Teaching Portfolio - Supplement 1

Rutgers University

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Contents

Chapter 1

Introduction

This document provides a supplement to my teaching portfolio. It contains an extended version of my statement of teaching philosophy, some sample materials from the two summer classes mentioned in this statement, and a more detailed description of all of the extra teaching activities that I participated in as a graduate student at Rutgers,

1.1 Teaching Philosophy

One of the most important things in education, and particularly in math education, is the idea of self-efficacy—student's beliefs about their ability to complete a given task. In my opinion, a lot of students struggle with math because they go into classes with the mindset that math is hard or impossible, and if they were able to get past this, they could be more successful. For this reason, I have focused most of my teaching efforts on trying to improve self-efficacy in my classroom, helping students believe that they can succeed in my class, even if it seems challenging.

My commitment to the goal of improving self-efficacy can be seen throughout all of my teaching, but three types of experiences in particular both demonstrate this very well and have significantly impacted the way I think about teaching. These are

- the Summer 2017 Differential Equations class that I ran as a flipped classroom,
- the Summer 2018 Differential Equations class that I ran as a very active classroom with assignments and projects designed to encourage learning and self-efficacy, and
- the varied groups and communities dedicated to teaching that I have become involved with.

While there are many possible ways to attempt to address the problem of self-efficacy in the math classroom, two of the main techniques that I have tried to use to improve self-efficacy have been active learning and peer teaching. The idea of both of these is that getting students more involved in the learning of the material will help them to internalize it better and understand that it really is not that bad. These ideas became the foundation for the classes that I taught near the end of my time as a graduate student.

Summer 2017 - Math 244

During the summer of 2017, I taught a section of Rutgers' Differential Equations class for engineering majors. This is a 4-credit class that all engineering majors need to take before they get into the bulk of their major-specific classes. I decided to move the class to more of an 'active learning' format, and did so by running the section as a flipped classroom because I felt this would help the students understand the material better. I recorded video lectures for the entire class, and students spent the in-class time working on problem sets in groups, presenting problems to the rest of the class, or taking quizzes.

The goal in running the class this way was the same as the motivation for most flipped classrooms: students learn math concepts best by working problems, and this format gives them time to work on the homework-type problems in class, where I can fix any issues in understanding before they spend too much time doing problems incorrectly. By giving them this time to discuss things both with their classmates and with me, I had hoped to help them understand that things in this class were not too challenging, and it was something that they all could do. Overall, this class was successful. My experience in the class and student feedback seemed to indicate that some of the groups really enjoyed the format and took advantage of the time they were given to work on problems and did very well in the class. Some of the comments I received on the course were

- "The teaching style of this class was great for *actually learning* the material and understanding it."
- "He has reinvigorated my *passion* for the subject"
- "I like the structure of the class. It is very different than the other calc classes I have taken at Rutgers. The way this class is set up encourages learning in a great new way. All math classes at Rutgers should be taught in this way. Active collaborative learning is the best!"

On the whole, I saw a lot more ownership of the material in this class than I had seen in my previous classes, and I think it helped with some of the students being more confident in their ability to tackle math classes and problems in the future, but I also learned things about teaching a class like this that would help me to improve my future classes.

Summer 2018 - Math 252

One of the most common feedback comments I received from that class was my Summer 2017 I should lecture at the start of each class on top of the videos that the students had to watch before class. I took this feedback into consideration when designing my summer 2018 Differential Equations class, where I knew that I still wanted to use some of the active learning ideas that I had developed the previous summer, but also wanted to modify the course to make it better. In order to do this, I removed the video component of the course and added in condensed mini-lectures at the start of each section of material.

Due to the format of the course, this resulted in two mini-lectures each class day, with time between them for the students to work on problems from the section that I had just talked about. At the end of each problem session, the students would have to write up the solution to one problem from that section to turn into me that I would grade. I encouraged the students to work in groups during the problem set portions of the class and I think the atmosphere of the class and the amount of things they needed to turn into me made them more likely to actually participate. Within these groups, I saw the peer teaching that I was hoping to inspire develop on its own. Students would talk to each other and discuss their answers instead of asking me questions, and became more self-reliant in that way, trusting themselves and their groups to come to the correct answer instead of needing help or approval from the instructor. Student comments showed that they enjoyed this format:

- “I really enjoyed the active learning activities that we did. [...] helped reinforce what we learned and helped me have a better sense of what problems I understood and which I needed to review again.”

- “I liked the active learning aspect of the course, I felt like being able to do the problems in class let me figure out what I really needed to work on and what I knew.”

- “So many ways. I want to be a high school math teacher so every class I take I’m always learning classroom management and teaching techniques from the teacher even if it isn’t an education class. This class deepened my love of calculus and my want to be a teacher...”

I also encouraged peer instruction specifically with several activities in the course, including a Jigsaw-type activity, where the students were broken up in to groups, and each group had a distinct problem to work on. After all the groups were done, the groups were reshuffled so that each new group had one person in it that knew each problem, and they had to explain their solutions to the rest of the group. This helped to encourage students to discuss their work with each other throughout the course as a whole, and the need to explain things to someone else helped them to solidify that they could do these problems and they did understand this, and so they were able to succeed in a traditional exam setting, and would be able to take this confidence with them into future classes and their future career.

All in all, teaching is something that I have enjoyed for most of my life, and Rutgers has been a great experience in developing myself as a teacher. The various classes I have taught and groups I have been involved in have given me a foundation in and a passion for education that I am looking to expand on in the future. It has taught me that when students are confident and believe that they can complete the tasks you set out for them, it is fairly easy for them to succeed, and it is the job of the educator to set up an environment where this can happen. While we are just teaching a math class, the impact we can make on students goes well beyond that; inspiring confidence in a class that they find difficult will push them to tackle challenges that they face later in life. Calculus may be important, but the belief that a student can surpass whatever obstacles stand in their way is the most important thing that we can try to instill in our students.

Chapter 2

Course Details

2.1 Summer 2017 - Math 244

2.1.1 Class Overview

Math 244 is one of Rutgers' two classes on Differential Equations. This is a four-credit version of the class that mostly consists of students from the School of Engineering. For some of them, it is the last math class they need to take, while the rest of the students will go on to take Math 421. The class covers the basics of differential equations: Solving first-order equations, second and higher order equations, linear systems, and analysis of non-linear systems. As the course is meant for engineers, it tends to focus on applications, showing the engineers how the material in this class will be used in their future courses and jobs. It also includes an introduction to linear algebra, since that is not a prerequisite for this course and is required in order to analyze the linear systems that they will see. Since they will see more linear algebra in 421, this is a very brief introduction, only covering the material needed to do the problems from this class.

As a four credit class, the course lasted for 8 weeks, meeting 4 days a week for 2 hours. My version of the class covered the same material as during the semester, but my course looked substantially different because I flipped my class, recording video lectures and posting them for the students to watch before they came to class. In class, they would then work on problems in groups, discussing the material with their classmates and me, and then class would end with either in-class presentations or a quiz. While watching the videos and reading the sections in the book, students would have a worksheet to fill out that they would bring to class before starting on the group problems, but these were eventually replaced with quizzes at the start of class due to poor attendance at the start of class. The idea with this class format was to focus the in-class time on doing problems, which, in my opinion, is the most important part of Differential Equations, and how a student will best learn the material. I also developed two new projects for this class, one of which is the Fluid Flow project that is included in this document, since I felt that projects (and more involved applications of the material in general) were important for engineers to see while they were in my class. All of this went into how I decided to run my class over the summer.

2.1.2 Sample Course Materials

Sample materials that I created for this course can be found on the next few pages. Included in this section are

1. The course syllabus
2. The Fluid Flow project that I created
3. A fairly standard problem set to be worked on in class
4. A sample worksheet that the students would do while watching the videos

5. The worksheet quiz that corresponds to the previous worksheet that would be completed when the students arrived to class

The first three documents here after the syllabus are the things I am most proud of from this course. These are three project type activities that I designed in addition to the content needed to flip the course. The first two of these were designed to be completed by the students individually over the course of a week. The first, on Fluid Flow, was meant to introduce another application of differential equations, modeling of fluid flow, to the class, and give them an opportunity to play with it more. The second, the Bifurcation project, was meant to let them explore the idea of bifurcations, which are not generally covered in this class, through numerical experiments. The last of these assignments was supposed to let them practice numerical methods in a computer lab, where they could actually code the methods, but didn't work nearly as well as I would have hoped.

The last two documents show how the videos were integrated into the class, with the worksheet that the students would need to complete while watching the videos and the corresponding quiz that was given at the start of the next class. In addition, all of the vidoes that I created for this course are also on YouTube. The channel can be found here:
`https://www.youtube.com/channel/UCWmjNk4wyUW98C-SrctULQQ`.

MATH 244, Section C1 – Summer 2017
Syllabus

Instructor – Matt Charnley
Office: Hill 606, Busch Campus
Course Website - Canvas: canvas.rutgers.edu
Personal Website: math.rutgers.edu/~mpc163/Courses/SM17_MATH244.html

Class Meetings
MTWTh, 8:00 AM – 10:00 AM, Tillett 204, Livingston Campus

Office Hours
Monday and Wednesday – 10:00 AM – 12:00 noon, LSH 102C
By Appointment - Hill 606, Busch Campus

Exam Schedule
Midterm 1: Thursday, June 15 – In Class
Midterm 2: Thursday, July 6 – In Class
Final Exam: Thursday, July 20 – 8:00 AM – 11:00 AM

Course Information

The information for this course can be found on Canvas. Canvas is a newer Learning Management System that Rutgers is looking to implement in their classes. While I haven't used it for an actual class before, I feel like it's a lot better than Sakai, and I hope you'll like it too. The website is canvas.rutgers.edu. For the first week or so, I will also be posting links to everything on my personal website math.rutgers.edu/~mpc163/Courses/SM17_MATH244.html to allow everyone to keep up with the class if there are any issues with the Canvas site. After that, we will be exclusively using Canvas. If there are any issues, let me know as soon as possible.

Textbook

The textbook for this course is *Elementary Differential Equations*, **10th edition**. William Boyce and Richard DiPrima. ISBN: 978-0-470-45832-7.

Class Summary

This class is an introduction to Ordinary Differential Equations. In particular, this class is directed at engineering and physics students who will need knowledge of ordinary differential equations for future classes. To best do this, the class will focus on both the qualitative and quantitative aspects of differential equations, showing how both can be useful in different situations. There will be some instances where it may seem like the math has no connection to engineering or physics, but there will always be an attempt to emphasize the applications at every step. The topics covered in this class include:

- First Order Differential Equations
- Second and Higher Order Linear Differential Equations
- Systems of First Order Differential Equations
- Numerical Methods for Solving Differential Equations
- Non-Linear Differential Equations

Grade Breakdown

The final grades for this course will be calculated using the following distribution

Worksheets / Participation / Presentations	10%
Homework Writeups	5%
Quizzes (Including Syllabus Quiz)	10%
Projects and Maple Labs	15%
Midterms	28% (14% each)
Final Exam	32%

Note: No student will receive a final grade more than one mark higher than their average grade on the 3 exams, weighted in an appropriate manner. For instance, if your average exam grade is a C, you can receive no higher than a B for a final grade.

