AME 525: ENGINEERING ANALYSIS

Spring 2021

Course hours and credit: Mon-Wed: 12-2pm. Credit: 4 units. Location: Online.

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Zoom discussion session: Thursday 4:00-6:00pm

Course Description: This course focuses on learning techniques from applied mathematics with emphasis on (i) a deeper understanding of function calculus and of vector calculus; (ii) analytical methods for solving linear algebraic and differential equations; (iii) numerical methods for differentiation and integration. We will cover the following topics (not particularly in the order listed below):

- Functions of real variables in 1D: functions, integration, differentiation, fundamental theorems of integral and differential calculus, Taylor's formula and Taylor series expansion, Fourier series and Fourier transform, Laplace transform, etc.
- Ordinary differential equations:1^{st}- and 2^{nd}order homogeneous and inhomogenous linear ODEs, method of variation of parameters, linear ODE's with non-constant coefficients, using Laplace transform to solve IVP, the phase space, equilibrium points and their stability.
- Initial- versus boundary-value problems (BVP), using Fourier Transform to solve 1D BVP, introduction to the eigenvalue problem
- Quantitative methods, discrete calculus, and hands-on work with Matlab: numerical integration, differentiation, time-stepping methods, etc.
- Vector calculus in 2D and 3D: vectors, coordinate systems, base vectors, components, line integrals, curves, surfaces, and volumes, divergence, gradient, and curl, Gauss divergence theorem, Stokes theorem, Einstein's index notation
- Linear algebra: abstract vector spaces, extension to n-tuples, linear dependence, dimension and bases, function spaces and differentials as linear operators, matrices as linear transformations, the adjoint operator, the linear equation $Ax = b$, the inverse operator, the determinant, the eigenvalue problem. Systems of linear differential equations.

Examples will be drawn from Newtonian dynamics, rigid body mechanics, fluid mechanics and irrotational flows, diffusion of concentration fields, and the conduction of heat in solids.

Pre-requisites: Advanced calculus and basic knowledge of ordinary differential equations. Basic knowledge of Matlab.

Books and Resources: There is no recommended textbook. For reference, I like the book by Greenberg, Foundations of Applied Mathematics, I also like the book called "Div, Grad, Curl and all that," for differential calculus, and the book "Nonlinear Dynamics and Chaos" by Steve Strogatz for differential equations. I might also consult and assign problems from O'Neil's Advanced Engineering Mathematics (I have the 7th edition at home). For numerical analysis, I use Dahlquist and Björck, Numerical Methods. I just purchased a book called "Coding the Matrix" by Philip Klein, which I might consult and use. For a classical book on Numerical Linear Algebra, check out the book by Trefethen and Bau. I will also use Grant Sanderson's wonderful videos: 3blue1brown (The Essence of Linear Algebra) and the Khan Academy (available for free on youtube).

Homework assignments: There will be weekly homework sets, **due Mondays at 11:59am** – right before class starts. The purpose of these assignments is to help you understand the material, practice working with Matlab, and communicate your knowledge clearly in a written format with proper visuals. It is mandatory that you submit your homework every Monday electronically and you submit a self-graded version of your hw the next Monday once the solution is posted. We will grade your self-graded hw. It is mandatory that you submit two versions of each hw assignment (the initial hw and the self-graded hw a week later) to receive a grade for your work.

Grading: Grades will be based on the following categories:

Categories	Date	Weight
Class attendance and participation (via online forum)		20%
Homework assignments		80%