Mathematics of Physics and Engineering I
MATH 245, Fall 2024
Lecture Section 39606D: 1-1:50pm, MWF, SOS B44
Prerequisite: Calculus III: MATH 226 or MATH 227 or MATH 229
Course Description: (4 units) First-order differential equations; second-order linear differential equations; determinants and matrices; systems of linear differential equations; Laplace transforms.

Instructor: Calum Rickard
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Office: Kaprielian Hall (KAP) 416A
Office Hours: Tue 4-5pm, Thu 10:30-11am, F 3:30-5pm in KAP 416A
Also available to meet on Zoom during these hours by request.

Teaching Assistant: Qimin Wang
Email: qiminw@usc.edu
Office: Math Center, KAP 263
Office Hours: Wed 4-5pm, Fri 11am-1pm in the Math Center, KAP 263
Discussion Section 39499R: 2-2:50pm, Tue Thu, KAP 164
Discussion Section 39522R: 3-3:50pm, Tue Thu, KAP 164

Textbook: *Differential Equations* (including any version *with Boundary Value Problems*), by John Polking, Al Boggess, David Arnold, 2nd Edition (including any Classic Version), Required
There will be no use of MyLab for homework (see below), so all you require for the class is a hard copy or digital version of this text.

For additional reference materials, see the following free-licensed textbooks:
Notes on Diffy Qs: Differential Equations for Engineers, by Jiri Lebl
Elementary Differential Equations with Boundary Value Problems, by William F. Trench

Homework: Will be assigned on Gradescope approximately every Wednesday (see Lecture Schedule below) and due on Gradescope by the following Wednesday at 11:59PM.
No late homework will be accepted. Your two lowest homework grades will not be included when computing your final grade (see Grading below).

Simulations: There will be 5 MATLAB numerical simulation assignments during the semester. The 5 simulations will each be assigned on Gradescope on a Tuesday before discussion (see Simulations Schedule below) and due on Gradescope by the following Tuesday at 11:59PM.

The simulations require the use of MATLAB which you can click here to access. An introduction on setting up MATLAB and basic operations will be provided during discussion in the first two weeks of class. Furthermore, instructions on how to use MATLAB for the simulation assignments will be provided during discussion throughout the semester.

Quizzes: Will be held in discussion in-person approximately every Thursday (see Quiz Schedule below) covering the homework due the day before. You will have 20 minutes to complete each quiz. All quizzes are closed book (no notes) with no calculators allowed.
There will be two quiz retake opportunities during the semester: in the discussion after each midterm you will be allowed to retake a single (modified) quiz. Otherwise, there are no make up quizzes. Your two lowest quiz grades will not be included when computing your final grade (see Grading below).

Exams: Midterm 1: Wednesday, October 2, In Class Exam
Midterm 2: Wednesday, November 6, In Class Exam
Final Exam: Wednesday, December 18, 11am-1pm, SOS B44
Midterms are closed book (no notes) with no calculators allowed.
The final is a cumulative exam, covering all topics presented in the course with extra emphasis placed on the material covered after the second midterm. You must take the final to pass the class. It is university policy that no student may take the final early. You will be allowed to use handwritten notes of single standard index card size (3 inch by 5 inch) on both sides on the final. No calculators.

Grading: Homework (10%), Simulations (5%), Quizzes (15%),
    Midterm 1 (20%), Midterm 2 (20%),
    Final Exam (30%)
Each homework assignment, simulation and quiz is worth an equal amount towards its respective component of your final grade. Your two lowest homework scores and two lowest quiz scores will be not be included when computing your final grade.

Course announcements, assignments and grades will be posted on Brightspace.

Course Communication: For general course questions including mathematical queries, this class will make use of Slack as a "quick" communication tool as you will be able to write brief sentences (questions, clarifications, etc.).

Click here to access the course Slack channel.

Questions will be answered by the instructor, teaching assistant and fellow students. As with regular & Brightspace email, using Slack should be viewed as a professional form of communication. Use Slack to ask general course questions including mathematical queries.

Topics Covered: We will cover Chapters 1-2, 4-5 & 7-10 of the text. The main topics are:

- First Order Differential Equations (Chapters 1-2)

- Second Order Linear Differential Equations (Chapter 4)

- The Laplace Transform (Chapter 5)

- Systems of Linear Differential Equations (Chapters 7-10)

See below for detailed Learning Objectives.

Lecture Schedule (subject to change), Simulations Schedule & Quiz Schedule:
Section numbers are from the text which you can use as reading suggestions.

