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Syllabus

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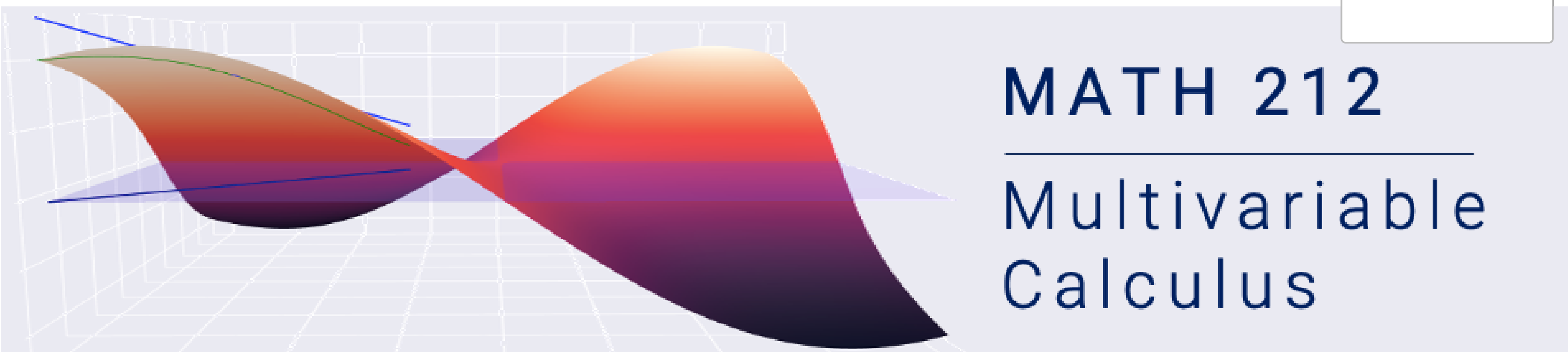

Syllabus

Contact Information

Instructors

Office hours (see Zoom Meetings section of this site; all times are Durham times;

Name	Email address	Office hours (see Zoom Meetings section of this site, all times are Durham times, all students are invited to all of these hours)
Clark Bray (co-coordinator)	cbray@math.duke.edu	Wednesdays 10-11am
Ingrid Daubechies (co-coordinator)	ingrid@math.duke.edu	Wednesdays 1-2 pm (shared with Nadav Dym and Barak Sober)
Woojin Kim	woojin@math.duke.edu	Fridays 4-5pm
Nadav Dym	nadavd@math.duke.edu	Wednesdays 2-3 pm (shared with Ingrid Daubechies and Barak Sober)
Barak Sober	barak.sober@duke.edu	Mondays 4-5 pm (shared with Ingrid Daubechies and Nadav Dym)
Jiuya Wang	wangjiuy@math.duke.edu	Thursdays 7-8 pm
Alexander Wagner	alexander.wagner@duke.edu	Thursdays 4-5pm
Sophia Santillan	sophia.santillan@duke.edu	Wednesdays 4-5pm
Mohammadreza Soltani	mohammadreza.soltani@duke.edu	Tuesdays 3-4pm

What background knowledge do I need before taking this course?

Credit for Math 22, Math 112L, Math 122L, or Math 122.

What will I learn in this course?

The text is **Calculus** by Edwards and Penney, 6th edition.

Lesson/Reading		Page/Exercises
I. *Vectors, curves, and surfaces*		
1. Vectors in $\mathbb{R}^2$	12.1	777/ 1, 7, 13, 17, 23, 31, 35, 40, 47, 52, 54, 55
2. Vectors in $\mathbb{R}^3$	12.2	786/ 5, 18, 23, 25, 31, 33, 39, 42, 43, 47, 53, 62, 67-70; 845/ 1
3. Cross product	12.3	794/ 3, 5, 7, 11, 15, 17, 19, 21, 23, 29, 30, 36; 845/ 5
4. Lines and planes	12.4	801/ 3, 7, 13, 14, 15, 17, 25, 27, 29, 30, 32, 33, 37, 40, 51, 53, 56, 57, 59
5. Curves in $\mathbb{R}^3$	12.5	813/ 2, 4, 11, 21, 31, 33, 45, 46, 49, 54, 55, 56, 64; 845/ 16
6. Curvature and acceleration	12.6	828/ 1, 6, 18, 23, 32, 34
7. Quadric surfaces	12.7	837/ 1, 3, 7, 9, 13, 15, 21, 25, 29, 30, 43, 51

