Math 2575 Course Outline

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1 Introduction to Math 2575

Welcome to Math 2575, Accelerated Calculus III. I'm happy to have you here with me as we complete the final semester of calculus. In my opinion, the last chapters in the calculus sequence are the most interesting, so you're in for a treat!

There are many of us in this class, coming from many different backgrounds and situations. I want my classroom to be as inclusive as possible. If the "default settings" for the class don't work for you, please don't hesitate to ask for accommodation. Not everyone has reliable high speed internet. Not everyone is able to attend scheduled classes without work/family/life getting in the way. But everyone deserves a fulfilling, enjoyable learning experience in each class.

We begin with some introductions: to the university, to the staff, and to the course.

1.1 Welcome to the University of Lethbridge

Oki, and welcome to the University of Lethbridge. Our University's Blackfoot name is Iniskim, meaning Sacred Buffalo Stone. The University of Lethbridge acknowledges and deeply appreciates the Siksikaitsitapii peoples' connection to their traditional territory. We, as people living and benefiting from Blackfoot Confederacy traditional territory, honour the traditions of people who have cared for this land since time immemorial. We recognize the diverse population of Aboriginal peoples who attend the University of Lethbridge and the contributions these Aboriginal peoples have made in shaping and strengthening the University community in the past, present, and in the future.

As usual, everything you need to know for the course will flow through our Moodle learning management system. Make sure you check in regularly to keep on top of what's happening in the course. (Possibly the hardest part of learning online is keeping track of deadlines.)

Don't hesitate to reach out if you have questions. I'll do my best to answer all of your course-related questions as quickly as possible. (See Section 3 for details on how to get in touch.) If you have questions that are not related to the course, you can ask those too, and I'll try to answer, or to direct you to someone who can. Some resources can be found on the University's Health and Safety website.

1.2 Course staff and contact information

My name is Sean Fitzpatrick. I can be reached via email at sean.fitzpatrick@uleth.ca.

Student hours: you are not going to get everything you need during class time. I will be available throughout the week for consultation, either one-on-one, or in small groups. Monday through Thursday, you can book appointments using Calendly. You'll find the links for booking appointments on Moodle. Any appointment can be in person, or over Zoom — just indicate your preference when booking. Friday I will have drop-in student hours: 9:30 – 11:30 am in my office.

1.3 Course description

Math 2575 deals with the calculus of vectors, and functions of several variables. We begin with vectors, and vector valued functions, before moving on to several variables, and then finally, combining the two at the end. Just like in one variable, differentiability corresponds to the existence of a linear approximation. We'll then explore multivariable versions of familiar topics, like critical points, extrema, and optimization.

Since Math 1410 is a prerequisite for this course, we can do a few things that don't always make it into a standard calculus course. (At many universities, linear algebra is taken *after* the calculus sequence is complete.) In particular, we'll be able to make better sense of the notion of linear approximation: the linear approximation to a surface is a plane; the linear approximation to a differentiable function is a matrix transformation!

We'll then move on to double and triple integrals, and finally, to vector calculus. Most of what we see in the standard curriculum for vector calculus was developed to deal with problems in Physics, and in particular, electrodynamics. Those of you who have done a course or two in Physics will hopefully be able to make some connections.

1.4 Online instruction and COVID policies

This time, only one section is online, but we should be prepared to go remote at any time, either individually (if you have symptoms or have been exposed to COVID), or as a class (if the 4th wave continues to get out of control). Note that it is likely there will be times when a class has to be taught online because the instructor is unavailable. We are likewise not allowed to come to campus if unwell. I may also have to teach from home because one of my kids is sick and has to quarantine.

I will do my best to ensure that the course experience is as similar as possible for all students, including those enrolled in the online section.

Our COVID policies will be as follows:

- Masks are required for all in-person interactions, as per university policy. If you cannot wear a mask, I would be happy to have you join us in the online section. This rule is non-negotiable. If a student attending in person refuses to wear a mask, our options are to either cancel class, or remove the offending student from the classroom.
- If you are at all ill, you must stay home. I will make arrangements for any in-class work to be done remotely.
- If an instructor for an in-person lecture or tutorial has symptoms, but is well enough to teach, that class will be temporarily moved online. A Zoom link will be posted to Moodle should this occur.
- I have two children in elementary school who cannot yet be vaccinated. There is a good chance that at some point I will have to move a class online because I have to stay home with them. I will give you as much notice as possible if this happens, and do my best to minimize disruption.

