Math 2401 Differential Equations (4 cr)

Meeting Time: MWF 8:00–9:05 in Sci 1030
Instructor: Barry McQuarrie
Office: Science 1380 (by exit to parking lot behind science building)
Office Hours: Mon 3:30-4:30pm, Tue 9:00-11:00am, Wed 3:30-4:30pm, Fri 9:15-11:00am
Email: mcquarrb@morris.umn.edu (preferred communication)   Phone: (320) 589–6302 (I do not use voicemail)
Course moodle site: https://ay15.moodle.umn.edu/course/view.php?id=483

Course Prerequisites: Math 1102

To succeed in this course you will need to have mastered introductory calculus (Calculus I and II). Although the only prerequisite to the course is calculus, we will be using ideas from linear algebra and complex-valued functions extensively. The underlying theory of differential equations has a deep connection with linear algebra, and I will be pointing out these connections as we proceed. We will develop the concepts we need from other areas of mathematics in class or on assignments.

Most students in the class will have some experience with the computer algebra system *Mathematica* from Calculus I and II. If you have never used *Mathematica* before, do not despair! I will be using it occasionally in class, and will provide you with resources to help you use *Mathematica* when you need it on Assignments. *Mathematica* will never do our thinking for us. It will help us understand concepts and answer questions that would be difficult to answer if we were working the solution out solely by hand. The vast majority of the work in this class will be done using our brains, pencils, and paper!

Learning Objectives

The primary goals of a student taking this course are to (full list of topics at end of syllabus)

- classify a given differential equation into the basic types,
- solve first order linear differential equations by various methods,
- solve second and higher order linear differential equations (both constant and variable coefficient) by various methods,
- solve systems of first order linear differential equations using eigensystems,
- determine stability of critical points in linear and locally linear systems.

Beyond the curriculum, you should also expect to

- develop skill at presenting solutions to problems,
- think beyond technique, and understand the problems studied in some depth,
- develop confidence in your problem solving skills,
- see the benefit of computers to aid calculation, but also see the *absolute necessity* of understanding the theory completely before using a computer.

Time Commitment

University policy says "one credit is defined as equivalent to an average of three hours of learning effort per week (over a full semester) necessary for an average student to achieve an average grade in the course". Our course is a four-credit course, meeting approximately three hours per week: 4 credits times 3 hours/week/credit - 3 hours/week in lecture = 9 hours/week outside class. Thus, you are expected to spend 9 hours per week working outside of class, reading the textbook and working problems.

Please make the most of my office hours! The content of the course can be difficult at times and I expect to see you all in my office at some time or other. To get the most out of the course you should

- do homework every day (more on this later),
- allot time to think about what it is we are doing,
- discuss the techniques we are studying and their implementation with your classmates,
- discuss any difficulties with me during office hours.

Textbook

The required textbook is Boyce and DiPrima *Elementary Differential Equations* 10th, 9th, 8th, or 7th Ed–the bookstore will have the latest edition, and the course calendar is based on the 10th Edition. The differences between the editions is minimal, but if you use an earlier edition be aware that some of the sections may be numbered differently, content may be slightly different, and problems listed as practice below may not line up with your older edition. Note there is also a version of the text with additional sections on Boundary Value Problems, which you may also use.

Another text that presents the concepts with more readability (but lacking the depth of Boyce and DiPrima) is Zill's *A First Course in Differential Equations with Modeling Applications*. If you are looking for a secondary reference this would be an excellent choice. **Zill's book is NOT the primary text for the course, it is optional.**

Course Components

Text. Please read the indicated sections of the text *before* the lecture. Boyce and DiPrima can be dense reading at times, but stick with it–some sections we will not cover in as much detail, but it is good practice to be reading math, even if it is difficult. If you have questions that aren't answered in class, post them on the forum or ask me during office hours.

Practice and Example Problems. Solutions to Practice questions suggested in the study guide are available in the text. Example Problems with my full solution are available on the course moodle site. The purpose of these problems is to focus your attention on the important lessons of the day, to serve as a starting point for solving the assignments, to serve as a guide to what I consider a complete solution to problems, and to serve as review for tests. You should do as much extra homework as you deem necessary to enhance your understanding of a topic. I can not stress enough how important it is that you work problems!

