

**BROWN UNIVERSITY DEPARTMENT OF MATHEMATICS  
DIRECTED READING PROGRAM  
FALL 2020 PROJECT DESCRIPTIONS**

SAM FREEDMAN, SHIYUE LI, AND JIAHUA ZOU

1. REPRESENTATIONS AND CHARACTERS OF GROUPS

**Author:** James and Liebeck

**Mentor:** Alex McDonough

**Project Description:**

**Expectations** I like to meet weekly. Honestly, I just want to learn rep theory and this is probably the best way. A class in abstract algebra is required for this project. This project can accept one to three students. The length could be one to two semesters.

2. TURING COMPUTABILITY: THEORY AND APPLICATIONS

**Author:** Soare

**Mentor:** Tom Stone

**Project Description:** Computability theory sits at the intersection of Mathematics, Philosophy, and Computer Science. We'll spend our time going over the fundamentals of Turing machines (introduced by the infamous Alan Turing) and talk about their generalization to Oracle Machines, and what they can tell us about the mathematical complexity of the natural numbers, computation, and modern logic. I find that computability theory is a great way to train yourself to think outside the box, it was probably one of the most helpful courses I took in my undergrad.

**Expectations:** I'm expecting a couple hours a week of individual/group work and reading, and an hour meeting with me once a week to discuss the material and the new directions. There are no necessary prerequisites, but familiarity with proofs or logic is helpful in getting started. Having familiarity with computer science is NOT needed whatsoever. This project can accept two to three students. The length could be one to three semesters.

3. MATRIX GROUPS FOR UNDERGRADUATES

**Author:** Kristopher Tapp

**Mentor:** Sam Freedman

**Project Description:** The book (by Kristopher Tapp) has 11 chapters and I'd

love to cover all of them, but our pace will be determined by you. Each week I'll expect you to have read a few sections and done some exercises related to those sections. We'll see for an hour a week, but the duration is up to your schedule (although I think we should strive to meet at least through Thanksgiving). I want you to take away an appreciation for Lie groups and their role as a bridge between geometry and algebra. We'll work through explicit examples and develop physical intuition for these fascinating groups of symmetries. Our driving example: how do we use group theory/ geometry to study the symmetries of the sphere?

**Expectations:** Required topics (if you're a bit rusty on some that's OK) : Linear algebra (the most important): vector spaces, linear transformations, change of basis, eigenvectors/eigenvalues, trace/determinant, etc. Abstract algebra: basic group theory such as normal subgroups, quotient groups, and abelian groups  
Calculus: Some familiarity up to multivariable calculus, but not necessarily from an analysis/proofs perspective.

This project can accept one student. The length could be one to three semesters.

#### 4. MATHEMATICAL ANALYSIS OF PROBLEMS IN THE NATURAL SCIENCES

**Author:** Vladimir Zorich

**Mentor:** Jiahua Zou

**Project Description:** The book has three topics: "Analysis of Dimensions of Physical Quantities", "Multidimensional Geometry and Functions of a Very Large Number of Variables", "Classical Thermodynamics and Contact Geometry". All of them are not big (around 50 pages) but interesting, but take some effort to be fully understood. The student could choose the favourite one and go through it and related topics during one semester. It is expected that approximately one section is read every week and then a discussion about the reading, while the specific time and length could be very flexible.

**Expectations:** Basic Calculus should be enough for this project. Knowing Linear Algebra could be better but not necessary. This project can accept one student. The length could be one to three semesters.

#### 5. INTRODUCTION TO TROPICAL GEOMETRY

**Author:** Maclagan and Sturmfels

**Mentor:** Steven Creech

**Project Description:** We will go through the first three chapters of Maclagan and Sturmfels Introduction to Tropical Geometry.

**Expectations:** Linear algebra, abstract algebra is required for this project. There is one student already in this project, one more student can be accepted. The length could be one to two semesters.

## 6. CATEGORY THEORY IN CONTEXT

**Author:** Emily Riehl

**Mentor:** Megan Chang-Lee

**Project Description:** I expect to go through the first three chapters of Riehl's *Category Theory in Context* (or the first four if it's a two-semester project).

**Expectations:** The workload shouldn't be more than an hour or two a week of reading and an additional hour of exercises (if the mentees would like to complete exercises alongside the reading), and I think meeting every week for half an hour to an hour would be ideal. I'd like mentees to take away from this project a greater confidence in math, an introduction to using the (very helpful!) tool of category theory, and exposure to concepts from higher-level/graduate math that are otherwise not accessible in undergrad curriculum. Since category theory is a topic that is very often utilized in math but not frequently covered in its own right, I hope that this project can equip mentees with the basics of category theory and prepare them for any higher-level math classes they might like to take in the future.

There is no strict prerequisites. Knowledge of abstract algebra and other standard (upper-level) undergraduate courses is helpful but not necessary.

This project can accept one to two students. The length could be one to two semesters.

## 7. THIRTY-THREE MINIATURES

**Author:** Jiri Matousek

**Mentor:** John Ahn

**Project Description:** The book we'll be reading is *Thirty-three Miniatures* by Matousek (free springer pdf download available from brown library website, but I'll just email it to you anyways).

**Expectations:** Each week we'll go through a chapter of the book; most weeks this probably will not take more than an hour. Each chapter is self-contained, so we can skip around depending on the students' interests (combinatorics/graph theory, CS/algorithms, geometry, linear algebra tricks that are interesting/funny). Meetings shouldn't be more than 30 minutes; we'll mainly just go over any questions. Chapter difficulty will certainly be adjusted based on how busy the students are that week.

Hopefully I'll show that you can already do some fun/clever stuff with just a semester of linear algebra. Aka it's good and powerful stuff, so just think of what else you can do if you decide to learn more math.

The project only requires first semester of linear algebra.

This project can accept one to three students. The length could be one to three semesters.

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