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Technical Portfolio

1 Introduction

This document serves to record and present the technical skills I have attained as of my graduation from Cornell University in December 2025. A more interactive version of the same information can be found on my website or via my LinkedIn profile.

It is worth recognizing explicitly that while my degree is in Mechanical Engineering, I have always focused on the more abstract and mathematical parts of the field. So while I have experience with CAD and FEM software and know my way around a workshop, my true expertise lies in mathematical modeling, programming, and research.

2 MATLAB

It is difficult to overstate the centrality of MATLAB to my workflow, as it has been the workhorse behind the successful implementation of various research, academic, and personal projects.

2.1 Independent Mathematics Research

This project began in my first semester when I brought a seemingly simple math problem of my own design to my math professor. What resulted was several semesters of independent study and a great deal of experience in advanced math and programming. As a research topic, a full explanation of the problem can be accessed through my GitHub page, but the short version is this: what are all the equilibrium distributions of n mutually repulsive points confined to a sphere?

One of the more programmatically elaborate scripts to come out of this project was an interactive app used for visualizing the potential energy distribution. Essentially, one can imagine each of the points in the diagram as electrons, and the contour lines as representing potential energy well of the blue point. The user can click and drag that point to move it around the sphere, but the confusing part is that the other points — those creating the potential well — also move. This is because the program preserves the symmetry of the original shape: each of the yellow points in Figure (1) is reached by reflecting the blue point across the dashed lines.
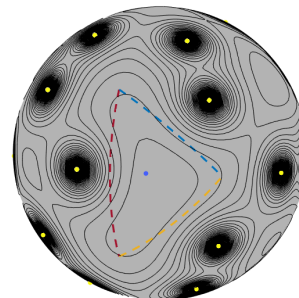

Figure 1: UI for potential energy visualization app

2.2 Dynamics Simulations

Dynamics is the physics of motion, a means of turning the complexity of the trajectories of rigid bodies into math. The trouble is that very few mechanical systems correspond to analytically solvable systems of differential equations. One way to deal with this is to manipulate the equations into forms that can be approximated as linear systems within a particular range of motion — this was the focus of my sixth semester class *Advanced Dynamics and Vibrations*. The other way forward is simulation, the focus of my other dynamics courses.

The most technically impressive simulation I developed was of a ball rolling within a hemispherical shell that itself can roll. There is no one aspect of the development process that I can point to as the primary technical or conceptual hurdle of that project, rather it was the integration of dozens of small challenges that combined into such a challenging whole.

More striking perhaps is the simulation I designed for my System Dynamics class of a satellite using reaction wheels to control its orientation. I was able to arrange the system to ensure the math was relatively simple so as to place a greater emphasis on the effect of the linear control law on the nonlinear system.
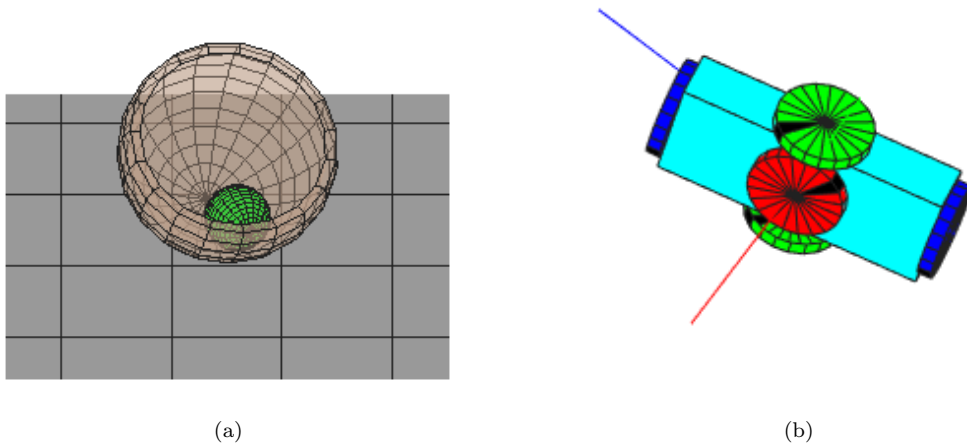
(a) (b)

Figure 2: (a) Simulation of a ball rolling within a larger rolling shell. (b) Simulation of a satellite adjusting to a new orientation

(a) (b)

Figure 3: (a) Original compass. (b) Digital replica.

These are not systems that a single image can do justice, but I do also have a gitHub page for these dynamics simulations.

3 AutoDesk Fusion360

The two examples below are from *MAE 2250 Introduction to Mechanical Design*, which I took in my fourth semester. The former is a more direct representation of the extent of my abilities whereas the latter is more a demonstration my design skills.

3.1 Replica

For this assignment I created a digital twin of an antique compass I own, which proved deceptively challenging to render on account of its many handmade details. For instance, the arms of the compass each feature a pair of tabs that allow for connection to a central block. One might imagine that these tabs would be parallel to one another and that both arms would be congruent, but apparently not. Similarly, the pen/pencil inserts used to draw the circle only fit in the compass arms because they were designed to be slightly flexible. The final CAD model is as close as I could get to reality, but this assignment proved a good reminder not to over-rely on the crisp geometry of digital space.
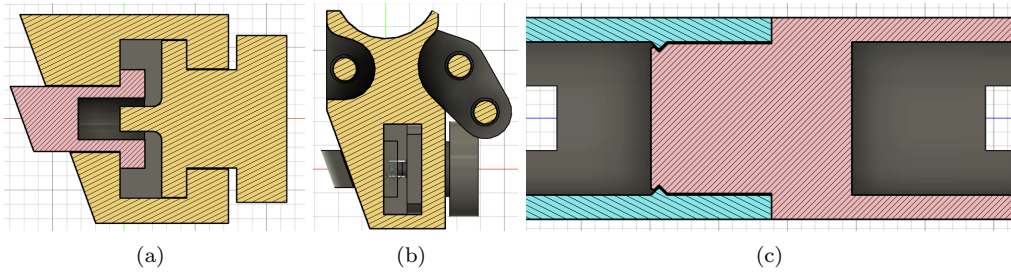
Figure 4: (a) cross section of the adjustable position-indicating bump. A spring fits between the two halves, holding the button in place against the interior wall of the channel. The piece on the right can be depressed to allow the bump to slide within the channel. (b) Cross section of the fabric strap lock. To secure the device to the instrument a fabric strap would be wrapped around the inlet tube and fed around the pair of cylinders on the right such that the strap could not be moved from within the loop. (c) Cross section of the snap-fit mechanism. The whole device was about 30" long, but was broken into three segments that could snap together.