II. *Differential calculus of functions of several variables*		
8. Limits and continuity	13.1-13.2 13.3	857/ 7, 11, 15, 25, 27, 29, 34, 37, 39, 41, 43, 53-58; 866/ 5, 13, 24, 27, 30, 43, 45, 51
9. Partial derivatives	13.4	875/ 3, 7, 13, 19, 22, 35, 41, 43, 53, 55, 57(a,c), 58(a,c), 60, 71; 896/ 43
10. Max-min	13.5	886/ 9, 12, 18, 24, 26, 28, 32, 38, 43, 57
11. Differentials	13.6	895/ 5, 7, 17, 18, 26, 34, 42
12. Chain rule	13.7	904/ 3, 7, 9, 19, 28, 37, 40, 43, 45, 51
13. Directional derivative	13.8	915/ 6, 8, 14, 19, 26, 28, 30, 33, 34, 36, 40, 48, 50, 51, 56, 57
14. Lagrange multipliers	13.9	924/ 5, 10, 15, 30, 41, 42, 43, 49, 62 (for n=3)
15. 2*nd* derivative test	13.10	933/ 1, 4, 6, 8, 10, 12, 20, 25, 29, 32
III. *Integral calculus of functions of several variables*		
16. Double integrals	14.1-14.2	945/ 3, 15, 17, 32, 34, 40; 953/ 1, 12, 18, 22, 23, 30, 31, 41, 42
17. Area and volume	14.3	959/ 3, 7, 18, 22*, 24, 28*, 30*, 37
18. Polar coordinates	10.2	635/ 1(a,b,c), 2(d), 6, 11, 24, 25, 39, 41, 42, 53, 56
19. Double integrals in polar coordinates	14.4	966/ 2, 5, 10, 12, 14, 23, 28, 29, 34, 38; 959/ 33, 34, 42
20. Applications	14.5	975/ 8, 15, 42, 44, 46
21. Triple integrals	14.6	985/ 2, 6*, 8, 10, 12, 14, 22, 28, 33
22. Spherical coordinates	12.8	843/ 1, 9, 15, 17, 23, 26, 27, 29, 30, 31, 33, 39, 55
23. Triple integrals in spherical coordinates	14.7	993/ 1, 3, 4, 5, 15, 20, 22, 26, 30, 38
24. Change of variables	14.9	1007/ 1, 3, 4, 6, 7, 8, 10, 12, 14, 17
25. Surface area	14.8	1000/ 2, 3, 7, 13, 15, 17, 18; 1010/ 49
IV. *Vector calculus*		
26. Vector fields	15.1	1018/ 1, 6, 9, 11, 12, 20, 21, 28, 32, 35, 36, 37, 38, 39, 40

27. Line integrals	15.2	1028/ 2-5 (ds's only), 6, 10, 11, 12, 14, 16, 21, 22, 36; 1072/ 9
28. Conservative fields	15.3	1036/ 2, 24, 26, 27, 28, 29, 30, 32, 35, 36
29. Green's theorem	15.4	1045/ 2, 3, 15, 16, 18, 22, 29, 34, 36, 38
30. Surface integrals	15.5	1055/ 2* , 6, 10, 14, 15, 18, 23; 1072/ 18
31. Divergence theorem	15.6	1063/ 4, 6, 7, 8, 15, 16,18,20, 22, AHP 5,6
32. Stokes' theorem	15.7	1070/ 1, 2, 5, 7, 9, 10, 13, 14, 16, 17, AHP 1,2,3,4,7

*SET UP ONLY. DO NOT EVALUATE

What will I do in this course?

