Ordinary Differential Equations: Math 537

Fall 2020
Schedule Number 22396

COURSE INFORMATION

Class Days:	MWF	Instructor:	Dr. Bo-Wen Shen
Class Times:	9:00-9:50 am	Phone:	619-594-5962
Mode of Delivery:	Online Lecture	Email:	sdsu.math537.shen@gmail.com
Meeting Tool:	"Zoom"	Office Location:	N/A
Zoom meeting ID:	sent by Emails	Office Hours:	1:30-2:30 pm MWF

Lecture notes and scores are available at Canvas.
Homework, quizzes, and exams are available at GradeScope.

COURSE MATERIALS

Materials	Required or optional	Where and how to obtain them
Hirsch, M.W., S. Smale, and R.L. Devaney, 2013: Differential Equations, Dynamical Systems and an Introduction to Chaos, 3rd Ed. Academic Press. ISBN: 0-12-349703-5.	required	
Bender, C. M., and S. A. Orszag, 2010: *Advanced Mathematical Methods for Scientists and Engineers.* Springer-Verlag, 593 pp. ISBN 978-1-4419-3187-0.	optional	
Lecture Power Point Slides (in PDF)		@Canvas
Homework/Quizzes/Exams		@GradeScope

STUDENT LEARNING OUTCOMES

- Students will learn the following topics: theory of ordinary differential equations: existence and uniqueness, dependence on initial conditions and parameters, linear systems, stability and asymptotic behavior, plane autonomous systems, series solutions at regular singular points.
    - Outcome 1: Perform the stability analysis of the 1st order ODEs and understand the concepts of critical points, bifurcation points, sink, source, and saddle points.
    - Outcome 2: Perform the stability analysis of the 2D and higher-dimensional systems of ODEs using eigenvalue analysis. Understand the determinant-trace diagram, the relationship of the genericity and the distinct eigenvalues, and repeated eigenvalues that are associated with generalized eigenvectors.
    - Outcome 3: Understand the concepts of homeomorphism, conjugacy, dynamical equivalence, hyperbolicity, and the Jacobian matrix toward the

understanding of the linearization theorem. Understand the concepts of continuous dependence on initial conditions (CDIC) and sensitive dependence on initial conditions (SDIC).

- Outcome 4: Understand asymptotic series, perturbation series, boundary layer theory, and WKB theory.

- Relation to Other Courses: Math 537 is an advanced topic for students Calculus I-II-III (Math 150 151-252) and ordinary differential equations (ODEs, Math 337). Students may further take advanced courses such as numerical matrix analysis (math543), partial differential equations (math531), advanced calculus (math534), nonlinear dynamics and chaos (math538), computational ordinary differential equations (math542), etc.

ENROLLMENT INFORMATION

- Prerequisites: Mathematics 337 with minimum grade of C

COURSE DESIGN AND ASSESSMENTS

Lectures are given with derivations, outlines and notes through the power point slides as well as the whiteboard. There are bi-weekly homework, several take-home quizzes, one mid-term exams, and one final exam, as listed below.

- Class Attendance: Students are required to attend all class meetings including discussion sections. The class attendance will be taken randomly.
- Make-up exams: Missed quizzes or exams can only be made up in the case of a University approved absence.
- One biweekly homework, available @GradeScope, is due at 11:00 pm every other Friday.

GRADING POLICIES

You will be guaranteed the following grades as given by your percentage score on the homework, quizzes, midterm, and final exam.

- Biweekly homework: 30%
- Take-home Quizzes 5%
- Mid Term Part A (Sep. 30, Wed) 15%
- Mid Term Part B (Oct., 2, Fri): 15%
- Final Exam Part A (Dec. 11, Fri): 15%
- Final Exam Part B (Dec. 14, Mon): 20%

A 90%	B 80%	C 70%	D 60%
A- [89%, 90%)	B+ [85%, 89%)	C+ [75%, 79%)	D+ [65%, 69%)
	B [80%, 85%)	C [70%, 75%)	D [60%, 65%)
	B- [79%, 80%)	C- [69%, 70%)	D- [59%, 60%)

