

**MAT 303–CALCULUS IV WITH APPLICATIONS; SPRING  
2023**

**Topics, Textbook and Prerequisite:** Topics to be covered: first order differential equations (DE), existence and uniqueness of solutions; solving special types of first order DE (e.g. separable DE, linear DE, exact DE); examples of first order DE (population models, acceleration-velocity model); second order and higher order linear DE with examples; homogeneous versus non-homogeneous linear DE; first and second order systems of DE expressed in terms of matrix theory, solving these systems of DE using eigenvalues and eigenvectors of a matrix. Etc.

Our text book is *Differential Equations and Boundary Value Problems* (5th edition), by Edwards, Penny, Calvis.

Course prerequisite: C or higher in MAT 127 or MAT 132 or MAT 142 or AMS 151 or level 9 on the mathematics placement examination.

**Course teachers:**

**Lecture:** Lowell Jones; email at lowell.jones@stonybrook.edu.; office hours (online) TBA — see “Lecture time office hours” and “General office hours” below.

**Recitation 01:** TBA

**Recitations 02:** TBA

**Recitation 03:** TBA

**Recitation 04:** TBA

**Homework:** Homework will be assigned each week and is due the following week. Each homework assignment will be posted under “Assignments” on your recitation blackboard website: just go to “Assignments” and download the pdf file containing the homework assignment, complete the problems, and then upload a pdf files containing your solutions onto the same website (i.e. onto your recitation website) by the due date.

**Tests:** There will be two online midterms during lecture time, and an in-person final exam; times TBA.

A makeup exam may be given if a student misses an exam for a reason beyond the control of the student (such as health emergency or car accident); a makeup will not be given for schedule conflicts with other courses, for travel plans, etc. So if you decide to continue with this course, make sure that the two midterm times and the final exam time do not conflict with any of your other course obligations or plans.

**Lectures:** The lectures will be recorded on zoom each week in advance of the actual scheduled lecture times. All of these lectures will be posted on our lecture website; just go to “Zoom Meeting” on our lecture blackboard website and click on “Cloud Recordings”. Since our lectures will be recorded, and therefore available for your viewing at anytime, our official lecture times will be used for tests (as described above) and for “Lecture time office hours” (as described below).

**Lecture Time Office Hours.** As mentioned above, there will be tests during some of the scheduled lecture times. During all other lecture times I will conduct “lecture time office hours”. These are zoom office hours just for the students in this MAT 303 class. To join these zoom lecture time office hours just go to “Zoom Meeting” on our lecture blackboard website, during the assigned lecture time, and join the zoom meeting. You may show up at any time and leave the zoom meeting at any time as long as the zoom meeting is still in progress. During these zoom office hours I will try to answer any of your math questions; you are welcome to attend even if you have no questions of your own.

**General Office Hours:** In addition to the lecture time office hours just mentioned, I will have 3 additional zoom office hours each week for any student in any class that would like to join. The times of these general office hours are TBA . To join these general office hours just go to the math department website, click on “Advising” and then “Office Hours” to find the link for these general office hours.

### **Grading Policy**

Homework:20%,

Midterms: 20% for each of the two midterms.

Final exam: 40%

### **Disability Support Services (DSS) Statement**

If you have a physical, psychological, medical or learning disability that may impact your course work, please contact Disability Support Services at (631) 632-6748. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential. Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and Disability Support Services. For procedures and information go to the following website: <http://www.stonybrook.edu/ehs/fire/disabilities>

### Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty are required to report any suspected instance of academic dishonesty to the Academic Judiciary. For more comprehensive information on academic integrity, including categories of academic dishonesty, please refer to the academic judiciary website at <http://www.stonybrook.edu/commcms/academic-integrity/index.html>

### Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, and/or inhibits students' ability to learn.

### An approximate Weekly Schedule:

**week of 1/23-1/27:** Cover sections 1.1-1.3.

Skills to learn: finding solutions to a simple differential equation (DE) such as  $y' = f(s)$ ,  $y' = ky$ ,  $y'' = ky$ ; – solving DE which describe the vertical movement of an object subject to gravitational attraction; illustrating the slope field for a DE and understanding how the slope field is related to the graphs of the all the solutions for a DE.

**week 1/30-2/3:** Cover sections cover 1.4-1.5.

Skills to learn: how to find all solutions to a “seperable” DE; how to find all solutions to a (first order) “linear” DE; how to solve examples of first order DE which describe “natural growth” of a population, Newton's law of cooling, the mixing of two substances.

**week 2/6-2/10:** Cover section 1.6.

Skills to learn: how to find all solutions to an “exact” first order DE; how to use substitution to transform a first order DE into a solvable form (e.g. this works for a “homogeneous” DE).

**week of 2/13-2/17** Cover sections 2.1-2.2. .

Skills to learn: how to solve a solve a more nuanced DE (more nuanced than the natural growth DE) which describes the growth of a populations – e.g. the “logistic” DE and the DE which describes the harvesting of a logistic population; a deeper understanding of the relation between the slope field and the graphs of solutions for an “autonomous” DE by finding the “equilibrium” solutions for autonomous DE and determining whether or not each equilibrium solution is “stable” – the logistic DE is an example of an autonomous DE.