WeBWorK. You will be completing some of your assignments using the online homework utility WeBWorK. The WeBWorK problems are provided to give you practice implementing the computational techniques we will be studying, although occasionally a problem will be more theoretical in nature. There are seven WeBWorK problem sets for the course.

Assignments. Assignments will be handed out well in advance of the due date. The assignments will take some time to complete, and it is important that you begin work on them immediately. Assignments will be handed in during class on the day they are due, unless you have spoken to me beforehand and I have granted an extension.

Assignment solutions should be a self-contained document. They should be written legibly, contain diagrams or tables where appropriate, and should state the problem and clearly explain the solution.

If you have used a significant amount of *Mathematica* in your solution, please upload the *Mathematica* notebook in moodle. Make sure it is easy for me to find all parts of each solution in both the handwritten part and the *Mathematica* notebook (use proper *Mathematica* typesetting for sections, text used for explanation, etc.).

Your *Mathematica* file should not have any syntax errors, and should be your own creation (not a creation of multiple students). You may modify the *Mathematica* code from my *Mathematica* files on the course moodle site, but do not use any of my words of explanation in those files (use your own words of explanation).

Unit Exams and Final Exam. There will be two Unit Exams–possibly some short answer or true/false questions, along with questions dealing with the application of the techniques we have learned. You will not be allowed any outside material on your desks during the exams and calculators will not be allowed on tests. These exams should not be significantly harder than the assignments; my tests tend to be long, so do not be alarmed if you require the entire class time to complete them. There will be no *Mathematica* component to the exams. The Final Exam will be similar in format to the Unit Exams, except slightly longer.

Applied Project. There will be an Applied Project you complete in groups, composed of a paper and an electronic presentation. The former I will read and the latter will be shared with the entire class. I will provide a handout for the Applied Project in the second week of the semester, which outlines the process and my expectations.

Grading

The University utilizes plus and minus grading on a 4.000 cumulative grade point scale in accordance with the following:

A	4.000	Represents achievement that is outstanding relative to the level necessary to meet course requirements
A−	3.667	
B+	3.333	
B	3.000	Represents achievement that is significantly above the level necessary to meet course requirements
B−	2.667	
C+	2.333	
C	2.000	Represents achievement that meets the course requirements in every respect
C−	1.667	
D+	1.333	
D	1.000	Represents achievement that is worthy of credit even though it fails to meet fully the course requirements
S		Represents achievement that is satisfactory, which is equivalent to a C- or better

The grade for the course will be calculated by the following formula (there is no extra credit):

Assignments (Sep 14, 28, Oct 12, 26, Nov 2, 16, 30, Dec 11)	30%
WeBWorK (Sep 11, 18, 25, Oct 2, 23, Nov 13, Dec 4)	10%
Applied Project (Checkpoint Dates: Sep 21, Nov 25, Dec 4, Dec 11)	15%
Unit Exams (Oct 9, Nov 4)	25%
Final Exam (Wed Dec 16 4:00-6:00pm Sci 4655)	20%

Your numerical grades will be converted to letter grades and finally Grade Points via the following cutoffs (grades are not rounded up):

Numerical	95.0%	90.0%	87.0%	83.0%	80.0%	77.0%	73.0%	70.0%	65.0%	60.0%	Below 60.0%
Letter	A	A−	B+	B	B−	C+	C	C−	D+	D	F
Grade Point	4.000	3.667	3.333	3.000	2.667	2.333	2.000	1.667	1.333	1.000	0.000

A Healthy Learning Environment

- **Attendance.** Attendance does not count towards your final grade, but missing class means you don't get the benefit of what we do in class, so please come to class and make sure to be in class on time. Neither I nor your fellow classmates enjoy the disruption late arrival causes. I know that situations crop up that will entail late arrival (please come even if you are late!) but try to ensure it is the exception and not the rule. Buy an alarm clock with a battery backup, as the power often goes out for a moment in Morris. If you are coming from another class and fear you may be late often, just let me know and don't stress about it. If you need to leave class early, let me know before class and slip out as unobtrusively as possible.