Whether online or in person, you can expect:

- More emphasis on:
    - Conceptual understanding
    - Discussion
    - Context (the whole "what is this good for?" routine)
    - Being generally swell human beings
- Less emphasis on:

- Memorization (because how am I gonna stop you from looking stuff up, anyway?)
- Routine computational proficiency (let's be honest: the computer can do this better than us most of the time)
- Tests and exams (so I can spend more time teaching and less time as the Math Police)

We are scheduled to meet in person as long as this is feasible. I hope you'll be able to make it to each class. There will be opportunities for discussion, and to work on problems (including ones you'll be handing in) with your classmates.

But our first priority this year is to protect the health of everyone. If you are feeling sick, please stay home. If you can, please let me know when you're unable to attend, so I can plan accordingly.

I'll do my best to also support asynchronous learning. Lots can be done on your own time, even if you do make it to class. The textbook is free, online, and full of videos. Most of our work is designed to be done as in-class exercises, but I can provide these to you online as needed.

2 Essential course information

This section covers essential course information, including the meeting times, textbook, and grading scheme.

2.1 Course website

The primary course website is Moodle. On Moodle, you can expect to find:

1. Links to important resources, like this syllabus, and the textbook.
2. Links to key course activities, including the online homework, and the discussion forum. (The links will log you into those services automatically.)
3. Details about your grades and assessments.
4. A weekly topics schedule.

As you learn to navigate online learning (and as I learn how to guide you), the weekly topics schedules will be key to staying on top of your course material. Every week you can expect to receive details on readings, videos, homework, and assessments, as well as information on what will be taking place in class, and how to access those classes.

In case there's a day when Moodle isn't working properly and you need access to course materials, you can find some of them (like this syllabus) on my personal website. The textbook for this course (and many others) is available on our Open Textbook Server.

2.2 Scheduled classes

All of our classes will involve synchronous instruction. If necessary, this will take place online, but we hope to do most of it in person. There will be time each class for you to ask me questions and request examples, but most of class time will be spent working together on problems.

2.3 Course textbook

Our course textbook is APEX Calculus, by Greg Hartman. This book is an **open education resource** (OER). That means that the book is fully free, both in terms of cost, your freedom to use and share the book however you see fit.

If getting the book for free somehow feels wrong, or you worry you're missing out by not buying anything, here are two great books you can buy:

1. Mathematics for Human Flourishing, by Francis Su.
2. Change is the Only Constant, by Ben Orlin.

Neither of these books are in any way needed for the course. But they're cool books, and they're about math. (The second is even about Calculus!) So if you feel like you need to spend money on a book, you can. (Or I don't know, go to the library or something.)

About APEX: For the last year or so, I've been working with Greg and others to convert the textbook to a system called PreTeXt. The PreTeXt language allows us to write a book that can be produced in a variety of formats.

There is a PDF version, which will be available on Moodle in both colour and black and white versions. The PDF version is useful if you want to print the book, or simply want to be able to read when there is no access to internet.

The real advantage of PreTeXt is that we can output to HTML format. The HTML version of the textbook can be found at `https://opentext.uleth.ca/apex-accelerated/part-calculus-III.html`. This version of the book can be read on both desktop and mobile web browsers. It also contains a number of nice features, including embedded videos, interactive graphics, and annotation tools.

2.4 Grading scheme

Our assessment principles this year:

- No big high stakes assessments: lots of little ones instead.
- More concepts, and less rote computation. We have computers for a reason.
- Classes (the synchronous part) will be used for work, not lecture. (Nobody wants to sit though a 75 minute Zoom lecture on Calculus, including your instructor.)
- Group work is good for you. (Even if you don't always like it!)

Note: I am indebted to Dr. Spencer Bagley of Westminster College for providing advice and a sample syllabus, upon which much of the outline below is based.

Online Homework The homework will focus on building fluency with the computational procedures of calculus. You can expect a new problem set every week. Homework will be delivered through the **WeBWorK** online homework system. See Subsection 4.1 for details. Homework sets will be due each Tuesday, but extensions will usually be granted. (Due dates can be considered as "best before" dates, as in, it will be best for you if you are done before the indicated date.)

Assignments You will spend a significant portion of each class working together on assigned problems. Work will be submitted individually, however, using Crowdmark. There will be one assignment per week, for a total of 11 assignments. (Crowdmark submission means I can return your work to you electronically, and therefore, faster.)

