ENGINEERING
McMaster-Mohawk
Bachelor of Technology
Partnership

McMaster University

# Course Outline

## 1. COURSE INFORMATION

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| **Session Offered** | Winter 2022 | |
| **Course Name** | Finite Element Analysis | |
| **Course Code** | ENG TECH 4FA3 | |
| **Date(s) and Time(s) of lectures** | Thursdays, 18:30 – 21:20 | |
| **Program Name** | Civil Engineering and Infrastructure Technology<br>Manufacturing Engineering Technology | |
| **Calendar Description** | Matrix operation. Direct stiffness method to form global stiffness matrix and solve problems. Derivation and application of rod, truss, beam, frame and 2D element. Dynamic and thermal stress analysis using FE method. Create and analyze structure models with ANSYS. | |
| **Instructor(s)** | S. Tanu Halim | E-Mail: tanuhasm@mcmaster.ca<br>Office Hours & Location: Thusdays 18:00 – 18:30, 21:30 – 22:00, by appointment |

## 2. COURSE SPECIFICS

**Course Description**

**Instruction Type**

| Code | Type | Hours per term |
|---|---|---|
| C | Classroom instruction | 24 |
| L | Laboratory, workshop or fieldwork | 12 |
| T | Tutorial | |
| DE | Distance education | |
| | **Total Hours** | 36 |

**Resources**

| ISBN | Textbook Title & Edition | Author & Publisher |
|---|---|---|
| ISBN-10: 0-13-189080-8 | Finite Element Analysis, Theory and Application with ANSYS<br>Third Edition | Saeed Moaveni & Pearson |

| Other Supplies | Source |
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| **Prerequisite(s)** | ENG TECH 3ML3, ENG TECH 3MA3 |
| **Corequisite(s)** | |
| **Antirequisite(s)** | ENG TECH 2FE3, 3FE3, 3FN3 |
| **Course Specific Policies** | • This course requires student to download and use ANSYS free student software, this product can be installed on any supported MS Windows 64-bit machine.<br>• Missed assignment and late lab submissions will not be marked. |
| **Departmental Policies** | Students must maintain a GPA of 3.5/12 to continue in the program.<br>In order to achieve the required learning objectives, on average, B.Tech. students can expect to do at least 3 hours of “out-of-class” work for every scheduled hour in |

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| | class. "Out-of-class" work includes reading, research, assignments and preparation for tests and examinations.<br><br>Where group work is indicated in the course outline, such collaborative work is mandatory.<br><br>The use of cell phones, iPods, laptops and other personal electronic devices are prohibited from the classroom during the class time, unless the instructor makes an explicit exception.<br><br>Announcements made in class or placed on Avenue are considered to have been communicated to all students including those individuals that are not in class.<br><br>Instructor has the right to submit work to software to identify plagiarism. | |
| **3. SUB TOPIC(S)** | | |
| Week 1<br>(13 Jan) | - Matrix Algebra<br>  ○ Definition of a Matrix<br>  ○ Matrix Operation<br>  ○ Inverse of a Matrix by Row Reduction<br>  ○ Solving simultaneous equations using Gauss Elimination method and Cramer's Rule<br>- Uniaxial Rod Elements<br>  ○ Assembling global stiffness matrix of a spring assemblage using direct stiffness method<br>  ○ Specify boundary conditions for structure models<br>  ○ Work equivalent loads | Chp 2<br>Chp 1.4-1.5 |
| Week 2<br>(20 Jan) | - Plane Truss Elements<br>  ○ Transformation of vectors two dimensions<br>- Assembling global stiffness matrix in global reference frame<br>- Principle of Minimum Potential Energy Approach to Derive Rod Element Equations<br>  ○ Development of rod element shape functions<br>  ○ Express stress/strain relationship in matrix notation<br>  ○ Derive Rod Element stiffness matrix from strain energy<br>  ○ Comparison of Finite Element Solution to Exact Solution for Rod Element | Chp 3<br>+ Notes<br>Chp 5.1, 5.2, 5.4<br>+ Notes |
| Week 3<br>(27 Jan) | - Principle of Minimum Potential Energy Approach to Derive Beam Element Equations<br>  ○ Development of beam element shape functions | Chp 7.3, 9.3, 10.2<br>+ Notes |

