Example Projects

Text: Kramer and Eden, Case Studies in Neural Data Analysis: A Guide for the Practicing Neuroscientist
Description: “The book will cover neural field data and spike train data, spectral analysis, generalized linear models, coherence, and cross-frequency coupling. Each chapter offers a stand-alone case study that can be used separately as part of a targeted investigation. The book includes some mathematical discussion but does not focus on mathematical or statistical theory, emphasizing the practical instead. References are included for readers who want to explore the theoretical more deeply.”

From UC Berkeley: https://math.berkeley.edu/wp/drp/project-ideas/

Text: Devaney, An Introduction to Chaotic Dynamical Systems
Description: The study of dynamical systems is a very broad topic, encompassing the mathematics of modeling any system that evolves over time. An active field of mathematical study, dynamical systems also has applications to many different sciences, e.g. physics and biology. This project is an introduction to dynamical systems, with a focus on systems which are considered “chaotic.”

Text: John Conway, On Numbers and Games
Description: The suggested text begins by describing a formal theory of infinite numbers. It then introduces game theory and relates games to infinite numbers in a few different interesting ways. Those more interested in game theory could probably skip some of the theory of infinite numbers to focus primarily on the game theory.

Text: David Cox, Primes of the Form x^2+ny^2
Description: Class field theory, roughly speaking, is the study of field extensions of the rational numbers with abelian Galois group. This project is an historical and example-motivated introduction to class field theory. The suggested text focuses on one example problem in particular: given a fixed integer n, can we characterize prime numbers that can be written as x^2+ny^2 for some integers x and y? The text assumes no background in number theory, but those that do have a background in the subject could skip the earlier chapters and focus more on the discussion of modular forms and/or elliptic curves in Chapter 3.

From University of Maryland: http://drp.math.umd.edu/projectideas.php

Text: Machine Learning by Tom Mitchell.
Description: "After a brief introduction to some foundational ideas in linear algebra, we will begin to study the mathematical foundations behind PCA (principle component analysis) and other types of linear dimension reduction. We will then shift gears slightly and develop the ideas behind SVM (support vector machines) and other foundational ideas in classification. The goal

of the project is to begin working with a real world data set (facial data set, sensors, etc.) and try to do meaningful dimension reduction and classification on the data."

Text: Calculus, by Michael Spivak.
Description: "We will be investigating the ideas of transcendence and irrationality of real numbers. We will begin by studying continued fractions, building up tools to prove the irrationality of numbers like e and pi. After further analytical preparation, we'll turn our attention to our main goal, Liouville's theorem, which provides an explicit transcendental number. Time permitting, we'll try to show that e is transcendental as well."

From Brandeis University:
http://www.brandeis.edu/departments/mathematics/undergraduate/DRP.html

Text: An Introduction to Category Theory, Harold Simmons
Description: “Category theory provides a structure and language in which to study all other types of mathematics. One has the category of sets, the category of groups, the category of abelian groups, etc. In studying general category theory one obtains new techniques for proving results that were otherwise out of reach or incredibly difficult. It allows us to study the relationship between seemingly different structures, such as geometric things and algebraic things. Sometimes, category theory inspires a new question whose answer has nothing to do with category theory in general but is of great use. In short, knowing a bit of category theory can help in almost every field of mathematics.”

Text: Algebraic Curves, William Fulton
Description: “Algebraic geometry is one of the central fields in modern mathematics. This project offers a first introduction to this field via the theory of algebraic curves. The book is a classic and widely considered a great first introduction to algebraic geometry. Even though rather elementary in spirit, this book prepares the reader well for modern algebraic geometry. The prerequisites are minimal: basic properties of rings, ideals, and polynomials, such as is often covered in a one-semester course in modern algebra. We will learn the required commutative algebra as needed.”

From Tufts University: https://sites.tufts.edu/mathdrp/current-and-past-projects/

Text: Wagon, The Banach-Tarski Paradox
Description: “The Banach-Tarski paradox asserts the striking fact that one can chop up the unit ball in R^3 into a few pieces and, just by rotating the pieces, create two new balls with the same volume. We will walk through the construction and touch on the connection to actions of free groups.”