**week of 2/20-2/24:** Cover sections 2.3-2.4.

Skills to learn: by taking into account complications (such as air resistance and variation in gravitational acceleration due to Newton's law of gravitation), we obtain DE relating position, velocity, acceleration which are more nuanced than those discussed in section 1.2; learn how to solve these more complicated DE; also, learn how to approximate the solutions to a first order DE by using "Euler's method", using the slope field for the DE.

**week 2/27-3/3:** Cover sections 3.1-3.2.

Skills to learn: understand how to construct a second order linear DE which involves a mass, springs, and a dashpot; how to discover if two solutions to a second order linear homogeneous DE of second order are linearly independent – for example compute the "Wronskian" of these solutions; find the general solution to a second order homogeneous DE with "constant coefficients" in the case that its "characteristic polynomial" has real numbers for roots, and how to find the unique solution with given initial conditions; some of the above for linear DE with order greater than 2.

**week of 3/5-3/10:** Cover sections 3.3-3.4.

Skills to learn: how to find all the solutions to a homogeneous linear DE with constant coefficients (no restriction on order of DE) in terms of the roots of its characteristic equation — distinct roots (both real and complex), repeated roots (both real and complex); know how to solve the DE (in section 3.4) which describe the motion of a pendulum and a system of a mass, a spring, and perhaps a dashpot – there is a bit of terminology to learn here including "damping constant", "damped" and "undamped" motion, "amplitude", "phase angle", "frequency", etc.

**week of 3/13-3/17 :** NO CLASSES (SPRING BREAK).

**week of 3/20-3/24:** Cover section 3.5.

Skills to learn: in section 3.3 you learned how to find all the solutions for a homogeneous linear DE with constant coefficients – now you should learn how to find one "particular solution" to a non-homogeneous linear DE with constant coefficients, by using a method of "undetermined coefficients". By combining this method with the techniques of section 3.3 (solving homogeneous linear DE with constant coefficients) with Theorem 5 in section 3.2 you have a method for finding all the solutions to many linear DE with constant coefficients.

**week of 3/27-3/31:** Cover sections 4.1-4.2.

Skills to learn: how to express a single DE of order  $n$  as a system of  $n$  DE each of order 1; how to set up a system of DE which describe a system of masses and springs with more than one mass; how to set up a system of DE which describe a mixing problem with more than one tank; using the “method of elimination” to solve a system of DE.

**week of 4/3-4/7:** Cover section 5.1: (This is an introduction to linear algebra.)

Skills to learn: adding and multiplying matrices; computing the determinant and the inverse of a matrix; computing the derivative of matrix valued functions; using the product rule and sum rule for computing the derivative of a product or sum of matrix valued functions; expressing a system of first order linear DE in matrix form (solutions are then column-vector valued functions); how to use the “Wronskian” to see if a finite number of column-vector solutions to a system of DE are linearly independent.

**week of 4/10-4/14:** Cover sections 5.2

Skills to learn: compute the “characteristic equation” for an  $n \times n$  matrix  $A$ , solve this characteristic equation to find all the “eigenvalues” for  $A$ . For each eigenvalue  $\lambda$  for  $A$  find an “eigenvector”  $\mathbf{v}$  for  $A$  associated to  $\lambda$  (i.e.  $A\mathbf{v} = \lambda\mathbf{v}$ ). Find the general solution for the system of first order homogeneous linear equations (in matrix form)  $x' = A\mathbf{x}$  (which might represent a mixing problem) , assuming that there are  $n$ -distinct (complex or real) eigenvalues for  $A$ , ; find all solutions to the system of second order linear homogeneous equations  $\mathbf{x}'' = A\mathbf{x}$  (which might represent a spring and mass problem).

**week of 4/17-4/21:** Cover section 5.4.

Skills to learn: compute the eigenvalues for a square matrix  $A$  and the “multiplicity” of each eigenvalue; assuming that all the eigenvalues for  $A$  are real numbers, then for each eigenvalue  $\lambda$  for  $A$  find a “spanning set” for the set of all “generalized eigenvectors” for  $A$  associated to  $\lambda$  consisting of a finite set of disjoint “chains” of such generalized eigenvectors; now write out the general solution to the system of DE  $\mathbf{x}' = A\mathbf{x}$ .

**week of 4/24-4/28:** Cover section 5.5.

Skills to learn: the definition of “ $e$  raised to the power  $tA$ ” – denoted  $e^{tA}$  — where  $A$  is an  $n \times n$  matrix and  $t$  is a real number variable; find all solutions for  $\mathbf{x}' = A\mathbf{x}$  in terms of  $e^{tA}$ ; compute  $e^{tA}$  — using a “fundamental matrix” for the system  $\mathbf{x}' = A\mathbf{x}$  – and compute  $A^k$  for any positive integer  $k$ .

**week of 5/1-5/5:** Review sections 5.4-5.6.