

MATH 252: Calculus II
Model Syllabus 2021-2022
Course coordinator: Dan Dugger

Instructor: Put your name and contact information and office hours.

Prerequisite: C- or better in Math 112, or satisfactory placement exam score.

Text: *OpenSTAX Calculus Volume II*. An electronic edition of this text is available for free at

<http://openstax.org/details/books/calculus-volume-2>

Note: For the past couple of years we have been in the process of transitioning from Stewart to OpenSTAX. As of this year we would like to complete the move and have everyone use OpenSTAX. However, if there is a compelling reason for an instructor to stick with Stewart you can bring the issue to the course coordinator, Director of Undergraduate Studies, or Department Head for consideration.

If you find errors in OpenSTAX, or things you don't like and wish were different, please keep track of these and send a list to the course coordinator at some point. We plan to repair these errors and improve the text over time.

This course covers most of Chapters 1–4 in the OpenSTAX text (which corresponds roughly to Chapters 5–7 in Stewart). One big difference from Stewart: The OpenSTAX text covers basic applications of integrals (volumes, center of mass, work problems, etc.) **before** integration by parts and other semi-advanced integration techniques. Probably it will not be hard to cover those sections in whichever order you wish. Another big difference: **the OpenSTAX book does not start with antiderivatives, which is in the previous volume. Antiderivatives should still be covered in this course, though.**

Overview: Chapter 1 covers the notion of integral, the Fundamental Theorem of Calculus (which allows you to use your knowledge of derivatives to evaluate some integrals) and various techniques for calculating integrals.

Chapter 2 covers various applications of the integral to things like areas, volumes, and lengths of curves, and to physics, engineering, biology and economics.

Chapter 3 covers additional techniques of integration (starting with integration by parts) and improper integrals.

Chapter 4 (which we only cover briefly) concerns elementary ordinary differential equations.

Warning: If you have never used Wolfram Alpha, do the following as soon as possible: go to <http://www.wolframalpha.com>, type

“integrate from 0 to pi $x^2 \sin^3(x)$ ”

and see what comes back. In light of the ability of modern technology to do symbolic integration, it is worthwhile to spend some time thinking about how that should impact the amount of time we spend on teaching integration techniques. I am not suggesting an answer, just that you think about it before (or while) teaching the course. It is also important to keep in mind during the course that every student knows about Wolfram Alpha and will happily use it for homework problems, no matter how many times you tell them that they can't use it on the exams.

It would be nice to figure out how to incorporate modern technology into this course in a reasonable way. However, I do not know anyone who has taken steps in this direction. If you end up developing materials for this, please let me know!

Exams: I've written a schedule for two midterms and a final. One midterm is really not a good idea, since the students in this course need more feedback rather than less.

Bear in mind that there are calculators out there that do symbolic differentiation and integration, and even solve some differential equations. If you allow calculators on the midterms, then you will need to write problems that don't give students who possess such calculators an unfair advantage.

On your syllabus you should put the time of your final exam, from the registrar's website based on your class starting time.

Grade Scheme:

Homework	20%
Midterm 1	25%
Midterm 2	25%
Final Exam	30%

Instructors should feel free to change this system a bit as they see fit, but the above is fairly typical. Large changes should be discussed with the course coordinator.

Workload: There will be homework due every week, as well as reading and class attendance. Some years I have broken up the homework assignment and had the problems due twice a week, say on Tuesdays and Fridays—this keeps students from putting everything off until the last minute and not practicing the skills that are being used in lecture.

An average well-prepared student should expect to spend about 12 hours per week on this course (including time in class), but there will be a lot of variation depending on background and ability.

Broad Course Learning Goals:

The students in Math 252 are mostly science majors of some kind. They need to understand how to model problems that can be solved with calculus and then use calculus to solve those problems. (Only a very small percentage of students in Math 252 are math majors, and thus mathematical proof is not a reasonable emphasis for the course.)