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|---|---|---|
| | ○ Express stress/strain relationship in matrix notation<br>○ Derive Beam Element stiffness matrix from strain energy<br>Comparison of Finite Element Solution to Exact Solution for Rod Element | |
| Week 4<br>(3 February) | - Frame Elements<br>Solving structure models that combine beam and rod elements | |
| Week 5<br>(10 February) | **Test 1** | |
| Week 6<br>(17 February) | Lab 1 | |
| Week 7<br>(24 February) | Reading week (no class) | |
| Week 8<br>(3 March) | Lab 2 | |
| Week 9<br>(10 March) | Lab 3 | |
| Week 10<br>(17 March) | - Frame Elements<br>- Solving structure models that combine beam and rod elements<br>- Two Dimensional Finite Element<br>○ Basic concepts of plane stress and plane strain<br>- Two-Dimensional state of stress and strain | |
| Week 11<br>(24 March) | - Two Dimensional Finite Element<br>○ Basic concepts of plane stress and plane strain<br>- Two-Dimensional state of stress and strain | |
| Week 12<br>(31 March) | - Structural Dynamics with FE<br>- Rod Element<br>○ Derivation of Consistent Mass Matrix for Rod Element<br>○ Modal Analysis of a Rod<br>- Truss Element<br>○ Derivation of Consistent Mass Matrix for Plane Truss Element<br>- Beam Elements<br>○ Derivation of Consistent Mass Matrix for Beam Elements<br>○ Modal Analysis of a beam<br>- 2D Elements<br>○ Derivation of Consistent Mass Matrix for 2D Elements<br>○ Modal Analysis of a 2D structure | Chap 11 + Notes |

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| Week 13<br>(7 April) | - Thermal Stress<br>○ Formulation of thermal stress problem<br>○ Evaluate thermal force matrix<br>Thermal stress analysis of rod element, truss element, 2D plane element | Notes |

Classes end: Tuesday, April 12th 2022

Final Examination Period: Thursday, April 14 to Friday, April 29

All examinations MUST be written during the scheduled examination period.

Note that this structure represents a plan and is subject to adjustment term by term.
The instructor and the University reserve the right to modify elements of the course during the term. The University may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes.

| 4. ASSESSMENT OF LEARNING *including dates* | Weight |
|---|---|
| Mid-term test (10 February 2022) | 25% |
| Assignment (Due 17 March 2022) | 20% |
| Labs | 5% |
| Final examination (tests cumulative knowledge) | 50% |
| **TOTAL** | **100%** |

Percentage grades will be converted to letter grades and grade points per the University calendar.

## 5. LEARNING OUTCOMES

1. Able to use direct stiffness method to solve finite element problems.
2. Understand and apply the concept of minimum potential energy to generate various types of element equations.
3. Solve structural, thermal problems and modal analysis.
4. Able to use commercial code ANSYS to design problems into finite element models. Interpret and compare the results yield when using various types of elements. Explain the trends obtained from the model.
5. Implement various techniques such as symmetric, axisymmetric and localized mesh refinement to optimize computational time using ANSYS.

## 6. COURSE OUTLINE – APPROVED ADVISORY STATEMENTS

### ANTI-DISCRIMINATION

The Faculty of Engineering is concerned with ensuring an environment that is free of all discrimination. If there is a problem, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.
http://www.mcmaster.ca/policy/General/HR/Discrimination_Harassment_Sexual_Harassment-Prevention&Response.pdf

### ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or

suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/

The following illustrates only three forms of academic dishonesty: The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

## AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com, please go to www.mcmaster.ca/academicintegrity.

## COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

## ONLINE PROCTORING

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

## COMMUNICATIONS

It is the student's responsibility to:

- Maintain current contact information with the University, including address, phone numbers, and emergency contact information.
- Use the University provided e-mail address or maintain a valid forwarding e-mail address.
- Regularly check the official University communications channels. Official University communications are considered received if sent by postal mail, by fax, or by e-mail to the student's designated primary e-mail account via their @mcmaster.ca alias.
- Accept that forwarded e-mails may be lost and that e-mail is considered received if sent via the student's @mcmaster.ca alias.
- Check the McMaster/Avenue email and course websites on a regular basis during the term.

## CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

## ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

## REQUESTS FOR RELIEF FOR MISSED ACADEMIC TERM WORK

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

## ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests. http://www.mcmaster.ca/policy/Students-AcademicStudies/Studentcode.pdf

## COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

## EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.