ENGN/PHYS 225—Winter 2021
Challenge Problem 2
Due Date: Monday, 29 Mar, in class

Introduction

We've covered a lot of ground the last several weeks including: Euler's ID and complex numbers; ODEs; and recently the eigenvector/value problem in linear algebra. Now it is time to take a deeper dive and apply some superposition of these to a real world problems!

Teams of (up to) 4 students will work together to develop a math solution and class presentation for one of the problems described below. Feel free to pick the one that tickles your math taste buds. There should be no boring math!

Once you select a project and team, the instructor will provide further resources to help you approach the problem. Regardless of which problem you choose, expect this to be a challenging, rewarding, and fun exploration through a combination of math methods we've studied thus far!

Problems on Offer—Choose One!

1. **Carrots are good for your i's: solutions to Schrodinger's Equation.** Why are carrots orange? What are quantum dots and how might they be used in novel cancer detection therapies? What is a "tunneling microscope" and how does it allow one to visualize individual atoms? Any or all of these sound interesting? Then dive in to solve Schrodinger's Equation (the time independent version) to find out! Math-wise this is an integration of concepts from complex numbers and ODEs.

2. **Good Vibrations: spring-mass models of many things.** Rockets mechanically shake during lift-off and in flight. Ditto airplane wings. Bridges and buildings shake during earthquakes. Microwaves make water molecules jiggle to warm your food and beverage. Baseball bats, hockey sticks, and golf clubs vibrate after striking a ball or puck. In essence, all of these systems can be modeled by masses coupled by springs. Choose your favorite system; model it; and solve for the resultant vibrational modes! Math-wise this is a tour through linear algebra (eigenvalue/vector problem) plus a small dose of ODEs.

3. **The Postal Service: hand-writing recognition.** Principal Components Analysis (PCA) is a linear algebra-based technique that allows one to identify written characters and numbers. The USPS was one of the early adopters of PCA to automate address recognition and speed up mail processing. Want to learn more about inner workings? Then take on this challenge problem! Math-wise, this is straight ahead linear algebra with a small dose of statistics. Please note: this challenge problem is best suited for students interested in AI/ML; that all team members must have a moderate to substantial amount of coding experience.