SCHEDULE

- August 24 (M): First day of classes
- September 2 (W): Last day for faculty to drop students from classes
- September 4 (F): Last day to officially withdraw from the university without penalty fee for Fall semester 2020
- September 7 (Tu): Labor Day
- Sep. 30 (W): Mid-Term Part A (take-home) (by 11:59 pm)
- Oct. 2 (F): Mid-Term Part B (9:00-9:50am)
- Oct. 31 (Sat): Last day to officially withdraw from all classes for Fall 2020 and receive a prorated refund ((withdrawal after September 4 requires special approval and a penalty fee is assessed)
- November 11 (W): Veteran Day. Faculty/Staff holiday
- November 26-27: Holiday—Thanksgiving recess
- Dec 10 (Th): Last day of classes before final examinations
- December 11–17: Final examinations
- Dec 11 (F): Final Exam Part A: (take-home) (by 11:59 pm)
- Dec 14 (M): Final Exam Part B (8:00-10:00) (scheduled by SDSU)
- Dec 31 (Th): Grades due from instructors. (11 p.m. deadline)

UNIVERSITY POLICIES

Accommodations: If you are a student with a disability and are in need of accommodations for this class, please contact Student Ability Success Center at (619) 594-6473 as soon as possible. Please know accommodations are not retroactive, and I cannot provide accommodations based upon disability until I have received an accommodation letter from Student Ability Success Center. Your cooperation is appreciated.

Student Privacy and Intellectual Property: The Family Educational Rights and Privacy Act (FERPA) mandates the protection of student information, including contact information, grades, and graded assignments. I will not post grades or leave graded assignments in public places. Students will be notified at the time of an assignment if copies of student work will be retained beyond the end of the semester or used as examples for future students or the wider public. Students maintain intellectual property rights to work products they create as part of this course unless they are formally notified otherwise.

Religious observances: According to the University Policy File, students should notify the instructors of affected courses of planned absences for religious observances by the end of the second week of classes.

Medical-related absences: Students are instructed to contact their professor/instructor/coach in the event they need to miss class, etc. due to an illness, injury or emergency. All decisions about the impact of an absence, as well as any arrangements for making up work, rest with the instructors. Student Health Services (SHS) does not provide medical excuses for short-term absences due to illness or injury. When a medical-related absence persists beyond five days, SHS will work with students to provide appropriate documentation. When a student is hospitalized or has a serious, ongoing illness or injury, SHS will, at the student's request and with the student's consent, communicate with the student's instructors via the Vice President for

Student Affairs and may communicate with the student's Assistant Dean and/or the Student Ability Success Center.

SDSU Economic Crisis Response Team: If you or a friend are experiencing food or housing insecurity, or any unforeseen financial crisis, visit sdsu.edu/ecrt, email ecrt@sdsu.edu, or walk-in to Well-being & Health Promotion on the 3rd floor of Calpulli Center.

Resources for students: A complete list of all academic support services--including the Writing Center and Math Learning Center--is available on the Student Affairs' Academic Success website. Counseling and Psychological Services (619-594-5220) offers confidential counseling services by licensed therapists; you can Live Chat with a counselor at http://go.sdsu.edu/student_affairs/cps/therapist-consultation.aspx between 4:00pm and 10:00pm, or call San Diego Access and Crisis 24-hour Hotline at (888) 724-7240.

Academic Honesty: The University adheres to a strict policy prohibiting cheating and plagiarism. Examples of academic dishonesty include but are not limited to:

- copying, in part or in whole, from another's test or other examination;
- obtaining copies of a test, an examination, or other course material without the permission of the instructor;
- collaborating with another or others in work to be presented without the permission of the instructor;
- falsifying records, laboratory work, or other course data;
- submitting work previously presented in another course, if contrary to the rules of the course;
- altering or interfering with grading procedures;
- assisting another student in any of the above;
- using sources verbatim or paraphrasing without giving proper attribution (this can include phrases, sentences, paragraphs and/or pages of work);
- copying and pasting work from an online or offline source directly and calling it your own;
- using information you find from an online or offline source without giving the author credit;
- replacing words or phrases from another source and inserting your own words or phrases.

The California State University system requires instructors to report all instances of academic misconduct to the Center for Student Rights and Responsibilities. Academic dishonesty will result in disciplinary review by the University and may lead to probation, suspension, or expulsion. Instructors may also, at their discretion, penalize student grades on any assignment or assessment discovered to have been produced in an academically dishonest manner.