Class Structure

This class will be run as a flipped classroom. What this means is that the process of learning basic concepts and content (normally done via lecture) will be done on your own outside of class, and the practice of problem solving (normally done as homework) will be done in class when I am present to help you. The learning process outside of class will be facilitated by videos that I will be making over the course of the summer and worksheets that I will give you corresponding to both sections in the textbook and these videos. The worksheets will be due at the start of each class, at which point is expected that you will have read the sections in the textbook and completed the worksheet. These worksheets will contain questions about the important parts of the textbook sections as well as a few simple problems to get you started. Class will consist of a short lecture discussing the material and answering any questions from the previous night's reading, followed by group problem solving work. This will be similar to the workshop process in Calculus 1 and 2. The end of class will either consist of presentations or quizzes. The last page in this syllabus outlines the general process for a given class period.

Academic Integrity

All students in this course are expected to be familiar with and abide by the academic integrity policy (http://academicintegrity.rutgers.edu/academic-integrity-at-rutgers). Violations of this policy are taken very seriously. In short, don't cheat, and don't plagiarize. In terms of exams, it's fairly easy to understand what cheating/plagiarism is. However, this class is going to be heavily based on group work and projects. Everyone is expected to submit their own work, which means copying or borrowing answers from someone else in the class is plagiarism. Since you are expected to work together for some of the problems, this can be tricky. The general method that you should use in this class is that during the group work, you should only write notes about the problems, but don't work on the actual write-up. Then, outside of class, you can do the write-up using your notes, which will result in your write up still coming from the work you did in class, but will not be identical to your classmates. See the Canvas page for more information.

Attendance

Attendance at every class meeting is mandatory. Attendance will be taken in the form of the worksheets at the beginning of class and participation points for the problems solved in class. You are also expected to watch all of the videos that I link on the Canvas page. With the speed of all summer classes, missing any class will result in you falling significantly behind. If you must miss a class for any reason, come talk to me as soon as possible.

Problem Sets

The in-class problem sets will consist of three parts. The first, ‘Warm-ups,’ consists of problems that give a basic idea of the topics. All groups in the class should do all of these problems, or at least verify that they know how to do all of them. These are all fair game for quiz and exam questions. The second section, ‘Exercises,’ are a little more complicated and involved. These are the problems that will be presented at the end of class (see the Presentations section), and problems similar to these are around the level of exam questions. The final section, ‘Problems,’ are more involved and multi-step problems. These will be turned in as a part of the homework write-ups (see the Homework section).

Presentations

Whenever there is not a quiz at the end of class, there will be in-class presentations of the problems that were worked on that day. Each group will get a different problem to work through (assigned around the middle of class), and one person from the group will need to present it to the class in the last 30 minutes of class. The person presenting at the board will need to rotate every time a presentation is done, but the entire group can help in presenting the problem or giving guidance from their seats. The entire group can also work together to write the solution on the board before the presentation, and then only one person will talk through it to the class. The goal here is to build confidence in talking about the course material, as well as give everyone practice talking about math.

Quizzes

Every Tuesday and Thursday class (except exam days) will end with a quiz. This quiz will cover material from the previous two days of class, but can also be more cumulative depending on the situation. The problems on the quizzes will be on a comparable level to the in-class exercises. They will be closed book, closed note, individual quizzes. The first quiz is already posted on Canvas. It is a quiz about this syllabus and how the class is structured. It is worth triple of all of the other quizzes, and can not be dropped. It is due at the end of the day on Tuesday, June 6. You have unlimited attempts to get it right, and can use this syllabus and the Canvas website while you are taking the quiz.

Homework

Homework for this class will not be assigned in the typical manner. Before each class, you will be expected to complete a worksheet summarizing sections in the textbook. There will also be problems on here to be completed from the videos that you need to watch. This will be due at the start of class, graded during class, and returned to you the same day. At the end of each class, approximately one problem from each homework set covered that day will be assigned. These will need to be written up individually, although you will be doing the problems in groups, so you are definitely welcome to talk about the problems as you do them. The write-ups should be fairly complete, somewhere between workshops and normal homework. The write-ups should also be your own work, completed without collaborating with other students. These will be graded and returned to you.

Maple Assignments

There are 3 Maple labs that will need to be completed and turned in over the course of the summer. The dates are included in the tentative schedule below, and all of the necessary materials will be posted to Canvas. There will also be some introductory materials posted there if you need more information. If you have any issues with the Maple labs, come talk to me in office hours or send me an email. I will briefly mention each of them as they are assigned, but you will be overall responsible for completing them on your own, and coming to me with any questions. I will be spending minimal in-class time discussing the Maple labs.

Projects

There will be two projects assigned over the course of the summer. The due dates for these projects are in the schedule at the end of the syllabus. These projects will be somewhat similar to lab reports, in that math and writing will be incorporated together into a single document. You will need to both present solutions to the given math problems and discuss the implications of the results in an actual situation. The project description will make it clear what you are expected to talk about and how to use the mathematical results to do so. The idea with the projects is to show you how the math you do in this class is applicable to physical situations and understand yourself how to do these applications. The projects will be done individually, although you are allowed to discuss it with both me and your fellow students.

Exams

There will be two midterm exams and a final exam. The dates for these exams are posted above as well as on the tentative schedule below, but are subject to change. These will be exams in the standard sense, 80 minutes for the midterms and 180 minutes for the final, and will be taken individually. Calculators and electronic devices will not be permitted on the exams, and they will be closed book and closed note.

Make-Up Policies

There will be no make-ups for any of the in-class activities or homework assignments. In order to compensate for this, the lowest quiz, lowest 2 worksheets, and lowest 2 homework grades will be dropped at the end of the summer. Under no circumstances can an exam be made up after the fact. If there is a legitimate reason for missing an exam, i.e., doctor’s note, then we can discuss possibilities moving forward, but you will not be able to take the exam later. If there is an excessive need to miss class, talk to me about it sooner rather than later.

Disability Accommodations

I will be happy to provide appropriate accommodations for students who provide me with a letter of accommodation from the Office of Disability Services (ODS). For more information, see http://ods.rutgers.edu/.

Changes

This syllabus is subject to change at any point. Any changes will be announced in class and posted on the Canvas site.

Tentative Class Schedule

DATE	SECTIONS	DUE DATES
5/30	1.1, 1.3	
5/31	1.2, 2.2	
6/1	2.1	Quiz
6/5	2.3	
6/6	2.4, 2.8	Quiz
6/7	2.5	
6/8	2.6	Quiz
6/12	2.9	Project 1 Due
6/13	3.1, 3.2	Quiz
6/14	5.4, Review	
6/15	MIDTERM 1	
6/19	2.7, 8.1-8.3	Maple 1 Due
6/20	3.3, 3.4	Quiz
6/21	3.7	
6/22	3.5, 3.6	Quiz
6/26	3.8	Project 2 Due
6/27	Chapter 7, Day 1	Quiz
6/28	Chapter 7, Day 2	
6/29	7.5, 7.6	Quiz
7/3	7.8, 9.1	
7/4	NO CLASS	NO CLASS
7/5	C7, Day 3, Review	
7/6	MIDTERM 2	
7/10	7.7	Maple 2 Due
7/11	7.9	Quiz
7/12	9.2, 9.3	
7/13	9.4, 9.5	Quiz
7/17	9.7, 9.8	Maple 3 Due
7/18	Chapter 4 and 5 Summary	Quiz
7/19	Review	
7/20	FINAL EXAM	

Class Structure

Outside of Class:

1. Read assigned sections in the textbook.
2. Watch the corresponding videos through Canvas.
3. Fill out the worksheet and complete the problems from the videos.
4. Complete in-class problem write-up.

In Class:

1. Turn in worksheet, previous class’s homework, and ask any questions from the previous sections.
2. Listen to brief lecture about the material.
3. Work on book problems or other assigned problems in groups.
4. Ask questions about the problems as needed.
5. Midway through class, end of class and homework assignment will be discussed.
6. Class will end with either presentations or a quiz.

Worksheets will be returned the same day they are collected. Homework assignments will be returned a day later.

Project 1: Fluid Flow

Matt Charnley

April 15, 2017

All fluids have a material property called viscosity, which basically measures how much the fluid likes to move or flow. For instance, honey is much more viscous (has a higher viscosity) than water. In this project, you will investigate how using ODE's to model fluid flow can help us to calculate the viscosity of a fluid in two types of viscometers.

The main equations we will be using is the Navier-Stokes equations, which are, in their original form, the following partial differential equation:

$$\rho\frac{\partial \vec{u}}{\partial t} + \rho(\vec{u}\cdot\nabla)\vec{u} = -\nabla P + \mu\Delta\vec{u} + \rho\vec{g} \tag{1}$$

where this is actually 3 equations, one for each coordinate direction, i.e., one of them is

$$\rho\frac{\partial u_x}{\partial t} + \rho(u_x\frac{\partial u_x}{\partial x} + u_y\frac{\partial u_x}{\partial y} + u_z\frac{\partial u_x}{\partial z}) = -\frac{\partial P}{\partial x} + \mu\Delta u_x + \rho g_x \tag{2}$$

and the Laplacian Δ is

$$\Delta u_x = \frac{\partial^2 u_x}{\partial x^2} + \frac{\partial^2 u_x}{\partial y^2} + \frac{\partial^2 u_x}{\partial z^2}$$

μ is the viscosity parameter we want to find, and ρ is the density of the fluid.

In each of the cases below, we'll be able to simplify the equation in order to reduce it down to a simple ODE that you can solve. This assignment will guide you through the simplifications needed, and allow you to do some analysis on this system. Note, the ODEs in this problem are really simple. Don't overthink it.

1 Torque Viscometer

For this first version of the calculation, we will consider fluid flowing between two parallel plates, the bottom plate being fixed in place, and the top moving at a velocity V.

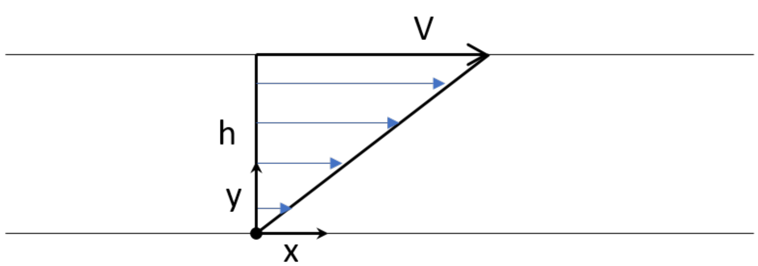

Figure 1: Sketch of the flow between parallel plates

We will assume that coordinates are aligned so that the origin is as marked in the image, the x direction is to the right, the y direction points up, and the z direction is back into the page. The assumptions we are allowed to make here are that the fluid only moves in the x direction, that is, $u_y = u_z = 0$ everywhere. We also assume that nothing depends on the z coordinate because the problem is infinite in that direction, that is, every derivative in z is zero. Finally, a different property, the continuity equation, lets us conclude that $\frac{\partial u_x}{\partial x} = 0$.