A successful student in this course **should be able to model and solve a wide class of problems that can be answered by calculating an appropriate integral. This is the focus of Chapter 2.** In particular, there is a certain skill that I don't have good words for but which is basically "understanding how to write down an integral from a situation in which something to be calculated can be broken up into slices/regions/pieces on which some feature is constant." The real point of all of the applications in Chapter 2 is in developing this skill.

Much of the other material covered in MATH 252 is necessary for the above objective. So subgoals include:

- (1) Learning to calculate and (roughly) estimate as appropriate the value of a definite integral by examining the graph of the integrand using the definition of the integral as a (signed) area.
- (2) Being able to state and apply the Fundamental Theorem of Calculus.
- (3) Learning how to integrate symbolically (using the Fundamental Theorem of Calculus), including integration by parts and substitution. Note that there is a tension: one could spend the entire term becoming a crack symbolic integrator and do no applications. That isn't appropriate, but at the same time one must master the basic techniques of symbolic integration.
- (4) Understanding heuristically how to think about the integral as being a limit of Riemann sums. This is often needed in applications in the process of recognizing a question as being one that can be answered by integrating.

It is not important for students to understand the formalized definition of an integral as the supremum of the lower sums/infimum of upper sums (or whatever your favorite formalization is) in this course.

A secondary goal is to learn some basic applications that involve solving simple ordinary differential equations. Students who need differential equations for their major will take Math 256, but even students who don't need that course should understand what a differential equation *is*. And of course the only way to do that is to see at least a few types of examples.

- (1) Students should be able to set up and solve basic separable differential equations (Chapter 4.3), in particular the ones that model exponential growth and decay.
- (2) [Optional] Students should be able to set up and solve population growth problems using the logistic equation (Chapter 4.4).

More Detailed Learning Goals: All sections of 252 should cover learning goals (1)–(14) below. Some instructors may wish to cover a selection of goals (15)–(21). If you are adopting additional learning goals, that should be discussed in advance with the course coordinator.

- (1) Set up and evaluate formulas for Riemann sums, given the function, interval, and number of rectangles.
- (2) State and use the fundamental theorem of calculus.
- (3) Evaluate integrals of polynomial and exponential functions, as well as sine and cosine.
- (4) Evaluate integrals using substitution and integration by parts.
- (5) Use standard trig identities where appropriate as part of integral computations for some trig functions. [Here “standard trig identities” means the Pythagorean Theorem, formulas for sine and cosine of a sum, and the double angle formulas.]
- (6) Interpret the area between two graphs as an integral.
- (7) Interpret an integral as a signed area.
- (8) Set up one-variable integrals that represent the solutions to a variety of modeling problems. Examples: Total mass of a rod when given the density function, total mass of a disk when the density depends only on the distance from the center, total loss of water from a tank when the rate of flow is given as a function of time, etc.
- (9) Evaluate improper integrals.
- (10) Compute volumes of surfaces of revolution using both the disk and shell methods, and recognize which method is most appropriate to a given problem.
- (11) Compute average values of functions over a closed interval.
- (12) Determine if a given function is a solution to a given differential equation.
- (13) Write down a linear differential equation that models a given situation that is described in words, typically where the rate of growth is a linear function of the amount.
- (14) Find general and particular solutions to basic separable differential equations.

Optional learning outcomes:

- (15) Use integral tables in combination with other techniques to evaluate complex integrals.
- (16) Evaluate integrals using appropriate trigonometric substitutions.
- (17) Evaluate integrals using partial fraction decompositions.
- (18) Use some form of technology to evaluate complex integrals.
- (19) Compute probabilities and expectation values given a probability distribution.
- (20) Use integration to determine whether or not a given function is a probability distribution.
- (21) Use and apply modern technology (e.g., computer software) in some way that engages with the other learning outcomes.

