UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Term 1 2020

MMAN4410

FINITE ELEMENT METHODS

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1. Staff contact details

Contact details and consultation times for course convenor

Name: Garth Pearce
Office location: 208E Ainsworth
Tel: (02) 9385 4127
Email: g.pearce@unsw.edu.au

Preferred correspondence is via class Team. Direct messaging through Teams should be reserved for individual questions, not technical ones. Face-to-face consultation available after the lecture (Friday 11am – 12pm)

Contact details for demonstrators
The course demonstrators are available through the class Team:

- Olivia Ng
- Nimal Kumar Balasubramani
- Joseph (Yeo Cheon) Kim
- Quang Tran
- Dane Zielinski-Nicolson
- Boming Zhang

For other contact details, please see the course Moodle.

2. 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

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 11 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	Friday (Weeks 1-7, 9-10) Tuesday (Week 11)	9 – 11am	Webster Theatre B
(Web stream)	Any	Any	Moodle/Teams
Demonstrations*	Friday (Weeks 1-7, 9-10)	12 – 2pm	Ainsworth 203/204
	Friday (Weeks 1-7, 9-10)	2 – 4pm	Ainsworth 204

*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 will teach you to analyse real world structural mechanics problems using the finite element method. You will be introduced to the mathematical basis of finite element analysis, on which nearly all structural analysis software is built. You will learn how to apply commercially available finite element software to solve real-world engineering problems. The course will cater to the specific challenges of engineers across all mechanical disciplines (Aerospace, Manufacturing, Mechanical and Mechatronic). Any student wishing to extend their structural analysis skills should take this course.

The primary aim of this course is to train you to solve complex engineering structural mechanics problems with finite element analysis. The course will provide deep insight into the operation of finite element analysis software by teaching you the underlying computational methods involved. You will be taught to execute a detailed finite element study including planning, modelling, meshing, solving, evaluating results and validating against real world data.

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.	Apply fundamental finite element analysis techniques to solve simple engineering problems	2.1, 2.2
2.	Explain the underlying mathematics behind finite element analysis software solvers	1.2, 3.2
3.	Plan and execute appropriate finite element analyses to solve a range of solid mechanics and other engineering problems	2.1, 2.2, 2.4, 3.2
4.	Perform a detailed finite element study to investigate a real-world engineering problem	2.1, 2.2, 2.4, 3.2, 3.3

4. Teaching strategies

The approach to teaching in this class is shaped by a range of formal and informal best-practice approaches. The objective, when at all possible, is for you to experience the concepts in multiple modes (theory, example problems, simulations, demonstrations, etc.). New teaching strategies and teaching technologies are deployed every year to ensure that the course is as up-to-date as possible to leading teaching standards.

This course includes two face-to-face teaching methods:

1. Lectures to introduce fundamental finite element analysis concepts
2. Software laboratories to apply fundamental concepts in common finite element analysis packages

In addition to the face-to-face teaching, a range of blended techniques will be used through Moodle to engage you with independent learning. The major assignment, for example, includes a significant research component which will allow you to study an engineering problem which is specific to your own interests.

5. Course schedule

Week	Name	Topic	Location	Reading (Author initials)
1	FE Basics	Introduction to FEA; Discretisation; FE Terminology; Stiffness Matrices for Bars and Trusses; Element Library Introduction.	Webster Theatre B	CB Ch 1-3
2	Mathematics of FEM	Applying Loads and Boundary Conditions; Assembly; Solving for Nodal Displacements; Constitutive Laws; Interpolation of Stress and Strain	Webster Theatre B	CB Ch 2-3
3	The Element Library	2D Triangles and Quads; Shells; 3D Tets and Hexes; Solid Shells; Isoparametric Elements; Quadratic and Higher Order Elements; Choice of Element Types	Webster Theatre B	CB Ch 5-9
4	Good FE Practice	FE Problem Solving Approach; Assumptions, Mistakes and Errors; Meshing Strategy; Convergence; Validation; Computational Resources; CAD; FE Reporting	Webster Theatre B	Class Notes
5	Buckling and Non-linear Analyses	Eigenvalue Solutions; Linear Buckling; Material Non-linearity; Geometric Non-linearity and Buckling; Iteration Schema and Incremental Analysis; Contact	Webster Theatre B	CMPW Ch 18
6	Composite Analysis	Basics of Composites and Composite Mechanics; Modelling Challenges; General Approaches to Modelling Orthotropic and Layered Materials; Industry Case Study	Webster Theatre B	Class Notes
7	Vibration and Transient Analyses	Modal Analysis; Harmonic Analysis; Other Vibration Solutions; Transient Solutions and their Applications; Choice of Time Discretisation	Webster Theatre B	CB Ch 11
9	Thermal Analysis	Scalar Field Problems; Heat Transfer Refresher; Steady-state Thermal Analysis; Transient Analysis; Radiation; Thermo-mechanical and Electro-thermal Analysis	Webster Theatre B	CB Ch 10 and Notes
10	Advanced FE Topics	What else can we use FEM for? Topics may include: Mechanisms and Rigid Dynamics; Fluid-Structure Interaction; Magnetostatics; Soil Modelling; etc.	Webster Theatre B	Class Notes
11*	Final Exam Preparation	Tackling a past exam question	Webster Theatre B	N/A