Date	Sections	Topic	Homework (HW)
Mon, Aug 26	1.1, 2.1	Introduction, Classification	
Wed, Aug 28	2.1, 2.2, 2.4	Separable, Direction Field, Linear First Order, Constant Coefficient	HW 1 assigned
Fri, Aug 30	2.4	Linear First Order, Variable Coefficient: Integrating Factor	
Mon, Sep 2	No class	Labor Day	
Tue, Sep 3		*Simulation 1 assigned*	
Wed, Sep 4	2.4, 2.9	Bernoulli's Equations	HW 1 due, HW 2 assigned
Thu, Sep 5		**Quiz 1**	
Fri, Sep 6	4.1, 4.3	Second Order: Fundamental Solutions and Characteristic	
Mon, Sep 9	4.1, 4.3	Second Order: Real Roots, Abel's Theorem	
Tue, Sep 10		*Simulation 1 due*	
Wed, Sep 11	4.3	Characteristic Repeated Roots	HW 2 due, HW 3 assigned
Thu, Sep 12		**Quiz 2**	
Fri, Sep 13	4.3	Characteristic Complex Roots	
Mon, Sep 16	4.1, 4.4	Application: Vibration, Amplitude-phase form	
Tue, Sep 17		*Simulation 2 assigned*	

Date	Sections	Topic	Homework (HW)
Wed, Sep 18	4.4	Second Order: Undetermined Coefficients	HW 3 due, HW 4 assigned
Thu, Sep 19		**Quiz 3**	
Fri, Sep 20	4.5	Second Order: Undetermined Coefficients	
Mon, Sep 23	4.5	Variation of Parameters	
Tue, Sep 24		*Simulation 2 due*	
Wed, Sep 25	4.6	Application: Electrical Circuits	HW 4 due
Thu, Sep 26		**Quiz 4**	
Fri, Sep 27	4.7	Higher Order ODE	
Mon, Sep 30	Sample Midterm 1	Midterm 1 review	
Wed, Oct 2		***Midterm 1***	HW 5 assigned
Thu, Oct 3		**Quiz retake opportunity**	
Fri, Oct 4	5.1	Intro to Laplace Transforms	
Mon, Oct 7	5.2	Properties of Laplace	
Tue, Oct 8		*Simulation 3 assigned*	
Wed, Oct 9	5.2	Properties of Laplace	HW 5 due, HW 6 assigned
Thu, Oct 10	No quiz	Fall Recess	
Fri, Oct 11	No class	Fall Recess	
Mon, Oct 14	5.3	Inverse Laplace	
Tue, Oct 15		*Simulation 3 due*	
Wed, Oct 16	5.4	ODEs with Laplace	HW 6 due, HW 7 assigned
Thu, Oct 17		**Quiz 5**	
Fri, Oct 18	5.5	Unit Step Function	
Mon, Oct 21	5.5	ODEs with Unit Step	
Tue, Oct 22		*Simulation 4 assigned*	
Wed, Oct 23	5.5	Laplace of Periodic Functions	HW 7 due, HW 8 assigned
Thu, Oct 24		**Quiz 6**	
Fri, Oct 25	5.6	Delta Dirac Function	
Mon, Oct 28	5.6	Impulse Response	
Tue, Oct 29		*Simulation 4 due*	
Wed, Oct 30	5.7	Convolution	HW 8 due
Thu, Oct 31		**Quiz 7**	
Fri, Nov 1	8.1, 8.4	Intro to Systems of ODEs	
Mon, Nov 4	Sample Midterm 2	Midterm 2 review	

Date	Sections	Topic	Homework (HW)
Wed, Nov 6		*Midterm 2*	HW 9 assigned
Thu, Nov 7		**Quiz retake opportunity**	
Fri, Nov 8	7.1, 7.2, 7.6, 7.7	Review of Matrices, Vectors and Linear Systems	
Mon, Nov 11	No class	Veterans Day	
Tue, Nov 12		*Simulation 5 assigned*	
Wed, Nov 13	9.1	Eigenvalues and Eigenvectors	HW 9 due, HW 10 assigned
Thu, Nov 14		**Quiz 8**	
Fri, Nov 15	9.1, 9.2	System of ODEs	
Mon, Nov 18	9.2, 9.3	System of ODEs: Complex Eigenvalues	
Tue, Nov 19		*Simulation 5 due*	
Wed, Nov 20	9.2, 9.3	System of ODEs: Repeated Eigenvalues	HW 10 due, HW 11 assigned
Thu, Nov 21		**Quiz 9**	
Fri, Nov 22	9.9	Non-homogeneous system of ODEs	
Mon, Nov 25	9.9	Non-homogeneous system of ODEs	
Wed, Nov 27	No class	Thanksgiving Holiday	
Thu, Nov 28	No quiz	Thanksgiving Holiday	
Fri, Nov 29	No class	Thanksgiving Holiday	
Mon, Dec 2	9.6	Exponential of a Matrix	
Wed, Dec 4	2.6	Exact Differential Equations	HW 11 due
Thu, Nov 5		**Quiz 10**	
Fri, Dec 6	Sample Final	Final Exam review	
Wed, Dec 18		***Final Exam***	

