UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Semester 1 2018

MMAN4410

FINITE ELEMENT METHODS

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Course Convenor: Mr. Phil Howlin
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Head Demonstrator: Declan Walsh
Email: declan.walsh@unsw.edu.au

Other Demonstrators: (alphabetical)
Jake Bradbury
Darson Li
Keith Ly
Olivia Ng
Harshad Ranadive
Congyuan Tao
Paul Yip

Consultation

Consultation concerning this course is available primarily during the software laboratories. Phil and Declan will generally be available during the software laboratories. Outside of these hours, the convenor and demonstrators can be contacted through the Moodle platform. *Any questions about course content and assessment that are not of a private nature should be directed to a Moodle forum first*. Any *personal* queries about course administration can be directed to Phil or Declan via direct email or Moodle direct message.

2. Important links

- Moodle
- UNSW Mechanical and Manufacturing Engineering
- Course Outlines
- Student intranet
- UNSW Mechanical and Manufacturing Engineering Facebook
- UNSW Handbook

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 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. Thus, for a full-time enrolled student, the normal workload, averaged across the 16 weeks of teaching, study and examination periods, is about 37.5 hours per week.”

This means that you should aim to spend about 9 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	1pm - 3pm	Colombo Theatre C (K-B16-LG05)
(Web Stream**)		Any	Any	Moodle
Software Laboratory	***Lab A***	Friday	9am – 11am	Ainsworth J17/203
	Lab B	Friday	9am – 11am	Ainsworth J17/204
	Lab C	Friday	11am – 1pm	Ainsworth J17/204

Lectures commence in Week 1 and continue to Week 8. Software laboratories commence in Week 2 and continue to Week 13.

** Web Stream students are welcome to attend the face-to-face lectures on Friday. Otherwise, videos of the lectures will be available through Moodle, both as live-streamed lectures and as recordings.

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 train 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, for example Adaptive Tutorials in Smart Sparrow to engage you with independent learning. The major assignment also includes a significant research component which will allow you to study an engineering problem that is specific to your own interests.

5. Course schedule

Week	Date	Name	Topics	Reading (Author initials)
1	2-Mar	Introduction to FEM	Introduction to FEA; Discretisation; FE Terminology; Stiffness Matrices for Bars and Trusses; Element Library Introduction.	CB Ch 1-3
2	9- Mar	Numerical Solution Procedure	Applying Loads and Boundary Conditions; Assembly; Solving for Nodal Displacements; Constitutive Laws; Interpolation of Stress and Strain	CB Ch 2-3
3	16-Mar	The Element Library	2D Triangles and Quads; Shells; 3D Tets and Hexes; Solid Shells; Isoparametric Elements; Quadratic and Higher Order Elements; Benefits and Limitations of Different Element Types	CB Ch 5-9
4	23-Mar	Good FE Practice	A General FE Problem Solving Approach; Modelling Assumptions; Meshing Strategy; Convergence; Validation; Sources of Error in FE; Computational Resources; Interfacing with CAD; FE Reporting	Class Notes
5	30-Mar	Public Holiday, Good Friday		
Break	6-Apr	Teaching Recess		
6	13-Apr	Buckling and Non-linear Analyses	Eigenvalue Solutions; Linear Buckling; Material Non-linearity; Geometric Non-linearity and Buckling; Iteration Schema and Incremental Analysis; Contact	CMPW Ch 18
7	20-Apr	Vibration and Transient Analyses	Modal Analysis; Harmonic Analysis; Other Vibration Solutions; Transient Solutions and their Applications; Choice of Time Discretisation	CB Ch 11
8	27-Apr	Advanced FE Topics	Mechanisms and Rigid Dynamics; Modelling Composites; Thermal Analyses; Fluid-Structure Interaction; Magnetostatics; Soil Modelling	CB Ch 10

6. Assessment

Assessment overview

Assessment		Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
1	Group Assignment	15 pages max	10%	1 & 3	Thorough planning and execution, Report writing and communication skills.	5pm* Thursday Week 4 22rd March via Moodle	5pm Saturday Week 4 24th March	Sooner than two weeks after submission
	Individual Assignment	10 pages max	10%	1 & 3	Thorough planning and execution, Report writing and communication skills.	5pm* Thursday Week 6 12th April via Moodle	5pm Saturday Week 6 14th April	Sooner than two weeks after submission
2	Quizzes (2)	1 hour each	10% (2 x 5%)	1, 2	Lecture material delivered before the quiz date.	Quiz 1: Monday Week 5 26th March via Moodle Quiz 2: Monday Week 9 30th April via Moodle	At the close time of the Moodle Quiz	At the close time of the Moodle Quiz
3	Final Exam/Practical	3 hours	20%	1, 2 & 3	Fluent use of ANSYS and application of lecture content.	Final Exam Period	At the conclusion of the Exam	With Final Results
4	Major Project Report	Draft: 20 pages Final: 25 pages	50% (15%+35%)	3,4	<See later>	Draft: 5pm* Thursday Week 9 3rd May via Moodle Review: 9am Friday Week 10 11th May via Moodle Final: 5pm* Friday Week 13 1st June via Moodle	Draft: 9am Friday Week 9 4th May** Review: 9am Friday Week 10 11th May** Final: 5pm Friday 8th June	Draft & Review: Friday Week 10 Final: With Final Results

* Assignments are due at 5pm but may be submitted as late as 11:55pm without penalty. See 'Submission' below.

