AME 404 – Computational Solutions to Engineering Problems, Fall 2015

Lecture: MW 8:00-9:20 am (class # 28754R) SLH 102
MW 11:00-12:20 pm (class #28755R) OHE 132
MW 11:00-12:20 pm (class # 29005D) DEN
Instructor: Dr. Takahiro Sakai
Office: RRB 213
Contact Info: tsakai@usc.edu ; (213) 740-5367
Office Hours: Mon 2-3:30 pm; Tue 10:30am-12pm
Textbook: Not required.
Supplemental book: Gilat and Subramaniam, *Numerial Methods for Engineers and Scientists*, Wiley
Teaching Assistant / Office hours:
TBD

Course description: Mathematical aspects of the solutions to typical advanced mechanical engineering problems. Modeling, simulation, computational aspects, computer solutions, and computational tools.

Course Objective: The goal of this course is to introduce numerical methods and effective numerical tools in simulating and analyzing typical problems that arise in aerospace and mechanical engineering. At the end of semester students will have skills to: formulate a simple problem, implement numerical methods to a computer program, simulate the problem and evaluate the corresponding results.

Selected Topics (some topics may change):

Part 1. Numerical Simulations of Dynamical Systems

- Simulation methods of Ordinary Differential Equations (ODEs)
- The 1st order, the 2nd or higher order ODEs and the 1st order systems
- Fourier spectral analysis, Signal processing

Part 2. Numerical Solutions to Two-point Boundary Value Problems (BVP)

- Iterative method (the shooting method)
- Eigenvalues and Eigenfunctions

Part 3. Numerical Solutions to Partial Differential Equations (PDEs)

- Finite differences
- 1D steady state heat conduction problems
- Solution methods to linear system equations
- Direct method for two-point BVP
- 2D steady state heat conduction problems
- 1D unsteady heat conduction problems

Grading: Based on homework and projects. Weights TBD

Computer Programming Language: MATLAB programming language is required for this course. Students are expected to have basic MATLAB programing skill (e.g., AME150L or equivalent).

Homework Policy (IMPORTANT):

- In general students are expected to work on homework independently. Discussion with peer students is not discouraged. However, students must write computer programs and the other part of the work independently. Your work will be carefully monitored for academic integrity throughout the semester. If graders determined that academic plagiarism is highly likely, then the work will receive a score of zero. If plagiarism persists, then such a case will be filed to Student Judicial Affairs & Community Standards (http://www.usc.edu/student-affairs/SJACS) with a recommended course grade of F. This is the worst scenario and, should be avoided at all times. If you worked on a problem in a group, it would be likely that your work looks similar to others'. In order to avoid your work miscounted as a plagiarism, therefore, please list all the group members' names on your work. This does not harm your score.

- Your questions on grading will be accepted for one-week counting from the day the homework is returned, and the homework grade will be frozen thereafter and no appeal or excuse will be accepted.

- Partial credit will be given even the program does not output correct results. Late homework is never accepted.

- In general, submitted work must include written formulation, printout of computer program and corresponding results other than that required by the assignment.

- Grading is based on the results. If presentation of your results is not clear, you may not be able to receive full credit even you obtained correct computational results.

- On-campus student - electronic submission of homework is never accepted. On-campus student must submit a hard copy of hw. Please do not email your work for whatever the reason is.

- Please do not email your codes to instructor or TAs and ask for debugging. The instructor team will never debug your code online. Students are rather encouraged to consult us during our office hour.

Project Policy (IMPORTANT):

- Project policy basically follows the homework policy except that students are required to work on projects all independently. No collaborating work is permitted. This means that all the students must submit their original work. TAs and instructor will assist you only in clarifying the problems but not in solving. Late submittal is never accepted.

- Do not ask anybody to turn in your work on your behalf. They may take advantage of your work. The person who you asked to turn in might take your work off. This actually happened in final project in past semesters.

DEN Blackboard: All course documents (lecture notes, homework, project, etc.) will be posted to DEN Blackboard (https://www.uscden.net/) and available for all the students. However, online lectures and video archives are available for DEN students only (section 29005).

Academic Integrity: The Department of Aerospace and Mechanical Engineering adheres to the University's policies concerning Academic Integrity as described in SCampus. All faculty, staff and students share the responsibility for maintaining an environment of integrity. Students are expected to be aware of, and to observe, the academic integrity standards set forth in SCampus. We will collectively follow these standards in this section of AME 404.

Note: This syllabus is tentative and subject to change as needed during the semester. Any changes will be announced in class in advance.

Tentative Schedule and Assignments

week	Day	Covered Topics	Assignment
1	24-Aug	Intro to the 1st order model, Numerical solution of the 1st order ODE, Euler's method	
	26-Aug	Numerical accuracy, Runge-Kutta method, ode45 built-in function, integration error control	
2	30-Aug	Labor Day holiday (no class)	
	2-Sep	Numerical simulation of the 2nd-order model (spring-mass-damper system)	Hw 1
3	7-Sep	Simple pendulum model; Intro to higher order model (multi-degree of freedom problem)	
	9-Sep	Numerical simulation of high order model - Heat exchanger system	Hw 2
4	14-Sep	Simulation of Airplane longitudinal dynamics; system matrix, eigenvalue/vectors, stability	
	16-Sep	Fouier series - Review: periodic functions, convergence, Gibbs phenomenon	Hw 3
5	21-Sep	Fourier spectral analysis - complex Fourier series, Discrete Fourier Transform, Power spectrum	Project 1
	23-Sep	Fast Fourier Transform, nonuniformly sampled signals & nonperiodic signals, aliasing error	Hw 4
6	28-Sep	2pt Boundary Value Problem - the shooting method, laminer boundary layer equation	
	30-Sep	Modal solutions of 2pt BVP - Torsional vibration of a shaft: Analytical approach	Hw 5
7	5-Oct	Torsional vibration of a shaft (cont.) - Implementation of shooting method; Project 1 - review	
	7-Oct	Intro to PDE: classification, derivation of the heat conduction equation, boundary conditions	
8	12-Oct	1D steady heat equation: Dirichlet problem - Finite differences, tridiagonal system	
	14-Oct	1D steady heat equation: Neumann problem, consistency, numerical accuracy, convergence	Hw 6
9	19-Oct	Steady heat conduction in a circular rod submerged in water, numerical treatment of the pole	Project 2
	21-Oct	Steady heat conduction in a gas turbine blade, variable shape, convection boundary condition	Hw 7
10	26-Oct	Revisit modal solutions of 2pt BVP - direct solution by finite difference method	
	28-Oct	2D steady heat conduction: Frourier series representation of solution, scalar/vector field plotting	Hw 8
11	2-Nov	2D steady heat conduction: Finite difference formulation, array mapping via pointer	
	4-Nov	2D steady heat conduction: numerical implementation of direct method	
12	9-Nov	2D steady heat conduction: iterative approach - Jacobi, Gauss-Seidel, SOR methods	
	11-Nov	1D unsteady heat conduction: Fourier series representation of solutions, making animation	Hw 9
13	16-Nov	1D unsteady heat conduction: Explicit scheme (FTCS scheme), Numerical stability	
	18-Nov	1D unsteady heat conduction: Implicit scheme I (Fully-Implicit method), Neumann BC	Hw 10
14	23-Nov	No class	Project 3
	25-Nov	Thanks giving holiday (no class)	
15	30-Nov	1D unsteady heat conduction: Implicit scheme II (Crank-Nicolson method), Convection BC	
	2-Dec	Project 3 - review, Course wrap up	
	11-Dec	Project 3 Due	