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"In mathematics too some things appear to be not easy to prove for want of a definition. But, when the definition is expressed, the said property is immediately manifest." Aristotle

The limit is the essential idea of the calculus. It took more than 2000 years for the definition to evolve into the form we have today. The long struggle to formulate clearly and accurately this definition testifies to its richness and complexity. Thus, it is no surprise that students have difficulty understanding the limit and related notions. These laboratory exercises represent our efforts to help students become comfortable with the definition of limit and other important, related definitions in analysis, such as supremum and infimum, boundedness, limit superior and limit inferior, continuity, and uniform convergence.

The list does not come close to exhausting the list of topics covered in a first course. That was not our intention. Rather, the labs are designed to help students develop useful conceptions of the most elementary definitions and tools so that they can apply these fundamental ideas in the study of more difficult and involved topics such as differentiation, integration, and series of functions. In using the labs with our students, we have found that they have become more adept at solving problems and in proving theorems that involve their application of these fundamental concepts. In this sense, the labs have succeeded in helping our students to see the definitions of supremum/infimum, boundedness, limit, and continuity as building blocks, as opposed to stumbling blocks.

In designing these labs, we were inspired by the work of Ellen Parkes of DePauw University, who has used a laboratory approach to teach group theory. Each of her labs was designed to facilitate concept development or to guide students to formulate conjectures on the basis of working with a vast collection of finite groups that could be easily accessed and studied through use of computer software packages. Her approach intrigued us because it reflects the process by which some mathematicians formulate ideas. We have tried to emulate the same approach in this project, although our materials do not depend upon the use of a particular software package. In fact, several of the labs are designed to be done by hand, and many can be completed using a graphing calculator. For those labs where the use of technology proves to be beneficial, we have written Visual Guide Sheets using Maple code. Each Visual Guide can be found by going to the Real Analysis Resource link at www.summa.edu/~scho/jones. The Visual Guides also appear in the appendix. They will be updated periodically online to make refinements and additions.

One important way mathematicians understand concepts and suggest theorems is by working with specific examples. As a means of encouraging this practice, we have students work with many examples. However, we are not advocating a position that mathematics is an empirical field of inquiry.

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Over the past decade, the undergraduate abstract algebra classroom has undergone a dramatic transformation. Many faculty who were exposed to new pedagogical techniques during the calculus reform wanted to experiment with those techniques in more advanced classes. A variety of software packages were written or extended for use in abstract algebra. This collection of articles is the outgrowth of several gatherings of mathematicians who were interested in discussing the teaching and learning of abstract algebra. We, the editors of this volume, organized two contributed paper sessions entitled *Innovations in Teaching Abstract Algebra* at the 1997 and 1999 Joint Mathematics Meetings. One of the editors co-organized the NSF-UEF workshop *Exploring Undergraduate Algebra and Geometry with Technology* held on the DePauw University campus in June, 1996. We invited participants from these two contributed paper sessions and the workshop, as well as several other mathematicians, to write articles on a variety of new approaches in teaching abstract algebra.

We have chosen the articles that appear in this volume for several different purposes: to disseminate various

we have created a web site that accompanies this volume. It can be found at: <http://www.central.edu/MAANotes/>.

Engaging Students in Abstract Algebra. We begin this volume with several articles that present individual overviews of course structures. While these are personal examples, we hope that readers can extract useful information for their own classrooms. After a meeting at a NEXE session, Laurie Burton, Sarah Meric Bekasovic, and Maria McCormick decided to share their experiences with each other as they each navigated teaching algebra for the first time. The reflections in their article may be particularly appropriate for other first-time algebra instructors. Steve Benson and Brad Finkel provide a good discussion of some modified discovery techniques that the reader can implement. Gary Gordon uses geometry to help teach group theory, aided by several dynamic software packages. His article focuses on how the groups of symmetry can illustrate many algebraic concepts. Paul Fjelstad discusses how he has used some concrete experiences (special decks of cards, for example) to motivate students to build various abstract structures. Su Dorée shares



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Students who are U.S. citizens or permanent residents and will be undergraduates in the fall of 2009 are eligible to apply.

Preference will be given to applications received by February 31.

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