(a) Those assumptions tell us that we only need to care about the u_x equation from Navier-Stokes, i.e., the equation in 2. Using the above assumptions, plus the fact that the system is at steady state (time derivatives are zero) and gravity points in the y direction ($g_x = 0$), simplify 2 to get a simple ODE for u_x.

(b) What is the general solution of this ODE? Again, don't overthink it.

(c) Assuming the channel is of height h, the "no-slip" condition tells us that we must have $u_x(0) = 0$ and $u_x(h) = v$. Using these conditions, solve for the constants to get a specific solution.

(d) For this type of situation, the *stress* on the lower plane (something like the force the fluid imparts on the plane) is given by $\tau = \mu \frac{\partial u_x}{\partial y} \mid_{y=0}$. Compute this in terms of the given situation above.

(e) Now, we want to use this in a specific situation to compute viscosity. A torque viscometer is a pair of nested cylinders, where the fluid lies between them.

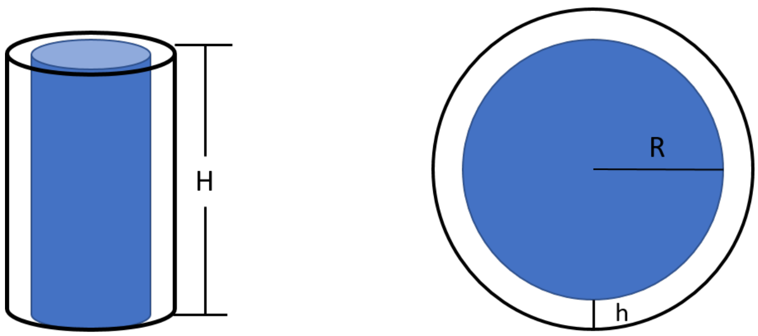

Figure 2: Sketch of a Torque Viscometer, both in profile and in cross-section

If the radius of the outer cylinder is really large compared to the gap between the cylinders, we can ignore the fact that the setup is curved, and pretend it is flat, which is what we just solved above. Assume we have a setup like this of height H in the z-direction. The torque T on the inner cylinder is given by the stress factor τ multiplied by the surface area of the cylinder (giving force) and then multiplied by the radius. Find a formula for the torque in terms of v, R, H, h, μ and other constants.

(f) Describe a procedure to use this system to calculate the viscosity of a fluid. You can leave all of the parameters of the problem in terms of variables or pick values for them. Determine which things are physical parameters of the system, which things you can measure, and how to calculate the viscosity from that.

We are a little bit off in the calculations here, because we assumed the round cylinder was flat, but it's only around a 1% error in most situations. So, a simple setup like this will allow us to approximate the viscosity of a fluid.

2 Capillary Viscometer

In this problem, we will consider flow in a cylindrical pipe.

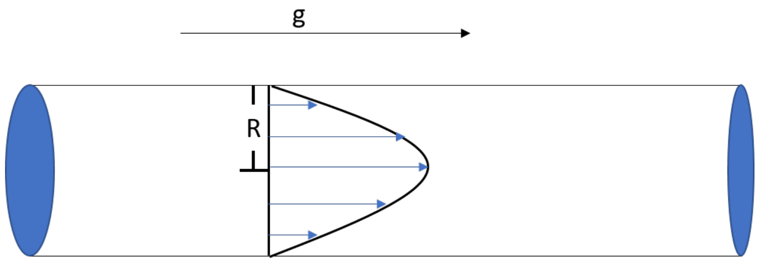

Figure 3: Sketch of flow in a cylindrical pipe

In order to find the equations here, we will want to use cylindrical coordinates, because that best fits the geometry of our system. We will assume that z points along the axis of the pipe, r is in the direction of the radius of the pipe, and θ points around the pipe. We will again assume that the fluid only moves in the z direction, so that $u_r = u_\theta = 0$. Thus, we only care about the u_z equation, which, in these coordinates is

$$\rho\frac{\partial u_z}{\partial t} + \rho(u_r\frac{\partial u_z}{\partial r} + \frac{u_\theta}{r}\frac{\partial u_z}{\partial \theta} + u_z\frac{\partial u_z}{\partial z}) = -\frac{\partial P}{\partial z} + \mu\left[\frac{1}{r}\frac{\partial}{\partial r}(r\frac{\partial u_z}{\partial r}) + \frac{1}{r^2}\frac{\partial^2 u_z}{\partial \theta^2} + \frac{\partial^2 u_z}{\partial z^2}\right] + \rho g_z \tag{3}$$

(a) Making the assumptions above, along with the steady state assumption from part 1, and the additional fact that $\frac{\partial u_z}{\partial z} = 0$, we can simplify this equation. For this part of the problem, we will assume that $\frac{\partial P}{\partial z} = 0$, but $g_z = g$ is the normal acceleration due to gravity. Make the cancellations above to get an ODE for u_z.

(b) Integrate both sides twice in r, clearing the factors of r each time, to get a general solution for u_z.

(c) The boundary conditions we want here are that $u_z(R) = 0$, another "no-slip" condition, and that $u_z(0)$ is finite, because fluid moving infinitely fast is generally not a good thing. Using these conditions, find a specific solution for u_z.

(d) In order to calculate the flow rate Q, we need to integrate this velocity profile over the circular cross-section of the cylinder. Integrate u_z over the circle of radius R to find a formula for Q.

(e) Describe a procedure where you use this information to calculate the viscosity of a fluid. Hint: The fact that the fluid flow is being driven by gravity means you need to have the pipe be vertical. You will want to have the fluid flow through the pipe and measure something, just like in part 1 you measured the torque.

These calculations are the basis of the Capillary viscometer, which can also be used to find the viscosity of a fluid.

Problem Set 17: Sections 7.5 and 7.6

Matt Charnley

June 29, 2017

These problems are to be worked on in class. All groups should work on the first set of problems, then move on to the second and third sets. The second set will be done as presentations, and the third set will have a problem assigned as homework. This problem is due at the start of next class.

1 Warm-ups

(a) Problem 3 on page 405

(b) Problem 15 on page 405

(c) Problems 24-27 on page 406 (only need to do part (a) and take a guess at part (b))

(d) Problem 3 on page 417

(e) Problem 9 on page 417

(f) Problem 13 on pages 417-418

2 Exercises/Presentations

The first two problems here I think are really nice and tie these new calculations back to the second order systems. The other ones are more computation.

(a) Problem 29 on page 406

(b) Problem 28 on page 419

(c) Problem 1 on page 405

(d) Problem 6 on page 405

(e) Problems 1 and 6 on page 417

(f) Problems 15 and 18 on pages 417-418

3 Problems

Write up the solution to the following problems. In both cases, solve the given initial value problem and describe the behavior of the solution as $t \to \infty$.

1. Problem 16 on page 405:

$$\vec{x}\,' = \begin{bmatrix} -2 & 1 \\ -5 & 4 \end{bmatrix} \vec{x} \qquad \vec{x}(0) = \begin{bmatrix} 1 \\ 3 \end{bmatrix}$$

2. Problem 10 on page 417:

$$\vec{x}\,' = \begin{bmatrix} -3 & 2 \\ -1 & -1 \end{bmatrix} \vec{x} \qquad \vec{x}(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$$

Worksheet 18: Sections 7.5 and 7.6

June 29, 2017

Name: ____

Assignment: Read Sections 7.5 and 7.6 and watch the 'Day 18 Videos' posted to the Canvas site. The last few questions for each section will come from the ends of the videos.

1 Section 7.5

1. What name do we give to the drawings of a sample of trajectories for a system of the form $\vec{x}' = A\vec{x}$, particularly when there are two functions in $\vec{x}$?

2. If we know that ξ is an eigenvector of A with eigenvalue r, then what function do I know solves $\vec{x}' = A\vec{x}$?

3. What are the three different options for the type of equilibrium point at 0 for a system $\vec{x}' = A\vec{x}$ where A has two distinct real eigenvalues?

4. What are the other two options for the eigenvalues of a 2×2 matrix (other than real and distinct roots)?

2 Section 7.6

1. If the eigenvalues of A are complex conjugates, then what do we know about the corresponding eigenvectors?

2. If $r = \lambda + i\mu$, what does the **complex valued** solution look like?

3. How do we get from the above solution to two independent solutions? How is this more complicated than the similar process for the second order ODE case?

4. What kind of equilibrium points can we get for complex eigenvalues?

3 Video Questions

1. Section 7.5 Video 1 Question

2. Section 7.5 Video 2 Question

Worksheet 18 Quiz

June 29, 2017

Name: ____

Find the general solution of the following ODE system

$$\vec{x}\,' = \begin{bmatrix} 2 & 2 \\ 0 & 3 \end{bmatrix} \vec{x}$$

2.1.3 Class Reflection

This class was a fantastic experience. It was a lot of work, even more than I had expected, but as my first foray into the world of Active Learning, I think it went very well. On they whole, the class seemed to buy in to what I was trying to do and participated in the activities and group work in class. I got several comments, both on the end of semester surveys and during the class itself that students enjoyed the videos and like the way the class was run. I feel like the students learned a lot in this class, and I gained a lot more experience in running an active classroom. I also learned what needs to go into preparing and recording video lectures, which, as the way things are heading with technology in the classroom, will likely be very useful in the future. Recording lectures caused me to think a lot more about what I was saying or writing and why I was doing it. Trying to keep videos under 10 minutes when recording lectures for a differential equations class, which has long computations involved, is difficult, and it made me realize what was really important in the lecture and what I could cut out. It also encouraged extra thought into the structure of the lecture, because even though the lectures ended up being 3 or so videos per section, they still needed to be distinct videos, containing some form of complete information on a topic. I know this practice of planning lectures carefully has already come into play with more recent classes I have taught, and it will continue to do so.

