions using Newton-Euler and basis-free formulations and appropriate computational tools as necessary.	1.1, 1.2, 1.3 2.1, 2.2 3.2, 3.4
4.	Apply the principles of engineering mechanics to the dynamics of particles and rigid bodies in three dimensions. Apply the principles of equilibrium, minimum potential energy and objectivity to the mechanics of deformable bodies.	1.1, 1.2, 1.3 2.1

Learning Outcome		EA Stage 1 Competencies
5.	Discern the relevant principles that must be applied to describe or measure the equilibrium or motion of dynamic systems or the relevant measures in finite deformation for both stress and strain; Discriminate between relevant and irrelevant information in the context.	1.1, 1.2, 1.3 2.1

4. Teaching strategies

This course will be delivered both in the classroom and online. Full participation in the class means that you will participate fully in both arenas. That is, you will be held accountable for all content, instructions, information, etc. that is delivered either in class or online. There will also be homework exercises that you will have to complete during your self-study time.

Online: The online forum for participation in this class is the Moodle Platform, specifically the MECH4320 course at http://moodle.telt.unsw.edu.au/. All official online interactions will take place or be linked clearly and appropriately from this site.

In class: There are two in-class activities in a typical week which we refer to as the Lecture and Problem Solving Class based on the timetable above.

Both the online and in-class segments of this course are organised on the following principles:

1. **Learning:** Student learning is the first priority - teaching and assessment are secondary concerns. Learning here is defined as gaining new ways of seeing the world, not as being filled with information. We are trying to transform you into engineers and critical thinkers in the discipline.

2. **Peer Interaction:** Learning is a social activity, and research shows that you will learn most and best when you are actively taught by your peers and, in turn, when you teach them.

3. **Authenticity:** We will have as much authenticity of engineering practice as is possible within the constraints of the course and where it does not restrain your learning.

4. **High standards:** We will have high standards for achievement in the course, and everyone (including staff) will be accountable for putting in the effort to get you to the standard.

5. **Openness:** As much of the course as possible will be conducted in the open where all participants can be aware of it and comment upon it.

6. **Process:** The focus of the course will be on processes, not outcomes. The right outcomes will be a by-product of following the correct processes.

5. Course schedule

	Week		Topics
Block 1	1	Mathematical Background	**Week 1-** Linear algebra, general coordinate systems, covariant and contravariant basis vectors, linear transformations
	2		**Week 2-** Tensor algebra, indicial notation, matrix notation, absolute tensor notation
	3		**Week 3-** Tensor calculus
Block 2	4	Mechanics of Solid Bodies	**Week 4-** Kinematics and Kinetics of Particles in three dimensions Work-energy formulations for particles. Conservative forces.
	5		**Week 5-** Kinematics of rigid bodies in three dimensions: rotation and angular velocity tensors Kinetics of rigid bodies in three dimensions: Newton-Euler formulation, centre of mass, inertia tensors and principle axes, work – energy formulations
	6		**Week 6-** Kinematics: Deformation tensor and polar decomposition, Finite strain tensors Forces, tractions Finite stress tensors and transformations, Lagrangian and Eulerian measures
Block 3	7	Mechanics of Deformable Bodies	**Week 7-** Constitutive modelling Material tensors Orthotropic material modelling
	8		**Week 8-** Material nonlinearity and hyperelasticity Strain energy functions Compressible and incompressible materials
	9		**Week 9-** Principle of minimum potential energy Balance laws Objectivity: Principle of Material Frame indifference
	10		**Week 10-** Revision and practical examples

6. Assessment

Assessment overview

Assessment	Group Project? (# Students per group)	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Weekly Hand-in of problem sets	No	3-6 Questions	1% each, max 9%	1 and 4	A sound attempt at all questions.	Hand in during the following problem solving class, students who come late or leave early will be given 0.5 maximum.	One week late, maximum 0.5 marks	Immediate
3 Block Tests	No	30-45 mins	12% each, max 36%	1 - 5	Lecture material up to weeks 3, 6 and 9.	During weeks 4, 7 and 10	No supplementary	Two weeks later
Assignment	No	3 weeks	10%	1, 3, 4	Document presentation, report writing, analysis	Week 9	Week 10	End of each block
Final exam, 9 questions	No	3 hours	45%	1 - 5	All course content from Weeks 1-10 inclusive.	Exam period, date TBC	N/A	Upon release of final results

Assignments

Presentation

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. 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

The final exam will be 3 hours and have 9 questions, with 1 question on each topic/week of trimester. You are required to pass the final exam in order to pass the course.

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 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

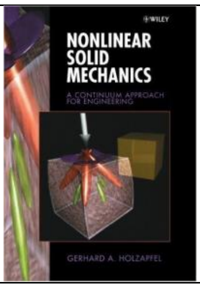
If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to submitting an assessment or sitting an exam.

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

The following textbooks will be used for this course. I have chosen an economic textbook that are also high quality reference books that you will be able to use throughout your career. I expect all students to bring the relevant book to class during the coverage of each topic.

	**Nonlinear Solid Mechanics: (NSM)** **A Continuum Approach for Engineering** ***1st Edition (2000)*** ***by Holzapfel, Gerhard A.*** *John Wiley and Sons, Ltd*	**Topic:** Mechanics of deformable bodies **Covered:** Weeks 2-10	Available from UNSW Bookshop $106.95

Weekly course material will be available on the MECH4320 Teams site (use Teams app) at https://teams.microsoft.com *(sign in using* zID@ad.unsw.edu.au*) and Moodle Page at* http://moodle.telt.unsw.edu.au/

These and many other relevant resources are available at the UNSW Library: http://info.library.unsw.edu.au/web/services/services.html

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.

In this course, recent improvements resulting from student feedback include:

- More reasonable workload, in line with typical 6UOC subject
- Better textbooks
- Improved structure
- Improved lecture notes
- More past papers
- More learning resources and more practice questions
- More practical questions relating to engineering applications

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. 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. Academic honesty and plagiarism

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
- Computing Facilities
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Lab Access

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