ENGR 495/695 Advanced Topics in Engineering Mathematics Fall 2026

Instructor:	David Kelley (e-mail: dkelley) Breakiron 368, 577-1313	**Class**: **Lab**:	MWF 1:00–1:50 pm, BRKI 066 TBD
Office Hours:	TBA		

Course web site: www.eg.bucknell.edu/~dkelley/engr695

Course Goals: The primary purpose of this course is to develop skills and understanding of mathematical methods applicable to problems drawn from the realm of the engineering sciences (also known as applied physics). Such problems are often expressed as systems of linear equations or as ordinary differential equations (ODEs) or partial differential equations (PDEs). Significant effort will focus on understanding the forms that ODEs and PDEs can take and methods to obtain solutions to them. Similarly, various solution strategies for matrix equations will be explored as well as the physical significance of seemingly abstract concepts such as eigenvalues and eigenvectors. Many mathematical details and methods must be brought together to find solutions to these types of problems. This course provides only an introduction to the topic, but what you learn will prepare you to take on more complex problems.

Specific goals of this course are to:

- Review basic concepts of linear algebra.
- Apply linear-algebraic methods to the solution of applied problems.
- Develop the concept of an eigenvalue problem in both linear algebra and differential equations.
- Introduce important analytical and numerical methods for the solution of PDEs.
- Develop proficiency with a structured programming language (*Matlab* or *Python*) to provide solutions to problems that cannot be solved using analytical methods.

All but the last topic listed above are standard fare for a typical first-semester graduate engineering math course. The last item has been added to prepare you for a separate computational and/or numerical methods course that you might take or to give you a starting point for computational work in your own studies. The goal is to increase your confidence in your ability to use coding as a tool for solving problems that might come your way in the course of your research. This course is not intended to delve into the theory of numerical methods.

Prerequisites: There are no explicit prerequisites; however, you should have the following mathematical background:

- Engineering calculus courses, including differentiation, integration, and some vector calculus
- At least one course in ordinary differential equations (MATH 212 or equivalent)
- Matrix-based solutions of systems of linear equations
- Proficiency with a computer for numerical calculations (*Excel*, *Matlab*, *Python*, …). Expert status in a language is not required but you should expect to develop proficiency as we move along.

Textbook and Other Resources: The course textbook is:

Dennis G. Zill, *Advanced Engineering Mathematics*, 6th ed., Jones & Bartlett Learning, 2016. ISBN: 9781284158229.

The book covers most of the course topics in an accessible way, and you should find it to be a useful addition to your professional library. A few supplemental readings will also be assigned that cover topics not included in the textbook.

Evaluation: Your final course grade will be computed as shown below, although your weighted exam average must be greater than 60 out of 100 points for you to pass the course. Significant extra credit opportunities are not likely to be provided.

Homework	10%	weighted equally; lowest score dropped
Coding Problems	20%	weighted equally
Exams #1, #2, Final	2×30%, 10%	lowest score weighted less than others

Homework, exams, and possibly coding assignments will sometimes have parts that will be different for graduate and undergraduate students. Those problems and sections will be clearly indicated. The graduate materials will tend to be more challenging.

While the exam weightings might seem high, they are typical of courses at other graduate-level programs. They implicitly assume that students will be highly engaged and therefore adequately prepared for high-stakes exams. (See "Expectations" section below.)

The weightings above might be adjusted and/or alternative assessment methods might be introduced if necessary to account for unusual circumstances, such as a major error on my part in the preparation of an exam or other assignment, a health-related change in instructional mode, or a long-term university closure. Changes will be announced with as much advance notice as possible.

Scores on major assignments will not be discussed until a 24-hour "cooling off" period has passed unless points have been added incorrectly to obtain an overall score. An absolute scale with the following distribution will be used to determine your final course grade.

93–100 A	87–89.9 B+	77–79.9 C+	60–69.9 D
90–92.9 A–	83–86.9 B	73–76.9 C	< 60 F
	80–82.9 B–	70–72.9 C–	

Expectations: This course was originally designed for Bucknell engineering graduate students. Almost immediately, undergraduates were invited to take the course as well with the understanding that the course would retain its graduate-level character, meaning that students would be expected to exhibit more independence and sophistication in their work than in a typical undergraduate course. Moreover, students are assumed to be more highly motivated to engage with the material and to develop at least a partial ability to assess their progress themselves. Part of what has made this course valuable for undergraduates seriously considering graduate school is that it has allowed them to experience to some degree what graduate school courses are like.