Assignments will be graded using the "EMRN" rubric:

- *E: exceeds expectations.*
  Work that is factually correct, and professionally presented. Everything is organized, clearly explained, and neat. Thoughtful commentary is provided as needed.

- *M: meets expectations.*

  Work demonstrates practical and conceptual understanding of the material. Calculations and explanations are provided, and work is correct, except possibly for minor errors.

- *R: revisions needed.*

  Work does not yet demonstrate understanding of the material. There are significant errors in understanding or process, but effort has been made in solving the problem.

- *N: not assessable.*

  There is no way to assess the work, either because it has not been submitted, or the work submitted is insufficient to assess.

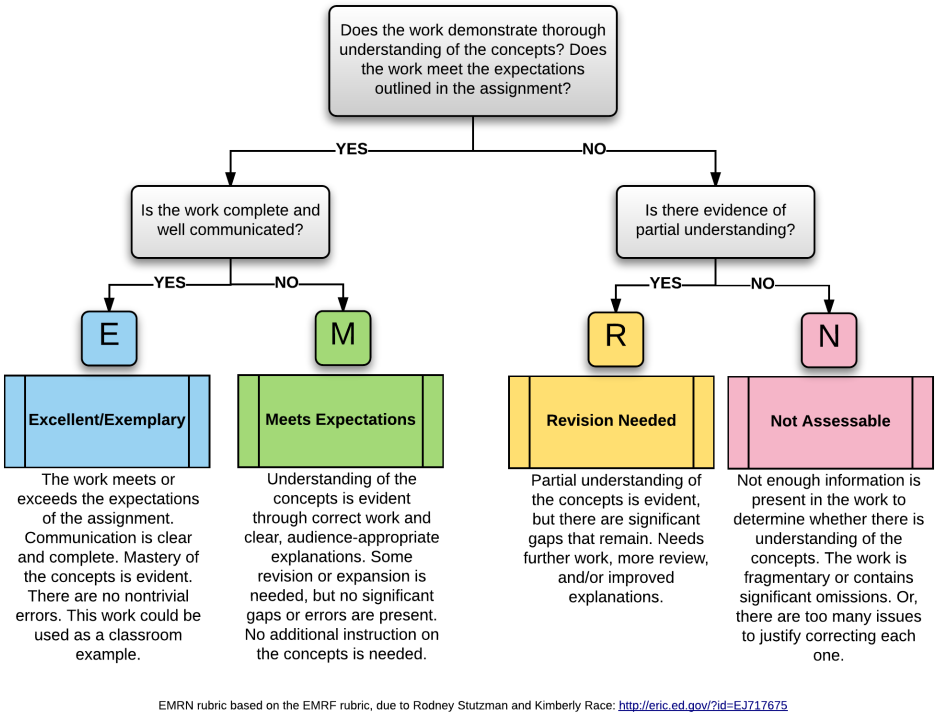

Figure 2.1 The EMRF rubric, courtest of rtalbert.org

Revisions Assignments that receive a score of "R" or "N" can be revised and resubmitted. The deadline for resubmitting is one week from receipt of your feedback. Any assignment can be revised up to two times. An "N" grade is usually only assessed if there is no work to grade, either because you left the question blank, or did not write anything of substance. If you have no idea how to solve the problem, even writing an explanation of what you don't understand, or where you are stuck, is enough to get an "R". Problems with an "N" do not receive written feedback.

Your revision must contain not only corrected work, but also a reflection on your original work:

- What was incorrect on your previous attempt?
- What factors contributed to getting the question wrong?
- What have you learned in the meantime that changed your understanding of the question?

Most reasonable requests for extensions to submission deadlines for assignments and revisions are granted.

Project By the end of the semester, you will have to submit a written project. The project can be on any topic related to the course. It can be theoretical, or applied. The submission can be an essay, a video, artwork, a coding project, or anything else that occurs to you. Just check in with me before getting started.

Learning outcomes Your work on each assignment will be tied to a set of 40 learning outcomes, which are listed below in Section 5. Once a problem on an assignment has received a grade of "M" or "E", you will receive credit for the associated learning outcome.

Once an learning outcome has been achieved, you have credit for that outcome, even if you get a future problem incorrect that is tied to the same outcome.

