Ordinary Differential Equations for Engineers

CME 102 / ENGR 155A

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1. Objective

This course covers Ordinary Differential Equation, or ODE, which is used to model various engineering or scientific problems. Certain forms of ODE can be solved analytically, i.e., their solution is a closed-form mathematical expression. However, a closed-form solution is often not available for most realistic engineering problems; and must be solved numerically on computers. Thus, the goals of this course are to familiarize students with common analytical methods, as well as popular numerical algorithms of solving ODEs. This is a five-unit course.

2. Prerequisites

Knowledge of single-variable calculus equivalent to the content of Math 19-21. Matlab or other programming background.

3. Materials

- Course reader (required): available at Stanford bookstore.
- Matlab (required): for numerical solutions of ODEs to be carried out on computers. Stanford students can download Matlab free of charge through a Stanford Matlab portal (must have a free MathWorks account using Stanford email address), https://www.mathworks.com/academia/tah-portal/stanford-university-30569029.html#new.
- Reference textbook (recommended as second source material only): Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley, ISBN 978-0-470-91361-1.

4. Lecture Time/Location

T,W,Th, 9:30 am – 11:20 am PDT, First lecture: Tuesday, 6/23/2026.

5. Homework/Exam Policy and Grading Structure

The course letter grade will be assigned based on the class curve made up of all students' composite grade. The composite grade is the combination of homework and exams according to the following weight assignments.

	Grade	Date	Location	Policy
Homework	30%	Assigned weekly (posted online) Due approximately one week after assignment	Gradescope online submission	• Late submission subject to penalty • Students are welcome to discuss assignments with classmates, but the work submitted **must be their own**
Midterm	30%	Midterm (Tuesday 07/21) (tentative)	In-Class	• Closed book/notes • No solution of homework or previous exams • One sheet of paper is allowed where students can write equations, formulae, etc. or any information they choose
Final	40%	Final exam (Friday 08/14)	In-Class	

6. Communication and Other Applicable Software

Canvas: Canvas will be used for posting various additional materials, handouts, grades, announcements, etc. Registered students are automatically added to Canvas. Canvas is accessible with SUID through the link https://canvas.stanford.edu.

Gradescope: All assignments will be submitted and graded using Gradescope (https://gradescope.com) which is free to all Stanford students.

7. Students with Documented Disabilities

Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty. For students who have disabilities that don't typically change appreciably over time, the letter from the OAE will be for the entire academic year; other letters will be for the current quarter only. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066, URL: http://oae.stanford.edu).

8. Topics

First-Order ODE methods

- Direction field method
- Separation of variables; logistics equation
- Equilibrium solutions
- Linear 1st-order ODE method
- Bernoulli equation
- RC circuit
- Eigenvalues and eigenvectors
- System of 1st-order ODEs using eigenvalue/eigenvector method

Second-Order ODE methods

- Linear homogeneous ODE: reduction of order method
- Linear homogeneous ODE with constant coefficients: characteristic equation method
- Euler-Cauchy equation
- Linear inhomogeneous ODE: variation of parameters method
- Linear inhomogeneous ODE with constant coefficients: undetermined coefficient method
- Spring-mass oscillatory system: unforced and forced motions
- Linear 2nd-order ODE with constant coefficients: Laplace transform method
- ODE with discontinuous forcing functions
- LRC circuit with step or impulse voltage input

Numerical Methods

- Solving 1st-order ODEs using Euler and Backward Euler methods
- Numerical accuracy and stability
- Higher order-of-accuracy methods: Improved Euler, Runge-Kutta family, Matlab ode45
- Solving system of ODEs and higher-order ODEs
- Boundary value problem: direct method
- Boundary value problem: shooting method
- Multi-step methods