CVEN9820

Computational Structural Mechanics

Term 1, 2022

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Chongmin Song	c.song@unsw.edu.au	Tuesday 2-4PM; Thursday 2-4PM	CE717B	55021

Lecturers

Name	Email	Availability	Location	Phone
Chongmin Song	c.song@unsw.edu.au	Tuesday 2-4PM; Thursday 2-4PM	CE717B	55021

School Contact Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries e.g. admissions, fees, programs, credit transfer

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

Course Details

Units of Credit 6

Summary of the Course

Stiffness analysis of structures. Basis of finite elements: principle of virtual work, variational theorems, constraint equations. Effects of inplane rigid floors and axially rigid members on the behaviour of multi-storey frames.

Course Aims

This course focuses on the practical aspects of applying the finite element method to structural analysis. Students will acquire appropriate and efficient finite element modelling techniques to produce a reasonably reliable prediction of the response of a "real life" engineering problem and to identify and, if possible, estimate the error introduced by the modelling process. Selected underlying fundamental theory of the finite element method is provided to enable students to appreciate the advantages, limitations and possible pitfalls of the numerical methods as applied to engineering problems. Hands-on exercise at computers will enable students to perform finite element analysis of structures by using commercial software.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Define problems (mathematical models) on which numerical modelling is based.	PE1.1, PE1.2, PE1.3
2. Create finite element models.	PE1.1, PE1.2, PE1.3
3. Understand the fundamental theory of the finite element method.	PE1.1, PE1.2, PE1.3, PE1.4
4. Write simple computer programs in MATLAB for finite element analysis.	PE2.1, PE2.2, PE2.3
5. Calculate and interpret results necessary for design purpose.	PE1.2, PE1.3, PE1.5
6. Evaluate the reliability and the accuracy of results.	PE1.2, PE1.3, PE1.5
7. Use commercial numerical simulation software.	PE1.5, PE2.1, PE2.2, PE2.3
8. Communicate analyses in written and graphical form.	PE3.1, PE3.2

Teaching Strategies

This subject consists of a mixture of lectures, exercise classes and hands-on computer sessions.

Both teaching and exercises concentrate on the use of advanced methods in civil engineering. Lectures will introduce you to the basic theories on which the computer simulation techniques are based and the

computer software used to accomplish your assignment. The emphasis will be placed on the application of the theories to formulate guidelines in the analysis of practical engineering problems.

The exercise classes provide you with the opportunity to discuss the lecture material with your demonstrators and to solve the set problems. In order to understand the subject matter well, it is essential to attend the exercise classes and solve the problems by yourself.

For each hour of contact it is expected that a student will put in at least 1.5 hours of private study. Students are recommended to review the course materials weekly.

The teaching/learning activities are summarized in the following table:

Lectures	• Cover material to be learned for assessment tasks • Follow worked examples • Hear announcements on course changes
Workshops	• Practice solving set problems • Be guided by demonstrators • Ask questions
Computer Sessions	• Hand on exercises using commercial finite element software • Familiarise with pre- and post-processors • Reflect and discuss on practical issues in numerical simulation
Private Study	• Review lecture material and textbook • Preparation for the exercise classes and do set problems and assignments • Reflect on class problems • Study relevant references • Download materials from Moodle • Keep up with notices and find out marks via Moodle
Assessments (assignments, examinations)	• Demonstrate your knowledge and skills • Demonstrate higher understanding and problem solving

Suggested approaches to learning in this course include:

- Regular participation in lectures and workshops. *Review course materials. Follow worked examples. Reflect on class problems and quizzes.*
- Weekly reading and recording of your learning.
- Appropriate preparation for workshops.
- Planning your time to achieve all assessment requirements (see assessment).
- We encourage you to work with your peers. A good way to learn the material is in small study groups. Such groups work best if members have attempted the problems individually before meeting as a group. A valued and honest collaboration occurs when, for example, you “get stuck” early on in attacking an exercise and go to your classmate with a relevant question. Your classmate has the opportunity to learn from your question as well as help you. You then bring something to the collaboration.
- Students who perform poorly in the assessment tasks are strongly encouraged to discuss their progress with the lecturer during the term. Please do not suffer in silence – seek help at an early stage! We would like you to make most of this learning process and receive a high grade in the course.

Additional Course Information

You will study modern numerical methods and their applications to structures and other civil engineering problems by the use of commercial finite element software. The acquired knowledge is applicable to the analysis and design of many types of civil engineering constructions such as buildings, foundations, dams, etc. You are expected to be familiar with the theories and concepts introduced in the previous structural engineering courses. This course lays the foundation for in-depth study on the numerical simulation, which is a rapidly evolving and multi-disciplinary field. The material covered in this course is essential in modern structural analysis and design.

