Several Variable Calculus, MATH 34

I want you . . .

1. *to be successful.* My top goal in teaching this course is to see you be successful. By "successful," I mean that you will **grow** considerably as a learner of mathematics, **demonstrate** deep personal understanding of the main content in the course, **solve** challenging problems independently or with modest support, considerably **improve** your oral and written communication skills, and that you will go on to **achieve** similar successes in subsequent courses with 34 as a prerequisite.

2. *to be an active, caring, and productive contributor* in our Math 34 learning community.

3. *to improve in your ability to learn independently* through reading the text on your own, watching selected videos, working with peers in class on group activities, and solving challenging problems with new components.

4. *to be willing to struggle.* Struggle - temporary failure - is an important part of learning mathematics. Or anything. Thomas Edison famously said, "I haven't failed. I've found 1000 ways that don't work." Part of answering hard questions involves trying and failing. Part of learning involves making mistakes and understanding why they are mistakes. The best kind of struggle is productive struggle: productive struggle pushes us further down the path of understanding and often provides new ideas that are key to making progress. Work to have a growth mind-set and challenge yourself to always get better through your work.

5. *to enjoy the course.* You may have had previous experiences with mathematics that were frustrating to you, ones that made you think that you don't like mathematics. Especially if that is the case, I want you to have a good experience in this one and to find learning calculus interesting, satisfying, and yes, enjoyable.

6. *to build conceptual understanding* of the topics we study from several perspectives so that you gain greater ability to apply ideas in new settings, deepen your logical reasoning skills, and build an appreciation for the beautiful connections present in the mathematics of calculus. Throughout the course, I urge you to ask yourself questions like "What is the big idea here?," "What do these symbols mean?," "Do the concepts we are studying make sense to me?"

7. *to grow in your written and oral communication skills.* Through regularly assigned work throughout the course, you will be expected to communicate your thinking in writing: writing in complete sentences with proper spelling and grammar is an essential part of many written assessments in the course. Moreover, in all of your written work, correct notation is essential. In addition, through opportunities to discuss material with your peers and contribute to whole-class discussions, you will have the chance to grow in your oral communication of mathematical ideas.

8. *to exhibit academic integrity.* While we will regularly collaborate on certain tasks and assignments in this course, there are some that must be completed entirely individually. When I communicate that you must work independently, it is essential that you honor this expectation. Please know that I have no tolerance for academic dishonesty; we are all partners in having integrity.

9. *to be successful in the course.* Again, this is my top goal for the course. By "successful" I mean that I want you to develop deep, personal understanding of fundamental concepts so that you can demonstrate this understanding on written assignments, verbally in class, and on timed assessments. In order to help you reach this level of success, expect that I will consistently push you to work hard, challenge you with difficult ideas, and demand that you spend significant time outside of class on a regular basis on course material outside of class. Good grades are a consequence of being successful, not the definition of success. Ultimately, I want you to be able to describe yourself - for your performance in this course - as a creative and independent problem solver, an effective communicator, and a hard worker.

What is Multivariable Calculus?

Calculus III should really be renamed, *The Greatest Hits of Calculus*. We revisit all of the amazing theory we learned in Calculus I and II, but now we just generalize it to the multivariate setting. We also generalize it to Vector Fields at the end of the course. At times during this course, the topics may seem disjointed. For example, we start the semester with parametric equations and an introduction to vectors. Differentiation and integration is still there, but isn't the main event during this time. We then get into the greatest hits part of Calc 3 and revist differentiation and integration. At this point in the course, you may think, wait, but what about the vectors? Don't worry. Our last month will be combining the multivariate calculus with vector calculus and this culminates in several important theorems which tie all of Calculus III topics together into several beautiful and useful packages!

Course Learning Objectives

To help each student

- understand multivariable calculus concepts (partial derivatives, multiple integrals, vector calculus);
- apply multivariable calculus concepts to various applications;
- develop conceptual understanding of multivariable calculus from several perspectives;
- be better able to do mathematics independently and cooperatively; and
- more effectively communicate mathematical ideas.

Text

We will be primarily using *Active Calculus - Multivariable + vector*, by Matthew Boelkins. You can access the text online from https://activecalculus.org/vector/frontmatter.html.

Technology

The only technology you are required to have is a computer and a way to write mathematics on the computer screen. You can purchase a Wacom tablet through the bookstore with bookstore funds or feel free to use another equivalent device if you have one.

It will be helpful to graph in 3D in this course. I recommend CalcPlot3D but any equivalent tool is fine.

Course Structure

Everything about this class is based on one idea—**You will learn better by actively doing math**. In class we will do calculus together and individually, through activities and discussion. We will focus on understanding the big ideas at the heart of calculus. You will prepare for class by reading the textbook for comprehension and answering questions about fundamental ideas before class. This will let us tackle the hardest, most confusing, and most fascinating ideas together in class. After class, you will practice these new ideas with homework.