Classroom Conduct Standards: SDSU students are expected to abide by the terms of the Student Conduct Code in classrooms and other instructional settings. Prohibited conduct includes:

- Willful, material and substantial disruption or obstruction of a University-related activity, or any on-campus activity.
- Participating in an activity that substantially and materially disrupts the normal operations of the University, or infringes on the rights of members of the University community.
- Unauthorized recording, dissemination, or publication (including on websites or social media) of lectures or other course materials.
- Conduct that threatens or endangers the health or safety of any person within or related to the University community, including
    1. physical abuse, threats, intimidation, or harassment.
    2. sexual misconduct.

Violation of these standards will result in referral to appropriate campus authorities.

COURSE OUTLINE

Chapter	Sections	Remarks
1: First Order Equations		~ 1.5 weeks
	1.1 The Simplest Example	
	1.2 The Logistic Population Model	
	1.3 Constant Harvesting and Bifurcations	
	1.4 Periodic Harvesting and Periodic Solutions	
	1.5 Computing the Poincaré Map	
2: Planar Linear Systems		~ 1.5 weeks
	2.1 Second-Order Differential Equations	
	2.2 Planar Systems	
	2.3 Preliminaries from Algebra	
	2.4 Planar Linear Systems	
	2.5 Eigenvalues and Eigenvectors	
	2.6 Solving Linear Systems	
	2.7 The Linearity Principle	
3: Phase Portraits for Planar Systems		~ 1 week
	3.1 Real Distinct Eigenvalues	
	3.2 Complex Eigenvalues	
	3.3 Repeated Eigenvalues	
	3.4 Changing Coordinates	
4. Classification of Planar Systems		1.5 lectures
	4.1 The Trace-Determinant Plane	
	4.2 Dynamical Classification	
5. Higher Dimensional Linear Algebra		~ 2 weeks
	5.1 Preliminaries from Linear Algebra	
	5.2 Eigenvalues and Eigenvectors	
	5.3 Complex Eigenvalues	
	5.4 Bases and Subspaces	
	5.5 Repeated Eigenvalues	
	5.6 Genericity	
6. Higher Dimensional Linear Systems		~ 1.5 weeks
	6.1 Distinct Eigenvalues	
	6.2 Harmonic Oscillators	
	6.3 Repeated Eigenvalues	
	6.4 The Exponential of a Matrix	
	6.5 Nonautonomous Linear Systems	
7. Nonlinear Systems		~ 1 week
	7.1 Dynamical Systems	
	7.2 The Existence and Uniqueness Theorem	
	7.3 Continuous Dependence of Solutions	
	7.4 Linearization and The Variational Equation	

8. Asymptotic Series and Local Analysis (Chapter 3 of Bender and Orszag)		~ 1 week
	8.1 Classification of Singular Points	
	8.2 Local Behavior Near Ordinary Points	Taylor Series
	8.3 Local Series Expansion About Regular Singular Points	Frobenius Method
	8.4 Local Behavior at Irregular Singular Points	Asymptotic series;

		asymptotic relations; controlling factor
	8.5 Local Analysis of Inhomogeneous Linear Eqs.	
	8.6 Asymptotic Relations (for Oscillatory Functions)	
	8.7 Asymptotic Series	
9. Perturbation Series (Chapter 7 of Bender and Orszag)		~ 1 week
	9.1 Perturbation Series	
	9.2 Regular and Singular Perturbation Theory	
	9.3 Asymptotic Matching	
10. Boundary Layer Theory (Chapter 9 of Bender and Orszag)		~ 1 week
	10.1 Introduction to Boundary Layer Theory	
	10.2 Mathematical Structure of Boundary Layer	
	10.3 Higher Order Boundary Layer Theory and Internal Boundary Layers*	
11. WKB Theory (Chapter 10 of Bender and Orszag)		~ 1 week
	11.1 Introduction to WKB Theory (WKB expansion)	
	11.2 Conditions for Validity of the WKB Approximation	
	11.3 Patched and Matched Asymptotic Approximations*	

*Optional: these lectures will be presented subject to time availability.