This course will use a "flipped" format. Students will get a first presentation on the material by watching recorded lectures from course coordinator Prof. Clark Bray's section of this same course in a past term. Those recordings should be studied before each scheduled class meeting (of course, being from last year, you should ignore all references in those recordings to specific events and dates!). Students should also study the corresponding pages of the lecture notes and the corresponding sections of the textbook.

During the scheduled class meeting times, each section of the class will meet with their instructor by way of a Zoom meeting, where the format will be mostly examples, discussion, and Q&A. Students are encouraged to come with questions about the recorded lecture, the lecture notes, old exam questions, or any other materials on the topic of discussion. These Zoom class meetings will be recorded and available for student viewing later.

Details:

- The Lecture Schedule shows where to find the recordings, which recordings to study before each class meeting, the corresponding pages of the lecture notes and the corresponding sections in the textbook to be studied, and the visualization tools that might be available for each lesson.
- Zoom class meetings will be accessed from Sakai sites for individual sections, not this shared site.
- Recordings of the Zoom class meetings will be accessible through that section's Sakai site in the "Zoom Meetings" section, on the "Cloud Recordings" tab.

What required texts, materials, and equipment will I need?

The required text is **Calculus** by Edwards and Penney, 6th edition (ISBN-13: 9780130920713). The publisher tells us also that **Multivariable Calculus** by Edwards and Penney, 6th edition (ISBN-13: 9780130339676) is a subset containing Chapters 10-15; these chapters are all you should need for this course. (If your copy of the book has not arrived yet, note that Math 212 students from Spring 2020 might have temporary substitutes they could share in the meantime. You might also communicate about this with other students in this offering of the course through the Piazza page of this Sakai site.)

Sakai site.)

All additional assigned videos and readings will be open access and made available to students through Sakai. You might also find it useful to work from Clark Bray's old midterm exams (use the blanks for practice, the solutions to check and then to study and form questions). Also of possible interest are the related midterm exams from Clark Bray's offerings of this course taught in summer terms (very similar but slightly different content due to use of a different textbook).

As this course will be conducted in an online format, you will need a computer and a reliable internet connection.

Live interactive class sessions will be hosted using **Zoom**. This software can be downloaded to a computer or installed as an app on iOS or Android smartphones. It is recommended that you have a headset or headphones/earbuds with a microphone to use for the interactive Zoom sessions. Here are instructions on using Zoom.

IT Support

If at any time throughout the course you have technical difficulties with the downloaded software or online applications, please **contact Duke OIT**:

- Call: (919) 684-2200
- Live Chat: https://oit.duke.edu/help
- Submit a Ticket: https://oit.duke.edu/help/request-information-or-assistance

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How will my grade be determined?

Homework

Homeworks assignments and due dates are indicated on the Lecture Schedule. Note in particular that the exercises to be submitted are only those listed on the syllabus above. Student work will be submitted, graded, and returned through Gradescope.

If an incapacitating illness prevents you from getting the homework submitted on time, you must send an Incapacitation Form to Clark Bray in order for your late submission to be accepted and graded. Please be sure that your Incapacitation Form documents the nature of your incapacitation. If you submit your work on Gradescope late (the "late submission" date will also be visible on Gradescope) without sending in an Incapacitation Form, it will not be graded and you will not receive credit for the work.

Midterm Exams

Teaching under the present COVID-19 conditions is as new to us as it is to you -- the details of the procedures below may get tweaked if it becomes clear that they are not working as well as we hope or expect.

The exam questions will be sent as a pdf by email on the scheduled day of the exam; and when you are done with your work, you will submit your work through Gradescope.