Types of work and assessment

Your semester grade will be based on a system known as proficiency-based grading: this approach doesn't use points, but rather requires you to meet key course learning targets at the level of "proficiency" or better. This approach is likely different than you've encountered in past courses and will take some time to understand and acclimate to. You will meet the main goals of the course by engaging in the following regular tasks and activities.

- **Class prep assignments**: Before each day of class you will complete the preview activity for the section of the book we are working on. Preview activities will be turned in before class.
- **Weekly practice**: During class and afterwords as homework we will work on activities from the book and problems on webwork. These will be due on Friday.
- **Reflections**: Short weekly reflections on a variety of topics, also turned in Friday.
- **Checkpoint Assessments**: After each chapter we will have an checkpoint assessment. Each assessment will consist of a variety of problems on learning targets that students are working on. You will decide which problems to work on and turn in. Any problems that you do not meet proficient on can be revised and you can attempt that standard on a future checkpoint assessment.

Achieving targets

On the next page of this syllabus, you'll find the full list of targets for the course. These are the achievements that every student is expected to meet; meeting them at different levels will result in different semester letter grades. You will meet targets on checkpoint assessments. For example you'll see the following among the learning targets:

F.1 I can identify, evaluate and interpret functions of two variables using formulas, tables, graphs, and contour maps.

F.2 I can compute dot products of vectors as well as use dot products to find lengths, angles, and projections. I can compute cross products of vectors and interpret them geometrically.

"F.1" is the name of one learning target; "F.2" is another. In order to "check a box", you have to demonstrate "proficiency" on a checkpoint assessments. To receive "profieciency" you must fully meet all requirements for the assignment.

Revision and reassessment

If you do not achieve proficiency on a particular standard you will be allowed to revise your work and reattempt the standard on the next checkpoint. See the guidelines for submitting a revision on the course website. You must submit your revision before attempting the problem on a future checkpoint.

Translating proficiency into a semester grade

The following table shows how proficiency will translate into a semester grade. Every time you pass a standard in a certain category you will check a box on the table below. To earn a certain grade you must achieve a certain number of proficiency's in *every* row.

Category	D	C	B	A
Core standards (out of 20)	13	15	17	19
Supplementary standards (out of 10)	0	3	6	9
Class prep assignments (out of 23)	12	14	16	20
Weekly reflections (out of 11)	6	8	9	10
Activities and webwork (out of 11)	6	8	9	10

Grade examples

- Iesha is excited to learn multivariable calculus! She gets a strong start on the semester and passes 5 of the 6 standards on the first checkpoint activity. As soon as she gets it back she revises the standard she missed so that she can attempt it on the next checkpoint. Sadly, Iesha is feeling ill during the next checkpoint and with a cloudy head only passes 3 of the 7 new checkpoints but does pass the one she missed on the first checkpoint. Once again she revises and on the third checkpoint passes 2 of the ones she is missing and 7 of the 9 new ones. On the final checkpoint she passes 8 of the 9 new standards and 2 of the 4 she is missing. This guarantees her an A since she is only missing 1 core standard and 1 supplementary standard.
- Toumas has a rough start. He only passes 1 of the first 6 standards. But after revising all of them and changing his study habits he passes 4 of the 7 on the next standard and makes up 2 of the 4 he missed the first time. He continues this trend on the third and fourth checkpoints ending with 17 core standards and 7 supplementary standards which guarantees a B.

How +/- grades are determined

The above table guarantees you a minimum grade. You can earn a +/- in a higher grade by earning extra proficiency above the minimums for your grade. For example, you might earn a - at a higher level than you met if you are only deficient in one row. I will only ever use this system to mark students up at my discretion.

Standards

Chapter 9: I can use and interpret multivariable and vector functions.

☐ F.1 I can identify, evaluate and interpret functions of two variables using formulas, tables, graphs, and contour maps.

☐ F.2 I can compute dot products of vectors as well as use dot products to find lengths, angles, and projections. I can compute cross products of vectors and interpret them geometrically.

☐ F.3 I can find equations of lines and planes in space in various forms.

☐ F.4 I can draw curves in space and define vector-valued functions for space curves.

☐ F.5 I can evaluate and interpret derivatives and integrals of vector-valued functions.

☐ F.6 ** I can find arc length of space curves.

Chapter 10: I can calculate, use, and interpret partial derivatives.

☐ D.1 ** I can evaluate limits of functions of two variables.

☐ D.2 I can evaluate and interpret first-order partial derivatives of functions of two variables using formulas, tables, graphs, and contour maps.

☐ D.3 I can evaluate and interpret second-order partial derivatives of functions of two variables using formulas, tables, graphs, and contour maps.

☐ D.4 I can find equations of tangent planes for functions of two variables and use them to approximate function values.

☐ D.5 ** I can compute and interpret derivatives using various chain rules and the total derivative.