** The Draft and Review activities are peer reviewed and, as such, late submissions cannot be accepted without special consideration.

To pass the course, you must achieve an overall mark of at least 50%.

See pages following for additional assessment information.

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 students in understanding the expectations of the Individual Assignment and Major Project draft and final reports.

Individual Assignment

Proper planning, execution and reporting of analyses are crucial skills for any engineering graduate. When using FE analysis techniques to solve and report on a problem, there are countless opportunities to exercise poor technique. At best, poor technique detracts from the quality of the solution and at worst leads to dangerous or negligent results.

During this assignment, you will study a very simple engineering problem using FEM but will learn best practice techniques to ensure you produce high quality results and write an excellent report.

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

Major Project

Students will complete a flexible major project which will form the largest component of the assessment for the course. Students may choose from a selection of projects pre-written by the demonstrators *or* may work on a project of their choosing.

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 selection and choosing between a pre-written project or your own project (Opens Friday Week 3, due Friday Week 4)
- For students submitting their own project, topic selection submitted for approval (Thursday Week 5)

    - A topic title and 200-word outline will be submitted to the demonstrators for approval by Thursday Week 5.
    - Must be submitted and passed to progress
    - If the original submission is not approved, the demonstrator will include comments of changes required. The proposal is to be re-submitted.
- Draft findings (Monday Week 9)
    - A small report will be submitted by Monday Week 9 with preliminary findings, which will be peer assessed.
    - The peer-assessment process will be worth 15 of the 50 marks for the major project.
- Final Report (Friday Week 13)
    - A major report on you FE project will be due in Week 13
    - The final report will be worth 35 of the 50 marks for the major project.

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. Calculations, where they are necessary, should be shown professionally in a manner befitting the submission type. *Scans of hand calculations will not be accepted in this course.*

Submission

The submission of online material should follow the instructions given on the appropriate Moodle page.

Online submissions are required to be submitted via Moodle. No cover sheet is required as all assignments will be identified through your Moodle account. *All digital assignments are due by 5pm on the due date.* An additional allowance will be granted automatically to submit assignments until 11:55pm without penalty, but you accept any risk of technical difficulties with submission. *If you try to submit between 5pm and 11:55pm and Moodle does not accept the submission for any reason, the assignment will be considered late.*

Late submissions will be penalised 5 marks per calendar day (including weekends). An extension may only be granted in exceptional circumstances. Special consideration for assessment tasks must be processed through student.unsw.edu.au/special-consideration.

It is always worth submitting late assessment tasks when possible. Completion of the work, even late, may be taken into account in cases of special consideration.

Where there is no special consideration granted, the ‘deadline for absolute fail’ in the table above indicates the time after which a submitted assignment will not be marked, and will achieve a score of zero for the purpose of determining overall grade in the course.

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

Quiz 1 and 2

There will be 2 'open book' quizzes in this course. The quizzes will be available in Moodle for a 24 hour period and must be completed in a 1 hour duration. The window for Quiz 1 will be Monday Week 5 26th March. The window for Quiz 2 will be Monday Week 9 30th April.

Although these quizzes are open book and done on your own time, you are required to complete them on your own as individual tasks and you are requested not to share the contents of the quiz with your fellow students until after the quiz has closed.

To undertake the quiz, you will need a computer with an internet connection. You may use your own or one of the computers on Level 2 of the Ainsworth J17 building.

Final Practical Exam

There will be a final ANSYS practical exam during the June examination period. Provisional Examination timetables are generally published on myUNSW in May. You must be available for this examination.

Details of this assessment will be expanded on in lectures and on Moodle. The task is designed to test your understanding of good FEA practices and your fluency with the ANSYS workbench tool. (Note: If you are more competent and fluent with another FEA software package, you may use that package during this exam. Please discuss with the course convenor)

The exam will be held in an allocated computer laboratory, and students may use any engineering software installed on those computers, except for communication/file sharing with other students.

For further information on exams, please see the Exams section on the intranet.

Special consideration and supplementary assessment

For details of applying for special consideration and conditions for the award of supplementary assessment, see the School intranet, and the information on UNSW's Special Consideration page.

7. Attendance

You are required to attend a minimum of 80% of all classes, including lectures, labs and seminars. It is possible to fail the course if your total absences equal to more than 20% of the required attendance. Please see the School intranet and the UNSW attendance page for more information.

8. Expected resources for students

Learning Management System

Moodle LMS, https://moodle.telt.unsw.edu.au/ will be used for this course. Lecture notes, software laboratories, assignments, links and forums will be available on Moodle. Moodle is a powerful tool that you are encouraged to use for all course needs.

Microsoft OneNote Class Notebook

Enrolment in UNSW gives students access to Office365 applications in a web browser or Windows or iOS operating environment. This session, class notes will be distributed using the OneNote Class Notebook.

Textbooks

- 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.

Other Resources

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

9. 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 introduce students more steadily into the course, and lengthening the final exam from 2 hours to 3 hours.

10. 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

Further information on School policy and procedures in the event of plagiarism is available on the intranet.

11. 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, Participation and Class Etiquette
- UNSW Email Address
- Computing Facilities
- Assessment Matters (including guidelines for assignments, exams and special consideration)
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Student Support 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