- **Computers/Cell Phones.** During class, cell phones and music devices should be turned off, and headphones removed from ears. If I find you are surfing the internet during class I will ask you to leave.
  http://policy.umn.edu/Policies/Education/Education/STUDENTRESP.html

- **Personal Conduct In Class and Online.** Be mindful of your peers around you, and keep stray chatter in class to a minimum. In the discussion forums and email communications, please consider the tone of your writing. We must maintain a respectful, open environment if we hope to have effective forum discussions. Also, make sure to use correct grammar, spelling, and punctuation in all your electronic communications. The UMM Student Conduct Code is available at http://regents.umn.edu/sites/default/files/policies/Student_Conduct_Code.pdf

- **Academic Dishonesty.** Cooperation is vital to your future success, which ever path you take. I encourage cooperation amongst students where ever possible, but the act of copying or other forms of cheating will not be tolerated. Academic dishonesty in any portion of the academic work for a course is grounds for awarding a grade of F or N for the entire course. Any act of plagiarism (presenting the ideas, words, or work of someone else as your own) that is detected will result in a mark of zero on the entire assignment or test. I will make it clear during class what is appropriate collaboration for each activity, but if you still have questions about what constitutes academic dishonesty, please come and talk to me. UMM's Academic Integrity policy and procedures can be found at www.morris.umn.edu/committees/scholastic/academicintegrity/.

  Academic Dishonesty FAQ: http://www.oscai.umn.edu/integrity/student/index.html

- **Appropriate Student Use of Class Notes and Course Materials.** Taking notes is a means of recording information but more importantly of personally absorbing and integrating the educational experience. However, broadly disseminating class notes or other course materials beyond the classroom community or accepting compensation for taking and distributing classroom notes undermines instructor interests in their intellectual work product while not substantially furthering instructor and student interests in effective learning. Such actions violate shared norms and standards of the academic community. **Students may not distribute instructor-provided notes or other course materials, except to other members of the same class or with the express (written) consent of the instructor.** For additional information, please see:
  http://www.policy.umn.edu/Policies/Education/Education/STUDENTRESP.html.

- **Late Work/Missed Exams.** Since the assignments are handed out days in advance, only under exceptional circumstances (which can be officially documented) will I accept late work. You will receive a mark of zero if an assignment is submitted late. **However, please talk with me asap (do not wait until the next class) if you missed turning something in, even if it is after the deadline.** If an assignment is partially complete but you are not granted an extension, still submit the work you have completed so you can earn some partial credit. This is far preferable to earning zero on the assignment by not submitting anything.

  If you are going to miss a test (for a documented reason), let me know in advance so we can work out alternate plans. If you unexpectedly miss an exam/quiz/etc for a documentable reason, get in touch with me asap so we can work out alternate arrangements, or schedule a make-up.

  Assignments are due in class (come to class and turn them in). Slipping assignments into my mailbox or under my office door while I am teaching your course is **severely frowned upon** unless we have agreed that you will be doing this.

- **Your Health.** As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating, and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. If you have any special needs or requirements to help you succeed in the class, come and talk to me as soon as possible, or visit the appropriate University service yourself. You can learn more about the range of services available on campus by visiting the website:
  http://www.morris.umn.edu/academicalert/studentresources/

- **Disability Resource Center.** The University of Minnesota Morris is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center (DRC) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

  If you have, or think you may have, a disability (e.g., mental health, attentional, learning, autism spectrum disorders, chronic health, traumatic brain injury and concussions, sensory, or physical), please contact DRC at 240 Briggs Library or call 320-589-6178 to arrange a confidential discussion regarding equitable access and reasonable accommodations.

- **Academic Alert.** I am strongly invested in making my best effort to ensure all my students (advisees, students in my classes, students I know through other avenues) have both a positive and productive experience at UMM.

  To this end, I use academic alert periodically throughout the semester to inform students when their academic performance in my class could be improved. These alerts are not a punishment, and not an indication of a student's ability to be successful in the class–they are meant to give the student and the student's advisor a heads up that there are some areas to work on which can help improve the student's mastery of the material.

  If you receive an academic alert from me, stop by my office (if you haven't already) to talk with me about your academic progress in the class to date, and we can discuss if there are opportunities or changes to your study practices that could help improve your understanding of the course material–and ultimately, of course, your grade!