☐ D.6 I can evaluate and interpret directional derivatives and gradients of functions of multiple variables.

☐ D.7 I can find and classify critical points of functions of two variables.

Chapter 11: I can calculate, use, and interpret multiple integrals.

☐ I.1 I can define and interpret double integrals of functions of two variables over rectangles and numerically approximate them using double Riemann sums.

☐ I.2 I can set up and evaluate double integrals over general regions. I can interchange the order of integration.

☐ I.3 I can set up and evaluate double integrals in polar coordinates.

☐ I.4 I can find surface areas for parametrically defined surfaces.

☐ I.5 I can set up and evaluate triple integrals over general regions. I can interchange the order of integration.

☐ I.6 ** I can set up and evaluate triple integrals in spherical and cylindrical coordinates.

☐ I.7 ** I can make change of coordinates to double and triple integrals by changing bounds and finding the Jacobian.

☐ I.8 I can define, evaluate, and interpret line integrals of scalar functions on parametrized lines.

☐ I.9 I can define, evaluate, and interpret surface integrals of scalar functions across parametrized surfaces.

Chapter 12: I can calculate, use, and interpret vector calculus

☐ VC.1 I can identify, evaluate, sketch and interpret vector fields in the plane and in space.

☐ VC.2 I can define and interpret line integrals of vector fields along oriented curves. I can use parametrizations to evaluate line integrals of vector fields along oriented curves.

☐ VC.3 I can use the Fundamental Theorem of Calculus for Line Integrals to evaluate line integrals of gradient fields.

☐ VC.4 ** I can define, evaluate, and interpret the divergence of vector fields. I can define, evaluate, and interpret the curl of vector fields.

☐ VC.5 ** I can use Green's Theorem to evaluate circulations of smooth vector fields along simple closed curves in the plane.

☐ VC.6 ** I can define, evaluate, and interpret flux integrals of vector fields across parametrized surfaces.

☐ VC.7 ** I can use Stokes' Theorem to evaluate circulations of smooth vector fields along simple closed curves in space.

☐ VC.8 ** I can use The Divergence Theorem to evaluate flux of continuous vector fields through closed surfaces in space.

Independent Learning

Despite the fact that we will meet for 3 hours each week, the amount of class time is not sufficient to discuss every important detail related to multivariable calculus (though we will obviously strive to do as much as possible in class). Through assignments, I will expect you to confirm understanding from class, as well as learn some extended ideas on your own. An important goal for us in this class is to improve our ability to learn independently. Please take advantage of office hours to discuss concepts with me, as well as study groups to do so with your peers to assist you in this aspect of learning course material.

Collaboration

Collaboration is an important part of learning mathematics and I strongly encourage you collaborate with your classmate. The expectation for each group is that each member will be involved with solving every question on an assignment, but each person will write up their own submission. It is fully expected that each person understands the solution to every problem as submitted. One good strategy for this is to do scratch work "solving" the problems while working with your group, but then write up the copy to hand in on your own. If you find yourself asking a group mate a question and then immediately writing down what they say verbatim you probably did not process the answer.

Academic Integrity and the Internet

The Internet is obviously a fantastic tool for accessing facts. Used well, it can also be a wonderful learning device as well. However, a great deal of mathematics on the web consists of solved problems being presented for students to basically copy. Googling a question will likely lead you to such information. While this may enable you to write down an answer to one question on one assignment, it won't build any understanding. I request that you avoid using the web for support in your work to complete assignments and solve problems. In a similar way, you should avoid using Wolfram Alpha to answer WeBWorK questions. Wolfram Alpha is great for computation, but it can't be a substitute for thinking. If you'd like to talk to me about some possible resources that would be valuable study aids, I'd be happy to have that conversation and suggest some.

On any course assignment, the only electronic resources you should use are our course textbook, Active Calculus, links to YouTube videos that are distributed by your instructor, and your class notes. If you want to use another resource I would be happy to approve them if you talk to me about it before you use them. You are not to go looking for completed solutions to problems in any other texts or resources. In particular, you should not search the internet for solutions to problems nor submit requests to internet sites that offer "homework help."

Do note that I am generous with hints and am always willing to discuss exercises with you. While I will never simply give you an answer, I will offer direction and guidance that will assist you in coming to a solution on your own.

Academic Accommodations

If you believe you need accommodations for a disability or a chronic medical condition, please contact Student Disability Services via email at studentdisabilityservices@swarthmore.edu to arrange an appointment to discuss your needs. As appropriate, the office will issue students with documented disabilities or medical conditions a formal Accommodations Letter. Since accommodations require early planning and are not retroactive, please contact Student Disability Services as soon as possible. For details about the accommodations process, visit the Student Disability Services website. You are also welcome to contact me privately to discuss your academic needs. However, all disability-related accommodations must be arranged, in advance, through Student Disability Services.