**The University of Texas at Tyler**
**Department of Mechanical Engineering**

**MENG 5340: Advanced Topics in Mechanical Engineering**
**Finite Element Analysis**

---

Credits: 2 hours lecture, 1 hour laboratory per week

Instructor: Dr. Chung Hyun Goh, Assistant Professor of Mechanical Engineering

Text(s): Saeed Moaveni, *Finite Element Analysis: Theory and Application with ANSYS*, 4th ed., Pearson (Lecture session)

Huei-Huang Lee, *Finite Element Simulations with ANSYS Workbench 19: Theory, Applications, Case Studies*, SDC Publications (Lab session)

Additional Material: Class handouts

Course Information

Catalog Description: An introduction to basic fundamentals and applications of the finite element method (FEM) in mechanical engineering. Set up modeling, mathematical formulation, and computer implementation in finite element analysis (FEA).

Prerequisites: MENG 43xx Finite Element Analysis

Required, Elective, Selected: Elective

Course Goals

Evaluation Methods: (only items in dark print apply):

1. Examinations / Quizzes
2. Homework
3. Report
4. Computer Programming
5. Project
6. Presentation
7. Course Participation
8. Peer Review

Course Objectives[1]: By the end of this course students will be able to:

1. understand basic FE formulation techniques and the general steps of FEA. (1,2,4,5,7)
2. calculate the strength and behavioral characteristics of a material under given conditions using finite element analysis (FEA). (1,2,4,5,7)

3. perform FE modeling and interpret results for linear, 2- and 3-dimensional problems using a commercial finite element software package (ANSYS). (3-6)
4. identify and solve basic problems and perform case studies using FEA. (1,2,4,7)
5. be an effective team member on a group project to apply FEA for improving performance in real-world problems. (3-8)

*[1]Numbers in brackets refer to method(s) used to evaluate the course objective.*

Relationship to Student Outcomes (only items in dark print apply)[2]: This course supports the following Mechanical Engineering Program Student Outcomes, which state that our students will:

1. be able to apply science, mathematics, and modern engineering tools and techniques to identify, formulate, and solve engineering problems. (1-5)
2. be able to be able to design and effectively-communicate, with a range of audiences, mechanical components or systems. (1-5)
3. be able to develop and conduct experiments, collect, analyze, and formally communicate the results.
4. be able to apply a broad-based educational experience to understand the interaction of engineering solutions with contemporary business, economic, and social issues.
5. recognize that ethical behavior and continuous acquisition of knowledge are fundamental attributes of successful mechanical engineering professionals.

*[2]Numbers in brackets refer to course objective(s) that address the Student Outcome.*

Topics Covered

- Review of mathematical preliminaries and energy and virtual work principles
- Overview of FE approaches (direct formulation, weighted residual formulations)
- Analysis of linear, 2-D, and 3-D problems based on ANSYS FE software
- Considerations in FEA: element and material Selection
- Introduction to FE-based hands-on skills such as fluid-structure interaction and topology optimization
- Applications in stress analysis and in one or more of the following areas: fluid analysis, thermal analysis, and modal analysis

Prepared By: Chung Hyun Goh Date: 01/08/2019

**NOTE:**

Course syllabus, course material and handouts will be posted in Canvas. Please review all the material posted in Canvas on a regular basis. Canvas will be used to post announcements and contacting students by e-mail.

**GUIDELINES (UNIVERSITY POLICIES):**

**CALCULATOR POLICY:** You are allowed to use your own scientific calculator TI-30X IIS at each exam. You are not be allowed to use any other calculator or store any class material in the calculator during the exams. You cannot have i-phones, i-pads, i-watches or other electronic devices with you. If you bring i-phone or other electronic devices to the room, please leave them in your bag. It is recommended that you buy the TI-30X IIS calculator (for about $12) and get familiar with its use before the first examination.

**THERE WILL BE NO MAKE-UP EXAMS**. The percentage of any exam missed by a student will be added to his/her final comprehensive exam only if prior approval is granted. The student is responsible to contact the instructor at least a week before the scheduled exam date to get an excuse from the exam. If you have to miss an exam due to emergencies (such as medical and other emergencies) please inform the instructor as soon as possible before or immediately after the exam. Class average for each exam will be announced in class and also posted in Canvas after each exam. Final course grades will be determined on the basis of the class average. If you miss any exam without getting **prior approval from the instructor at least a week before the exam date**, it will be counted as zero in the calculation of your final course grade. If you intend to be absent for a university-sponsored event or activity, you (or the event sponsor) must notify the instructor at least a week prior to the date of the planned absence.