Learning Objectives: By the end of this course, you should be able to:

1. Understand the basic terminology and concepts related to differential equations, including order, degree, linearity, and initial value problems (1.1, 1.3, 2.1)

2. Solve first-order ordinary differential equations (ODEs) analytically using techniques such as separation of variables and integrating factors (1.3, 2.2, 2.4, 2.6)

3. Understand the concept of stability and apply it to analyze equilibrium points of autonomous equations (2.9)

4. Solve second-order linear ODEs with constant coefficients using characteristic equations and find the general solution (4.1, 4.3)

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5. Use the method of undetermined coefficients and variation of parameters to solve non-homogeneous ODEs (4.5, 4.6)

6. Analyze and solve applications of ODEs in various fields, such as physics, engineering, biology, and economics (1.1, 4.1, 4.4, 4.7)

7. Understand the concept of Laplace transforms and apply them to solve initial value problems, including those which involve piecewise-defined and periodic functions (5.1, 5.2, 5.3, 5.4, 5.5)

8. Understand the Delta Dirac Function and use Laplace Transforms in the context of impulse response (5.6)

9. Use convolution to solve linear constant coefficient differential equations (5.7)

10. Understand linear algebra techniques such as matrix invertibility and determinants that are used in the study of ODEs (7.1, 7.2, 7.6, 7.7)

11. Understand and solve systems of first-order linear ODEs using matrix methods and eigenvalues/eigenvectors (9.1, 9.2, 9.3, 9.6, 9.9)

12. Demonstrate proficiency in using MATLAB to solve, analyze and interpret ordinary differential equations

The section numbers above are from the text.

Policies and Statements:

Class Recordings & Virtual Lectures: Attendance in-person is recommended but if needed you are able to attend lectures live virtually using the "USC Zoom" link found under "Course Tools" on the class Brightspace page. You should keep your microphone muted, but you may unmute yourself to ask questions. You can also watch recordings of lectures posted in "USC Zoom" under "Course Tools" on the class Brightspace page.

Midterm absences: To protect academic integrity, all midterm exams must be taken in-person on the day the midterm is given in class. Due to the challenge of calibrating the difficulty of a midterm, there are no make-up midterms. If you anticipate missing a midterm, you must inform me with at least 24 hours notice (or in the case of an emergency, as soon as possible given the circumstances). Your other exams (including the final) will then be weighted to compensate.

Incomplete grade: If you miss the final for a documented emergency, you will receive a grade of IN. Consult the Office of Academic Records and Registrar for more information about an IN grade.

Students and disability accommodations: USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfront-desk@usc.edu.

Course Content Distribution and Student Recording Policies: USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. (Living our Unifying Values: The USC Student Handbook, page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relation to the class, whether obtained in class, via email, on the internet, or via any other media. Distributing course material without the instructor's permission will be presumed to be an intentional act to facilitate or enable academic dishonestly and is strictly prohibited. (Living our Unifying Values: The USC Student Handbook, page 13).

Statement on Academic Integrity: The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, compromises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Support Resources:

Math Center:
The USC Math Center (KAP 263) is a place to go if you want help with your math classes. Please visit the Math Center website for more information.

Counseling and Mental Health:
Phone: (213) 740-9355 (available 24/7)
Website: https://sites.usc.edu/counselingandmentalhealth/
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline:
Phone: 988 for both calls and text messages (available 24/7)
Website: https://988lifeline.org/
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline consists of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number

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makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP):
Phone: (213) 740-9355 (24/7, press "0" after hours)
Website: https://sites.usc.edu/clientservices/
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity, Equal Opportunity, and Title IX (EEO-TIX):
Phone: (213) 740-5086
Website: https://eeotix.usc.edu/
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment:
Phone: (213) 740-2500
Website: https://report.usc.edu/
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title IX for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS):
Phone: (213) 740-0776
Website: https://osas.usc.edu/
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention:
Phone: (213) 740-0411
Website: https://campussupport.usc.edu/
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC:
Phone: (213) 740-2101
Website: https://diversity.usc.edu/
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various

resources for students.

USC Emergency:
Phone: UPC: (213) 740-4321, HSC: (323) 442-1000 (available 24/7)
Website: https://www.usc.edu/emergency/
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety:
Phone: UPC: (213) 740-6000, HSC: (323) 442-1200 (available 24/7)
Website: https://dps.usc.edu/
Non-emergency assistance or information.

Office of the Ombuds:
Phone: UPC: (213) 821-9556, HSC: (323) 442-0382
Website: https://ombuds.usc.edu/
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice:
Phone: (323) 442-2850
Email: otfp@med.usc.edu
Website: https://chan.usc.edu/patient-care/faculty-practice
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.