The semester was not without its issues, however. At the beginning of the semester, there was a student who contacted the Summer Section coordinator to tell him that I was 'not teaching' the class, because I was having the students watch videos outside of class and in class had them working on problems. The coordinator responded and took care of the situation and I never heard anything else after that. I also had an issue of students not arriving to class on time in the morning. My assumption to this end was that, since I was not lecturing in class, the students who were showing up late didn't feel like they were missing out on anything by showing up late. It got to the point where I needed to change something, because students were showing up late enough to throw off the class. This motivated me to change the worksheets that students would do outside of class while watching the videos to worksheet quizzes that the groups would have to do at the start of class. These quizzes were graded as a group (resulting in less grading for me) and needed to be turned in within the first 15 minutes of class, forcing students to be on time. I could have also moved some of the actual quizzes to the start of class, which is something I decided would happen in my future classes, not only for making sure students arrive on time, but also give them time to practice the material outside of class before the quiz. I had a few students make comments to that end during the class, and I feel like that's something that could be implemented fairly easily. I did not want to do this initially because my class started at 8 AM, but I could (and probably should) have done it anyway.

In addition with getting practice with a more active classroom, this summer also afforded me the opportunity to start working towards designing my own assignments and classes that were not quite identical to the ones that are run during the semester. The Fluid Flow project was a little bit of a struggle for the students to get through, but I think it went well on the whole. I'm fairly certain the students did not enjoy having to present problems in front of the class, but I think most of them gained something out of the experience. Overall, the combination of designing my own assignments as well as running a flipped classroom is an experience that will pay dividends as I continue to improve as an instructor in years to come.

2.1.4 Student Feedback

The student feedback results from this class are included on the next few pages.

Rutgers University Student Instructional Rating
(Online Survey - Sakai)

Charnley Matthew Summer 2017, 01:640:244:C1 — DIFFERENTIAL EQUATIONS FOR ENGINEERING AND PHYSICS (index #00276) Enrollment= 25, Responses= 13	**Student Responses**						**Weighted Means**			
Part A: University-wide Questions:	**Strong Disagree 1**				**Strong Agree 5**	**No response**	**Section**	**Course**	**Level**	**Dept**
1. The instructor was prepared for class and presented the material in an organized manner.	0	0	0	1	12	0	**4.92**	4.61	4.54	**4.68**
2. The instructor responded effectively to student comments and questions.	0	0	1	2	10	0	**4.69**	4.39	4.48	**4.56**
3. The instructor generated interest in the course material.	0	0	0	1	12	0	**4.92**	4.30	4.37	**4.54**
4. The instructor had a positive attitude toward assisting all students in understanding course material.	0	0	0	0	13	0	**5.00**	4.63	4.60	**4.64**
5. The instructor assigned grades fairly.	0	1	1	2	9	0	**4.46**	4.30	4.43	**4.56**
6. The instructional methods encouraged student learning.	0	0	0	2	11	0	**4.85**	4.37	4.34	**4.50**
7. I learned a great deal in this course.	0	0	0	3	10	0	**4.77**	4.49	4.43	**4.55**
8. I had a strong prior interest in the subject matter and wanted to take this course.	1	2	3	3	4	0	**3.54**	3.57	3.75	**3.61**
	Poor				**Excellent**					
9. I rate the teaching effectiveness of the instructor as:	0	0	0	4	9	0	**4.69**	4.34	4.33	**4.53**
10. I rate the overall quality of the course as:	0	0	0	5	8	0	**4.62**	4.26	4.25	**4.41**

What do you like best about this course?:

"The flipped class setting alllowed for better and more learning."

"The reverse classroom style"

"The method of doing video lectures at home then problems in class"

"The flipped classroom made learning easier. "

"He posted his lectures as YouTube videos to be watched at home so we spent our time in the classroom practicing problems and working together which was a great way to learn the material. "

"The format of learning and in class work."

"I like the structure of the class. It is very different than the other calc classes I have taken at Rutgers. The way this class is set up encourages learning in a great new way. All math classes at Rutgers should be taught in this way. Active collaborative learning is the best!"

"I liked that the instructor posted videos of the course material online. It allowed me to learn on my own prior to the next class meeting. "

"What I liked best about this course is the problems given to us. I felt like working on exercises everyday in class was an effective way to learn the material."

"The online pre lecture videos were very beneficial to learning because most of class time was spent working on problems in groups "

"I like the "flipped classroom" style."

"The teaching style of this class was great for actually learning the material and understanding it."

If you were teaching this course, what would you do differently?:

"Hace fewer write ups."

"I would have five more partial credit on exams like all my past professors have done. If there was one silly mistake but the logic was correct I would still get 0 points of out 8, even though I knew what I was doing so it was frustrating at some times."

"Nothing, done very well"

"Do an example before class to make sure students understand the videos"

"Nothing"

"Nothing"

"I believe that although there are online videos available, a brief lecture in class is still necessary. "

"I would assign various problems that are easy, medium, and hard, than just one hard question for homework."

"Nothing"

In what ways, if any, has this course or the instructor encouraged your intellectual growth and progress?:

"This method of teaching worked very well and helped me understand the material much better."

"Very helpful in class, encouraged questions, and was every enthusiastic about this course in class. "

"I am better at articulating my answerings and recognizing graphing patterns when given a function or set of functions "

"He has reinvigorated my passion for the subject."

"The instructor had taught us how to apply math problems in a real world setting related to our majors. "

"working on the material everyday has progressed and encouraged my intellectual growth."

"Group work and projects relating to applications "

Other comments or suggestions::

"Very well done"

"The use of canvas and how the class was taught in respect to the use of videos and other materials helped me learn like no other class before"

"Best class I took at rutgers "

"The videos were very helpful."

"Great teacher!!"

2.2 Summer 2018 - Math 252

2.2.1 Class Overview

Math 252 is Rutgers' other version of Differential Equations. This one is more directly aimed at math majors (or non-Engineering majors) and requires Linear Algebra as a prerequisite. This allows the class to cover the same amount of material as Math 244, while only being a 3 credit class. This works out fairly well during the school year, but as a summer class, it means everything is even more compressed than it was in Math 244. In addition, this class ran 3 times a week, for 2 hours and 45 minutes a session, which is a significantly different schedule than what I had taught for summer courses in the past. In addition to the accelerated rate of covering material, this assignment also brought with it the challenges of how to handle a class period that was twice as long as a normal lecture during the semester, while still covering the material that would be discussed over a full week of classes.

In order to do this, I ran this course as a very active classroom. The goal was to minimize the amount of time I was lecturing to the students and maximize the amount of time they would spend working on problems during class. They were free to work in groups and discuss these problems, and I hoped that this format would allow them to get more comfortable talking about math, as well as help them understand the material better. To facilitate spending time on problems in class, I needed to move some of the introduction of material to outside of class. This was done via assigning sections of the textbook to read, which was tested via open-book Readiness Assessments at the start of class. In addition, to cut down on the amount of grading I had to do for the class (and prevent the academic integrity issues I saw the previous summer), no homework was collected. Instead, problems were recommended, and these were assessed via Mini-Quizzes that happened at the start of every class that didn't contain a larger assessment. Examples of these are shown in the sample materials for this course.

2.2.2 Sample Course Materials

Sample materials that I created for this course can be found on the next few pages. Included in this section are

1. The course syllabus
2. A sample Mini-Quiz with its solution
3. A fairly standard example of a problem set that would be worked on in class
4. A sample practice problem with its solution
5. Assignment sheet for the bifurcation jigsaw activity

After the syllabus, the next two documents outline some of the general procedure of each class: the mini-quiz that replaced assigned homework, given at the start of class, a problem set, and then a practice problem. The final document is one of the several new activities that I designed for this class. It is a jigsaw activity based around bifurcations, where each group of students would work one a different bifurcation problem, and then the groups were mixed so that each new group had someone from each old group, and they all discussed the problems they had previously solved.

MATH 252 - Section B6 - Summer 2018

Contact Information

Name: Matt Charnley
Email: charnley@math.rutgers.edu
Office: Hill 606

Office Hours

Mondays, 3:30 - 5:00 PM
Tuesdays, 5:00 - 7:00 PM
or by appointment.

Class Meetings

MWF 6:00-8:45 PM, SEC 220

Exam Schedule

- Midterm 1: Friday, June 1 - First half of class
- Midterm 2: Wednesday, June 13 - First half of class
- Final Exam: Friday, July 6 - 6:00 - 9:00 PM

Textbook

This course will use *Differential Equations*, **4th edition**, by Paul Blanchard, Robert Devaney, and Glen Hall. ISBN-13: 978-1-133-10903-7.

Course Information

The information for this course can be found on Sakai. All announcements and assignments will be posted to this site. If you have any issues accessing the Sakai site, let me know as soon as possible. My personal website will also likely have some of these materials posted to it, but the most up-to-date resource will be Sakai.

Learning Goals

During this course, students will

1. Gain a familiarity with differential equations, which will show up in a variety of places after this class.
2. Understand how qualitative, quantitative, and numerical techniques can be applied to a problem, and when each one should be used.
3. Improve skills and confidence in talking about and presenting mathematics to their peers.
4. Become exposed to some of the ideas from higher-level mathematics, which will be expanded upon in future classes.

Class Overview

MATH 252 is an introduction to differential equations, generally directed at math majors. The course takes a three-pronged approach to studying differential equations: Qualitative methods (general behavior of solutions), Quantitative methods (analytical solutions), and Numerical methods (approximating solutions on a computer). We will take a look at all three of these over the course of the summer. The topics this course will cover are:

- First Order Differential Equations
- Systems of Differential Equations
- Linear Systems and Higher-order Linear Differential Equations
- Numerical Methods for ODEs
- Non-linear Systems of ODEs

NOTE: Linear Algebra (Math 250) is a prerequisite for this class. You will be expected to know the basics of linear algebra and matrix manipulation for this class. See the Midterm 1 topic outline for more information.

Grade Breakdown

Final grades for the class will be decided according to the following breakdown:

In-Class Assignments	10%
Quizzes	10%
MATLAB	10%
Midterm Exams	$10\% + 25\%$
Final Exam	35%

Class Structure

This class will be run in a mix between lecture and workshop formats. A lot of research has been done fairly recently on the implementation of Active Learning practices in math classrooms, and an article to this end has been posted to Sakai. I personally feel like these types of activities are very helpful in learning math, as you learn math best by doing problems, not by sitting around listening to lectures. Therefore, my plan is to implement several different activities in the classroom to move it more towards Active Learning. These may be things that you haven't seen in a math class before, but both I and the current research in the field believe that they are helpful in developing a better understanding of the course material. It only really works if you buy into it though, so I'm hoping you can give it a shot with me. If you have any questions, let me know and I'd be happy to talk about it.

The general plan for the class is as follows. Monday and Friday classes will generally start with a mini quiz and a Readiness Assessment, the first of which will test your knowledge of the homework problems assigned in the previous class, and the second will cover the readings assigned for the current class. You will be expected to have read the appropriate sections of the book before coming to class, and the Readiness Assessment will test your basic knowledge of these sections. These will be done individually, but there may be a group component to them afterwards. The rest of the class will consist of a mixture of workshop time, various activities, and lecture on the topics of the day. Over the course of each day, there will be two Practice Problems which will be completed, allowing you to practice the topics we are going over in class and show me that you know what is going on in class. Wednesday classes will be slightly different in that they will start with a quiz, testing material from the previous week of class. The rest of class will more or less be the same, consisting of lectures, activities, and workshops to help deepen or expand your knowledge of the material being covered.

