ME415/515 Computational Simulation and Analysis
Spring 2021

ME415/515 is an advanced undergraduate/graduate course on the application of numerical methods and simulation techniques used in engineering disciplines for the analysis of state-of-the-art design problems. Emphasis of the course is on the basic implementation, accuracy, stability and efficiency of the numerical methods used to solve linear, nonlinear algebraic and differential equations. Throughout the course a number of case studies will be used to illustrate the approach and application of the methods. Students must have **strong background** in linear algebra and differential equations, such as MATH201 and MATH202.

COMSOL's model library is extensively used to demonstrate multidisciplinary examples which include but not limited to various sensors and actuators.

Texbooks
- *Numerical Methods Using MATLAB,* 4th ed, J.H. Mathews, K.D. Fink, Pearson, 2004.
- *Numerical Methods with MATLAB,* A. Gilat, V. Subramaniam, Wiley, 2011 (Text book)

References
- *Applied Numerical Methods for Engineers Using MATLAB and C,* Schilling and Harris, Brooks & Cole, 2001
- *Finite Difference Methods for Ordinary and Partial Differential Equations*, R.J. LeVeque, SIAM, 2007.
- *COMSOL modeling library*, Comsol Inc (available online)

Instructors
- Serhat Yesilyurt, syesilyurt@sabanciuniv.edu, FENS 1052, x9579
  Office Hours: Flexible, drop emails when you need, make appointments if necessary.
- Recitation Assistant: TBA

Grading

Grading is based on midterm exams, projects, homework and in-class participation. Depending on progress, distribution of weights may change but more or less the following will be adopted:

- Open-book, zoom camera-on midterms (2): 20% Your webcam and microphone should be on during the exam. In the case of non-compliance with this and other declared exam procedures, your exam will be void. Make sure to check that your webcam and microphone function properly before the exam. Non-compliance with any of exam instructions may warrant a follow-up oral exam.
- Term project: 20%
  - A simulation-based analysis study must be carried out for the design analysis of a part or a component that involves a 2D transient or a 3D model. Examples could be obtained from COMSOL model library. Mesh convergence and validation of the numerical results must be presented. Variations in the geometric dimensions as well as importance of physical assumptions must be presented in the results. Project reports must be in ASME or IEEE conference format including the sections Introduction, Approach, Results and Conclusion. (Further details will be provided in the assignment.)
- Take-home assignments (about 7): 20%
  - Assignments are due Fridays at 5pm unless otherwise noted by the TA.
  - Late returns will be subject to grade cuts of up to 50%.
- Quizzes (about 15): 10%
- Attendance & participation bonus: 10% (Based on participation in quiz attendance (not quiz score) (40%), polls (about one in every lecture) (40%) and zoom lectures (20%) with total duration of 40 minutes or more per lecture. Total attendance score must be more than 70%, otherwise the bonus is set to the Quiz Score:

$$AttendanceBonus = QuizScore + max\left\{0, \left[100 \times \frac{(AttendanceScore - 70)}{30}\right]\right\}$$

NA (not-attended) grade will be given in case of following conditions:

i. less than 50% attendance score
ii. 3 or less take-home assignments turned-in

Each student is responsible for his or her take-home project, may discuss with others on approach and strategies, but must work on the project independently. In suspicious cases, there will be a written quiz about the assignment. Plagiarism and cheating may cause disciplinary action and failure in the course with an F grade.

Tentative Schedule

Week 1-2: Part 0: Introduction, error analysis, sources of error, Taylor's series
Week 3-8: Part 1: Solution of nonlinear algebraic equations (root finding)
- Solution of linear system of equations
- Solution of Ordinary Differential Equations

- **MIDTERM (Approx. the 7th week)**

Week 9-13: Part 2: Numerical solution of Partial Differential Equations (Bending and deformation of beams and plates, temperature distribution in solids, velocity and pressure distribution in flows, potential distribution in electrostatic actuators)

- Application of the finite-difference method to one-dimensional, two-dimensional and time-dependent problems; solution of heat equation, convection-diffusion equtions, and the wave equation.

Week 14: Project presentations (10 minutes each during lecture and recitation hours.)