Assessment

The standard UNSW late penalty for assignments is 5% per day, for all assessments where a penalty applies, capped at five days (120 hours), after which a student cannot submit an assessment, and there is no permitted variation.

It is your responsibility to ensure that all the assessment materials are properly submitted, and that your submission is finalised for marking and recorded accordingly in the system.

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Quiz 1	10%	Not Applicable	1, 2, 3, 5, 6, 8
2. Quiz 2	10%	Not Applicable	1, 2, 3, 5, 6, 8
3. Quiz 3	10%	Not Applicable	1, 2, 3, 5, 6, 8
4. Assignment	20%	22/04/2022 04:00 PM	1, 2, 3, 4, 5, 6, 7, 8
5. Final Examination	50%	Not Applicable	1, 2, 3, 4, 5, 6, 7, 8

Assessment 1: Quiz 1

Start date: 08/03/2022 12:00 PM
Assessment length: 50min

Quiz 1 covers the contents of Weeks 1-3

Assessment criteria

- Correct interpretation of and compliance with assessment requirements
- Demonstration of understanding of subject matters and problem-solving ability
- Clear and logical steps in problem solving
- Correctness of final and other numerical answers
- Appropriate use of engineering drawings, diagrams, and figures

Assessment 2: Quiz 2

Start date: 05/04/2022 12:00 PM
Assessment length: 50min

Quiz 2 covers the contents in Weeks 4-7

Assessment criteria

- Correct interpretation of and compliance with assessment requirements
- Demonstration of understanding of subject matters and problem-solving ability
- Clear and logical steps in problem solving
- Correctness of final and other numerical answers
- Appropriate use of engineering drawings, diagrams, and figures

Assessment 3: Quiz 3

Start date: 19/04/2022 12:00 PM
Assessment length: 50min

Quiz 3 covers the contents in Weeks 8-9

Assessment criteria

- Correct interpretation of and compliance with assessment requirements
- Demonstration of understanding of subject matters and problem-solving ability
- Clear and logical steps in problem solving
- Correctness of final and other numerical answers
- Appropriate use of engineering drawings, diagrams, and figures

Assessment 4: Assignment

Start date: 15/03/2022 12:00 AM
Due date: 22/04/2022 04:00 PM

Assignment on finite element programming and on use of commercial finite element packages

Assessment criteria

- Correct interpretation of and compliance with assessment requirements
- Demonstration of understanding of subject matters and problem-solving ability
- Clear and logic steps in problem solving
- Correctness of final and other numerical answers
- Appropriate use of engineering drawings, diagrams, and figures
- Clarity of presentation
- Correct referencing and using of source materials
- Completeness of reports and solutions
- Neatness of assignment submissions

Assessment 5: Final Examination

Start date: Final exam period
Assessment length: 2 hours

The final exam covers all contents

Assessment criteria

- Correct interpretation of and compliance with assessment requirements
- Demonstration of understanding of subject matters and problem-solving ability
- Clear and logic steps in problem solving
- Correctness of final and other numerical answers
- Appropriate use of engineering drawings, diagrams, and figures

Hurdle requirement

A mark of at least 40% in the final examination is required before the class work is included in the final mark.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 14 February - 18 February	Lecture	Introduction. Mathematical modelling of diffusion: Laplace equation and boundary conditions. Finite-element method for 1D potential problem – shape functions and element stiffness matrix.
Week 2: 21 February - 25 February	Lecture	Finite-element method for 1D potential problem (using seepage flow as example) – assembly of global stiffness matrix, boundary conditions and solutions. Finite element analysis of spring and bar systems.
	Workshop	As above
Week 3: 28 February - 4 March	Lecture	Triangular elements. Assembly of global stiffness matrix, boundary conditions and solutions. Introduction to programming finite element analysis using MATLAB.
	Workshop	As above.
Week 4: 7 March - 11 March	Lecture	Theory of elasticity – Stress versus strain laws and boundary conditions. Energy methods: Spring and bar elements and beam elements.
	Workshop	As above.
	Assessment	Quiz 1
Week 5: 14 March - 18 March	Lecture	Introduction to a commercial finite-element program ANSYS: frame analysis. Constant strain triangular elements.
	Laboratory	Computer Lab session on programming finite element analysis using MATLAB and frame analysis.
	Assessment	Assignment set
Week 6: 21 March - 25 March	Lecture	**Flexibility week for all courses (non-teaching)**
Week 7: 28 March - 1	Lecture	Modelling issues in finite element method.

