Part I

Syllabus

Basic Logistics

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Meeting times The course meets four times per week in Howard 102:

- Monday 8:10-9:00
- Tuesday 8:40 - 9:30
- Wednesday 8:10-9:00
- Friday 8:10-9:00

Textbook There is no official textbook for this course. You are expected to attend each lecture and take good notes during class. If you would like additional resources, I suggest the following openly available online textbooks:

- *Calculus III* by Marsden and Weinstein. https://aimath.org/textbooks/approved-textbooks/marsden-weinstein/
- *Vector Calculus* by Corral. https://aimath.org/textbooks/approved-textbooks/corral/

If you prefer a traditional hardbound textbook, I can highly recommend:

- *Vector Calculus* by Barr. https://www.pearson.com/us/higher-education/program/Barr-Vector-Calculus-2nd-Edition/PGM248244.html

Warning: The modern presentation of material in this class is not necessarily the same as in many "standard" textbooks and online resources.

Educational Goals

Multivariable functions:

- Students will learn how to interpret and construct multivariable functions.
- Students will learn to work with various coordinate systems.
- Students will learn to visualize multivariable functions, both "by hand" and using technology.

Vectors:

- Students will learn basic vector computations (dot product, cross product, etc.) in $\mathbb{R}^2$ and $\mathbb{R}^3$, and be able to geometrically interpret these computations.
- Students will learn basic matrix algebra skills needed to represent and analyze linear functions using matrices.
- Students will gain understanding of connection between vectors and derivatives.

Differential calculus:

- Students will become fluent in multivariable differentiation, conceptually and computationally.
- Students will learn, and apply, Taylor approximations for scalar-valued functions.

Integral calculus:

- Students will gain theoretical knowledge and computational ability for integration in multiple variables, and in multiple coordinate systems.

Vector calculus:

- Students will gain theoretical knowledge and computational ability for concepts of derivatives in vector calculus (divergence, curl, gradient).
- Students will learn, and be able to apply, fundamental theorems of vector calculus.

The assessment of each goal is based on student performance on the relevant homework assignments and exam problems.

Homework, Activities, Exams

All work is graded using the 4.0 scale. The grades are based on

- use of valid procedures and appropriate concepts, and
- correctness of computations.

In general, credit is not given for late or incomplete work. I may, at my discretion, accept late work and file it away in my "miscellaneous" folder; such work is considered only if your course grade is borderline.

Homework

Homework is assigned multiple times each week. Be sure to start the homework as soon as it is assigned!

Students are encouraged to collaborate on assignments, but must submit their own work for evaluation. If you work with other students, be sure that you understand each step of what is being done!

All homework is to be submitted in the SQRC. Please make sure that

- your name and the assignment number/title are clearly written at the top of the first page,
- your work is neatly presented, and
- all pages are stapled together.

Work that does not meet these standards are at risk of being placed in to one my "miscellaneous" folders, from which few documents ever return.

Activities

There are a small number of in-class activities. Some activities provide an opportunity to review/synthesize material, while others allow you to develop new theory in a non-lecture format.

Exams

There are two hour-long exams, currently scheduled for Tuesday 15 October and Tuesday 26 November. Note that while class officially starts at 8:40 on Tuesdays, I will allow students to start the exam at 8:00 if they wish. Exam dates will be confirmed one week prior to the exam. Exams cannot be rescheduled without documentation of extenuating circumstances. Students receiving accommodations through the Student Support Services office should arrange to take the exams through that office.

There is a cumulative final exam, given during the official final exam time. The final exam cannot be rescheduled. Make your holiday travel plans accordingly.

Citizenship

I expect good academic citizenship from all students in this course.

Citizenship in this class It is important to treat our joint academic endeavor respectfully and responsibly. This includes

- being respectful of yourself;
- being respectful of your fellow classmates, faculty, staff, etc; and
- begin respectful of the course material and the learning process.

Citizenship in the LC community All students are expected to be an active and responsible member of our college community. In order to encourage this, you are required to attend two (2) official LC events during the semester. These events cannot be required of another course you are enrolled in, and must be officially advertised or sponsored in some way. After you have attended each event, you need to complete a google form that:

- tells me what the event was, and includes a link to the advertisement or description of the event,
- describes the content or activity of the event, and
- tells me your impressions of the event (what you learned, enjoyed, etc.).

The link to the google form appears on the course website. You can find out about events on campus via the online campus calendar.

Course grades

Course grades are determined using the following process:

1. For each category of educational goals above you will receive a grade determined by your performance on the corresponding portion(s) of exams, homework assignments, etc. Using these grades, I compute a preliminary course grade according to the following weighting:

    - Multivariable functions: 20%
    - Vectors: 20%
    - Differential calculus: 20%
    - Integration: 20%
    - Vector calculus: 20%

    Computing within each category is roughly broken down as 1/3 homework/activities, 1/3 exam, 1/3 final exam.