**MOBILE DEVICE POLICY**

The use of mobile devices is strictly prohibited unless consent is given by the instructor. This includes: texting, photography, videography, voice recordings, searching/browsing the internet, listening to music, etc. These actions can lead to distractions so please be courteous to your fellow classmates by silencing and refraining from using your mobile devices during the allotted class- meeting time.

**STUDENT ACADEMIC CONDUCT STATEMENT**

Students are encouraged to study in groups and to prepare for exams. However, during exams, students are to work alone. Cheating will not be tolerated. The University regulations are very explicit about academic misconduct, and these regulations will be fully enforced. During exams, a code of honor will apply under which students are to work alone and neither give help to others nor receive help from any sources. Students also are expected to help enforce this code. The minimum penalty for cheating will be a failing grade in the course. Maximum penalties, up to university expulsion, will be pursued in extreme or repeat cases ((see also University Policies).

**CONDUCT TOWARD OTHERS**

Engineers come from all walks of life (e.g. varying ethnicities, different religious beliefs, gender, etc.) and it is very important that you are able to work professionally with others in different environments. Under no circumstances will any derogatory remarks or actions toward race, gender, religion, or the like be tolerated in this course.

**UT TYLER A TOBACCO-FREE UNIVERSITY**

Beginning August 15, 2016, all forms of tobacco will not be permitted on the UT Tyler main campus, branch campuses, and any property owned by UT Tyler. This applies to all members of the University community, including students, faculty, staff, University affiliates, contractors, and visitors. Forms of tobacco not permitted include cigarettes,

cigars, pipes, water pipes (hookah), bidis, kreteks, electronic cigarettes, smokeless tobacco, snuff, chewing tobacco, and all other tobacco products. There are several cessation programs available to students looking to quit smoking, including counseling, quitlines, and group support. For more information on cessation programs please visit www.uttyler.edu/tobacco-free.

**CONCEALED HANDGUN POLICY**

We respect the right and privacy of students 21 and over who are duly licensed to carry concealed weapons in this class. License holders are expected to behave responsibly and keep a handgun secure and concealed. More information is available at http://www.uttyler.edu/about/campus-carry/index.php .

Academic policies regarding withdrawal from the course, state-mandated course drop rule, grade forgiveness, student rights, absence for religious observance, grade replacement, social security and privacy, learning disability, academic dishonesty and others can be found at https://www.uttyler.edu/wellness/rightsresponsibilities.php. Some of the policies are reproduced below for your information.

**GRADE REPLACEMENT/FORGIVENESS**

If you are repeating this course for a grade replacement, you must file an intent to receive grade forgiveness with the registrar by the 12th day of class. Failure to do so will result in both the original and repeated grade being used to calculate your overall grade point average. Undergraduates will receive grade forgiveness (grade replacement) for only three course repeats; graduates, for two course repeats during his/her career at UT Tyler.

**STATE-MANDATED COURSE DROP POLICY**

Texas law prohibits a student who began college for the first time in Fall 2007 or thereafter from dropping more than six courses during their entire undergraduate career. This includes courses dropped at another 2-year or 4-year Texas public college or university. For purposes of this rule, a dropped course is any course that is dropped after the 12th day of class (See Schedule of Classes for the specific date).
Exceptions to the 6-drop rule may be found in the catalog. Petitions for exemptions must be submitted to the Registrar's Office and must be accompanied by documentation of the extenuating circumstance. Please contact the Registrar's Office if you have any questions.

**DISABILITY SERVICES**

If you have a disability, including a learning disability, for which you request disability support services/accommodation(s), please contact Ida MacDonald in the Disability Services office so that the appropriate arrangements may be made. In accordance with federal law, a student requesting disability services/accommodation(s) must provide appropriate documentation of his/her disability to the Disability Services counselor. In order to assure approved services the first week of class, diagnostic, prognostic, and prescriptive information should be received 30 days prior to the beginning of the semester services are requested. For more information, call or visit Disability Services located in the University Center, Room 3150. The telephone number is (903) 566-7079. Additional information may also be obtained at the following UT Tyler Web address: http://www.uttyler.edu/disabilityservices.

**STUDENT ABSENCE FOR UNIVERSITY-SPONSORED EVENTS AND ACTIVITIES**

If you intend to be absent for a university-sponsored event or activity, you (or the event sponsor) must notify the instructor at least two weeks prior to the date of the planned absence. At that time the instructor will set a date and time when make-up assignments will be completed.