Other Policies

- **Makeup Work for Legitimate Absenses.**
  http://policy.umn.edu/Policies/Education/Education/MAKEUPWORK.html.

- **Student Conduct.**
  http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf

- **Sexual Harassment.**
  http://regents.umn.edu/sites/regents.umn.edu/files/policies/SexHarassment.pdf.

- **Equity, Diversity, Equal Opportunity, and Affirmative Action.**
  http://regents.umn.edu/sites/regents.umn.edu/files/policies/Equity_Diversity_EO_AA.pdf.

- **Academic Freedom and Responsibility.**
  http://regents.umn.edu/sites/regents.umn.edu/files/policies/Academic_Freedom.pdf.

Course UMM Campus Student Learning Outcomes (CSLO)

Knowledge of Human Cultures and the Physical and Natural World through:

- SLO-1b.(R) In-depth study in a particular field: its schools of thought, advanced theories, language, and methods of inquiry

Intellectual and Practical Skills, practiced extensively across students college experiences, including:

- SLO-2a.(R) Inquiry and Analysis
- SLO-2b.(R) Critical thinking and problem-solving
- SLO-2d-1.(I) Written
- SLO-2e.(M) Quantitative literacy
- SLO-2f.(R) Information and technology literacy

Capacity for integrative learning, including:

- SLO-4b.(R) Application of knowledge, skills, and responsibilities to new settings and progressively more complex problems
- SLO-4c.(R) Skills for sustained learning and personal development

Topics

- 1.1 Some Basic Mathematical Models; Direction Fields
- 1.2 Solutions of Some Differential Equations
- 1.3 Classification of Differential Equations
- 2.1 Linear Equations: Integrating Factors
- 2.2 Separable Equations
- 2.3 Modeling with First Order Equations
- 2.4 Differences Between Linear and Nonlinear Equations
- 2.5 Autonomous Equations and Population Dynamics
- 2.6 Exact Equations and Integrating Factors
- 2.7 Numerical Approximations (Taylor's Method of Order 2)
- 2.8 The Existence and Uniqueness Theorem
- 3.1 Homogeneous Equations with Constant Coefficients
- 3.2 Solutions of Linear Homogeneous Equations; the Wronskian
- 3.3 Complex Roots of Characteristic Equation
- 3.4 Repeated Roots; Reduction of Order
- 3.5 Nonhomogeneous Equations: Undetermined Coefficients
- 3.6 Nonhomogeneous Equations: Variation of Parameters
- 3.7 Application: Mechanical and Electrical Vibrations
- 3.8 Application: Forced Vibrations
- 4.1 General Theory of nth Order Linear Equations
- 4.2 Higher Order Homogeneous Equations with Constant Coefficient
- 4.3 Higher Order Nonhomogeneous Equations: Undetermined Coefficients
- 4.4 Higher Order Nonhomogeneous Equations: Variation of Parameters
- 5.1 Review of Power Series
- 5.2 Series Solution about Ordinary Point I
- 5.3 Series Solution about Ordinary Point II
- 5.4 Euler Equations; Regular Singular Points
- 5.5 Series Solution about Regular Singular Point I
- 5.6 Series Solution about Regular Singular Point II
- 5.7 Bessel's Equation
- 6.1 Definition of Laplace Transform
- 6.2 Solution of Initial Value Problem
- 6.3 Step Functions
- 6.4 Differential Equations with Discontinuous Forcing Functions
- 6.5 Impulse Functions
- 6.6 The Convolution Integral
- 7.1 Introduction to Systems of First Order Linear Equations
- 7.3 Systems of Algebraic Equations; Linear Independence; Eigenvalues and Eigenvectors
- 7.4 Basic Theory of Systems of First Order Linear Equations
- 7.5 Homogeneous Linear Systems with Constant Coefficients
- 7.6 Complex Eigenvalues
- 7.8 Repeated Eigenvalues
- 7.9 Nonhomogeneous Linear Systems
- 9.1 The Phase Plane: Linear Systems
- 9.2 Autonomous Systems and Stability
- 9.3 Locally Linear Systems
- 9.4 Competing Species
- 9.5 Predator-Prey Equations