Academic Integrity Policy

All students in this course are expected to be familiar with and abide by the academic integrity policy (`http://academicintegrity.rutgers.edu/academic-integrity-at-rutgers`). Violations of this policy are taken very seriously. In short, dont cheat, and dont plagiarize. In terms of exams, its fairly easy to understand what cheating/plagiarism is. For homework, you are definitely allowed to work with other students, but everything you turn in should be your own work. In particular, this means that you should NOT just write down and turn in a solution that you got from a friend, classmate, or the Internet. You should also be able to explain every step of what you turn in to me if asked. I would much prefer that you turn in a half-finished assignment than one that you looked up online or took from a classmate. In the first case at least both you and I know what you need to improve on and can work towards it. If you have any questions about this policy, please let me know. I am more than happy to talk about it.

Attendance Policy

Attendance is mandatory at every class. Each day in the classroom during the summer corresponds to an entire week of class during the semester. Therefore, missing a single class can be very detrimental to your learning and development in this course. Attendance will be taken in the form of practice problems and Readiness Assessments given out every day in class. If you need to miss a class, come talk to me about it as soon as possible.

Homework Assignments

There will be no traditional homework assignments for this course. There will be homework assigned each night, but the assignments will not be collected or graded. It is up to you to determine how many of the problems you want to do and how completely you want to work them out. You will get credit for this homework in terms of the quizzes and Readiness Assessments that will take place at the start of each class. These will be taken from problems very similar to those on the homework, so doing these problems will directly help you to do well on the mini-quizzes, as well as on the exams. I am also planning to post answers (not solutions) to the homework if the answer is not already in the book, so that you can check your work after doing the problems.

You will also be expected to read sections of the textbook and/or watch videos online before class. These will be announced at the end of the preceding class, and your knowledge of these sections will be tested with the Readiness Assessments at the start of each class. These assessments will cover basic knowledge of these sections. With the active learning component of the class, there will be less time for lecturing, so you all having a base level understanding of the material before you show up to class will help things to run smoothly. I also taught MATH 244 as a flipped classroom last summer, which means I made video lectures for the entire course. I may, at points throughout the summer, send you links to the videos for the appropriate sections for you to watch before class.

Projects / MATLAB Assignments

There will be 5 MATLAB assignments over the course of the summer. Each of these will involve taking pre-written code and modifying it to run some experiments that will illustrate concepts from class. These are assignments that have been given for the last several years, and I think they are well-made assignments. The assignments and sample code will be posted to Sakai, and you can download MATLAB by following the link here: `https://software.rutgers.edu/product/3437`.

In-Class Assignments

In-class assignments will take 3 forms. Monday and Friday classes will start with a mini-quiz about the homework from the previous class. This will be very similar to the homework problems assigned from that class. These mini-quizzes will be followed by a Readiness Assessment, covering basic knowledge on the reading assignments for the current class. Finally, there will be Practice Problems assigned each day in class, giving samples of the types of problems that could be seen on quizzes or tests related to the material being discussed in class.

Quizzes

On each Wednesday class that does not have a midterm, the class will start with a quiz. This quiz will cover the material that has been discussed over the last week. The quiz will last approximately 40 minutes and will be of similar difficulty to problems from the homework. These will be done individually and will be closed-book, closed-note.

Exams

This course will consist of two midterm exams and a final exam. The first midterm will happen this Friday, June 1. This exam is a prerequisite exam, covering material that you should know coming into this class, and is worth 10% of the final grade. There is an file on Sakai that contains an outline of what will be covered on this exam. This exam will take an hour. The second midterm will happen near the middle of the course and the tentative date is listed at the top of the syllabus. This exam will last 80 minutes. Due to the length of each class period, this will only take up half of the class, and we will continue with lecture/activities after the exam. These will be closed-book, closed-note exams, which will be taken individually. Calculators and electronic devices will not be permitted on exams.

Exam Rewrites

For each of the midterm exams, you will be allowed to rewrite the problems that you do not get full points on. You will receive exams with scores on the problems, but no marks on the pages, and can rewrite problems to get back half of the points that you missed. However, in order to get any points back for the rewrite, the rewritten version of the problem needs to be completely correct. More details about this process will be provided when the first midterm is returned.

Final Exam

The final exam will take place on Friday, July 6, from 6:00 - 9:00 pm in the normal classroom, and will be cumulative. Calculators and electronic devices will not be permitted on the final exam.

Make-Up Policies

There will be no make-ups for quizzes, practices problems, or exams. There is a decent chance that I will drop some number of practices problems or Readiness Assessments at the end of the course, but that will depend on how things go throughout the summer. If you have a legitimate reason for missing a midterm exam or quiz, then we can discuss potential options for your grade at that point, but try not to miss them. If you will not be in class on a day when an assignment is due, you need to send me a scanned version of the document before the end of class on that day. Pictures of the assignment will not be accepted, and anything received after the end of class will not be graded.

Disability Accommodations

Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: `https://ods.rutgers.edu/students/documentation-guidelines`. If the documentation supports your request for reasonable accommodations, your campuss disability services office will provide you with a Letter of Accommodations. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. To begin this process, please complete the Registration form on the ODS web site at: `https://ods.rutgers.edu/students/registration-form`.

Adjustments

All information in this syllabus is subject to change at any time. Any changes will be announced on Sakai, changed on this document, and announced in class.

Tentative Course Schedule

Date	**Section(s)**	**Topics**	**Due Dates**
W 5/30	1.1, 1.2, Notes	Introduction, Solutions, Modeling	
F 6/1	1.2, 1.5	MIDTERM 1, Separation of Variables	
M 6/4	1.3, 1.4, 1.6	Geometric and Numerical Methods	
W 6/6	1.7	Bifurcations	MATLAB 1 Due, Quiz 1
F 6/8	1.8, 1.9	Theoretic and Analytic Methods	
M 6/11	2.1, 2.2, 2.5	Introduction to Systems	
W 6/13	2.7	MIDTERM 2, SIR Model	MATLAB 2 Due
F 6/15	3.1, 3.2, Notes	Linear Systems	
M 6/18	3.3, 3.4, 3.5	Phase Plane Analysis	
W 6/20	3.7	Trace-Determinant Plane	MATLAB 3 Due, Quiz 2
F 6/22	1.8, 2.3, Notes	Analytic Solution Methods	
M 6/25	3.6, 4.1, 4.2	Second Order Equations	
W 6/27	4.3, 4.4	Resonance, Steady State	MATLAB 4 Due, Quiz 3
F 6/29	5.1, 5.2	Non-Linear Systems	
M 7/2	5.3, 3.8, 2.8	Other Topics, Review	MATLAB 5 Due
F 7/6		FINAL EXAM	

MATH 252 - Mini-Quiz 4

June 18, 2018

Name: Key

Find the general solution to the system

$$\frac{d\vec{x}}{dt} = \begin{bmatrix} 3 & -1 \\ -2 & 4 \end{bmatrix} \vec{x}$$

and determine the particular solution with initial condition $\vec{x}(0) = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$.

Find eigenvalues: $\det \begin{bmatrix} 3-\lambda & -1 \\ -2 & 4-\lambda \end{bmatrix} = (3-\lambda)(4-\lambda) - 2$

$\lambda^2 - 7\lambda + 12 - 2$

$\lambda^2 - 7\lambda + 10 = \underline{(\lambda-5)}\underline{(\lambda-2)}$

$\lambda = 5$

$$\begin{bmatrix} 3-5 & -1 \\ -2 & 4-5 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \vec{0}$$

$-2v_1 - v_2 = 0$

$-2v_1 - v_2 = 0$ $\Rightarrow$ $v_1 = 1$, $v_2 = -2$ $\quad \begin{bmatrix} 1 \\ -2 \end{bmatrix}$

$\lambda = 2$

$$\begin{bmatrix} 1 & -1 \\ -2 & 2 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \vec{0}$$

$v_1 - v_2 = 0$ $\Rightarrow$ $v_1 = 1$, $v_2 = 1$ $\quad \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

So, the general solution is

$$\vec{x}(t) = k_1 \begin{bmatrix} 1 \\ -2 \end{bmatrix} e^{5t} + k_2 \begin{bmatrix} 1 \\ 1 \end{bmatrix} e^{2t}$$

To match the initial condition, we need

$k_1 + k_2 = 1$

$-2k_1 + k_2 = 2$

$3k_1 = -1 \quad k_1 = -1/3 \quad k_2 = 4/3$

$$\Rightarrow \vec{x}(t) = \begin{bmatrix} -1/3 e^{5t} + 4/3 e^{2t} \\ 2/3 e^{5t} + 4/3 e^{2t} \end{bmatrix}$$

MATH 252 - Problem Set 10

Matt Charnley

June 25, 2018

Part 1

For this set, we will be looking at section 4.1. In addition to the problems presented, you should also identify what kind of an equation it is. That is, is the system undamped, underdamped, critically damped, or overdamped, or does it not model a mass on a spring (this is when any of the coefficients are negative).

1. Section 4.1, Problems 1-11 odd.
2. Section 4.1, Problems 13, 15, 17.
3. Section 4.1, Problems 20, 21, 23.
4. Section 4.1, Problems 25, 27, 29.

Part 2

For this set, the same additions hold as for part 1. The only thing different here is going to be we have periodic forcing instead of exponentials or constants. You should begin to connect the amount of dampening in the system with what the solution formula and graphs look like. For all of these, I'm expecting you to solve them by Undetermined Coefficients, not the complex method they describe in the book. You should also be able to get the amplitude of the answer and know how to get the phase angle. I obviously won't expect you to be able to find the phase angle by hand, because that is generally impossible without a calculator.

1. Section 4.2, Problems 1-13 odd.
2. Section 4.2, Problem 17. This is a very good problem for checking your understanding of how these equations work.