**SOCIAL SECURITY AND FERPA STATEMENT**

It is the policy of The University of Texas at Tyler to protect the confidential nature of social security numbers. The University has changed its computer programming so that all students have an identification number. The electronic transmission of grades (e.g., via e-mail) risks violation of the Family Educational Rights and Privacy Act; grades will not be transmitted electronically.

For additional information and details about these items, please see SYLLABUS POLICY posted on Canvas and the University Catalog.

# Course Outline

**MENG 4350 / 5340: Finite Element Methods**
**Spring Semester, 2019**
**MWF 1:00 PM - 1:55 PM RBN 2012**

Instructor: Chung Hyun Goh, Ph.D. (Office: RBN 1012, 903-566-6125, cgoh@uttyler.edu)

Text: S. Moaveni, *Finite Element Analysis: Theory and Application with ANSYS,4th ed,* Pearson/PH, 2015 (Lecture)
H.-H. Lee, Finite Element Simulations with ANSYS Workbench 19, SDC publications, 2018 (Lab)

| Mtg | Day | Date | Topic | Reading* | Self-Study Sets** |
|---|---|---|---|---|---|
| 1 | M | 1/14 | Introduction to the course and ANSYS | Handout | |
| 2 | W | 1/16 | Chap 1 – Introduction / Chap 2 - Matrix Algebra | Chaps 1-2 | 1.3,1.21,1.24,2.8,2.11,2.14 |
| 3 | F | 1/18 | **Examples of Trusses** | **3.5** | |
| 4 | M | 1/21 | **No Class (Martin Luther King Jr. Day)** | | |
| 5 | W | 1/23 | Chap 3 – Trusses | 3.1 – 3.4 | 3.1, 3.2, 3.3, 3.6, 3.11, 3.14 |
| 6 | F | 1/25 | **Examples of Members, Beams, and Frames** | **4.6** | |
| 7 | M | 1/28 | Chap 4 – Axial Members, Beams, and Frames | 4.1 – 4.3 | 4.1, 4.4, 4.5, 4.6, 4.7 |
| 8 | W | 1/30 | Chap 4 – Axial Members, Beams, and Frames | 4.3 – 4.5 | 4.9, 4.10, 4.13, 4.16, 4.19 |
| 9 | F | 2/1 | **Examples of 1-D Problems** | **6.3, 8.10** | |
| 10 | M | 2/4 | Chap 5 - 1-D Elements | 5.1 – 5.3 | 5.1, 5.2, 5.9, 5.12, 5.13 |
| 11 | W | 2/6 | Chap 5 - 1-D Elements | 5.4 – 5.6 | 5.15, 5.16, 5.18, 5.20, 5.21 |
| 12 | F | 2/8 | **Examples of 2-D Heat Transfer/Solid Mechanics** | **9.7, 10.6** | |
| 13 | M | 2/11 | Chap 6 - Analysis of 1-D Problems | 6.1 | 6.1, 6.3, 6.4, 6.5, 6.6 |
| 14 | W | 2/13 | Chap 6 - Analysis of 1-D Problems | 6.2 | 6.7, 6.8, 6.9, 6.12 |
| 15 | F | 2/15 | **Exam 1 - Chapters 1 - 6** | | |
| 16 | M | 2/18 | Chap 7 – 2-D Elements | 7.1 – 7.7 | 7.1, 7.4, 7.8, 7.14, 7.18 |
| 17 | W | 2/20 | Chap 9 – Analysis of 2-D Heat Transfer Problems | 9.1 – 9.3 | 9.2, 9.4, 9.7, 9.10 |
| 18 | F | 2/22 | **Case 1: Pneumatic/Flexible Fingers** | TBD | |
| 19 | M | 2/25 | Chap 9 – Analysis of 2-D Heat Transfer Problems | 9.4 – 9.6 | 9.11, 9.15, 9.16, 9.21, 9.24 |
| 20 | W | 2/27 | Ch 10 – Analysis of 2-D Solid Mechanics Problems | 10.1 – 10.2 | 10.1, 10.3, 10.4, 10.6, 10.7 |
| 21 | F | 3/1 | **Case 1: Pneumatic/Flexible Fingers** | TBD | |
| 22 | M | 2/26 | Ch 10 – Analysis of 2-D Solid Mechanics Problems | 10.2 – 10.5 | 10.8, 10.11, 10.13, 10.15 |
| 23 | W | 2/28 | **Term Project Progress Presentation** | | |
| 24 | F | 3/5 | **Case 2: Spur Gears / Gear Trains** | TBD | |
| **Spring Break (3/11 - 3/15)** | | | | | |
| 25 | M | 3/18 | Chap 11 – Dynamic Problems | 11.1 – 11.2 | 11.2, 11.3, 11.6, 11.7, 11.10 |
| 26 | W | 3/20 | Chap 11 – Dynamic Problems | 11.2 – 11.5 | 11.12, 11.15, 11.16, 11.21 |
| 27 | F | 3/22 | **Case 3: Beam Bracket** | TBD | |
| 28 | M | 3/25 | Chap 12 – Analysis of Fluid Mechanics Problems | 12.1 – 12.2 | 12.1, 12.2, 12.3, 12.4, 12.5 |
| 29 | W | 3/27 | Chap 12 – Analysis of Fluid Mechanics Problems | 12.2 – 12.3 | 12.6, 12.7, 12.8, 12.9, 12.10 |
| 30 | F | 3/29 | **Case 4: Fluid-Structure Interaction (FSI)** | TBD | |
| 31 | M | 4/1 | Introduction to FSI and finite volume method (FVM) | TBD | |
| 32 | W | 4/3 | **Discussion I** | TBD | |
| 33 | F | 4/5 | **Case 4: Fluid-Structure Interaction** | TBD | |
| 34 | M | 4/8 | Chap 13 – 3-D Elements | 13.1 – 13.5 | 13.1, 13.2, 13.4, 13.8, 13.11 |
| 35 | W | 4/10 | Intro. to design optimization & topology optimization | TBD | |
| 36 | F | 4/12 | **Case 5: Topology Optimization** | TBD | |
| 37 | M | 4/15 | Intro. to local enrichment approximation method | TBD | |
| 38 | W | 4/17 | **Discussion II** | TBD | |