These exams will be "open book and open note", meaning that you are allowed to refer to the textbook, and to your own handwritten notes that you may have prepared before the exam. However, these are the only resources you may use -- using any other resources, such as other books, internet searches, or communications with other people, or working outside of the allowed time, is strictly disallowed. *(In this very challenging time for the university -- and the entire world, of course -- it is critical that this community work together. We appeal sincerely to the community responsibility of each student to contribute to this collaboration with strictly honest adherence to the Duke Community Standard in relation to these exams.)*

Each exam will be written to be completed in one hour. However, students are allowed to work on the exam questions for any continuous three hour period (SDAO accommodated students adjust accordingly). Given this extended time, there will be a higher than usual expectation on clarity. Students are encouraged to recopy their work if necessary to improve the flow of their reasoning, and general clarity (communication and handwriting). Clarity is considered in the scoring of your work.

Given logistical issues (students in different time zones, various schedule disruptions, time required for scanning and submitting...), the exam will be due on Gradescope the following day -- approximately 24 hours after it is sent. The exact due time will be indicated in the email containing the exam pdf.

The submission format of this exam will be very much like the homework submissions. You can do your work using as much space as you need. You may also use as much scratch paper as you would like, and are not required to submit your scratch paper. Please though, start each exam question on a fresh sheet of paper.

When your three hour exam time is done, scan the work and upload to Gradescope. Once your work is uploaded, the Gradescope system will require that you identify which pages correspond to which exam questions -- please do this carefully, because we can't give you points if we can't see your work! After you finish, be sure to click through your submission and confirm that for each question all of the correct work is showing.

Despite the above noted flexibility on time, students should begin the exam as soon as feasible upon receiving the pdf through email. Students should not look at the exam questions before starting the three-hour clock. At the end of the selected continuous three hour period, students are not allowed to make any additional marks on their paper. Scan the work and submit on Gradescope as soon as feasible, making sure that all work is crisply clear and legible. Getting this done as early as possible in the 24 hour period allows the maximum possible time for the resolution of technical difficulties that might arise.

If on the day of the exam you are incapacitated due to illness, you must send to Clark Bray an Incapacitation Form (commonly called a "Short Term Illness Notification Form", or by its abbreviation STINF) in order to be excused. Please also document the nature of your condition in that STINF, or in a separate email.

Course Grade

Raw scores on exams will be assigned corresponding letter grades using curves set by the course coordinators for each exam. All of these curves will be informed by department standards. At the end of the term homework averages will be computed as a simple average of all of those scores of each student, after dropping the lowest, and a corresponding letter grade will be computed by a curve set by the course coordinators. (NB, homework scores student, after dropping the lowest, and a corresponding letter grade will be computed by a curve set by the course coordinators. (NB; homework scores tend to be high due to the time and resources available to students in doing that work, so the expectation will be correspondingly high when converting to letter grades.)

The above item letter grades will be converted to numbers on the 4 point scale as noted in the first table below. Your weighted average will be computed from those numbers by way of the item weights listed in the second table below. Your weighted average will then determine your course grade by the ranges indicated in the third table below.

Converting letters to numbers

Item grade	4-point grade
A+	4.3
A	4.0
A-	3.7
B+	3.3
B	3.0
B-	2.7
C+	2.3
C	2.0
C-	1.7
D+	1.3
D	1.0
D-	0.7
F	0.0

Item Weights

Item	Weight
Midterm exam 1	25%
Midterm exam 2	25%
Midterm exam 3	25%
Homework ave.	25%

Converting numbers to letters

Weighted average	Course grade
[4.05 --)	A+
[3.8 -- 4.05)	A
[3.5 -- 3.8)	A-
[3.15 -- 3.5)	B+
[2.85 -- 3.15)	B
[2.5 -- 2.85)	B-
[2.15 -- 2.5)	C+
[1.85 -- 2.15)	C
[1.5 -- 1.85)	C-
[1.15 -- 1.5)	D+
[0.9 -- 1.15)	D
[0.6 -- 0.9)	D-
[-- 0.6)	F

What are the course policies?