April		Programming finite element stress analysis using MATLAB.
	Workshop	As above.
Week 8: 4 April - 8 April	Lecture	Element quality for stress analysis and shear locking and volumetric locking. Rectangular elements.
	Workshop	As above.
	Assessment	Quiz 2
	Laboratory	Computer lab session on commercial finite-element package ANSYS.
Week 9: 11 April - 15 April	Lecture	Isoparametric representation and isoparametric quadrilateral elements.
	Workshop	As above
Week 10: 18 April - 22 April	Lecture	Isoparametric representation and isoparametric quadrilateral elements (continued).
	Workshop	As above.
	Assessment	Quiz 3
	Assessment	Assignment due

Resources

Recommended Resources

COURSE MATERIALS

The course materials consist of

- Lecture notes provided on selected topics,
- Kranh J. (2004), “Stress and Deformation Modeling with SIGMA/W: An Engineering Methodology”, Geo-Slope International Ltd (available as PDF file).
- Workshop examples of ANSYS.

Online manuals, engineering methodology books (Kranh J. 2004) and additional workshop examples of ANSYS can be viewed and printed directly from the software.

ADDITIONAL READINGS

- Logan, D. L. (2011), “A First Course in the Finite Element Method”, Brooks/Cole, 5th edition.
  Print**:** **https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781305637344**
  Digital: **https://unswbookshop.vitalsource.com/products/-v9781305887718**
- Moaveni,S. (2014) "Finite Element Analysis Theory and Application with ANSYS" Prentice Hall, 4th edition. Print: **https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9780273774303**
  Digital: **https://unswbookshop.vitalsource.com/products/-v9780273774334**
- Cook, R. D., *et. al,* (2002), “Concepts and Applications of Finite Element Analysis”, Wiley, 4th edition.
  Print: **https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9780471356059**
- Felippa, Carlos, “Intro. to Finite Element Methods (ASEN 5007) Course Material.” **http://caswww.colorado.edu/courses.d/IFEM.d/Home.html**
- Zienkiewicz, O.C. and Taylor, R.L. (2000), “The Finite Element Method”, Volumes 1&2, 5th edition, Butterworth-Heinemann.
- Bathe, K. J. (1996), “Finite Element Procedures”, Prentice Hall.

A vast amount of various learning resources on the finite element method are available online. You are encouraged to explore and find resources suitable to your needs and learning style.

Submission of Assessment Tasks

Please refer to the Moodle page of the course for further guidance on assessment submission.

UNSW has a standard late submission penalty of:

- 5% per day, for all assessments where a penalty applies, capped at five days (120 hours), after which a student cannot submit an assessment, and no permitted variation.

Academic Honesty and Plagiarism

Beware! An assignment that includes plagiarised material will receive a 0% Fail, and students who plagiarise may fail the course. Students who plagiarise are also liable to disciplinary action, including exclusion from enrolment.

Plagiarism is the use of another person's work or ideas as if they were your own. When it is necessary or desirable to use other people's material you should adequately acknowledge whose words or ideas they are and where you found them (giving the complete reference details, including page number(s)). The Learning Centre provides further information on what constitutes Plagiarism at:

https://student.unsw.edu.au/plagiarism

Academic Information

Final Examinations:

Final exams in T1 2022 will be held online between 29th April - 12th May inclusive, and supplementary exams between 23rd - 27th May inclusive. You are required to be available on these dates. Please do not to make any personal or travel arrangements during this period.

ACADEMIC ADVICE

- Key Staff to Contact for Academic Advice (log in with your zID and password): https://intranet.civeng.unsw.edu.au/key-staff-to-contact-during-your-studies-at-unsw
- Key UNSW Dates - eg. Census Date, exam dates, last day to drop a course without academic/financial liability etc.
- CVEN Student Intranet (log in with your zID and password): https://intranet.civeng.unsw.edu.au/student-intranet
- Student Life at CVEN, including Student Societies: https://www.unsw.edu.au/engineering/civil-and-environmental-engineering/student-life
- Special Consideration: https://student.unsw.edu.au/special-consideration
- General and Program-Specific Questions: The Nucleus: Student Hub
- Refer to Academic Advice on the School website available at: https://www.engineering.unsw.edu.au/civil-engineering/student-resources/policies-procedures-and-forms/academic-advice

Image Credit

Mike Gal.

CRICOS

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Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	✓
PE3.2 Effective oral and written communication in 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	