3.2 Invention

The course project was a group assignment in which we were tasked with designing and prototyping some product — it was left deliberately vague. While I did learn a great deal of CAD and general design best practice from this assignment, in my mind it will always be principally associated with the truly abysmal group work dynamic I had to navigate. Suffice to say that I will be using the first-person singular pronouns in describing the product development process.

I've been playing the trombone at various degrees of rigor since elementary school, and one of the fundamental skills of the instrument that takes a long time to develop is slide control: it is very easy to put the slide in the wrong place and end up playing something very out of tune. So I designed a device that would attach onto the instrument and provide tactile feedback regarding the slide position. The main design challenges were

1. **Adjustability:** every trombone is different, so the feedback mechanism needs to be easily adjusted, ideally while holding the horn, but be resistant to accidental movement.

2. **Stability:** there isn't very much area on or around the trombone to attach something the length of the slide, so a rigid and impermanent connection needs to be established using very few points of contact.

3. **Portability:** both for the sake of manufacturing and end user convenience, the device should be constructed out of smaller segments that can easily be connected to reach the roughly 30" final length.

Fortunately, from a mechanical perspective, these challenges were able to be addressed mostly independently, with my solutions to each shown in Figure (4).

4 Ansys

4.1 Mechanical

The final project of *MAE 3270 Mechanics of Engineering Materials* involved the structural analysis of a cracked steel ring. The model was created in Fusion360 and imported into Ansys Mechanical for FEM simulation of deflection under constant load and fatigue strength under cyclic loading. These values were then compared to hand calculations.

4.2 Fluent

The final project of *MAE 4021 Wind Power* involved the performance evaluation of a given wind turbine blade and the improvement on that design. This required running hundreds of CFD simulations in Ansys
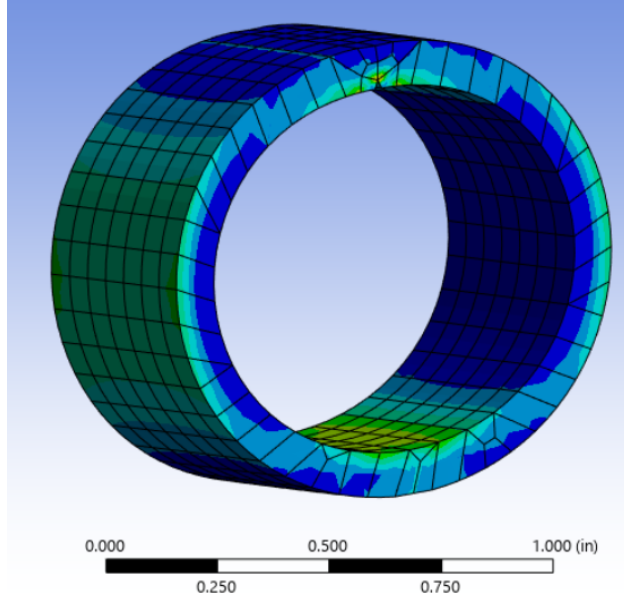
Figure 5: deformation contour of a compressed ring as produced by Ansys Mechanical

Fluent at diferent wind speeds, rotation rates, and blade pitch angles. That latter variable proved the most taxing as it required changing the domain geometry, and thus rerunning the meshing and simulation initialization. Fortunately I was able to parameterize the model geometry which prevented the need to manually make these changes.

A more notable aspect in my mind of this project than the experience with Ansys, however, was the unique derivation I used in the design portion. The details are tedious and subtle, but essentially I was able to identify and rectify a flaw in the mathematical argument made by the course textbook, and the result was a far simpler method of predicting blade performance that provided greater agreement with reference data than did the simulation. The full details can be found in my report submission via my website.
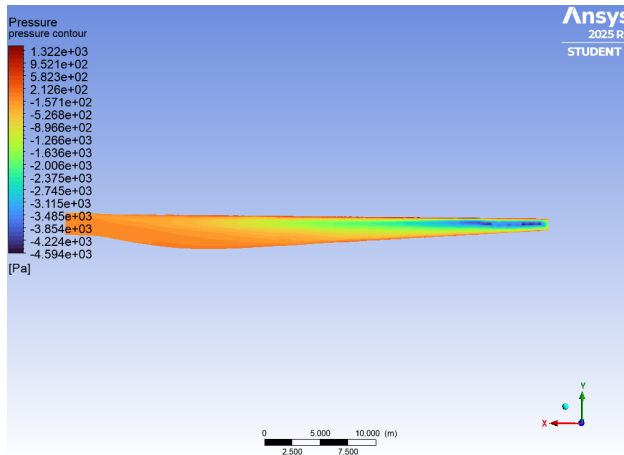

Figure 6: pressure contour on downstream face of a model wind turbine blade.

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