Learning Environment: The University of Oregon strives for inclusive learning environments. Please notify me if the instruction or design of this course results in disability-related barriers to your participation. You are also encouraged to contact the Accessible Education Center in 360 Oregon Hall at 541-346-1155 or uoaec@uoregon.edu.

Academic Conduct: The code of student conduct and community standards is at conduct.uoregon.edu. In this course, it is appropriate to help each other on homework as long as the work you are submitting is your own and you understand it. It is not appropriate to help each other on exams, to look at other students' exams, or to bring unauthorized material to exams.

APPROXIMATE SCHEDULE

This is only a suggested schedule. I have written it to follow the order of topics in Stewart, as this (somewhat) matches the standard WeBWork sets for the course. But one should be warned that this might not be the optimal way to use the OpenSTAX book. In particular, one could try switching Weeks 3 and 4 with 5 and 6.

Note that the course should start with antiderivatives, which are unfortunately back in Volume 1 of OpenSTAX (which luckily is available for free online).

Week 1	4.10 of Vol 1, 1.1, 1.2	Antiderivatives, areas, the definite integral
Week 2	1.3, 1.4, 1.5	Evaluating definite integrals, FTC, Substitution
Week 3	1.6, 3.1,	Integrals for logs and exponentials, Integration by parts
Week 4	3.5, 3.7,	Integration tables, improper integrals
Week 5	2.1, 2.2, 2.3	Areas, Volumes, Volumes by shells
Week 6	2.4, 1.2	Arc length (optional), average values
Week 7	2.5, 2.6	Mass and density, work, hydrostatic force; center of mass
Week 8	4.1, 4.2	Basic differential equations, direction fields (optional)
Week 9	4.3, 2.8	Separable equations, exponential growth and decay
Week 10		Review, catch-up.

Notes:

- (1) You can see that I cover sections 1.1-1.5 rather fast, possibly too fast. It might be a good idea to get to 1.3 as soon as possible, then going back and filling in ideas from 1.1 and 1.2 as necessary. One could spend essentially forever covering 1.1 and 1.2 without getting anywhere, and that would be a mistake.
- (2) I have not explicitly included sections 1.7 and 3.2–3.4 into the schedule, although there are plenty of places they could be inserted (e.g. week 6) and it might be wise to cover some of the topics from those sections.
- (3) It is not necessary to cover computer algebra systems from 3.5 (though you may). I think teaching students how to use integral tables is a good idea, but it is still listed as an optional learning goal.
- (4) I've skipped Section 3.6 on numerical integration. That would be good material to cover, but it isn't actually useful in applications unless you and the students are using software that does these sorts of calculations (or unless you make them write such software). You can certainly choose to cover this if you have software available to the students that makes this worthwhile. It is very nice for students to know about since in real life one often needs to do approximate integration.
- (5) The heart of the course is Chapter 2. Students have a very hard time with Sections 2.2-2.3 and 2.5-2.6. No matter how many examples you do in class, it is not enough. When I last taught MATH 252 I ended up spending an enormous amount of time on 2.2, 2.3, and 2.6 (maybe almost three weeks just on these sections) and ended up skipping 2.4. And I was still about a week behind what is in the above schedule! Be aware that this is the part of the course where you are most likely to get behind.
- (6) Regarding Chapter 4, for students it is very nice to be able to learn to solve separable differential equations: the technique is fairly easy, the easiness is sort of a relief after the struggles of Chapter 2, and it feels like you are really doing something. So in this part of the course the goal is really to do the basic theory from 4.3 and whatever applications from 4.4 or 4.5 one can fit in (the material from 2.8 fits naturally here as well). Section 4.2 is nice, and you might want to cover some of it if you have the time, but it is a bit of a distraction. I make a compromise by simply introducing what I need from

4.2 in lecture as needed. But one has to keep this in mind when assigning homework.

Of course another option, if there is time, is to cover 4.2.