MATH 252 - Practice 16

June 25, 2018

Name: Key

For the following second order equation, determine if it is undamped, underdamped, critically damped, or overdamped, find the general solution, and compute the particular solution if, at $t = 0$, the mass starts at the equilibrium point and is given an initial velocity of 2.

$$y'' + 5y' + 6y = \sin 2t$$

$r^2 + 5r + 6 = 0 = (r+2)(r+3) \longrightarrow$ Overdamped

Homogeneous Solution: $y_h(t) = C_1 e^{-2t} + C_2 e^{-3t}$

Undetermined Coefficients: Guess $y_p(t) = A \sin 2t + B \cos 2t$

$$y' = 2A \cos 2t - 2B \sin 2t$$

$$y'' = -4A \sin 2t - 4B \cos 2t$$

$$y'' + 5y' + 6y = -4A \sin 2t - 4B \cos 2t + 10A \cos 2t - 10B \sin 2t + 6A \sin 2t + 6B \cos 2t$$

$$= (2A - 10B) \sin 2t + (2B + 10A) \cos 2t$$

So $2A - 10B = 1$

$5(2B + 10A = 0)$

$52A = 1 \qquad A = 1/52$

$B = -5/52$

General Solution: $y(t) = C_1 e^{-2t} + C_2 e^{-3t} + \frac{1}{52} \sin 2t - \frac{5}{52} \cos 2t$

$$y'(t) = -2c_1e^{-2t} - 3c_2e^{-3t} + \frac{1}{26}\cos 2t + \frac{5}{26}\sin 2t$$

$$y(0) = c_1 + c_2 - 5/52 = 0$$

$$y'(0) = -2c_1 - 3c_2 + \frac{1}{26} = 2$$

$$c_1 + c_2 = 5/52 \rightarrow 2c_1 + 2c_2 = 5/26$$

$$2c_1 + 3c_2 = \frac{-51}{26}$$

$$-c_2 = \frac{56}{26} \qquad c_2 = -\frac{28}{13}$$

$$c_1 = \frac{5}{52} - c_2 = \frac{5}{52} + \frac{112}{52} = \frac{117}{52}$$

Particular Solution

$$\boxed{y(t) = \frac{117}{52}e^{-2t} - \frac{28}{13}e^{-3t} + \frac{1}{52}\sin 2t - \frac{5}{52}\cos 2t.}$$

MATH 252 - Bifurcation Jigsaw

Matt Charnley

June 6, 2018

Purpose

The purpose of this activity is to allow you, as groups, to explore bifurcations and the different types that exist by analyzing a problem on your own. It will also give you an opportunity to improve your skills at talking about math concepts with your peers, as you will be presenting your discoveries to the other students in the class.

Structure

This activity will have three parts. During the first part, you and your group will work on analyzing two different one-parameter families of ODEs to search for bifurcation points. Each group will be working on the same problems here, and after some time to figure it out, we will discuss the results, so you know what the answer to a problem like this looks like. During the second part of this activity, each group will analyze another bifurcation problem, but each group will have a different problem. As a group, you will be responsible for finding and analyzing the bifurcation points of your problem following the format below. Once I see that everyone has the proper results, we will move on to the last part of the activity. Finally, in the 'Jigsaw' part of the activity, the groups will be shuffled so that every new group has at least one person in it who did each of the problems. Then, everyone in the new group will take a turn sharing what they discovered about the problem they analyzed. That way, at the end of class, everyone will have heard about all of the problems.

Format of Answer

Given a one-parameter family of ODEs, your analysis of any bifurcation points should contain the following.

1. A determination of any/all bifurcation points of the family of equations. This may include sketches of the graph of the function $f_\mu(y)$.
2. For each of the bifurcation points, a phase line (with solution sketches) for a value slightly larger and slightly smaller than the bifurcation point.
3. A description of what happens at the bifurcation points. (How many equilibrium points are there before and after? What type are they?)
4. A sketch of the bifurcation diagram for this family.

In terms of turning in this assignment, each group will need to hand in one copy of their bifurcation analysis for the second part of this activity. It can be handed in today or at the start of class on Friday.

Problems

For the initial part of this activity, each group will analyze the families

$$\frac{dy}{dt} = y^2 - \mu y$$

and

$$\frac{dy}{dt} = \mu - y^3$$

For the second phase, the possible familes of ODEs are

1. $\dfrac{dy}{dt} = \mu y - y^3$
2. $\dfrac{dy}{dt} = 2y\left(1 - \dfrac{y}{10}\right) - \mu$
3. $\dfrac{dy}{dt} = y^2 - \mu y + 1$
4. $\dfrac{dy}{dt} = (y^2 - \mu)(y^2 - 9)$
5. $\dfrac{dy}{dt} = y^3 + \mu y^2$
6. $\dfrac{dy}{dt} = y^4 + \mu y^2$

where, in each case, μ is the parameter to be varied.

2.2.3 Class Reflection

Overall, this class was a success and a great conclusion to my run of teaching summer classes at Rutgers. The structure of the course caused me to think a lot about how I planned my lessons and what was really important to discuss in class. I also had the pleasure of meeting with an instructional designer to talk about how to plan out a class that meets for almost three hours at a time, and how to structure it in a way that allows for active learning in the classroom. This led me to figure out what the main components of the course were and design my lessons and weekly plans around getting these topics across to the students. I feel like this could have been done a little bit better, but it was a good start to the process, and a good exercise that I will continue to do in future classes. I felt that by the end of the class, I could have used some extra time, and a little extra foresight would have helped me speed things up at the start of the course to get this extra time at the end. I also noticed that, when structuring the class to involve short lectures and in-class problem solving, the material covered in the lectures gets reduced to only the essential elements, which means there isn't time to talk about more of the side material or personal experiences. There were several moments in the course where I felt like I could have spent quite a bit of time talking about related ideas, but just did not have the time with this format. It was an interesting dilemma, and something that I think requires more consideration in the future.

This was also the first class where I attempted the Readiness Assessments and Mini-Quiz approach. I think, on the whole, the Mini-Quizzes were successful. They did eat up a little bit of class time, but I feel like they did the job of making sure the students had, at least to some degree, understood the material from the previous class before we moved on to new material. It made for extra preparatory work on my part to get these problems ready, but slightly reduced the grading, as I only needed to look at one problem for each student instead of a full homework set. The Readiness Assessments, on the other hand, were less successful. The goal of these was to make sure that students had read the sections in the textbook before coming to class, so I only needed to give a brief lecture on the material before they would be ready to work on problems. After the first one didn't go so well, I decided to make the rest of the open book, open note, but timed, so that if you hadn't read the sections in advance, you likely would not be able to complete the assessment in time. Grades on these stayed relatively low throughout the semester, and I have a few ideas as to why. The first is the possibility that the class was just not reading the textbook before class, and besides making these worth more, there's not too much to be done about that. Another possibility is that they didn't understand what I was expecting them to get out of the reading. I had hoped that this would sort itself out as the class went on, but I'm not sure if it did. This could be remedied by providing notes on the section(s) in addition to the textbook, or switching the in-class assignments to worksheets like I had the previous summer. The last option is that I was writing the Assessments too hard or too complicated that the students could not complete them before class. I feel like this may have been the case for a few of the assignments, so making them simpler may have been more beneficial to the students. The worksheets might be the way to go here; while they would give me less control over the environment in which the students were completing the assignment, it would make it more likely that they could find the answers and get things sorted out before coming to class. In addition, the student feedback showed that they were also not thrilled about the readiness assessments, which I think was a combination of the fact that they did not go well overall and that students were unsure how to do well on them. Both of these could be improved in the future by making my expectations more clear and writing better assignments.

Another addition that I made to this class was a prerequisite midterm on the second day of class. Since this course requires linear algebra as a prerequisite, I wanted to make sure the students were aware of this and that I was expecting them to be able to do linear algebra when we came to that point of the course. I think the prospect of having an exam on the second day of class scared the students a bit, but it did make sure they were ready for the class. Scores on this exam were high (as they should have been) and I believe the exam got my expectations across to them more clearly than anything I could have said on the first day of class. I also introduced Exam Rewrites to this course, mostly copied from another colleague at Rutgers. With this, students were able to rewrite any problem from either of the midterms (the prerequisite exam or the actual midterm) that they did not get full credit on for a chance to earn back half of the points they missed. In order to do so, they needed to write up a completely correct solution to the problem, but could use their textbook, classmates, or me to make sure that this happened. For the prerequisite midterm, this went very well, but there were a few problems on the second midterm that several students did not manage to write correctly. While these were difficult to grade, I feel like giving the students the opportunity to review their mistakes (and encouraging them to do so with points) was worthwhile.

In addition to the standard 'active learning' problem solving sessions, I also created activities to take place during the Wednesday classes after quizzes. These included more group-centered activities like jigsaws or group presentations. The goal with these was also to encourage discussion and help the students to become more confident in discussing math with each other. I feel like the activities did a fairly good job of this, but they could have been better designed to accomplish more at the same time. For instance, I did not anticipate how difficult it would be to write a jigsaw activity that would allow all of the groups to finish at approximately the same time. The other activities were similarly successful, but had their issues with bringing the class back together as a whole after working on individual problems in groups. This is something that I feel like I will get better at personally with more practice.

I feel like a lot of these experiences are things that I will take with me as I move on to teach more classes in the future. I think the active components of the class went well, and will definitely keep trying to implement them in my future classes. It was also a good experience to see that not everything works the first time I try it out. While the Readiness Assessments are something that

I took from other instructors, they had not really been used in math classes before. Conceptually, they are a good idea, but the implementation may not have been the best, and this takes trial and error. The same goes for any new component I try to add to a class; the way I try to include it may not work perfectly well the first time, and that is ok. It is still worth it to try them out and see what kind of feedback I get about it, so that it can be improved the next time around. The end results of this class also taught me about sticking to the numbers in terms of assigning final grades. Even though students do well and are active participants in class doesn't necessarily mean that they deserve an A in the class. They have to put in the work for it and do well enough on the exams. I had several students this summer that were active participants and were involved throughout the entire class, but ended up with a B based on exam and other scores. I felt like I wanted to give them a higher grade, because they were good participants, but the numbers said otherwise, and so I had to stick with those grades. All in all, I think this class taught me a lot about myself as well as how stepping out of the lecture role doesn't necessarily mean the students learn less in the class. They may actually learn more this way, and I definitely plan to take that with me in the future.

2.2.4 Student Feedback

The student feedback from this course can be found on the next few pages.

Rutgers University Student Instructional Rating
(Online Survey - Sakai)

Charnley Matthew mpc163 Summer 2018, 01:640:252:B6 — Elem Diff Equations (index #00268) Enrollment= 27, Responses= 21 **Part A: University-wide Questions:**	**Student Responses**						**Weighted Means**			
	Strong Disagree 1				**Strong Agree 5**	**No response**	**Section**	**Course**	**Level**	**Dept**
1. The instructor was prepared for class and presented the material in an organized manner.	0	0	1	6	14	0	**4.62**	4.61	4.65	**4.62**
2. The instructor responded effectively to student comments and questions.	0	0	0	6	15	0	**4.71**	4.67	4.55	**4.54**
3. The instructor generated interest in the course material.	0	0	2	6	13	0	**4.52**	4.58	4.37	**4.40**
4. The instructor had a positive attitude toward assisting all students in understanding course material.	0	0	0	6	15	0	**4.71**	4.67	4.58	**4.61**
5. The instructor assigned grades fairly.	0	0	1	8	11	1	**4.50**	4.50	4.46	**4.39**
6. The instructional methods encouraged student learning.	0	1	0	6	14	0	**4.57**	4.61	4.40	**4.40**
7. I learned a great deal in this course.	0	0	3	4	14	0	**4.52**	4.55	4.46	**4.45**
8. I had a strong prior interest in the subject matter and wanted to take this course.	0	1	5	7	8	0	**4.05**	4.09	3.72	**3.48**
	Poor				**Excellent**					
9. I rate the teaching effectiveness of the instructor as:	0	0	1	3	17	0	**4.76**	4.82	4.55	**4.45**
10. I rate the overall quality of the course as:	0	0	1	6	14	0	**4.62**	4.70	4.43	**4.26**

What do you like best about this course?:

“The combination of lecture with in-class practice of problems made it so there were few occasions in which I left class with questions remaining. ”

“I really enjoyed the active learning activities that we did. Each of the practice problems and mini quizzes helped reinforce what we learned and helped me have a better sense of what problems I understood and which I needed to review again. ”

“As a math major I love Calculus and the professors own love and enthusiasm for the topic made the course one of the best I have taken at Rutgers. ”

“The instructor explains the concepts very clearly with effective examples. He also does a great job answering student questions and clarifying any topics that may be confusing.”