Academic Integrity

As a student, you should abide by the academic honesty standard of the Duke University. Its Community Standard states: Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity.

On every exam in this course you will be required to sign a statement that you have upheld the Duke Community Standard. Recall that when you assert that you uphold the Duke Community Standard, this includes the following assertions on your part:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.

On the homework assignments in this course, you are welcome to discuss the questions and trade ideas with others to help your understanding of the question and its solution. It remains though that the written work you submit must come purely from your own understanding. Copying is not allowed; and of course writing from memory of someone else's work is just another form of copying.

Academic Polices & Procedures

You are responsible for knowing and adhering to academic policy and procedures as published in the Duke Community Standard Guide. Please note, an incident of behavioral infraction or academic dishonesty (cheating on a test, plagiarizing, etc.) will result in immediate action from your instructor and/or the course coordinators, in consultation with university administration (e.g., Dean of Undergraduate Studies, the Office of Student Conduct, Academic Advising).

The pages linked below were written for past course offerings, before COVID. Still, there are valuable discussions there, on topics such as how to do well in this course, how this course might be different from courses you have taken in high school, different ways you might study, course expectations, and many other important topics. You are encouraged to read these pages, interpreting for the different structure of this remote instruction course.

http://www.math.duke.edu/%7Ecbray/Policies/General%20Policies.html
http://www.math.duke.edu/%7Ecbray/Policies/General%20Comments.html
http://www.math.duke.edu/%7Ecbray/Policies/Grading.html
https://services.math.duke.edu/~cbray/Policies/proofs.html

Academic Disruptive Behavior and Community Standard:

In both synchronous and asynchronous class activities you should avoid all forms of disruptive behavior, including but not limited to: verbal or physical threats, repeated obscenities, unreasonable interference with class discussion, and repeated unmuted disruptions during synchronous sessions. If you choose not to adhere to these standards, your instructor and/or the course coordinators will take action in consultation with university administration (e.g., Dean of Undergraduate Studies, Student Conduct, Academic Advising).

Academic Accommodations

If you need to request accommodation for a disability, you need to contact the Disability Management System (DMS) office. Your instructor and/or the course coordinator Clark Bray will work with that office to provide you with equal access to course materials and make accommodations for exams and other assessments.

Communication

Please do not hesitate to contact your instructor and/or course coordinator Clark Bray via email with questions or concerns about the course. We will do our best to respond to emails **within 24 hours**, and we **expect you to do the same**. You may email us directly using our Duke email addresses listed above.

What campus resources can help me during this course?

Academic Advising and Student Support

Please consult with your instructor and/or course coordinator Clark Bray about appropriate course preparation and readiness strategies, as needed. Consult your academic advisors on course performance (i.e., poor grades) and academic decisions (e.g., course changes, incompletes, withdrawals) to ensure you stay on track with degree and graduation requirements. In addition to advisors, staff in the Academic Resource Center can provide recommendations on academic success strategies (e.g., tutoring, coaching, student learning preferences). All ARC services will continue to be provided online. Note, there is an ARC Sakai site for students and tutors. Please visit the Office of Undergraduate Advising website for additional information related to academic advising and student support services.

If you are concerned about your physical or mental health? DukeReach can connect you with departments across campus to get you help and you contact CAPS directly for counseling services.

Advice On How To Do Well In This Course

Resources

1. Yourself! -- One of the most important things for doing well in a challenging course is to **actively view yourself as being responsible for your own learning**. Take the initiative to: set an appropriate, sufficient, but realistic study schedule for yourself; be honest with yourself about how thoroughly you are learning the material; identify when things are not going as they should; and be responsible for taking action to fix things that need to be fixed. Don't wait for your instructor to do these sorts of things!

