The University Of Sheffield.

Civil and Structural Engineering Department — Module Description : CIV8130

Module Title	Computational Structural Analysis and Research Skills
Credits	15
Co-Ordinator	Christopher Keylock
Semester	Autumn
Unit Description	This module integrates two components. The first covers the theoretical and practical aspects of using the Finite Element method in structural analysis. It starts with some basic concepts such as assembly and solving systems of equations. Next, weak forms and strong forms are discussed together with interpolation via finite element shape functions, so that general differential equations can be treated. Special emphasis is put on dynamic aspects such as different mass matrices and time integration algorithms. Part of the assessment is carried out via an individual piece of coursework that helps the student use professional finite element software.The second component will actually be taught first and is a self-contained 5 credit element on research skills. It combines lectures and a seminar with the primary learning objective to produce a pass-to-progress research proposal to support the semester 2 (MEng) or summer (MSc) individual research project.
Unit Aims	Gain (i) an understanding of the fundamentals and (ii) a working knowledge of the practicalities of the Finite Element method in static and dynamic structural analysis. Understand how to undertaken a piece of independent, academic research to a high level, and produce a research proposal that incorporates a critical literature review, explanation of detailed methodology and addresses health and safety issues.
Syllabus	Part A: Introduction to Finite Element analysis Establishing the field equations of elasticityMoving from the continous system to a discretised systemFinite Element shape functionsIsoparametric Finite ElementsLinear and quadratic 3D continuum elementsNumerical integrationIntroduction to time domain dynamicsAppreciation of element size and time step selection procedures Part B:Introduction to research project formulationUndertaking a critical literature reviewWhy choose a particular methodology (Experiment, fieldwork, modelling)?Experimental designVerification, validation and software validationTime & Resource Management, and Health and SafetyLibrary study session on searching for resources and plagiarism

Learning Hours

Learning Hours of the Unit		
Activity	Remarks	Hours
Lectures		26
Tutorials	Computer Modelling	5
Tutorials	Practical Classes	5
Indepentant Study(including Prep for Assessment)		110
Seminars	Seminars	2
Tutorials	Directed Reading and Directed Internet-based Research	2

Total Hours 150

Teaching Methods	Part A: 20 lectures to learn the fundamentals. 5 hours of tutorials to put fundamentals into practice. 5 hours of computer classes to learn how to use professional software. Part B: 6 lectures 1 Library skills tutorial 1 seminar to discuss research ideas with a member of staff.
H&S / Risk Management	Aspects of H&S pertaining to research will be covered in lectures and will form a necessary aspect of the research proposal.
Learning Outcomes	1. Derive the global stiffness matrix from a mesh of finite elements and reduce according to the boundary conditions 2. Derive the element stiffness matrix for continuum finite elements from a governing differential equation 3. Use finite element shape functions for the interpolation of a variable and its gradient. 4. Perform numerical integration of the element stiffness integral equations 5. Use time integration to perform dynamic analysis 6. Appreciate time step and element size selection procedures 7. Develop greater understanding of how to undertake a piece of civil engineering research. 8. Improve capability to undertake a critical review of the relevant literature. 9. Produce a high quality engineering research proposal.
Assessment Methods	Individual coursework (20%): This component tests the student's understanding of using finite element software, in particular the effects of element size on the accuracy of the solution. Written exam paper (80%): This component tests the student's understanding of the theory, fundamentals and applications of finite elements in statics and dynamics. Pass-to-progress research proposal to set the student up appropriately to undertaken their independent research project in subsequent parts of their degree. The deadline for students on CIV4002 will be two weeks later for this (Fri. wk 12).
Assessment Philosphy	A mixture of hands-on computer work without time constraints and an in-depth assessment of theory and fundamentals means that various skills are tested. Assessment of the ability to understand the research process is best-accomplished by a research proposal.
Module Assessment	Type of Assessment

Assessment Type	Learning Outcomes	Week	Day	Percentage
Individual Coursework, this includes lab reports, designs etc	(LO1)	Autumn Week 12	Monday	20
Written Exam Invigilated	(LO2)	Autumn Week 15	Exam Period	80
Individual Coursework, this includes lab reports, designs etc	(LO7,LO8,LO9)	Autumn Week 10	Friday	0

Total Percentage 100%

Fomative Assessment and Feedback

Written feedback on the coursework will be provided.

Formative feedback on the research proposal will permit students to reshape it until it is of a sufficient high a quality.

Recommended Reading

Book 1 - Recommended

- Title:
  The finite element method.
- Author: O. C. Zienkiewicz
- Edition: 3rd ed.
- Publisher: London : McGraw-Hill, 1977
- Identifier: ISBN 0070840725;ISBN 9780070840720
- Format: xv,787p.
- Notes: 3rd expanded & revised ed. of "The finite element method in engineering science".
- Subjects: Finite element method; Engineering mathematics; Finite element method; Engineering mathematics; Engineering Mathematics Finite element methods
- Record Id: 21174322250001441

Book 2 - Recommended

- Title:
  The finite element method : linear static and dynamic finite elment analysis
- Author: Thomas J. R. Hughes
- Publisher: Mineola, NY : Dover Publications, 2000
- Identifier: ISBN 0486411818;ISBN 9780486411811

- Format: xxii, 682 p. : ill. ; 24 cm.
- Notes: Reprint. Originally published: Englewood Cliffs, N.J. : Prentice-Hall, 1987. The author has corrected minor errors inthe text and deleted the sections of Chapters 10 and 11 that are no longer necessary.
- Subjects: Finite element method; Boundary value problems
- Further Information: Thomas J.R. Hughes.
- Record Id: 21185361010001441

Book 3 - Recommended

- Title:
  Finite element procedures
- Author: Klaus-Jürgen Bathe
- Edition: 2nd ed.
- Publisher: Englewood Cliffs, N.J. ; London : Prentice-Hall, 1996
- Identifier: ISBN 0133014584;ISBN 9780133014587
- Format: 1037p ; 24 cm.
- Notes: Previous ed.: 1992.
- Subjects: Finite element method; Engineering mathematics
- Further Information: Klaus-Jürgen Bathe.
- Record Id: 21169332610001441

Book 4 - Recommended

- Title:
  The finite element method. Vol.1, Basic formulation and linear problems.
- Author: O. C. Zienkiewicz
- Other Contributors: R. L Taylor
- Edition: 4th ed. / O.C. Zienkiewicz and R.L. Taylor.
- Publisher: London : McGraw-Hill, 1989
- Identifier: ISBN 0070841748;ISBN 9780070841741
- Format: xx,648p : ill. ; 24 cm.
- Notes: Previous ed, 1977. 1st ed. pub. 1967 with title "The finite element method in structural and continuum mechanics".
- Subjects: Finite element method; Structural analysis; Finite element method; Engineering mathematics
- Record Id: 21192356380001441

The finite element method (FEM) is a numerical method for solving problems of engineering and mathematical physics. Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations. The finite element method formulation of the problem results in a system of algebraic equations. The method The finite element method (FEM) is a numerical method for solving problems of engineering and mathematical physics. It is also referred to as finite element analysis (FEA). Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential.Â The finite element method formulation of the problem results in a system of algebraic equations. The method yields approximate values of the unknowns at discrete number of points over the domain.[1] To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. The finite element method was originally developed for the stiffness analysis of airplane [12]. Consequently, stress analysis is the most typical application of FEM. Generally, it is well known that the total potential energy II should be a minimum when thermal stress and/or an external force is applied to the body.Â The procedure for implementing the finite element method based on a variational approach is briefly summarized in this introductory chapter as follows. A more detailed description of the method is provided in later chapters. â–ª.