Math 51000: Vector Calculus
(Course No: 21495)

Meets: MW 9:00-10:15a in SL 051
Final Exam: May 5, 8:00-10:00a

Instructor: Carl Cowen **Office:** LD 224P **Phone:** 278-8846
Office Hours: M 10:30-11:30a and 3:00-4:00p, W 10:30a - 12:30p, or by appointment
E-mail: ccowen@iupui.edu
URL: http://www.math.iupui.edu/~ccowen/Math510.html

General Information and Goals

Calculus is one of the outstanding intellectual achievements of the human mind, in addition to being the foundation of many applications of mathematics to physics, chemistry, biology, statistics, economics, and many other natural and social sciences. The roots of calculus go back to Eudoxus, Archimedes and other Greek thinkers more than 2000 years ago, but the calculus as we know it began with the work of Isaac Newton, Gottfried Leibnitz, and other mathematicians of the 17th century with many improvements in understanding, development of applications, and refinements and extensions of the theory in the 18th and 19th century. In Math 165 and 166 (or Math 163 and 164), you learned how to use the ideas of calculus to solve many of the problems that calculus was invented to solve: describing how quantities change over time, to solve extremal problems, to find areas and volumes, to explore how functions describe natural phenomena, and to describe the structure of the functions.

However, it was clear even in those beginning calculus courses that what we had learned was inadequate because many natural functions were best understood as functions of more than one independent variable. This course has the goal to develop and understand functions of more than one variable in the same kinds of ways that we learned to understand functions of one variable in elementary calculus. While that was also part of the goal of Math 261, this course will tackle harder problems and develop more effective tools than we used in Math 261. In particular, we want to develop effective tools to understand the way in which functions of several variables change over time, to solve maximization and minimization problems in several variables, to find areas of curved surfaces, and find ways to describe the structure of such functions.

The official textbook for the course is:

Text: *Vector Calculus, Linear Algebra, and Differential Forms*
4th edition(2009), by J. H. Hubbard and B. B. Hubbard.

This text should be available at the bookstores, but it is also available at the publisher's website: http://www.MatrixEditions.com and there are also solutions manuals and other items (which I have never seen) available at that site. Last year, the course used the 3rd edition. There are very few changes between the 3rd and 4th editions, so if you can find a 3rd edition available at a lower price, you may wish to use it. While I will primarily be using the 4th edition, I have both editions available, so I can alert you to differing problem or page numbers for the homework assignments if you wish.

My goals for you in this course are

Short term goal: That you master the ideas and computations of the course, both theoretical and applied.

Long term goal: That you recognize the uses or ideas of calculus as you see them in your professional or your personal life and that you know or can quickly relearn the computations that are important to you throughout your life.

Just as tangent lines and linear approximations related to the derivative are used in calculus to describe the behavior of functions of one variable, multi-dimensional analogs of these objects will be used in this course; these are objects from linear algebra. The linear algebra book

Introduction to Matrix Analysis for Engineering and Science,
by Carl Cowen (ISBN 0-9650717-6-6)

is on reserve in the University library and it covers all of the topics from linear algebra that we will need. Similarly, the same is probably true for the book you used in Math 351, Math 511, Math 262, or Math 171 if you have taken one of these courses. In addition, sections 1.1 – 1.4, 2.1 – 2.7, and 4.8 of the Hubbard & Hubbard book also cover the topics we will need. Because we expect that you have had this material before, it will not be a formal part of this course, but you will need to be able to understand the terminology from linear algebra (such as vector, matrix, subspace, span, linear independence, and dimension) and to be able to do the computations related to these objects (such as finding inverses and determinants of matrices, solutions of systems of linear equations, and bases for subspaces such as the image (range) or kernel (nullspace) of a matrix). If you do not know these things right now, you should choose a source you find comfortable and learn some of the basics by January 20.

The developing schedule for the course will be announced in class, but will also be on the website for the class (see the URL above), updated regularly.

If you are comfortable doing so, you are welcome to use calculators or computers with MAPLE, MATHEMATICA, or MATLAB software to do your homework. Quizzes and tests, however, will be paper and pencil only; no machines will be permitted.

There will be two mid-term tests, each counting about 20–25% of your grade, and about 35% of your grade will come from the two–hour final exam given during Final Exam week (May 5). Weekly homework and occasional quizzes will make up the remaining 15–20% of your grade. Late homework will **not** be graded for credit and there will be **no make-ups** for missed quizzes. In compensation for this policy, your two lowest homework grades and your two lowest quiz grades will be dropped.

Some Important Dates

Date	
January 18	Dr. Martin Luther King, Jr. Day, no classes
March 5	Last day to withdraw with adviser's signature only
March 15–19	Spring Break!! no classes
April 2	Last day to withdraw (permission of adviser and instructor required)
May 5	Final Exam, 8:00–10:00a

General Academic Policies

The work you submit for homework, quizzes, tests, and exams must be your own. For homework, you will probably find it beneficial to consult with other students about the material and this kind of conversation and collaboration is encouraged. At the end of the consultation, however, each participant is expected to prepare their own summary of the discussion and their own solution to the problem. More information about student conduct can be found at

`http://registrar.iupui.edu/misconduct.html`

More information concerning adaptive services for learning or other disabilities at IUPUI can be found at

`http://life.iupui.edu/aes/`

The policies for this class will be those derived from IUPUI's policies on academic conduct and adaptive services.

Approximate Course Outline

This outline describes the topics we will cover in the course, approximately how much time we will spend on each topic, and in what order. It is, however, an estimate and the day to day schedule for the course will be announced in class and will be found on the course website: `www.math.iupui.edu/~ccowen/Math510.html`

Chap	*Topic*	*Lectures*
1.1–4	Review of Linear algebra & calculus	2
1.5	Limits in several variables	1
1.6	Important basic theorems of analysis	1
1.7,8	Differentiability in several variables	2
2.10	Implicit & inverse function theorems	2
3.1,2	Manifolds & tangent spaces	2
3.3	Taylor polynomials	1
	Midterm Test I (late February)	
3.6	Critical points & extrema	1
3.7	Constrained extrema: Lagrange multipliers	2
4.1	Integration in several variables	1
4.5	Fubini's Theorem: iterated integrals	2
4.8–10	Volumes & determinants – change of variables in integrals	2
5.1–3	Integration on manifolds	1
	Midterm Test II (early April)	
6.1	Differential forms	2
6.2	Integrating form fields over parametrized domains	2
6.3,4	Integrating forms over manifolds	1
6.5–10	Integral theorems of vector calculus	2

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