Letter grade conversion is slightly more complicated than it is for a usual percentage-based scoring system. The advantage is that your grade in this system can never go down, and will steadily improve throughout the semester.

Table 2.2 Calculation of letter grades

Grade	Learning Targets Achieved (/40)	WeBWorK (/100)	Assignments completed (/11)	Project
A	36	95%	9	A
B	33	85%	8	B
C	30	75%	6	C
D	20	60%	5	D

Note that an assignment is complete once it has a grade of M or E. To earn a grade of A+, at least 6 of the problem sets must have a grade of E. For a B+, C+, or D+, you must satisfy the requirements of the base grade, and qualify for the grade above in any category except WeBWorK. A grade of A-, B-, or C- will be assigned if one of the requirements for that grade level is below expectations. (If you are significantly below expectations in one category, a further grade reduction could occur.)

3 Communication

The following communication channels are available in this course:

1. *Forums.*

   There will be a primary course Q&A forum using Campuswire. We are switching to Campuswire for the first time this semester, because the forum we used to use (Piazza) has switched to a paid/ad-supported model. Use of Campuswire is not mandatory (some of you may have privacy concerns) but it is strongly encouraged.

   As far as I can tell, Campuswire provides a better product in any case. We still get a Q&A forum, and the forum still has useful features, like support for mathematical notation, and the ability for students to remain anonymous to their peers.

   What's better is that the forum uses individual replies, rather than a single wiki-style reply, where one student ends up overwriting the reply of another. You can also upvote questions and answers that you like.

   Another useful feature is the availability of chat rooms. Students have the ability to set up chat rooms, and you can make these private. (Yes, a private chat room can even exclude your instructor.)

Campuswire should be your primary communication channel. In particular, any questions about homework and course content should be asked there, since I can reply there with mathematical notation. You will also get a much faster reply on the forum than you will from email. If you have a question you don't want to ask publicly, you can send a direct message instead.

To access Campuswire, use the signup link and PIN code provided on Moodle. But note that to sign up this way, you will need to use your U of L email address. If you prefer not to provide your school email address to a third party company, you can ask me to send you an invite to a different email address.

2. *WeBWorK.*

   There is one exception to the "put all homework questions on Campuswire" rule: in our WeBWorK online homework system, there is an "Email Instructor" button you can click to send feedback. This is useful if you think there's an error in the question, or if you've tried it several times and can't figure out why you're wrong. That email comes with a link I can use to jump directly to your version of the question, and see what answers you've tried. See Subsection 4.1 for details.

3. *Email.*

   You can email me for questions that aren't related to course content. For example, if you have to miss class, or a test, you can email me to let me know.

4 Technology elements

To facilitate online teaching, our course will rely on several technological solutions. This section provides details on navigating the technology.

4.1 Online homework

Online homework is delivered via WeBWorK. WeBWorK is an open source homework system that I maintain on a local server. This service is provided to you free of charge, and your data never leaves campus. [1]

The value of WeBWorK is that questions are automatically graded, providing you with immediate feedback on your work. This is an excellent source of guided practice.

To access WeBWorK: simply click the relevant link in Moodle. You will be signed in automatically — there is no user name or password. But keep in mind that if your session times out due to inactivity, you have to return to Moodle to log in again.

Submitting answers: WeBWorK has an automatic preview feature. The mathematics in your answer will be rendered as you type. (You can turn this off in the user settings if you don't like it.) If everything looks good, click the Submit button. The system will immediately respond with "Correct" or "Incorrect". If your answer is correct, there is nothing more to do: your answer has been recorded, and you have credit for that problem. If your answer is incorrect, you get to try again. (*Exception*: I typically do not give unlimited attempts for true/false and multiple choice questions.)

Other notes:

- Some questions are "scaffolded" — there are multiple parts, and you need to complete one part before being allowed to access the next. For these, you want to click the Preview Answers button, rather than Submit, to check your work and move on to the next step.

[1] Okay, this is not entirely true. Since faculty are expected to teach from home, your data does travel from campus to my house via the university VPN.

- If you need to include scientific units in an answer, the automatic equation rendering can cause trouble. There's a little tool bar on the right hand side that lets you switch to *text mode* to enter units.
- At the bottom of each page is an "Email Instructor" button. If you are stuck on a problem, or if you think there is an error in the programming (it happens!) you can use this to let me know. WeBWorK will send me an email with your message, along with a link to the exact version of the problem you were working on. Often I can figure out where you're going wrong by looking at your answer.