“Matt is very enthusiastic.”

“the instructor put so much efforts to make sure we understand the stuff and the best thing is that he wants to make sure we absorb all of the in-class knowledge at the end of each class, which is really responsible. ”

“I like how the professor would engage the students and would always be receptive to questions. I also liked how I never was afraid to ask questions or felt stupid for asking. ”

“Everything is good.”

“How interactive everything was. Everything that was being taught, was easily understandable because we were constantly practicing them in class, at home, and through small assessments. ”

“I liked the active learning aspect of the course, I felt like being able to do the problems in class let me figure out what I really needed to work on and what I knew.”

“we have a lot of practices that helped me a lot to understand the materials.”

“Everything”

“The professor was excellent. He genuinely wanted students to learn. I appreciated his efforts. I also found that his class was engaging because of the problems we would receive at the end of each lesson. They were somewhat difficult problems that involved really understanding the material we learn in class so it got me to pay attention more. I really enjoyed the overall format of the class because it made me less lazy. It challenged me but at the same time allowed me to REALLY learn the material. I think the professor was very fair and it was actually refreshing watching him teach us. Professors with enthusiasm and effort like his allow me to feel more open to learning. Honestly, I think he is better than A LOT of the current full time mathematics professors at Rutgers; some of those professors are extremely lousy and do not deserve their positions. If I was on the administrative team... I would hire him in a heartbeat. ”

“This course helped me gain the foundations and understanding to take on more challenging upper level math courses. It broke down many concepts I couldn't understand and linked them back up in a more defined manner. ”

If you were teaching this course, what would you do differently?:

“Maybe shift the class towards being slightly more lecture based but I think the course worked well as is. Also, the Matlab component did not really aid in the understanding (outside of visualization), which I think is a result of the inconsistent software usage in Rutgers courses.”

“It was frustrating to wait until the last 5 minutes of class to get practice problems that sometimes took over 10 minutes to complete. The class period is already long enough. I didn't like staying after to complete a problem that could have been given to us just a few minutes earlier. I also think the Matlab assignments should have been due on Fridays. Having the Matlab assignments due the same day as our quizzes made it hard to find time to study. Some of the Matlab assignments took several hours to figure out so I would put off studying to work on them. If they were due on Fridays instead of Wednesdays we would have had more time to focus on one thing at a time. ”

“I honestly don't think I would do anything differently. I really enjoyed all aspects. ”

“Matlab assignments weren’t helpful since the assignments were intended to be done in order but we were skipping around. Seemed like there was important information explained in other assignments that we didn't do ”

“I would teach more examples.”

“I do not think the matlab thing really helps us because we never really learn about the basic principles and how to code in matlab and the HW just present the code and ask us to modify it, which is really harder than writing it by ourselves because we need to figure out what are the coder's thoughts. Besides, I believe that there is another way to organize the readiness assessments. It would be better for posting them online before everyday's class and then asking us to submit it at the beginning of the class.Because this book, honestly speaking, does not organize its thoughts very well and when we read about this book we feel so confused. Additionally, although we read about this book, we still do not know what the instructor wants us to know so we do not do good in RA. If the instructor can put the RA in advance, we can at least know what he want us to know and for the other confusing part, we can make it clear in the class because this instructor is clear enough.”

“I probably wouldn't give readiness assessments.”

“Maybe I wouldn't assign matlab, and have more workshop style assessments. ”

“While I really liked the active learning, I would do more example problems before giving us time to work on our own. I think if we were shown how to do one basic and one advanced type question before having to do them on our own it would've worked out a little better”

“none”

“nothing”

“I was not really pleased with the readiness assignments he gave us because they were unnecessary. I do not think we need to be tested on material based on the book that he still needed to teach us. Some students like myself have minor dyslexia and reading from the book does not necessarily help me grasp concepts very well. The professor even explained that some parts in the book were confusing yet still tested us on it. Maybe an alternative is to make readiness assignments based on concept videos to watch as homework as well? I also think some of the Matlabs were unfair. We should be tested on applying our knowledge on the CONCEPTS we've learned so far to the Matlabs; I think using intensive calculation-based numbers defeats the purpose. Furthermore, sometimes the professor gave us a problem when there were 5 minutes left in class... I do not think this was fair. ”

“Since there was a very restricted time limit on so many aspects, I wouldn't have made the course any different than the professor. He did a great job teaching and helping us practice the material. ”

In what ways, if any, has this course or the instructor encouraged your intellectual growth and progress?:

“While Differential Equations is not my particular area of interest, it has proven to be useful in considering other kinds of problems, such as alternate means of comparing the relation between two factors in an experiment.”

“So many ways. I want to be a high school math teacher so every class I take I'm always learning classroom management and teaching techniques from the teacher even if it isn't an education class. This class deepened my love of calculus and my want to be a teacher. The professor is inspired, engaging and implemented many different learning techniques. ”

“Reading before class begins.”

“The quizzes and practices in this class. I have never done so much quizzes and in-class practices in this university.”

“active studying helps me a lot. ”

“He has shown me the importance of active learning in classrooms, and obviously helped me improve my knowledge of differential equations. ”

“This class encouraged my growth because the Instructor not only knew what he was doing but he knew how to teach it to the class well. Mr. Charnley is hands down one of the best instructors I've had at Rutgers because his teaching style was very easy to follow and made difficult concepts easier to grasp. ”

“good”

“This class constantly made me actively learning. Since we would have quizzes every day, I retained information better and when it came time for the midterms, I was not cramming or stressing prior to the midterms because all these quizzes and work problems really prepared me well. This is the first time in a while that I felt confident studying for a mathematics exams. On the first day of class, I remember writing that i wanted to gain my confidence for learning math back and getting over math test anxiety — I definitely did. I'm very thankful for Mr. Charney for helping me heal and get over this mental obstacle. As a human to human influence, this has really re-encouraged me to be more hopeful in this path. (:”

“I feel more driven to understand the concept of computational mathematics rather than just plug and chug. Matthew helped break down formulas and concepts which I struggled in. He helped relate things we learned in class to real life scenarios and put his heart in making sure we understood the concept. Great professor!”

Other comments or suggestions::

> "The course was well taught and ultimately more enjoyable than I would have suspected. "

> "I really enjoyed this class and would recommend this summer section to anyone. It was fast passed but our professor broke it down to seem a lot less scary. I never felt afraid to ask questions or for help. This has been my favorite math class at Rutgers thus far. The professor made me not hate going to class on beautiful Friday nights, that takes a very good teacher. "

> "If you do one more example after the explanations of the context will be better "

> "For the quiz section of the grade add more quizzes or make it worth less, I think it's a little off balanced that the mini quizzes, practice problems, in class activities, and readiness assessments, and the Matlab's both account for the same amount of the grade but both areas had many more opportunities to make up for a bad assignment. "

> "great class. "

> "no"

> "Suggestion: Spend more times on showing students examples rather than giving them problems to try in class before the hand-in practice problem."

> "No other comments or suggestions. "

Chapter 3

Teaching Development Activities

This chapter contains summaries of the other teaching related activities that I participated in during my time at Rutgers. These include the Directed Readings Program, where advanced undergraduate students meet one-on-one with a graduate students to work through a topic of their choosing. The topics are generally not covered in the curriculum that the students would see normally over the course of their undergraduate careers, so this gives them a look into material they would not get to experience otherwise. In addition, this chapter will cover two different summer programs that I was involved in, the DIMACS REU, and the Rutgers Youth Scholars Program. It will also discuss the Math Teaching Group, which I co-organized for three years, and teaching-related presentations that I gave over the course of my Rutgers career.

3.1 Directed Readings Program

The Directed Readings Program at Rutgers provides an opportunity for motivated undergraduate students to explore topics outside the normal undergraduate curriculum in an independent study format. The leaders of these projects are graduate students, and pairings are made between undergraduate students and graduate student volunteers based on a survey that the undergraduate student completes when requesting to be enrolled in the program.

The general outline of the program is that during the first few weeks, the pair settles on a project that both the undergraduate is interested in and the graduate student has some knowledge in. After that, they meet for around 1 hour per week, talking about the topic, and the undergraduate student is expected to do around 2 to 3 hours of work on the project per week outside of the meetings. At the end of the semester, the undergraduate gives a 15 minute presentation on what they learned over the course of the semester.

I have had the privilege of working on 5 of these projects with fantastic undergraduate students. The topics of these projects were as follows.

3.1.1 Schrödinger Equation

The first DRP project that I worked on was with a student who was double majoring in math and physics. With an interest in PDEs and quantum mechanics, we settled on a project that would work through the Schrödinger equation and the model of the Hydrogen atom. The end goal for this project was a worksheet that I had received from Brian Hall (University of Notre Dame) during a workshop on Quantum Mechanics for Mathematicians. The worksheet presented a series of steps for solving the separated variables version of the Schrödinger equation for the Hydrogen atom. In order to attack this worksheet, the student and I needed to go over some basic material on PDEs, as well as the derivation and solution of the Heat and Wave equations. This provided a solid backing for talking about the Schrödinger equation for the second half of the semester. The last part of the semester involved us working through the entire worksheet, seeing where the fact that the quantum numbers of the atom needed to be integers, and the student's presentation outlined some of these concepts. I also helped the student with writing code that would plot some of the images from the work on the Hydrogen atom, showing the shapes of the orbitals that he had seen in Chemistry classes, and these were included on a handout given to the attendees of his presentation. I feel like this was a very successful first project and first foray into mentoring an undergraduate.

3.1.2 Fourier Analysis

My second DRP project was with a math major who wanted to learn about Fourier Analysis. We spent the semester talking about the basics of Fourier Series, both in terns of the standard sine and cosine functions and general orthogonal functions. We spent some time discussing the Gibbs Phenomenon and uniform convergence of Fourier Series. The semester then rounded out with a discussion of Fourier Transforms.

