School of Civil and Environmental Engineering

Term 3, 2020

CVEN9820 COMPUTATIONAL STRUCTURAL MECHANICS

COURSE DETAILS

Units of Credit	6	
Contact hours	CVEN9820: 4 hours per week	
Lecture	Tuesday 09:00 – 11:00	online
Workshop	Tuesday 11:00 – 13:00	online
Computer Session	Wednesday 10:00 – 12:00	online

Course Coordinator and Lecturer

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INFORMATION ABOUT THE COURSE

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.

The flow chart in Figure 1 shows diagrammatically how this course relates to other courses in the Civil Engineering program.

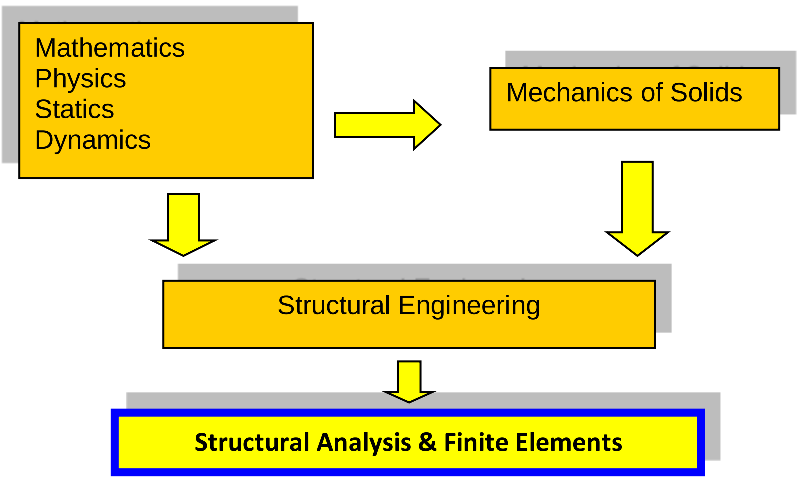

Figure 1. How this course relates to other courses in Civil Engineering.

HANDBOOK DESCRIPTION

Fundamental theory and application of finite elements to structural problems. 2D membrane elements and their application to potential problems, shear walls and panels subject to in-plane loading; Isoparametric elements; Computer programming of the finite element method, Use of commercial finite element packages, output checking.

See link to virtual handbook:

http://www.handbook.unsw.edu.au/postgraduate/courses/2020/CVEN9820.html

OBJECTIVES

This course focuses on the practical aspects of applying the finite element method to structural analysis. The students will acquire appropriate and efficient finite element modelling techniques to produce a reasonably reliable predication of the response of a "real life" engineering problem and, if possible, to identify and 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 when applied to engineering problems. Students' understanding of fundamental theory will be enhanced by writing simple computer programs in MATLAB. Hands-on exercise at computers will enable students to perform finite element analysis of structures by using commercial software.

This course will also provide you with opportunities to develop the following generic **graduate attributes**:

- An in-depth engagement with the relevant disciplinary knowledge in its inter-disciplinary context
- Capacity for analytical and critical thinking and for creative problem solving
- Ability to engage independent and reflective learning
- Information literacy
- Skills for collaborative and multi-disciplinary work
- A respect for ethical practice and social responsibility
- Skills for effective communication

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. You 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 THE COURSE

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 the help at an early stage! We would like you to make most of this learning process and receive a high grade in the course.

EXPECTED LEARNING OUTCOMES

This course is intended to present numerical methods and modelling techniques that are sound and commonly used in engineering practice. The theory necessary for the application of the numerical simulation techniques is presented. 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. Define problems (mathematical models) on which numerical modelling is based (PE1.1, PE1.2, PE1.3, PE1.4, PE2.1).

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

- Create finite element models (PE1.1, PE1.3, PE1.4, PE2.1).
- Understand the fundamental theory of the finite element method (PE1.1, PE1.2, PE1.3, PE1.4).
- Write simple computer programs in MATLAB for finite element analysis (PE1.4, PE2.1, PE2.2, PE2.3).
- Calculate and interpret results necessary for design purpose (PE1.2, PE1.3, PE1.5).
- Evaluate the reliability and the accuracy of results (PE1.2, PE1.3, PE1.5)
- Use commercial software for finite element analysis (PE1.5, PE2.1, PE2.2, PE2.3).
- Communicate your analysis in written and graphical form. (PE3.2)

COURSE PROGRAM

Week	Topic	Assessments
15/09/2020 (Week 1)	Introduction; Mathematical modelling of diffusion: Laplace equation and boundary conditions. Finite-element method for 1D potential problem – shape functions and element stiffness matrix.	

