

## **MMAN4410**

# **Finite Element Methods**

# Contents

1. Staff contact details .....	3
Contact details and consultation times for course convenor .....	3
Contact details and consultation times for additional lecturers/demonstrators/lab staff .....	3
Consultation .....	3
2. Course details .....	3
Credit Points .....	3
Contact hours.....	3
Summary of the course .....	3
Aims of the course .....	4
Student learning outcomes.....	4
3. Teaching strategies .....	4
4. Course schedule .....	5
5. Assessment.....	6
Assessment overview.....	6
Assignment 1 – FE Fundamentals.....	7
Assignment 2 – Good FE Practice.....	7
FE Fundamentals Exam.....	7
Major Project.....	7
Assignments .....	8
Presentation .....	8
Submission.....	8
Marking and Assessment Criteria.....	8
Special consideration and supplementary assessment .....	9
6. Expected resources for students .....	9
Learning Management System.....	9
Textbooks .....	9
Other Resources .....	9
7. Course evaluation and development .....	9
8. Academic honesty and plagiarism .....	9
9. Administrative matters.....	10
Appendix A: Engineers Australia (EA) Competencies .....	11

# 1. Staff contact details

## Contact details and consultation times for course convenor

Name: Dr Garth Pearce

Office Location: Ainsworth Building 208E

Tel: (02) 9385 4127

Email: [g.pearce@unsw.edu.au](mailto:g.pearce@unsw.edu.au)

Consultation: 1-3pm Friday (after the lecture). Room TBA via Moodle

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

Name (Head Demonstrator): Darson Li

Email: [darson.li@unsw.edu.au](mailto:darson.li@unsw.edu.au)

## Consultation

Consultation concerning this course is available primarily 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 Garth via direct email or Moodle direct message.*

# 2. 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	11am - 1pm	Webster Theatre B
Demonstrations	Friday	9am – 11am	Ainsworth 203/204
Midsession	Friday (Wk 8)	11am - 1pm	Room allocation TBA through Moodle

## Summary 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, Mechatronic and Naval). Any student wishing to extend their structural analysis skills should take this course.

### Aims of the 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 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

## 3. 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.

## 4. Course schedule

All lectures in Webster Theatre B, Friday 11am - 1pm.

Week	Date	Name	Topics	Reading (Author initials)	
1	3-Mar	Introduction to FEM	Introduction to FEA; Discretisation; FE Terminology; Stiffness Matrices for Bars and Trusses; Element Library Introduction.	CB Ch 1-3	
2	10-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	17-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	24-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	31-Mar	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	
6	7-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	28-Apr	FE Fundamentals Exam			
9	5-May	Advanced FE Topics	Mechanisms and Rigid Dynamics; Modelling Composites; Thermal Analyses; Fluid-Structure Interaction; Magnetostatics; Soil Modelling	CB Ch 10	
10	12-May	FEA in Industry	Case studies of FEA use in Industry	None	

## 5. Assessment

### Assessment overview

Assessment	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Assignment 1 - FE Fundamentals	15 page max	10%	1	Technical Results, Report writing and communication skills, creative problem solving	Friday Week 4 via Moodle	Midnight Sunday after due date	Friday Week 6
Assignment 2 - Good FE Practice	15 page max	10%	3	Thorough planning and execution, Report writing and communication skills.	Friday Week 6 via Moodle	Midnight Sunday after due date	Friday Week 8
FE Exam	2h	30%	1,2	Correct answer, Correct working, Logical approach	Week 8 during Lecture Time	N/A	Monday Week 10
Major Project Report	Draft - 20 page Final - 25 page	50%	3,4	<See later>	Draft - Wednesday Week 9 via Moodle Final - Friday Week 13 via Moodle	Draft - Midnight Sunday after due date Final - Midnight Wednesday after due date	Draft - Monday Week 11 Final - During exam period

### *Assignment 1 – FE Fundamentals*

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.

### *Assignment 2 – Good FE Practice*

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.

### *FE Fundamentals Exam*

A mid-session exam will use a combination of short answer questions, derivations and long form calculations to test your understanding and application of FE fundamentals.

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](http://student.unsw.edu.au/exam-approved-calculators-and-computers)

### *Major Project*

A flexible major project will be given to you at the beginning of semester and will form the largest component of the assessment for the course.

The topic of the project will be up to you to decide, but must represent a current FE simulation challenge in the scientific 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:

- Topic selection guidance and approval (Friday Week 5)
  - A topic title and 200 word outline will be submitted to the demonstrators for approval by Friday Week 5.
  - Must be submitted and passed to progress
- Draft findings (Wednesday 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.

## Assignments

### *Presentation*

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work. Presenting them 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.

*In this course there are currently no plans to use the school assignment boxes for physical assignments; all assignments will be submitted digitally.* If there are technological difficulties which force the use of physical assignment copies, they must include a School cover sheet, which is available from the school website, and are to be submitted before 11am on the due date so that they can be processed before close of business.

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. Where an assessment task is worth less than 20% of the total course mark and you have a compelling reason for being unable to submit your work on time, you must seek approval for an extension from the course convenor **before the due date**. Special consideration for assessment tasks of 20% or greater must be processed through [student.unsw.edu.au/special-consideration](http://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 and Assessment Criteria*

Assessment criteria 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.



## 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](#).

## 6. 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.

### Textbooks

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

### Other Resources

If you wish to explore any of the lecture topics in more depth, then other resources are available and assistance may be obtained from the UNSW Library. One starting point for assistance is the library website: <https://www.library.unsw.edu.au/>

## 7. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience (previously CATEI) 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.

Based on feedback last semester, some minor changes have been made to the course for this offering:

- Inclusion of some more FE theory examples and activities
- The course Moodle page now reflects the alignment between the lecture content and the FE software

## 8. 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](http://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](http://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](#).

## 9. Administrative matters

All students are expected to read and be familiar with School guidelines and policies, 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](#)

*Garth Pearce  
January 2017*

# Appendix A: Engineers Australia (EA) Competencies

## Stage 1 Competencies for Professional Engineers

	<b>Program Intended Learning Outcomes</b>
<b>PE1: Knowledge and Skill Base</b>	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
<b>PE2: Engineering Application Ability</b>	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
<b>PE3: Professional and Personal Attributes</b>	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