2. After computing the preliminary grade, I make adjustments based on inconsistent coursework (such as disregarding an outlier), trends throughout the semester (such as improvement), and other factors I deem relevant. Academic citizenship, and citizenship activities, are taken into account during this phase of the grading procedure.

3. Finally, I revisit the individual grades in view of the grade definitions provided by the College Catalog, seeking indicators of the synthesis of course material.

I emphasize that **ultimately grades are assigned according to the definitions in the college catalog**, based on my assessment of the student's knowledge and synthesis of the course material, as documented by the assignments and exams. While a weighted average of individual scores is an important tool for making this assessment, in no way is such an average definitive.

Finally, I note that students fail the course if either of the following occurs:

Insufficient engagement Missing the equivalent of three weeks of class sessions, missing the equivalent of three weeks of homework assignments, or missing one of the exams, will lead to a failing grade. Exceptions to this policy require documented extenuating circumstances.

Gross negligence Demonstration of gross ignorance or complete lack of understanding of key concepts on exams will lead to a failing grade. In particular, a student who has accumulated what might be construed as 'technically enough points to pass' but demonstrates a "clearly inadequate" lack of understanding which is "unworthy of credit" will be awarded a failing grade.

4.0 grading scheme

All coursework is graded on the 4.0 scale. The mapping between numerical and letter grades, together with the official definitions (taken from "Policies and Procedures" section of the Undergraduate Catalog), is as follows. The italics indicate an interpretation of the official definitions for the purposes of mathematics courses.

Grade A (4.0) Outstanding work that goes beyond analysis of course material to synthesize concepts in a valid and/or novel or creative way.

Computational problems are completely and correctly executed in a manner which displays a complete grasp of the theory behind the computation. Theoretical responses display a thorough understanding of the both precise details and the larger framework at hand.

Grade B (3.0) Very good to excellent work that analyzes material explored in class and is a reasonable attempt to synthesize material.

Computational problems are executed with minimal, insignificant errors (such as dropping a sign) and contain some indication that the relevant theory being used is understood. Theoretical responses display significant progress towards understanding of how the details fit in to a larger framework.

Grade C (2.0) Adequate work that satisfies the assignment, a limited analysis of material explored in class.

Solutions to computational problems display significant, though perhaps mechanical, understanding of basic procedures. Theoretical responses display an preliminary understanding of the topic at hand, but lack connections to the larger framework.

Grade D (1.0) Passing work that is minimally adequate, raising serious concern about readiness to continue in the field.

Both computational and theoretical responses display some non-trivial knowledge and skills, but raise concerns about whether basic ideas and methods are understood.

Grade F (0.0) Failing work that is clearly inadequate, unworthy of credit.

Fundamental misunderstandings, mis-use of methods or theory, seemingly random or un-related material, etc.

Tentative schedule

Week 1 (2–6 September)	Labor Day holiday Cartesian spaces Polar and cylindrical coordinates Spherical coordinates
Week 2 (9–13 September)	Functions $\mathbb{R}^n \to \mathbb{R}$ Activity: technology day Functions $\mathbb{R} \to \mathbb{R}^n$ Transformations $\mathbb{R}^n \to \mathbb{R}^n$
Week 3 (16–20 September)	Parametrizations $\mathbb{R}^2 \to \mathbb{R}^3$ Vectors and vector fields Linear functions & matrices Determinants
Week 4 (23–27 September)	The dot product Activity: projections Areas and volumes The cross product
Week 5 (30 September–4 October)	Jacobi matrix, linearization Activity: linearizations Chain rule The gradient vector field
Week 6 (7–11 October)	Second derivative, Hessian, Taylor approximation Activity: unconstrained optimization Constrained optimization Fall Break on 11 October
Week 7 (14–18 October)	Exam review Exam 1: Tuesday 15 October Line integrals Fundamental Theorem for gradient
Week 8 (21–25 October)	Integration in multiple variables Activity: Fubini Theorem Fubini Theorem Area and volume elements

Week 9 (28 October – 1 November)	Area element in polar coordinates Activity: integration Volume element in cylindrical coordinates Volume element in spherical coordinates
Week 10 (4–8 November)	Work and flux integrals for paths Activity Surface integrals Flux integrals on surfaces
Week 11 (11–15 November)	Divergence Activity: divergence in spherical coordinates Divergence Theorems Scalar curl and Green's Theorem
Week 12 (18–22 November)	Curl Activity: curl Stokes' Theorem Fundamental Theorems synthesis I
Week 13 (25–29 November)	Exam review Exam 2: 26 November Extravaganza Thanksgiving Break 28-29 November
Week 14 (2–6 December)	Changing domain of integration Activity Fundamental Theorem synthesis II Fundamental Theorem synthesis III
Week 15 (9–13 December)	Review Activity Course evaluation day Reading Period 13 December
Final Exam	Saturday 14 December 18:00-21:00