- (7) I usually use WeBWorK when teaching this course. As always, if you use the default WeBWorK homework sets (or any other WeBWorK problems) do them before you give the lectures on the relevant material so you know what the students will be expected to be able to do. Most likely the default set needs to be modified by individual instructors to reflect their particular choices on order of topics.

The current set of default assignments (setWeek1 to setWeek9) were designed for Stewart and cover as follows:

- Week1. Anti-derivatives and applications, integral as area, midpoint rule, etc. (31 problems)
- Week2. The Fundamental Theorem of Calculus (both parts). A few very easy substitutions. (32 problems)
- Week3. Substitution, integration by parts. (33 problems)
- Week4. More substitution, integration by parts and some improper integrals. (21 problems)
- Week5. Trig manipulation and substitution integrals. (19 problems)
- Week6. Areas, volumes. (28 problems)
- Week7. Force, work, average value plus a few problems on hydrostatic pressure, centers of mass, centroids. (26 problems)
- Week8. Introduction to differential equations, direction fields and Euler's method. (28 problems)
- Week9. Modeling exponential growth and decay and the logistic equation. (12 problems)

Of course you should expect to make adjustments to homework sets depending on how close you are to the given schedule.

Also, there are some other problem sets not on this list that you may assign all or part of, depending on exactly what you cover. There are three Simpson's Rule problems in the set SimpRul. There are two economics applications in EconApp. There are some center of mass and centroid problems (a few of which have been included in Week7) in CentMass. There are some hydrostatics problems (a few of which made it into Week7) in HydrPres. There are a bunch of separable differential equations in SepDEQ. Finally, there are some partial fraction problems in PartFrac.

Special COVID-related information for AY2021-22:

Because students have been engaged in remote learning for the last year and a half, there is a possibility that they will be coming to calculus with a shallower

understanding of the background material than we would normally expect. To the extent that it can reasonably be done, it will be good if we can try to help students through the “re-integration” process by finding ways to shore up their knowledge and fill in their gaps as the course progresses. Of course in extreme cases students might have to go back and repeat earlier courses, and that is sometimes the best way forward. But instructors should be prepared for challenges related to all of this. We routinely incorporate this kind of review into our courses anyway, but this year might require us to do this even more.

(Continued on next page)

Using WeBWork:

It can be useful to be proactive in teaching students how to “behave” with WebWork. My syllabus usually includes something like the following:

Showing work:

When working on your assignment you should have scratch paper available and neatly write out your thought process in solving the problem. While WebWork does not grade you on this process, writing it out carefully will train you in the skills you need. It will help you track down mistakes, and it will help *us* track down mistakes when you ask for our help. If you ask us a question about a homework problem in office hours, the first thing we will probably do is ask you to show us your work.

Also, remember that on quizzes and exams showing your work will sometimes be required. It is important to practice this each week while doing your homework assignments.

Logging in to Webwork: First go to the main login page at

<http://webwork.uoregon.edu/webwork2>

Select the “Math251-13891” section. Your username is your DuckID: for instance, if your uoregon email address is johndoe@uoregon.edu, your DuckID is “johndoe” (without the quotation marks). Your password is the same as your UO email password.

Getting help:

If you have a question about a homework problem, one excellent resource is the “Email instructor” button at the bottom of the WebWork screen. Clicking on that and typing a short message about what you’ve tried on the problem will help me diagnose the issue you’re having.

What you should NOT do: Do not send an email simply saying “What am I doing wrong on this problem” or “I can’t seem to get the right answer on this one.” On most homework problems it is impossible to figure out what you are doing wrong if I only see your answer (which is all WebWork shows me).

What you SHOULD do: If WebWork tells you your answer is wrong, first go back over your work and see if you can find the mistakes yourself. If you can’t, feel free to email me: but include a description of how you solved the problem as well as any work you did for intermediate steps. The more information you give, the more likely it is you will get a prompt and helpful reply.

Also note that the departmental webpage gives tips for using WebWork here:

<http://math.uoregon.edu/undergraduate/webwork>