Mechanical and Manufacturing Engineering

Course Outline

Semester 2 2017

MMAN4410

FINITE ELEMENT METHODS

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Course Convener: Mr. Phil Howlin (PH)
Office Location: Ainsworth Building J17/507
Tel: (02) 9385 4180
Email: p.howlin@unsw.edu.au
Consultation: 2-4pm Tuesday (after the lecture) or otherwise by appointment.

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

Guest Lectures by: Prof. Mark Hoffman (MH)
Professor Hoffman is not available for consultation for this course.

Head Demonstrator: Darson Li
Email: darson.li@unsw.edu.au

Consultation

Consultation concerning this course is available primarily during the software laboratories. Outside of these hours, the convener 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 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	Tuesday	12noon - 2pm	Tyree Energy Technology G16 (K-H6-G16)
(Web Stream)	Any	Any	Moodle
Laboratory/ Demonstrations	Friday	12noon – 2pm	Ainsworth J17/204
	Friday	2pm – 4pm	Ainsworth J17/204

Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes. Web Stream students are welcome to attend the face-to-face lectures on Tuesday. Otherwise, videos of the lectures will be available through Moodle.

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 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	By*	Name	Topics	Reading (Author initials)
1	25-Jul	MH	Introduction to FEM	Introduction to FEA; Discretisation; FE Terminology; Stiffness Matrices for Bars and Trusses; Element Library Introduction.	CB Ch 1-3
2	1-Aug	PH	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	8-Aug	PH	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
4	15-Aug	MH	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
5	22-Aug	PH	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	29-Aug	PH	Vibration and Transient Analyses	Modal Analysis; Harmonic Analysis; Other Vibration Solutions; Transient Solutions and their Applications; Choice of Time Discretisation	CB Ch 11
7	5-Sep	PH	Advanced FE Topics	Mechanisms and Rigid Dynamics; Modelling Composites; Thermal Analyses; Fluid-Structure Interaction; Magnetostatics; Soil Modelling	CB Ch 10
8	12-Sep	N/A	Quiz 2		
9	19-Sep	MH	FEA in Industry	Case studies of FEA use in Industry	None

*PH = Phil Howlin; MH = Mark Hoffman

6. Assessment

Assessment overview

Assessment	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Group Assignment	25 pages max	20%	1 & 3	Thorough planning and execution, Report writing and communication skills.	5pm* Thursday Week 6 31st August via Moodle	5pm Monday Week 7 4th September	Two weeks after submission
Quizzes (2)	1 hour each	10% (2 x 5%)	1, 2	Lecture material delivered before the quiz date.	Quiz 1: Monday Week 6 28th August via Moodle Quiz 2: Tuesday Week 8 12th September 12-2pm via Moodle	At the close time of the Moodle Quiz	At the close time of the Moodle Quiz
Final Exam/Practical	2 hours	20%	1, 2 & 3	Fluent use of ANSYS and application of lecture content.	Friday Week 10 6th October during Laboratory timeslot	4pm Friday Week 10 6th October	Two weeks after submission
Major Project Report	Draft: 20 pages Final: 25 pages	50% (15%+35%)	3,4	<See later>	Draft: 5pm* Monday Week 9 18th September via Moodle Final: 5pm* Friday Week 13 27th October via Moodle	Draft: 5pm Thursday Week 9 21st September Final: 5pm Friday 3rd November	Draft: Monday Week 11 Final: During exam period

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

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

See pages following for additional assessment information.

Assignments

Group 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. You will have the opportunity to demonstrate an appreciation for element types introduced in Week 4. Further details of the assignment will be released in Moodle.

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 Major Project draft and final reports.

Quiz 1 and 2

There will be 2 ‘open book’ quizzes in this course. The quizzes will be available in Moodle for a window of time, and must be completed in a given duration. The window for Quiz 1 will be 28th August, from 7am to 10pm. The window for Quiz 2 will be 12th September, from 12 noon to 2pm, during the normal lecture time for the subject. Quiz durations will be advised during the session, but are expected to be an hour or less.

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 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 Exam/Practical

In week 10 during the Friday laboratory timeslot, an examination in the form of a practical ANSYS task (or tasks) will be held. 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.

The exam will be held in the allocated computer laboratory (Ainsworth J17/204), and students may use any engineering software installed on those computers, except for communication/file sharing with other students.

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 (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. 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.

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.*

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 technical difficulties which force the use of physical assignment copies, they must include a School cover sheet which is available from the school intranet and are to be submitted before *11am* on the due date so that they can be processed before close of business.

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. 5pm is the time at which the assignment is 'another day' late.

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.

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/
Moodle: https://moodle.telt.unsw.edu.au/login/index.php

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 reducing the number of assignments from 2 to 1 to reduce student workload. The group nature of this assignment should also give students a forum to discuss and come to an understanding of how to undertake the assignment without resorting to plagiarism.

The exam for the course has also been split up to reduce the weighting of this event, with more emphasis placed on practical FEA skills and less on closed book knowledge.

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