| | | | | | |
|---|---|---|---|---|---|
| 39 | F | 4/19 | **Case 5: Topology Optimization** | TBD | |
| 40 | M | 4/22 | Introduction to BEM and XFEM | TBD | |
| 41 | W | 4/24 | **Discussion III** | TBD | |
| 42 | F | 4/26 | **Term Project Final Presentation / Demonstration** | | |
| 43 | | TBD | **Final Exam – Chapters 7, 9 – 13 and Other Topics** | | |

**Course Grading**

| | |
|---|---|
| One Hour Exam: | 20 points |
| Final Exam (2 hours): | 25 points |
| Homework: | 10 points |
| Attendance / Participation (Discussion Section) | 10 points |
| In-class Quiz / Small Group Work | 10 points |
| Design Project Report*** | 25 points |

* Reading assignment to be completed BEFORE coming to class on the day it is assigned
** Homework (HW) problems which are selected from Self Study sets will be weekly collected for the grading
*** The final report of the design project is due on April 26 (subject to change).

# Grading Policies

**Assessment and Measurement:**

The students will be evaluated on the basis of performance on periodic four examinations, weekly face-to-face quizzes and online quizzes and class participation. A percentage of total points possible determine the course grade.

| | |
|---|---|
| 90 – 100 | A |
| 80 – 89 | B |
| 70 – 79 | C |
| 60 – 69 | D |
| 0 – 59 | F |

***Course Structure:***

| | |
|---|---|
| 45 points | Four Non-Cumulative Exams (Exam I, and Final Exam) |
| 10 points | Homework |
| 10 points | In-class Quizzes / Small Group Work |
| 10 points | Class Participation (in-class discussion) / attendance |
| 25 points | Design Project Report |

Total Possible Points: **100 points**

***In-Class Quizzes:***

The in-class quizzes will be given at the start of the first class period for the previous week lecture material. **There will be no makeup quizzes given**. Therefore, it is imperative that you arrive early or on time for each class meeting. There may or may not be a quiz for a given week … therefore it is important to be prepared each time.

***Classroom Participation / Attendance:***

Students must actively participate in in-class activities and attend the class on time for full points. The following rubric will be employed to assign participation points. They will be added up in the final and the accumulated points will be converted into total 5 points out of 100 points for the final grade consideration.

| **Preferred** (4 pts) | **Acceptable** (3 pts) | **Won't ask you to leave** (2 pts) | **May ask you to leave** (1 pt) | **Will ask you to leave** (0 pt) |
|---|---|---|---|---|
| Arrives on time<br><br>Comments are relevant and reflect understanding and good participation<br><br>Clear enthusiasm | Arrives no more than 5 min. late<br><br>Comments are mostly relevant, but understanding may be slightly lacking<br><br>Not overly enthusiastic, but positive | Arrives no more than 10 min. late<br><br>Comments are minimal and demonstrate poor preparation<br><br>Demeanor is sluggish | Arrives more than 10 min. late<br><br>No comments are made<br><br>Sleeping, texting, disengaged | Absent<br><br>Disruptive or rude comments are made<br><br>Drawing others into disrespectful behaviors (showing texts, passing notes, hanging around during the class, etc.) |