Communication: Check your e-mail and the course web site at least once per day. Most announcements and course materials will be distributed via the web site or Moodle site. E-mail might also be used to distribute time-sensitive announcements. You are responsible for knowing and adhering to any policies or policy updates posted at the web site. You should contact me as soon as possible if you expect to miss a lab session or other scheduled activity.

You may expect prompt, but not instant, responses from me to e-mails, phone messages, and other forms of communication, and I will expect the same from you. We all have multiple responsibilities, and none of us should be expected to respond instantly to requests. I will strive to respond within a few hours but no later than 24 hours during the work week. You should not expect responses, nor should I, late at night or on weekends.

Academic Responsibility: You are expected to comply fully with the University's academic responsibility policies. General discussion of solution techniques is acceptable, but copying problem solutions or full or partial text, sharing step-by-step instructions for solving a problem, sharing computer files, and other forms of plagiarism are not acceptable. All submitted items must consist of your own work. Refer to the "Academic Responsibility" page at the University web site or contact me if these policies are not clear.

Artificial intelligence (AI) tools are proliferating, and it is tempting to use them to solve homework problems, produce written work, etc. It is impossible for me to monitor such usage; therefore, I cannot enforce a prohibition against it. However, you should be aware that if you use such tools, you will not fully develop your ability to solve problems and express ideas nor will you fully develop your technical skill and knowledge. You will not be able to use such tools during exams. Furthermore, if an AI tool generates an erroneous solution or text and you pass it along as your own, you must accept the resulting grade penalty. Claiming text generated by an AI tool as your own is considered plagiarism.

Electronic Devices: Please put away all electronic communication devices during class and lab time, including smart phones and watches, although they may be used briefly to take pictures of the whiteboard. Tablet PCs and tablet-like devices may be used to take notes in class if they are kept flat on the table and used with a thin stylus or quiet keyboard; however, they could be disallowed as well if they become a distraction. Please notify me if you need to monitor a device for an important reason such as an ongoing family crisis.

Intellectual Property: Exams, homework and lab assignments, exam and homework solutions, supplemental readings, and all other documents shared with the class are my or others' intellectual property and may not be posted online or otherwise shared with people outside the course without my permission. Distributing someone else's intellectual property without their permission is a serious matter.

Attendance, Conflict, and Lateness Policies: Attendance is expected at all scheduled class and lab meetings. You are likely to struggle in this course if you do not attend class. If you know that you will not be able to complete an assignment by its deadline or take an exam at its scheduled time, **you must notify me at least 48 hours in advance**. Official university commitments such as field trips, participation in university artistic performances, and participation in varsity athletics will normally be accommodated, as will job interviews, religious observances, and extraordinary personal opportunities. However, in accordance with university policy, incomplete or late work due to personal travel plans under your control (including those around the times of recesses and exams) will not be accommodated.

If you miss an exam, a major deadline, or other major activity due to illness, injury, or other misfortune, you must contact me as soon as possible. If a health professional or other relevant authority confirms the seriousness of your case, then your absence and/or missed deadline will be excused. In the case of an exam, a make-up opportunity will be arranged.

Unexcused absences or missed deadlines (e.g., due to oversleeping) will be handled on a case-by-case basis, probably in consultation with the Dean's office. If you begin an exam after the start time, you must complete it in the remaining allotted time. However, you may not take the exam if you arrive after the first student has completed it and left the room; this policy includes the final exam. Such a situation is equivalent to missing the exam. If you have an unexcused absence, you must notify me as soon as possible. Depending on the reason for the absence, a make-up opportunity of some kind *might* be offered. **However, regardless of the reason for the absence, the score will be reduced by 5 points (out of 100)**. The second unexcused absence will result in a 15-point reduction, and further unexcused absences will likely result in a score of zero or at least a 15-point reduction.

Each student may request *one* 1-day homework deadline extension, but otherwise a 10% per day score reduction will be imposed for homework submitted after the deadline. Homework will not be accepted at all after the solutions have been posted. Adjustments will be made for extenuating circumstances.