3.1.3 Functional Analysis

The third DRP project that I was a part of involved a student who was also a double major in math and physics. However, instead of an interest in the PDE aspect of physics, her concern was more with the δ function that had been used somewhat haphazardly in her physics classes. She wanted to see more of a rigorous justification of this 'function', and so we developed a project in Functional Analysis to get to this end. The basic trajectory of our project was to start with an introduction to Banach and Hilbert spaces as extentions of standard finite dimensional vector spaces over the real numbers. This gave the proper framework to talk about Linear Functionals, of which an example is the δ function. To wrap up the semester, we talked about general results in functional analysis, like the Hahn-Banach theorem, and discussed orthogonal polynomials, including the Legendre and Hermite polynomials, both of which she had also previously seen in physics classes.

3.1.4 Markov Chains

The fourth DRP project I helped mentor involved a math major who had already taken several probability classes and was fairly interested in that area. She brought forward a suggestion of looking at Markov chains for a project, and we went with that as a starting point. We spent the first part of the semester going over the basic definitions of Markov chains, as well as the subclasses of absorbing, ergodic, and regular Markov chains. We spent a decent amount of time going over the proofs of each of the different results so that she would be able to present them at the end of the semester. As the semester began to draw to a close, the student brought up the Metropolis algorithm as a potential application of Markov chains to discuss, which I had never heard of. After discussing the algorithm for a few weeks, we (mostly led by the student) figured out how and why it worked, and looked into other ways to apply the algorithm. The one we settled on was the Travelling Salesman problem, and code was written to simulate this procedure. I then helped the student prepare her presentation, which covered the basics of Markov chains, one major proof in the area, and discussed the application of this result to the Metropolis algorithm and approximate solution of the Travelling Salesman problem.

3.1.5 Fourier Analysis Round 2

During the summer, I served as a mentor for another undergraduate student who was looking to learn about Fourier Analysis. As this student was spending the summer away from campus, most of the meetings took place remotely, with the student sending me notes on the sections that I recommend, and me giving feedback on these notes. While the program started with talking about Fourier

Series, we moved on to Fourier Transforms, which provided a nice conclusion for the summer project.

3.2 Summer Programs

3.2.1 DIMACS REU

During the summer of 2015, I was, along with another graduate student, in charge of helping run the DIMACS REU that takes place every year at Rutgers. My role in this event was as an administrator. I helped make sure the students had places to stay before they arrived, organized the offices that the students would be working in while on campus, and planned several events over the summer. I was basically in charge of making sure that everything ran smoothly, including sorting out technical issues during the first week, ordering t-shirts for all of the attendees (35), and making sure students attended all of their presentations and turned work in on time.

A second component of the program involved a trip to Prague with 6 of the students at the end of the summer. Since I was going on this trip, I was also in charge of running the 'Bridge' sessions, which consisted of the 6 students going to Prague meeting with the 7 students who were at the REU from Prague to talk about topics in combinatorics. I ran a few of these sessions, the Czech students ran a few others, and the last ones were run by outside speakers from the math department at Rutgers. As I am not a combinatorist by trade, this was more challenging for me, but I was able to figure out the material well enough to teach the students who would be on the trip with me. The end of the summer resulted in a 2 week trip to Prague, where the first week consisted of workshop sessions with faculty from Charles University on combinatorics topics and the second week was filled with attending the Midsummer Combinatorial Workshop, held at Charles University.

While I am fairly certain I overbooked myself for this summer, the REU was a great experience. I got extra practice working with and mentoring undergraduates, including ones from all over the country. I got practice in conflict resolution whenever students had issues with each other, as well as dealing with maintenance and housing people when there were problems with the living arrangements. I also got exposed to a fair amount of combinatorics over this summer, which I think has done a lot to improve my well-roundedness as a mathematician.

3.2.2 Head TA

For the summers following my third, fourth, and fifth years as a graduate student, I served as the Head TA for the summer session. The role of the Head TA is to serve as a mentor for all of the graduate students who are teaching over the summer. Before classes start, we meet with graduate students, particularly those who had not taught in the past, in order to discuss their syllabi and how they plan to run the course. Once classes have started, we go around to observe all of the graduate student instructors and give them feedback on their teaching, meeting with them a few days later to discuss what we saw. While the feedback from the Head TA doesn't get recorded anywhere permanent, the goal of it is to help the graduate student improve their teaching before their official observation happens later in the summer. We also serve as a resource to all of the other graduate students for anything they would like to discuss about teaching or any issues that arise in their classes.

I feel like this position was a great experience, not only in that I was able to help out many other students in my department, but that I got to observe so many other students teaching, all of whom had a different approach to their class than I did. When I went to observe students, I took notes on what they were doing in class, not only to give them feedback later on, but also to remember the good things they did that I could potentially add to my own class. It also put me in direct contact with the other graduate students who cared about teaching and allowed us to combine and discuss ideas for classes, helping all of us to get better at it for future summers and future jobs. My summer classes have steadily gotten better not only because I have improved as a teacher, but also because I have had this opportunity to observe and discuss teaching practices with a large range of graduate students during my time as the summer Head TA.

3.2.3 RYSP

The other summer program I participated in was the Rutgers Youth Scholar's Program. This is a summer camp for high school students interested in math, where they learn about different topics in Discrete Mathematics from different instructors over the course of 4 weeks. I was brought in to teach the Combinatorics class during the second week of the program in Summer 2018. This was a very interesting experience for me because I was teaching a topic I didn't really know that much about to high school students. While the preparatory work took longer than I had expected because I didn't really know what to cover in a week of Combinatorics, but once I got all of that together, everything went very smoothly. The students were super motivated and picked up on everything I was trying to tell them very quickly, much faster than I anticipated. It was a good experience in writing note sheets for a group like this, since it was very different from anything I had done before for teaching. I am not sure how this experience will directly apply to in-class activities during a normal class, but it definitely showed me how these types of summer programs can run and that I would definitely be interested in being involved in programs like this in the future.

3.3 Teaching Group

During my 4th year at Rutgers, I, along with another graduate student, restarted the Math Teaching Group. This had been a seminar in previous years, but had stopped running due to either a lack of interest or lack of motivation. We decided that there should be a place where students in the math department could get together to talk about the issues that arise in teaching, from pedagogical decisions to dealing with students. There were seminars for subgroups in Analysis or Algebra, why shouldn't there be one for teaching? With that motivation, we emailed the administrators and got the seminar restarted.

For the first semester, we had the luxury of running alongside a MAA webinar about undergraduate education. This webinar met every few weeks, and gave some semblance of structure to a few of these sessions. Outside of that, we met to talk about whatever topics people found interesting. Usually this topics was decided on the week before, and someone (usually me) would come up with some notes to guide the discussion.

The second semester did not have the MAA webinar to follow along with, and with more members of the group getting more busy, several of the weeks just resulted in us getting together to talk about what was going on in our classes. While this was a nice discussion, it was not necessarily the most structured. Therefore, we attempted to fix this going into the next fall. We tried to have a more involved layout of topics, and pick topics at the beginning of the semester instead of waiting until the last minute. This helped quite a bit with the organization of the seminar and kept things on track. It also gave us the ability to invite outside speakers to talk, because things were planned out more than a week in advance.

Both the fall and spring of that academic year were much better for the teaching group. Topics ranged from the Honors Program at Rutgers, to Academic Integrity issues, to the TA Training program that first year graduate students partake in every year. We also started to have conversations with students from the Graduate School of Education, inviting them to join us in our discussions about teaching. We had outside speakers come in from the Learning Centers, the Graduate School of Education, as well two instances where former graduate students came back to talk about their experiences teaching at places other than Rutgers.

Overall, I think this teaching group has been a great experience for me, as well as a huge boost to my development as a teacher. It has gotten me to think more critically about how I design and handle things in the classroom, as well as given me specific opportunities to talk to other like-minded people about their teaching strategies, so that I can improve mine. I also do not think I would have been as motivated to try what I did in my classes had it not been for the Teaching Group and the discussions I had there.

3.4 TA-At-Large Program Organizer

In the Fall of my 4th year at Rutgers, I was assigned a role as a TA-At-Large (TAAL) for the semester. Part of this assignment was to hold both in-person and online office hours, and the online ones generally took place in a single room in the math building. I had been working to schedule my office hours, when it became clear to me that no one in the department was actively doing anything to get these courses set up. When I discovered that, I decided to take on this task and get the program set up myself.

The duties for being the *de facto* TAAL coordinator consisted of contacting all of the other TAALs to have them provide me with their rosters so that the students could be added to the corresponding online course. I was also in contact with the technology staff to help decide what platform we were going to use for the semester, as well as to provide them with the roster data and the information from the corresponding TA who needed access to be able to run the session. I helped to organize the training sessions, where new TAALs would be shown how to use the online platform, and scheduled the online office hours because all of the 12 TAs for the courses needed to use the same room for their sessions, and I served as the go-between for the TAs and the technology staff to make sure that everything worked out for both parties.

When the same problem arose at the start of the following Spring semester, a lot of the TAALs came to ask me what the situation was, because no one else had any information on how this program worked. Since the classes needed to get up and running, I took charge of the program again that semester, coordinating between the TAs and the technology staff to make sure the office hours happened, even though I was not a TAAL that semester. In order to shift these duties off of me before the following Fall semester, I prepared a document outlining the process of getting the online office hours started and passed that on to the Undergraduate Vice Chair. The hope of this was that the department would know what the process was and that which ever faculty member was assigned to this task would know how to do it as effectively as possible.

3.5 RASTL and TA Project

The Rutgers Academy for the Scholarship of Teaching and Learning (RASTL) is a invitation-based group of graduate students from various academic departments around Rutgers who meet on a monthly basis to discuss various issues in teaching and pedagogy. I have been a part of this group since May 2016 and have gotten a lot out of the opportunity to discuss these issues with students and teachers from other departments, as the problems they face in their classes are significantly different from those that I have seen. I have been able to take some of their experiences and adapt them to my own classes, changing the way I handle things in the classroom for the better. During my time in RASTL, I have also helped run a few of the sessions, leading discussions on 'Engaging Students and Managing Discussions' and 'Classroom Expectations'.

My time in RASTL has also led to my becoming more involved with the TA Project at Rutgers. This group organizes the TA Orientation for incoming TAs each fall and runs a workshop series every semester for current or future TAs to learn about different issues that may arise while they are teaching a class. For the last three years, I have been one of the TA Orientation leaders from the Math department, which means that I went to the orientation to give them advice on how the TA program works within the math department and how to make the most of it. I have also been a leader for several of the workshops run by the TA project, with topics including 'Teaching a Summer Course', 'Teaching Non-Majors', and 'Providing Feedback that Matters'.