  Please *do not* use the email button to ask me how to solve a problem. That's what the discussion forum is for. It should only be used after you've made several attempts at the problem, or if you see an error message of some sort.

Finally, some general advice: WeBWorK is not a new addition for the online environment. I've used it for awhile. The students who do well in this course are the ones who start their problem sets early. Please do not wait until the due date to begin: it leaves you no time to ask questions! The most effective way to use WeBWorK is to read the relevant portion of the textbook, try the problems, and then ask for help on the ones you're stuck on.

Oh, and please do not wait until you've made 50 unsuccessful attempts at a problem to ask for help. If you haven't figured out a question after 5 or 6 attempts, set it aside, and come back to it a bit later. If you still can't figure it out, go the discussion forum.

4.2 Crowdmark

Tests and assignments will be submitted through Crowdmark. Like WeBWorK, Crowdmark is connected to Moodle, so you just have to click a link in Moodle to access your assessment and submit your work. Unlike WeBWorK, Crowdmark lets you do your work using pencil and paper. For ease of reference, I've placed advice for using Crowdmark on a separate page.

Basic advice:

- Start each question on a clean sheet of paper.
- Use a scanner, or a scanning app on your smartphone. PDF is best, but JPG and PNG files are also supported.
- When you submit, make sure your pages are in order, and rotated correctly.

5 Learning outcomes for Math 2575

This page outlines the list of competencies each student is expected to achieve in Math 2575. The number following each outcome below indicates the corresponding textbook section. The online homework, tutorial assignments, and tests are all designed to help you achieve these outcomes.

By the end of the course, you should be able to:

A. General skills

   1) Communicate mathematical results clearly and effectively
   2) Use software to assist with computational aspects of the course

B. Chapter 12: Vectors

   1) Use dot and cross products to compare vectors and construct vectors such as projections and normal vectors
   2) Use vectors to describe equations of lines and planes

C. Chapter 13: Vector-Valued Functions

1) Understand the relationship between the formula for a vector-valued function and its graph (13.1)
2) Apply the algebra of vectors to vector-valued functions (13.1)
3) Apply concepts of calculus (limit, derivative, antiderivative) to vector-valued functions (13.2)
4) Understand the significance of the derivative of a vector-valued function in terms of tangents (13.2)
5) Use vector-valued functions to describe motion (velocity, acceleration, etc.) (13.3)
6) Compute the unit tangent and normal vectors and understand their significance (13.4)
7) Compute the curvature of a vector-valued function (13.5)

D. Chapter 14: Differential Calculus in Several Variables

1) Explain what it means for a function of several variables to be differentiable (14.1)
2) Compute and apply the total differential of a function of several variables (14.1)
3) Understand and apply the chain rule for functions of several variables (14.2)
4) Describe the chain rule in terms of matrix multiplication (14.6)
5) Understand the significance of the gradient vector (14.3)
6) Compute the directional derivative of a function of several variables (14.3)
7) Determine the equation of the tangent plane to a surface in three dimensions (14.4)
8) Find and classify critical points for functions of two variables (14.5)
9) Determine the absolute maximum and minimum values of a function subject to a constraint (14.5, 14.7)

E. Chapter 15: Integral Calculus in Several Variables

1) Understand the definition and properties of a double integral (15.1, 15.2)
2) Evaluate a double integral by writing it as an iterated integral (15.1)
3) Change the order of integration in a double integral (15.1, 15.2)
4) Evaluate a double integral using polar coordinates (15.3)
5) Use double integrals to compute centre of mass and moments of inertia (15.4)
6) Set up and evaluate a triple integral in rectangular coordinates (15.6)
7) Use cylindrical and spherical coordinates to evaluate a triple integral (15.7)
8) Use a general change of variables to evaluate a double or triple integral (15.8)
9) Determine the best method (or coordinate system) to solve a double or triple integral

F. Chapter 16: Vector Calculus

1) Set up and evaluate line integrals of scalar and vector fields (15.1, 15.3)
2) Compute the divergence and curl of a vector field, and interpret their meaning (15.2)
3) Determine if a vector field is conservative, and if so, find a potential function (15.3)

4) Understand and apply the Fundamental Theorem of Calculus for line integrals (15.3)
5) Understand and apply Green's Theorem (15.4)
6) Describe a surface in space using parametric equations (15.5)
7) Compute the surface area of a parametric surface (15.5)
8) Set up and evaluate the integral of a vector field over a surface (15.6)
9) Understand and apply Stokes' Theorem (15.7)
10) Understand and apply the Divergence Theorem (15.7)
11) Compare and contrast the different integral theorems, and the relationships between them

6 Course policies (an FAQ)

This section deals with questions about accommodations, missed tests, and other exceptional (yet common) cases.

