# Oscillations and Waves in Mathematica

## Preliminary Syllabus

Deep Springs College
Prof. Brian Hill
Academic Year 2024-2025, Spring Semester (Terms 4 & 5)

## Prerequisites

*Very good high school math* — *Accessible* <===|=+=|===> *Hard*

AP math helpful but definitely not required. The mathematical level will be similar to the Fall 2024 Bayesian Statistics course.

## Materials

* Tentatively, Stephen Wolfram, *An Elementary Introduction to the Wolfram Language, 3rd Edition*, 2023

* Tentatively, Steven Tan, *Introduction to Oscillatory Motion with Mathematica, First Edition Revised*, 2018

* *Mathematica* license: Desktop and Cloud is $75/year for a student. There is also a semester (six-month) plan for $50, and even a monthly plan, for $10/month which would work fine and save you $10 if you only used it for the four months from early-January to early-May (see also **Computing Resources** section below)

## Context and Overview

### The First Course within the Course

In order to do mathematical modeling, we need to learn a serious programming language, and for previously mentioned reasons, nowadays I prefer Mathematica for most purposes. Mathematica is a program that uses the "Wolfram Language." To learn this language, we will work through about half of a book by Stephen Wolfram himself: *An Elementary Introduction to the Wolfram Language, 3rd Edition.*

The printed edition is over 300 pages divided into 47 sections. If we do 2-3 sections a class we can do most of the material up to Section 40 during Term 4, at which point you will be in an extremely good position to apply Mathematica to any problem that interests you.

**The Second Course within the Course**

What we will do with Mathematica in this course is fundamental physics that all theoretical physicists know very well: oscillations and waves.

We will begin with simple oscillations involving a single particle. The classic is a mass on an idealized spring, and a significant increase in complexity when you next put the mass on the end of a pendulum rod. The next level of complexity is to step it up to two particles. If the two particles are connected, even weakly connected, this leads to all sorts of complex behavior that was not present for either particle separately.

The next level of complexity, is to step it up to *N* particles ***and then we take the limit that N goes to infinity!*** Waves appear! They appear completely naturally from laws governing a finite but ever larger number of ever more closely spaced and ever smaller particles.

Waves first show up in a single dimension, such as waves on a string. But then we can step up the complexity again and consider waves in two dimensions, such as waves on a drumhead. Finally the highest level of complexity we can hope to get to in a one-semester course, starting with no significant prerequisites, is just a taste of what quantum-mechanical waves look like in three dimensions.

I might hope that a course that smashes its way through increasingly levels of complexity as I have outlined above whets your appetite for further study of oscillations and waves. Even if it does not, exposure to these concepts will forever change the way you view the physical world, which is replete with oscillations and waves.

## Computing Resources

Disk Space: 18 GB with local documentation, 9 GB without local documentation. You don't have to have the local documentation, but it is nice to have so that you don't have to have internet access just to look up Mathematica features.