2. Textbook, class notes -- You should **read the appropriate sections of the book and Prof. Bray's lecture notes before coming to class**. It is not expected that you will fully understand everything that you read; but that initial exposure will help you get more out of the lecture by saving you from having to spend valuable class time with the more superficial aspects of the presentation, and allowing you more time to think about the deeper parts.

You should **<u>also read again after each class</u>**, as soon as possible. This will allow you to straighten out some of the ideas you were not entirely clear on during class, while those ideas are still pretty fresh in your mind.

Note also that **<u>not all of the material for the course will be covered in the recorded lectures or in the discussion sessions in class!</u>** The instructor will have to make tough decisions about how best to use class time, and as part of that process some examples and ideas will be left to the student to read. Going in to any of the exams, you are responsible for everything from all course resources -- the lectures, the book, the notes, the homework exercises,...

3. Instructors -- **<u>We want to be as much help to you as we can</u>**, within the constraints of the circumstances. You are also invited to the **<u>office hours of any of the instructors</u>** of the course; they are all listed above, and also in the Zoom Meetings section of this Sakai site. Even though office hour time is shared with other students it can still be a very effective use of your time.

   It may also help to **<u>re-watch the recorded lectures</u>** after you have had a chance to study and discuss the material, pausing it as often as you like, to think about things you might not have understood immediately, or when you need to figure something out, before hitting "play" again and keep going.

   Importantly though, note that Instructors are listed third on this list of resources. **<u>(There is just no substitute for self-motivated and focused study with the book and the notes!)</u>**

4. <u>Help Room</u> -- Students in this course have access to the **Math 202/212 Help Room**, operating on Sundays, Tuesdays, and Wednesdays. Most of the hours will be 7-10pm Durham time, but we will be trying to move some staffers' shifts around to earlier in the day to help accommodate students in different time zones. No appointment necessary, just drop in to the Zoom rooms with questions!

5. <u>Classmates</u> -- **<u>We are big believers in study groups!</u>** If you know people in the course that you think you can work with effectively, we strongly encourage you to do so. Of course it is great to be able to get help from other students when needed, but it is arguably even more valuable to give help -- because it will force you to explain the ideas that you think you understand through language, and this process is both surprisingly difficult and also surprisingly effective in revealing aspects of one's understanding that are actually not entirely polished yet.

   Working together on homework is fine, but an even more effective use of study groups is simply to **<u>create dialogue, one way or another</u>**. This creates opportunities for each speaker to test their understanding through their expression as noted above, and also the dialogue will naturally focus around whatever some two students see differently, in which case the resolution of the disagreement is that someone gets their understanding improved. You can create dialogue in different ways, such as having members of your group try to make confident statements about topics they think they understand, and then letting the group critique them.

   Of course, it should go without saying that **<u>any work that you turn in must be your own</u>**. See a more detailed discussion of what this means in the Academic Integrity section of this page.

6. ARC resources -- Check **the ARC's website** for possible resources that ARC might be offering this term, possibly including peer tutoring, small group tutoring, or study groups.

Expectations

- Note that students in this course will be expected to learn the material at different levels:
  - Execution/memorization -- As with any math class, of course you will be expected to know formulas and be capable of executing algorithms relevent to the course.

  - Understanding -- Very importantly, the above will not be sufficient. On the exams we will be designing questions that go to gauging the extent to which students actually understand the formulas and algorithms... Where do they come from? What do these objects mean? Why do the algorithms work?

  - Applications to unfamiliar situations -- On exams, you should expect also to see questions that require applying the ideas of the course to applications that were not specifically discussed in class or on the homework, but which are susceptible to the same tools and ideas that were presented. Students that have a clear understanding of the ideas underneath the formulas and algorithms should be able to identify how those ideas can be applied to the question, adapted as needed, to solve the problem.

- Why is it not sufficient just to memorize formulas and rehearse algorithms? Keep in mind that computer algebra systems these days are extremely powerful; Wolfram Alpha, for example, allows a user to type in a math question, in casual language without any significant syntax requirements, and will return almost instantly with the answer. (For example, type in something like, "What is the integral of x times the sine of x squared?" and look at the result it gives!)

