Detailed Syllabus for MATH 441 (Fall 2026): Differential equations

Instructor: **Gabriel Provencher Langlois**[*], Visiting Assistant Professor

Webpage: https://gabrielpl.com/teaching/math-441-fall-2026-differential-equations/.

Time: MWF 11:00-11:50 AM. The first lecture will be on **Monday, August 24th**.
Location: 111 Gregory Hall.
Office hours: Tu 3:50-4:50 PM in Harker Hall, Room 314i.

Text: None required. I will provide detailed notes in advance. Some supplementary textbooks I recommend include:

- Elementary Differential Equations, 12th edition, by W.E. Boyce and R.C. DiPrima. Previous editions are just as good. The book is filled with many examples and exercises. It is quite expensive, though.
- Elementary Differential Equations, by W.F. Trench. The PDF of this book is available online for free and legal download at `http://ramanujan.math.trinity.edu/wtrench/texts/index.shtml`.

Course content: This is a honors-level introductory course in ordinary differential equations (ODEs). We will focus mainly on classes of ODEs that have explicit or implicit closed-form solutions (which includes linear ODEs) and finding those solutions. This course will will be applied and emphasize techniques for solving differential equations. It will also, however, cover theory and present a more rigorous treatment of ODEs compared with MATH 285.

I plan to cover the following topics:

1. Introduction: Overview, terminology, basic tools for solving first-order and second-order ODEs, series solutions, graphical solutions.
2. Linear ODEs: Homogeneous ODEs (examples, general solutions, complex roots), linear inhomogeneous ODEs with constant coefficients, linear ODEs with non-constant coefficients, variation of constants, the Laplace transform and its applications (definition, rules, applications, discontinuous functions, the convolution rule, Green's functions).

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3. Linear systems of ODEs: Examples, first-order systems (systems of the form $d\boldsymbol{x}/dt = \boldsymbol{A}\boldsymbol{x}(t)$ with constant matrix $\boldsymbol{A}$, solution via diagonalization, solution via matrix exponentials, solution via the Laplace transform), stability analysis of linear systems, applications.

4. Nonlinear ODEs: The theorem of existence and uniqueness of ODEs, nonlinear systems of ODEs, stability analysis of nonlinear systems.

5. Numerical solutions of ODEs: One-step methods and multistep methods.

We may cover some topics that do not appear explicitly on the list. I will also highlight applications throughout the course.

Learning outcomes and goals: By the end of this course, you will be able to

- analyze and solve differential equations using analytical, qualitative, and numerical techniques;
- determine whether a differential equation has a solution and if the solution is unique;
- interpret solutions to the mathematical models in the original applied context;
- create differential equation models for a range of applications.

Prerequisites: MATH 241; MATH 314 or MATH 347 is recommended. **I expect all students to have a working knowledge of:** limits, differentiation, the chain rule, l'Hôpital rule, applications of the derivative for finding minimums and maximums of a function, Taylor series, the Fundamental Theorem of Calculus, and basic techniques of integration (change of variable, integration by parts, trigonometric substitution, and partial fractions). Knowledge of linear algebra and complex numbers is recommended but not required; I will review the essentials in class.

This course is a prerequisite for MATH 442 (Intro Partial Diff Equations) and MATH 489 (Dynamics and Differential Eqns). The content you will learn is also vital to many subfields of pure and applied mathematics in general.

Audience: This course is intended for majors in mathematics and anyone else with sufficient mathematical background. The treatment will be more rigorous than that given in MATH 285. Note: Credit for this course is not given for both MATH 441 and any of MATH 284, MATH 285, MATH 286.

Grading: Your score will be computed in terms of your overall performance following a flexible scheme. There will be several assignments, three in-class quizzes, and one final exam. Let C_H, C_{Q_1}, C_{Q_2}, C_{Q_3} and C_F denote your total assignment, Quiz 1, Quiz 2, Quiz 3, and final exam scores out of 100. Let A, Q_1, Q_2, Q_3, and F be weights out of 100. Your final numerical grade will be equal to

$$\max_{A,Q_1,Q_2,Q_3,F} \frac{1}{100}\left(AC_A + Q_1C_{Q_1} + Q_2C_{Q_2} + Q_3C_{Q_3} + FC_F\right)$$

subject to

$$
\begin{aligned}
&A + Q_1 + Q_2 + Q_3 + F = 100 && \text{(Maximum score is 100)}\\
&10 \leqslant A \leqslant 15 && \text{(Assignments matter)}\\
&0 \leqslant Q_i \leqslant 15 \quad \text{for } i \in \{1, 2, 3\} &&\\
&15 \leqslant Q_1 + Q_2 + Q_3 \leqslant 45 && \text{(The quizzes matter)}\\
&F \geqslant 40 && \text{(The final matters a lot)}
\end{aligned}
$$

I will provide a "mock" in-class quiz to help you prepare. The quizzes will be around 50 minutes long. The final exam will be around 3 hours long. There will be a few limited opportunities for extra credits.

Expectations.

1. The bi-weekly assignments are an essential part of the course. **I expect that you spend at least ∼8-12 hours per week on the assignments and reviewing the course material**. Avoid putting off working on the assignment right before it is due.

2. **Your assignments should be hand-written and handed in class on time.**

3. If you are stuck on a problem, you may come to office hours to seek my help or you may seek the help of a classmate. You are allowed to work on the assignments in groups, but you **must** 1) hand them in individually and 2) write with whom you collaborated. Do not neglect the assignments: experience shows there is a strong correlation between the work you put into them and how much you learn in the course, which will be reflected in your exams performance.

4. I will do my best to help you learn the course material and show you how to put in practice in many areas of mathematics, science and engineering. **But learning is ultimately your responsibility.** Research suggests that the act of taking notes, reflecting on what you are learning, and spending time solving the problems yourselves significantly helps with the absorption and retention of material.

5. When writing your solution to a problem or writing a proof, make sure you detail your steps and explain your reasoning clearly and fully. Do not be afraid to use complete sentences if needed — mathematical notation is useful for its conciseness and power in many contexts, but it does not substitute clearly written prose. Note that in an assignment or exam, a wrong answer preceded by an almost correct, well-argued justification will earn you lots of extra credits. The same answer with no explanation for what you did will earn you no points.

Academic Integrity: Academic integrity is taken very seriously. Please review Article 1-Student rights and responsibilities, Part 4, section 1-402 of the student code. See the following link for more information: `https://studentcode.illinois.edu/article1/part4`.

Course Policies:

Generative AI Policy: The use of generative AI to help you solve the assignment problems is **strictly prohibited**. It is also not permitted for writing assignments beyond finding spelling and grammar mistakes. Please keep in mind that the goal of this course, beyond teaching you differential equations, is to develop your problem-solving skills and technical aptitude. There is no substitute to working out yourself the problems, even if it means getting stuck from time to time (or even most of the time). Besides, you will not be permitted to use any laptops or computers for the in-class quizzes and exams and you will be expected to workout the exam problems yourself.

Absence Policy: Absences are allowed but you are required to learn what was covered during lecture. Note that the lectures are not recorded.

Illness Policy: If you are ill, please either do not come to class or office hours, or else wear an N95 mask.

Makeup Policy: Make-up exams will be given ONLY if you are excused for a university related activity, if you have a medical emergency, or for a serious personal problem. Proper official documentation is required.

Late Policy: Assignments submitted after the deadline but within 24 hours will receive 75% of the credit. Assignments submitted after 24 hours will generally not be accepted unless you are excused for any of the reasons listed in the Makeup Policy or other serious external circumstances.