***Design Project Report:***

Students will be organized by project teams (3-5 members), and each team must submit the design project report by the assigned deadline. The guideline for writing the project report will be provided by the instructor, in the similar manner to the template provided by the professional journal (or conference) committee. The rubric below will be used to assess the final report. The final points will be converted into 25 points (out of 100 points) for the final grade consideration as aforementioned.

| **Excellent** (8 -10 pts) | **Good** (5 – 7 pts) | **Fair** (2 – 4 pts) | **Poor** (0 – 1 pt) |
|---|---|---|---|
| Includes analysis or synthesis of course materials, personal experiences, and/or scholarly works.<br><br>Includes citations to external materials of high academic quality (e.g., peer-reviewed).<br><br>Thoughtful, academic, stimulating.<br><br>Pertinent to the course | Usually includes analysis or synthesis of course materials, personal experiences, and/or scholarly works.<br><br>Citations are of mixed quality (some academic, some less academic).<br><br>Pertinent to the course | Significant amount of course material copied or repeated from the course OR copied from external sources without considering through analysis or synthesis.<br><br>Citations are of mixed quality-high dependence on corporate websites or the like.<br><br>Loosely pertinent to the course | No evidence of cognitive processing of course material or analyzing own experience through the lens of the course content.<br><br>Not directly relevant to the course.<br><br>Poorly organized.<br><br>Poor or no citations given. |

## No Make-Up Exams:

THERE WILL BE NO MAKE-UP EXAMS. The percentage of any exam missed by a student will be added to his/her final exam only if prior approval is granted. The student is responsible to contact me at least a week before the scheduled exam date to get an excuse from the exam. If you have to miss an exam due to emergencies (such as medical and other emergencies) please inform me as soon as possible before or immediately after the exam. If you miss any exam without getting prior approval from me at least a week before the exam date, it will be counted as zero in the calculation of your final course grade. If you intend to be absent for a university-sponsored event or activity, you (or the event sponsor) must notify me at least a week prior to the date of the planned absence. Just to remember, quizzes and all exams, including the final, are to be taken at the assigned time. **There will be no exceptions!**

## Academic Dishonesty:

Academic or scholastic dishonesty includes cheating, plagiarism, collusion and/or falsifying academic records. University policy prohibits these acts and students suspected of academic dishonesty are subject to disciplinary proceedings. Therefore, no cheating of any kind will be tolerated. If you try to cheat, your course grade will be **"F"** and the incident will be reported to the University.

"Cheating" includes:

1. Copying from the paper of another student, engaging in written, oral or any other means of communication with another student, or giving aid to or seeking aid from another student when not permitted by the instructor;
2. Using material during an examination or when completing an assignment that is not authorized by the person giving the examination or making the work assignment;
3. Taking or attempting to take an examination for another student, or allowing another student to take an examination for oneself;
4. Using, obtaining, or attempting to obtain by any means, the whole or any part of an unadministered examination or work assignment.

"Plagiarism" includes the unacknowledged incorporation of the work of another person in work that a student offers for credit.

"Collusion" includes the unauthorized collaboration with another person in preparing written work that a student offers for credit.

## Grade Appeal Procedure

A student who wishes to contest a grade given by an instructor must initiate the procedure by contacting the instructor who assigned the grade. The instructor and the student should informally review the criteria for assignment of grades and the student's performance. The instructor may affirm the grade or revise the grade.

If the student is not satisfied after the informal discussion with the instructor, then the student may initiate a formal grade appeal by completing a Grade Appeal Form that may be obtained from the Office of Student Records. Normal grade appeals should be filed at the earliest date possible, but no later than six months from the final date of assignment. The instructor and the student should complete the appropriate parts of the form clearly indicating the instructor's rationale for the grade given and the student's basis for the grade appeal.

At each administrative level of the appeal process, an attempt will be made to resolve the issue. If the instructor holds one of the administrative positions used in the appeal process, then that level is omitted. If no resolution is reached at a particular level, then the appeal is forwarded with the recommendation of the administrator at that level with all documentation.

If the appeal is to be considered by the vice president for academic affairs, then a copy of the Grade Appeal Form shall be forwarded by the academic dean of the students. The Office of the President is the final step in the appeal process at The University of Texas at Tyler.

## Food and Drink in Classrooms

Consumption of food and drink in university classrooms is prohibited.

**Note: This course outline is subject to change based on the needs of the class.**