Accommodations and Support: If you have or develop a medical condition or a documented or suspected learning disability that might affect your work in this course and for which you might require an accommodation, please contact the Office of Accessibility Resources (570-577-1188 or OAR@bucknell.edu) as soon as possible. Moving an exam or obtaining approval for extra completion time requires official coordination with OAR.

Bucknell and I support efforts to maintain mental health. If you are struggling and believe that it could affect your performance in this course, please contact Associate Dean Terri Norton (570-577-1800 or trn005@bucknell.edu) or me if you feel comfortable doing so. Working through official channels will enable me to provide resources and support. If you require immediate mental health assistance, call the Student Counseling Center at 570-577-1604; after business hours, call 570-577-1604 and choose option 2.

Time Commitment: Time allotted to coursework outside of class is guided by the university's expectations for academic engagement: "Courses at Bucknell that receive one unit of academic credit [like ENGR 495/695] have a minimum expectation of 12 hours per week of student academic engagement. Student academic engagement includes both the hours of direct faculty instruction (or its equivalent) and the hours spent outside of class on student work." Some weeks the work load could be greater than average, some weeks less, but it should average at least 7–8 hours per week beyond lecture and lab time. If some aspect of the work seems to require an excessive amount of time, please let me know either directly or anonymously.

Health and Safety Protocols: Class and lab meetings are expected to be in person. The use of masks in class is optional but recommended if there is a local outbreak of a contagious illness such as flu. However, I reserve the right to require students to properly wear N-95 or KN-95 masks at all times in class in the case of a serious outbreak of COVID-19 or other health crisis. I realize that this policy could be more restrictive than the university's policy, but I must protect a family member who is at high risk of developing serious complications from infection.

Remote instruction via the Zoom online meeting platform might be used if, for example, I become ill, I must travel away from campus, or a major weather event makes travel dangerous. In such cases, I will provide as much advance notice as possible. It is also possible that the university will impose remote instruction or allow its adoption if an unforeseen crisis warrants it. Lectures, lab sessions, and other meetings conducted via Zoom will take place synchronously at their normally scheduled times.

Advice for Success: The best way to develop your skills in mathematics is to practice via active studying. That is, you should strive to apply new concepts and methods, work through example problems, and perhaps work through derivations yourself, not just passively listen to someone else (your professor, for instance) talk about them. To that end, you should participate in class discussions and offer solutions when you have them or pose questions when you don't have them.

I encourage you to work together to complete assignments and to help each other learn the material, even if you come from different engineering departments. However, you will have to complete examinations on your own, so at some point you must become proficient with the course material yourself. You should strive to gain a thorough understanding of the material via independent work.

Amendments: Additional policies or changes to the policies outlined above might be posted at the course web site. If so, they will be announced via e-mail and on the main web page. You are responsible for knowing and adhering to any posted additions and changes. Posted policies, if any, will be considered extensions or amendments to this document.

Topical Content: The course material will most likely be drawn from Chapters 1–3, 5, 7, 8, 10, 12–14, and 16 in the textbook. Some chapters will be covered thoroughly and some only lightly. Supplemental readings on additional topics might also be assigned. Specific reading assignments will be posted at the course web site. Shown below is a general but tentative framework.

- Linear (matrix) algebra for the solution of linear systems
    - Review of problem formulation and nomenclature
    - Solvability criteria and solution methods for the problem $A\mathbf{x} = \mathbf{b}$
    - The matrix eigenvalue problem – solutions to $A\mathbf{x} = \lambda\mathbf{x}$
    - Important matrix decompositions and representations (LU, QR, and SVD)
    - Important and interesting applied problems

- Review of the solutions to linear ordinary differential equations
    - Classifications: linearity, order, initial value problems (IVP) and boundary value problems (BVP)
    - General form of the solution to linear problems
    - Specific equations of importance to mathematical physics and engineering analysis
    - Linear differential eigenvalue problems
    - The Sturm-Liouville problem and the functions of mathematical physics

- Solution of partial differential equations via analytical and numerical methods
    - Nomenclature and definitions
    - Problem formulation – sources of PDEs
    - Separation of variables (SOV) for linear problems
    - Reduction of PDEs to sets of ODEs
    - Interpretation of solutions and significance of eigenvalues
    - Numerical methods using finite differences
    - Practical applications