# Multivariable Calculus
# Linear Algebra and Differential Equations

*Ivy Collegiate School*

Fall 2022/Spring 2023

| | | | |
|---|---|---|---|
| **Department:** | Mathematics | **Time:** | MTuW 10:10 – 11:10 |
| **Email:** | mathematics@ivycollegiateschool.org | **Place:** | Room 809. |

**Course References:** This is a list of various interesting and useful books and online resources that were used in the construction of the course. You are not required to purchase any of these, but they may be useful for occasional consultation. (Note: They are available in the restricted library.)

- Ron Larson, Robert P. Hostetler, and Bruce H. Edwards, *Multivariable Calculus*, Cengage Learning, 8th ed., 2005.
- Ron Larson, *Elementary Linear Algebra*, Cengage Learning, 8th ed., 2005.
- Jerrold E. Marsden and Anthony J. Tromba, *Vector Calculus*, W.H. Freeman  Sons, 2003.
- C. Henry Edwards, David E. Penney, and David T. Calvis, *Differential Equations & Linear Algebra*, Pearson, 4th ed., 2018.
- Gilbert Strang, *Differential Equations and Linear Algebra*, Wellesley-Cambridge Press, 2014.
- William E. Boyce and Richard C. Prima, *Elementary Differential Equations and Boundary Value Problems*, Wiley, 9th ed., 2009.
- Stormy Attaway, *MATLAB: A Practical Introduction to Programming and Problem-Solving*, Elsevier, 4th ed., 2017.
- Simone Deparis, *MATLAB and Octave for Beginners*, École polytechnique fédérale de Lausanne, edX, https://www.edx.org/course/matlab-and-octave-for-beginners

**Objectives:** This course is the first advanced course in the Ivy Collegiate School mathematics curriculum at the post-AP level. It is composed of two separate courses: Multivariable Calculus (Fall semester) and Linear Algebra and Differential Equations (LADE, Spring semester). The goal of these courses is to build a bridge from between students' previous knowledge of calculus and further topics in both applied and pure mathematics. Multivariable Calculus extends the study of differentiation and integration to functions and surfaces of several variables. LADE introduces students to new techniques for evaluating vector spaces and matrices and to approaches for solving ordinary differential equations (ODEs). LADE also introduces techniques for developing mathematical models. Both courses have a dual analytical and proof-based aspect to them, so students will begin working on more detailed methods of writing proofs. A sub-objective of the course is that, ultimately, upon successful completion, students should be more fluent in communicating complex ideas in math using both language and notation.

**Co-/Prerequisites:** Students must have successfully completed AP Calculus AB, but successful completion of AP Calculus BC is also recommended.

**Multivariable Calculus Course Outline:**

- Week One ..... Functions of several variables
- Week Two ..... Vectors and vector fields
- Week Three ..... Differentiating multivariate functions
- Week Four ..... Saddle points and Lagrange Multipliers
- Week Five ..... Integrating multivariate functions
- Week Six ..... Multiple integrals in various coordinates
- Week Seven ..... Vector fields and line integrals
- Week Eight ..... Path independence and Green's Theorem
- Week Nine ..... Surface integrals
- Week Ten ..... Stokes' Theorem
- Week Eleven ..... Divergence Theorem and Proofs
- Week Twelve ..... Review
- Week Thirteen ..... MATLAB/GNU Octave tutorial

**Linear Algebra and Differential Equations Course Outline:**

- Week One ..... First-order differential equations
- Week Two ... Linear first-order equations, substitutions, exact equations
- Week Three .... Numerical methods (Euler's Method and Runge-Kutta)
- Week Four ..... Linear systems, matrix operations
- Week Five ..... The determinant
- Week Six ..... Vector Spaces
- Week Seven ..... Higher-order linear differential equations
- Week Eight ..... Eigenvalues and eigenvectors
- Week Nine ..... Linear systems of differential equations
- Week Ten-Sixteen ..... SPRING REVIEW PERIOD
- Week Seventeen ..... Matrix exponential methods
- Week Eighteen ..... Nonlinear systems and the phase plane
- Week Nineteen ..... Laplace transform methods
- Week Twenty ..... Power series methods
- Week Twenty-one ..... CAPSTONE PRESENTATIONS

**Grading Policy:** Homework and quizzes (60%), Finals and Project (40%)

**Capstone Project:** The Capstone projects are designed to give you the opportunity to showcase (beyond the examination) what you have learned and the skills you have mastered as part of the course. While every project assignment may be different in scope, target, grading, and type of organization, each is intended to require you to "dig deep" and impress us with your creativity. For this set of courses, you are required to submit an original research paper related to a topic you have learned in class, produce a 30-minute video tutorial on a select topic, or develop a programming project related to a concept from the course. Rubrics will be available in the Spring semester.

**Important Dates:**

| | |
|---|---|
| Final Examination (Multi. Calculus) ..... | Dec 2022 |
| Final Examination (LADE) ..... | TBD |
| Capstone Deadline ..... | TBD |

**Course Policy:**

- You will be required to license and download MATLAB for this course (instructions will be provided in a separate document).
- Please download the latest version of GNU Octave at https://www.gnu.org/software/octave/index
- A TI-NSpire CX-CAS is recommended.

**Class Policy:**

- Regular attendance is essential and expected.
- All assignments should be submitted with complete worked-out solutions. All work must be completed and submitted via the Google Classroom in a typed-format using a math typesetting program such as MathType or LaTeX (unless otherwise stated).

**Academic Honesty:** Students are expected to abide by the policies regarding Academic Honesty as laid out in the ICS Student Handbook. Any violations will be forwarded for administrative review and the possible imposition of academic penalties.