  So if all you can do is execute algorithms, then you can't offer future employers or research programs anything that can't be done more quickly, probably more reliably, and certainly more inexpensively by this free website! (This is sort of a more modern version of what happened with the rise of computers and calculators... before such tools were available, someone could be useful even if all they were capable of was arithmetic/evaluations; but once calculators became commonplace such a person became much less useful.)

  On the other hand, computer algebra systems can NOT look at a real world problem, identify key features, recognize mathematical tools that might apply, and create a mathematical model for understanding the problem. These require real understanding. **That understanding is what you can offer in your future**, and that is a large part of the reason we focus on understanding so much in our courses.

- Why can't we just show you exactly the skills you will need, the problems you will face, in your future work and show you the math you need to do those things? Because, very importantly, we don't know what those skills are!

We will show you some examples and applications, of course, largely because this helps with developing a real understanding of the ideas. But **it is the ideas, abstractions, and general strategies that will help you solve future problems once you face them.**

- With these previous points in mind, be prepared that **the questions on the exams will not be just like those on the homeworks.** Students are often surprised by this, perhaps because in their high school math courses maybe the exam questions were just like the homeworks. In this context though, exam questions that are just like homework questions don't allow us to distinguish students who understand the important ideas from those who simply memorized. Said differently, in order to test true understanding, we really have to put unfamiliar questions on the exams.

- Similarly, keep in mind our interest in testing understanding when you write on the exams. Be sure to show all of your work and explain your reasoning as you work toward the answer. **We will be looking at the work and explanations far more than the final answer when thinking about scoring your work!**

  Of course you don't have to write a paragraph explaining every routine step of algebra that you use. But if you make a step in your solution on the basis of the geometry of the problem, draw a figure! If you use a theorem, indicate so and be sure to check any necessary conditions on that theorem! Your explanations can be terse, even very terse; but in order for us to give you points for your work, we need to be able to see clearly and with confidence, from what is written on your paper, what you were thinking in your solution. Don't presume that we will assume you understood something relevant to your work.

- Keep in mind that comprehension is not a binary thing, but instead is a spectrum. When you get to a point that you feel you understand a certain topic, it may be that you have simply raised your understanding up to a familiar "bar", defined by previous experience (in the past when you have gotten understanding up to that level your exams have gone well).

  Very importantly, the "bar" is set higher in higher-level math courses, and all math courses at Duke set their "bar" higher than almost all high school courses (even at prestigious high schools). So in order to be ready for this higher level of expectation, you have to recalibrate your internal expectations and standards accordingly. **In other words, you must raise your internal bar.**

  How do you know how high to raise your internal bar? This is a hard question to discuss, as there are no conventional metrics we can refer to. My old midterm exams and solutions (available at links above) give you a great number of such reference points though. Note in those exams the kinds of questions there are, the great variety of questions there that are not like any other; and also pay special attention in the solutions to the way the work is explained with words to accompany equations as needed.

  You might also consider how confident you might be in giving a talk on a given subject. For example, suppose you had to give a 15 minute talk to a group of classmates on a given topic (integration by parts, perhaps), addressing why it works, showing examples, and being prepared to answer questions that your classmates might have... how confident might you be in your ability to do this? If you feel super confident with the prospect of giving such a talk, then maybe you are okay with that topic. But if considering this makes you nervous, or if you find yourself worrying about certain topics you hope that no one would ask you, then these might be signs that your understanding is not at the level that it should be.

- It is common knowledge at Duke that this is a very challenging course. Make sure that you have enough time in your schedule to dedicate to this course, and expect to spend significantly more time in this course than most others. (As a reference point, I think **on average students should expect to need to spend about 15 hours per week on this course outside of class**, on homework and general studying. See the above recommendations on schedule for more specifics. And note that this is an average; some might do okay with less, but some will need more!)

