UNSW AUSTRALIA

Course Outline

Semester 1 2016

Never Stand Still | Engineering | Mechanical and Manufacturing Engineering

MMAN4410

FINITE ELEMENT METHODS

Contents

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

Contact details for Demonstrators
Jay Sul - Head Demonstrator
Email: j.sul@unsw.edu.au

Others TBA through Moodle

Consultation
Consultation concerning this course is available during the software laboratories. 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 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	Monday	4 – 6pm	Webster Theatre B
Software Lab (attend one only)	Monday	10am – 12pm	Ainsworth Building 204
	Monday	12 – 2pm	Ainsworth Building 204
Midsession (attend one only)	Monday Week 7	4 – 6pm	Webster Theatre B Law 203 CivEng 701

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 below 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 order to maximise the utility of the course for different streams of the students in MMAN (Mech, Aero, Naval, etc), software laboratory sets will be provided which cater to the individual disciplines in the most appropriate software for each discipline. For example, Aerospace Engineering employers request that the students are familiar with Patran/Nastran whereas ANSYS is more appropriate for Mechanical Engineers. The school supports both packages and will for the foreseeable future.

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

4. Course schedule

Week	Date	Name	Topics
1	**29-Feb**	**Introduction to FEM**	Introduction to FEA; Discretisation; FE Terminology; Stiffness Matrices for Bars, Trusses and Beams; Element Library Introduction.
2	**07-Mar**	**Numerical Solution Procedure**	Applying Loads and Boundary Conditions; Assembly; Solving for Nodal Displacements; Constitutive Laws; Interpolation of Stress and Strain
3	**14-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
4	**21-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
Easter Break			
5	**04-Apr**	**Buckling and Non-linear Analyses**	Eigenvalue Solutions; Linear Buckling; Material Non-linearity; Geometric Non-linearity and Buckling; Iteration Schema and Incremental Analysis; Contact
6	**11-Apr**	**Vibration and Transient Analyses**	Modal Analysis; Harmonic Analysis; Other Vibration Solutions; Transient Solutions and their Applications; Choice of Time Discretisation
7	**18-Apr**	**Mid-session Exam**	
8	**25-Apr**	**Anzac Day**	
9	**02-May**	**Guest Lecture**	Guest lecture by UNSW Engineering Dean, Prof Mark Hoffman.
10	**09-May**	**Advanced FE Topics**	Mechanisms and Rigid Dynamics; Modelling Composites; Thermal Analyses; Fluid-Structure Interaction; Magnetostatics; Soil Modelling

5. Assessment

The final course mark will be determined by the following weightings:

Task	Assessment Type	Mark	Learning Outcomes Assessed	Assessment Criteria	Task Due	Marks Returned
Ass. 1	Engineering Report	10%	1	Technical Results, Report writing and communication skills, creative problem solving	Friday Week 4	Friday Week 6
Ass. 2	Engineering Report	10%	3	Thorough planning and execution, Report writing and communication skills.	Friday Week 6	Friday Week 8
FE Exam	Exam (2h)	30%	1,2	Correct answer, Correct working, Logical approach	Monday Week 7	Monday Week 10
Major Project	Engineering Report	50%	3,4	<See later>	Monday Week 9 Friday Week 13	Monday Week 11 During exam period
	Total	**100%**				

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

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 (Friday Week 9)
    - A small report will be submitted by Friday Week 9 with preliminary findings, which will be peer assessed.
    - The peer-assessment process will be worth 15l 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 marks.

Presentation
All submissions should have a standard School cover sheet which is available from this subject's Moodle page.

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 https://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.

Assessment Criteria
This is a final year elective course. We are expecting submissions appropriate to your level as junior engineers. The assessments are intentionally open-ended in their scope to allow you to demonstrate your skills with the Finite Element Method.

If you complete the project and assignments to the basic standard outline in the assignment handouts, you will get a good mark, but not a great one. To excel in this course you need to demonstrate higher order abilities (see the Teaching Strategies section for more info).

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 School Office or the Engineering Student Centre prior to the examination. Calculators not bearing an “Approved” sticker will not be allowed into the examination room.

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
Recommended Resources (available from the library)

- 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.
- Chandrupatla, T. R., Belegundu, A. D. (2011) Introduction to Finite Elements in Engineering, 4th Ed, Prentice Hall (Pearson)

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: www.library.unsw.edu.au/.

7. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the Course and Teaching Evaluation and Improvement (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.

Finite Element Methods was a new course in 2015. We learnt a lot during that course and have made a number of changes to improve your experience. The primary change from last semester is to provide a better set of software laboratory problems and to provide more structure for the major project.

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 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.

9. Administrative Matters

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

Garth Pearce
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Appendix A: Engineers Australia (EA) Professional Engineer Competency Standards

	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