1. *I don't think I can attend the classes regularly. Can I still take the course?*

   Short answer: yes. I recognize that not all students have access to the same technology. If your home internet is unreliable, attending Zoom sessions could be a challenge. If you can't attend synchronous sessions, I will arrange alternatives for graded work done asynchronously. I will also try to connect you with other students in the same situation, so that you still have a group you can work with.

2. *What happens if I get sick?*

   I'll do my best to be accommodating of any illness that interrupts your studies. There is no need to provide details of the illness. If you miss a week or more of work, please get in touch to make a plan for catching up. One of the biggest challenges in math is that once you fall behind, it's difficult to catch up on your own.

3. *What exactly does academic honesty mean?*

   In short, that any work you represent as your own, is your own. Much of your work can be done in groups, but not all of it. I will assume that you have access to a calculator, including online tools (like Symbolab) that give you step-by-step solutions.

   Use of these tools is acceptable, but take care that you are not overly reliant on them. What is not acceptable is having someone else do your work for you. This includes tutors, classmates, friends, family members, and online "homework help" sites. If you are paying money in exchange for answers to graded work, you are committing an academic offence.

   Penalties for academic dishonesty are outlined in the Academic Calendar. Depending on the severity of the offence, penalties for a first offence can range from a grade of zero on an assessment, to an F in the courses. Academic offences are also reported to the Dean of Arts & Sciences. They keep a record of each offence, and students with multiple offences can be subject to supplementary discipline.

4. *Does that mean I'm not allowed to get help with my homework?*

   Not at all! But keep in mind that your course instructors will be available for help, free of charge. (OK, maybe not free of charge, but you've already paid for it with your tuition.) We will be responding on the discussion forum regularly, There will be time to ask questions in every class, and there will be online office hours. The Student Success Centre will also be running free help sessions (details TBA).

Some of you may still decide to pay for tutoring, and that's fine. But you have a duty to disclose sources of help on an assignment, and the individual tests are still tests, even if you won't have someone watching over your shoulder.

You should probably avoid the various paid "homework help" websites. Most of these don't offer help. They offer worked solutions for a price. Getting those solutions won't help with your understanding. More importantly, the people working for these sites are paid (poorly) per solution, and they often provide incorrect and/or badly written work. (We saw plenty of examples of this last Spring, and yes, all those students now have discipline reports on file.)

5. *I missed a test! What do I do? Do I get a zero?*

   First, contact me as soon as possible for any missed test. There are *five* tests, and I only count *four* towards your grade. As long as you only miss one test, there is no penalty. This is true regardless of your reason for missing the test.

6. *What if I really wanted to write that test?*

   Inform me of this when you contact me to explain your absence. There's no guarantee that I can schedule a makeup test, but I'll try. You're more likely to get a makeup test if you've contacted me in advance.

7. *Do I need a doctor's note?*

   No. This wastes health care resources and your time. (That was my answer before the pandemic, and it's doubly so now.) Just email me to say you were sick. However, if you miss more than one test due to illness, we'll need to meet to discuss how to adjust your grade.

8. *I receive learning accommodations. What arrangements can I make?*

   First, make sure that you have registered with the University's Accommodated Learning Centre. No need to let me know: they notify me of every student with accommodations.

   Some accommodations will look a bit different this year, but exam accommodations such as extra time are still possible.

   If there are any adjustments I can make to facilitate your learning, please do not hesitate to get in touch with me. All students deserve an equal opportunity to learn. Note that the HTML textbook is designed with accessibility in mind, and should work with screen readers. However, I regret that we have not had the time (or paid help) necessary to add elements such as alt-text descriptions for images. It's on the to-do list, but that list is long, and growing.

9. *Life intervened and I can't keep up this week. What do I do?*

   Send me an email. Extensions are usually granted as long as they're granted ahead of time. Online homework extensions need to be in place before solutions become available. Book an appointment with me as soon as you feel like you're falling behind and I'll do my best to get you up to speed.