22/09/2020 (Week 2)	Finite-element method for 1D potential problem (using seepage flow as example) – assemblage of global stiffness matrix, boundary conditions and solutions. Finite element analysis of spring and bar systems.	
29/09/2020 (Week 3)	Triangular elements. Assembly, boundary conditions and solutions. Introduction to programming finite element analysis using MATLAB. Theory of elasticity – Stress versus strain laws and boundary conditions.	**Quiz 1 (practice)**
07/10/2020 (Week 4)	Energy methods: Spring and bar elements and plane beam element. Introduction to a commercial finite-element program ANSYS: frame analysis.	
13/10/2020 (Week 5)	Constant strain triangular elements. Computer session on programming finite element analysis using MATLAB and frame analysis.	**Quiz 2** **Assignment Set**
20/10/2020 (Week 6)	***Flexibility week for all courses (non-teaching)***	
27/10/2020 (Week 7)	Modelling issues in finite element method. Programming finite element stress analysis using MATLAB.	
03/11/2020 (Week 8)	Element quality for stress analysis and shear locking and volumetric locking. Rectangular elements. Computer session on commercial finite-element package ANSYS.	
10/11/2020 (Week 9)	Isoparametric representation and isoparametric quadrilateral elements.	
17/11/2020 (Week 10)	Isoparametric representation and isoparametric quadrilateral elements (continued).	**Quiz 3** **Assignment Due**

ASSESSMENT

The final grade for this course will normally be based on the sum of the scores from each of the assessment tasks. The assessment breakdown and dates are as follows:

1.	Quiz 1		held: Week 3, 50min	value: 2%
	Quiz 2		held: Week 5, 50min	value: 14%
	Quiz 3		held: Week 10, 50min	value: 14%
2.	Assignment	set: Week 5	due: 4:00pm, Friday, Week 10	value: 20%
3.	Exam		held: Final exam period, open book	value: 50%
				Total 100%

Quiz1 is for you to practice on using the online platform and to get familiar with the format of the quizzes and final examination. 2% of the Final Mark will be awarded if you complete the practice. Your solution will not be graded. Instead, a sample solution of the questions will be posted online for you to perform a self-assessment of your progress.

The following criteria will be applied in grading of quizzes 2 and 3, assignment and final examination, when appropriate:

- 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

The final grade for this course will normally be based on the sum of the scores from each of the assessment tasks. The Final Examination is worth 50% of the Final Mark if class work is included and 100% if class work is not included. The class work is worth 50% of the Final Mark if included. ***A mark of at least 40% in the final examination is required before the class work (quizzes and assignment) is included in the final mark.*** *The formal exam scripts will not be returned but you are permitted to view the marked script.*

Students who perform poorly in the quizzes are recommended to discuss progress with the lecturer during the term.

Please note that late submissions of the quizzes and final examination will not be accepted. A late submission of assignment will be penalised at the rate of 10% per day after the due time and date have expired. The deadline for absolute fail of the assignment is 5 days after the due time and date.

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.

Supplementary Examinations for Term 3 2020 will be held on Monday 11th January – Friday 15th January 2021 (inclusive) should you be required to sit one. You are required to be available during these dates. Please do not to make any personal or travel arrangements during this period.

RELEVANT 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

- Moaveni,S. (2014) "Finite Element Analysis Theory and Application with ANSYS" Prentice Hall, 4th edition.
- Logan, D. L. (2011), “A First Course in the Finite Element Method”, Brooks/Cole, 5th edition
- Cook, R. D., *et. al,* (2002), “Concepts and Applications of Finite Element Analysis”, Wiley, 4th edition.
- 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.

DATES TO NOTE

Refer to MyUNSW for Important Dates available at:

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

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 ADVICE

For information about:

- Notes on assessments and plagiarism;
- Special Considerations: student.unsw.edu.au/special-consideration;
- General and Program-specific questions: The Nucleus: Student Hub
- Year Managers and Grievance Officer of Teaching and Learning Committee, and
- CEVSOC/SURVSOC/CEPCA

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

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