  But also be prepared for the fact that **this course accelerates though the term**. So the amount of time you will need to digest the ideas at the start of the term is likely less, and at the end of the term you should expect to need more. If you make time management decisions near the start of the term on the basis of your experience with the first couple of weeks of the course, you will likely need to re-evaluate those decisions later.

Asking Questions In Discussion Sections

We encourage students to ask questions in class. This can be hard to do for some students, due perhaps to a combination of shyness and/or self-consciousness. Certainly all students should try to overcome these impediments, as these should never be the reason that you don't ask a question in class. But there are also some related difficult questions -- about what sorts of questions are the best to ask, and what the best venue is for which kinds of questions.

Here are some bits of advice that might help you when you are thinking about asking a question.

1. If your question is about a big idea that we have just introduced, or a subtle or complex step that your instructor has just done in an argument, keep in mind that probably other students are wondering about it too! If everyone waits for someone else to ask the question, then it never gets asked...

2. In addition to the students that are wondering about the same question you are, note also that there are probably other students who may also have not understood, but who might not even have realized that they missed something!

3. If you have a question about how an idea we are discussing in the lecture may relate to something from an earlier lecture, you might be on to a great observation. Very often these are wonderful questions! Depending on the situation your instructor might not be able to elaborate fully on such a possible connection, but they might either note that the full explanation is coming later in the course, or suggest that they could give you a full discussion in office hours.

4. If it has been a while since anyone has asked a question, note that asking a question can be an appreciated change of pace for the lecture. So not only might it not be a distraction from the presentation, it might even help the presentation!

5. Of course there are limitations on how many questions can realistically be asked in a class meeting; and time spent on questions is time that then cannot be spent on other things. A lecture is unfortunately different from private tutoring, in that all students have this shared interest. So some judiciousness with questions is appropriate.

   The instructor will try to manage this somewhat; but your judgment in this is still important -- if everyone filters themselves and asks only their best questions, then that leaves time for other students' best questions, and the entire class benefits accordingly!

6. If your question is about something relatively low-level (perhaps a point of algebra, in the computation of a triple integral), then you might consider not asking in class. These sorts of things can be clarified after class or in office hours, and missing a low-level point should not impede you from following the rest of the lecture.

   Also, waiting for office hours will give you a chance to think about it on your own first, and possibly even figure it out for yourself. If you can do this, that's the ideal -- there is great benefit in working through something on your own. If you can do this, that is ultimately better for your learning.

   On the other hand, if you think the instructor might have made an oops, and are pretty confident about it, it is entirely possible that you might be right! Something like that can be a great question, as correcting the record will help the rest of the class avoid future confusion when going over their notes.

7. If you didn't hear something that the instructor said, for whatever reason, think about whether the lectures for the course are being recorded -- if they are, you can always just make a quick annotation of the time in your notes and go back and listen to the recording later. So, you don't need to ask the instructor to repeat what they said. (And of course, these sorts of circumstances would be best resolved in the future by being more focused in the lectures.)

8. Similar to the above, if you find yourself with only a partial understanding of something that your instructor said, and if you think that hearing it again would be all that you need to understand the rest of it, again consider the possibility that you might just make a quick annotation in the lecture notes and go back and listen to the recording later.

   Keep in mind that it is not expected that students will fully understand absolutely everything immediately in a lecture. It is a healthy and important part of the learning process to grapple with confusion and overcome it; this sort of experience is essential to becoming better at learning math!

9. If your question is a digression (for example, in a class on multivariable calculus, asking how the tools we study in that course are used to understand the heat equation in physics), then even though it might be a great question it is probably something that the rest of the class does not need to hear about. Such a question then might be a great choice to ask in office hours.

Of course when you are thinking about asking, you might not be entirely sure which of the above might apply to your question... No problem! If you ask, and if the instructor thinks there is a better venue for that question, they will just say so -- no harm done!