MATH245: Mathematics of Physics & Engineering I
Units: 4
Spring 2019
MWF: @ 9:00 - 9:50 am in THH 116 (class # 39601)
MWF: @ 11:00 -11:50 am in VKC 102 (class # 39609)

Instructor: Ramtin Sheikhhassani
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Course Description

This course introduces mathematical models that govern the laws of universe. These laws are formulated in terms of differential equations. Differential equations involve functions and their derivatives which are often with respect to time. Engineers and scientists should understand, construct, solve and interpret differential equations using contemporary analytical and numerical methods.

Learning Objectives and Outcomes

- Understand the concept of differential equations and their classification
- Develop, select and apply solutions for 1st order, 2nd order and higher order homogenous and non-homogenous equations by manual and numerical-based methods
- Apply Laplace transforms to solve ordinary linear differential equations (ODEs)
- Find solutions to systems of differential equations using eigenvalues, matrix of exponents and diagonalization
- Solving and approximating non-linear ODEs using analytical and numerical methods
- Demonstrate proficiency in using MATLAB to solve, analyze and interpret ordinary differential equations.

Prerequisite: Calculus III Math 226 or 227

Required Readings

Differential Equations: An Introduction to Modern Methods and Applications. 3rd Edition
James R. Brannan, William E. Boyce, ISBN: 978-1-118-53177-8, Jul 2015 Wiley

Description and Assessment of Assignments

1- HomeWorks: at least10 HWs will be assigned. Problems will be posted on blackboard.

2- Quizzes: weekly quizzes conducted in the discussion sessions, with problems extracted from assigned homework or similar problems. and NO "make-up" of any of the quizzes will be offered.

3- Exams:

    a. Midterm exams:

        i. **Midterm** 1: <u>Monday, February 11</u>, class time

        ii. **Midterm** 2<u>: Monday, Apr 1</u>,   class time

    b. **Final Exam**:

the final exam is comprehensive and will be held at the time specified in the University Schedule of Classes:

        <u>Friday,   May 3, 8-10 a.m.</u> for class # 39601
        <u>Wednesday, May 1, 11-1 p.m</u>. for class # 39609

A respectable performance on quizzes and exams can be realized by all students if attention and energy are given to the timely completion of assigned homework problems.

Grading Breakdown

Assignment	% of Grade
HWs	5
Simulations	10
Quizzes	20
Midterm#1	20
Midterm#2	20
Final	25
TOTAL	**100**

Grading Scale
Course final grades will be determined using the following scale

A	90-100
A-	80-89
B+	70-79
B	60-69
B-	55-59
C+	50-54
C	45-49

Assignment Submission Policy
No late homework will be accepted. One of the lowest grades in homeworks will be dropped.

Additional Policies
Some topics in class will be handled differently from the book. You will be responsible for the way things are done in class. Class attendance is strongly encouraged.

Cellphones, laptops, tablets (except for note-taking purposes) and anything else electronic are to be turned off during class.

Final grade will depend entirely on the performance on the above components and be independent of the financial support requirements (e.g., minimum grade requirement for tuition reimbursement).

Please schedule your work-related travel during time periods outside of the mid-term and final exams. Accommodation to take exams on different dates will be made only for family emergencies, religious observance and documented illness or health-related emergencies.

Course Schedule: A Tentative Weekly Breakdown subjected to adjustments

Lec	Date	Principle Topics	Reading	HomeWorks
1	Mon Jan 7	Intro, Classification, Separable 1st order, dir-field	1.1-3	
2	Wed Jan 9	Linear 1st order, constant coefficient ODE	2.2	
3	Fri Jan 11	Linear 1st order, variable coefficient ODE: Integral factor	2.4	
4	Mon Jan 14	Bernoulli's equations. Stability/Instability		
5	Wed Jan 16	2nd Order: Characteristic and Fundamental solutions	4.1-2	
6	Fri Jan 18	2nd Order homogenous ODE: Real roots, Abel's theorem	4.2	
8	Wed Jan 22	Characteristic repeated roots	4.3	
9	Fri Jan 24	Characteristic complex roots	4.3	
10	Mon Jan 28	application: vibration	4.4	
11	Wed Jan 30	Amplitude-phase form, Free damped motion	4.4	
12	Fri Feb 1	2nd Order nonhomogeneous: Undetermined coefficients	4.5	
13	Mon Feb 4	2nd Order nonhomogeneous: Undetermined coefficients	4.5	
14	Wed Feb 6	Applications: Electrical circuits. Resonance	4.6	
15	Fri Feb 8	Higher order ODE		
	Mon Feb 11	**Midterm #1**		
16	Wed Feb 13	Variation of Parameters	4.7	
17	Fri Feb 15	Intro to Laplace transforms	5.1	
18	Wed Feb 20	Properties of Laplace	5.2	
19	Fri Feb 22	Properties of Laplace	5.2	
20	Mon Feb 25	Inverse Laplace	5.3	
21	Wed Feb 27	ODEs with Laplace	5.4	
22	Fri Mar 1	Unit step function	5.5	
23	Mon Mar 4	ODE with unit step	5.6	
24	Wed Mar 6	Laplace of Periodic functions	5.5	
25	Fri Mar 8	Delta Dirac function	5.7	
26	Mon Mar 18	Impulse response	5.7	
27	Wed Mar 20	Convolution	5.8	
28	Fri Mar 22	Convolution	5.8	
29	Mon Mar 25	Linear systems and feed-back control	5.9	
30	Wed Mar 27	Review of Laplace		
31	Fri Mar 29	Intro to system of ODE		
	Mon Apr 1	**Midterm #2**		
32	Wed Apr 3	Review of matrices, vectors and linear systems	3.1 and App A	
33	Fri Apr 5	Eigenvalues and eigenvectors		
34	Mon Apr 1	System of ODEs	3.2	
35	Wed Apr 3	System of ODEs	3.3	
36	Fri Apr 5	System of ODEs: complex eigen values	3.4	
37	Mon Apr 8	System of ODEs: repeated eigen values	3.5	
38	Wed Apr 10	Non-homogenous system of ODE	3.6	
39	Fri Apr 12	Non-homogenous system of ODE	6.5	
40	Mon Apr 15	Exponential of a matrix	6.6	
41	Wed Apr 17	Intro to non-linear system of ODEs	7.1	
42	Fri Apr 19	Analysis of fixed points of non-linear systems	7.2	
43	Mon Apr 22	Exact Equations	2.1	
44	Wed Apr 24	Exact equations	2.6	
45	Fri Apr 26	Review		

Discussion MATLAB schedule:

- Introduction to MATLAB and Plotting
- Introduction to Runge-Kutta Method
- Use ODE45 to solve 1st order ODEs
- Plotting direction fields
- Apply ODE45 for parametric ODEs
- ODE45 and 2nd order ODEs
- Phase plots
- Nonlinear ODEs
- Higher Order ODEs and ODE45
- Laplace transforms and Inverses with MATLAB
- Transfer function and stability
- Eigenvalues, Eigenvectors and system of ODEs
- Predator and Prey

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Student Health Counseling Services - (213) 740-7711 – 24/7 on call
engemannshc.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call
engemannshc.usc.edu/rsvp
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086
equity.usc.edu, titleix.usc.edu
Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421
studentaffairs.usc.edu/bias-assessment-response-support
Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
studentaffairs.usc.edu/ssa
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.
Diversity at USC - (213) 740-2101
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 - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
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 - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.