* Week 11 class is on Tuesday

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
FE Assignment	Yes (5)	20 pages max	15%	1 and 3	Thorough planning and execution, Report writing and communication skills.	Sun 22nd March	Fri 27th March	Within two weeks of submission
Quizzes (3)	No	1 hour each	15% (3x 5%)	1 and 2	Correct responses.	Thu 5th March Thu 19th March Thu 2nd March	N/A	Following Monday
Major FE Project: - *Proposal* - *Portfolio* - *Peer Evaluation* - *Final Report*	No	See later	50%: *0%* *10%* *10%* *30%*	1,2,3 and 4	Thorough planning and execution; Report writing and communication skills; Creative solution to Engineering problem	Sun 15th March Thu 9th April Thu 16th April Tue 28th April	5 days after respective submission dates	Within two weeks of submission
Final Theory and Practice Exam	No	2.5 hours	20%	1, 2 and 3	Skilled use of ANSYS and application of lecture content.	Exam period	N/A	With final results

Assignments

Group Assignment

Finite Element Analysis is numerically intensive and is exclusively solved by powerful computers for all real engineering problems. Modern software packages hide the majority of complex tasks from the user. Unfortunately, this level of automation can lead to the false belief that FEA is an infallible tool. It is important that you as an engineer understand the computations being conducted on your behalf in order to understand their limitations and possible errors that can appear in your analyses. This assignment will teach you the fundamentals of the Finite Element Method through hand calculations and simple programming.

As in the professional practice of engineering, you will not choose the team that you work with; however, you may assign the different elements of the task among team members as you see fit. A group 'peer assessment' tool will be used to measure team member contribution and marks adjusted accordingly.

Feedback given on this report is intended to assist you in understanding the expectations of the Major Project draft and final reports.

Major Project

You will complete a flexible major project which will form the largest component of the assessment for the course. You may choose from a selection of project topics partially prewritten by the demonstrators. The topics will be broad enough to encourage you to solve the problem creatively.

The project will be a current FE simulation challenge in scientific or engineering literature or from a relevant engineering discipline. The assessment will be broken into pieces to ensure that adequate progress is being made throughout the semester:

- Mentor/topic selection – 0%
    - Each mentor will supervise one (or a few) projects related to their expertise
- Project proposal – 0%
    - A detailed summary of what you plan to do to address the topic problem
- Portfolio – 10%
    - A portfolio of work completed towards your project.
    - In addition to the project work, it can (and should) include class examples that have helped you to define your project
- Peer Evaluation and Reflection – 10%
    - Review the work of others conducting different analyses. Provide constructive feedback and review your own work critically.
- Final Report – 30%
    - The final report of your work

Detailed submission guidelines and marking rubrics will be provided on Moodle.

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

Three online quizzes will be held throughout the term (see timetable above).

You must be available for all quizzes, 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

Microsoft Teams and OneNote

Microsoft's new communication platform, Microsoft Teams, will be used for most communication in this course. It has native apps for Windows, Android, iOS and more. OneNote will be used to distribute the class notes (embedded in Teams).

myAccess and Matlab

UNSW myAccess provides access to your engineering software from many different devices. This course will use Matlab extensively, which is available through myAccess and the computer labs.

Learning Management System

The Moodle LMS, https://moodle.telt.unsw.edu.au/ will also be used for this course

UNSW Library

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

Textbooks (Suggested)

- Chandrupatla, T. R., Belegundu, A. D. (2011) Introduction to Finite Elements in Engineering, 4th Ed, Prentice Hall (Pearson)
- Cook, R. D., Malkus, D. S., Plesha, M. E., Witt, R. J. (2002). Concepts and Applications of Finite Element Analysis, 4th Ed, John Wiley & Sons.

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:

- Introducing a group assignment to smooth your transition into the course.
- Spreading assessments out over the term more evenly.
- Streamlining the topic selection process so that you are provide with more structure.
- Reducing and streamlining the assessment load to ensure that you have more time and that you can get feedback faster.

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. Administrative matters and links

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
- Equitable Learning Services

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