

The proposed project is for a group of **3 undergraduate students** at the University of Washington to do research and development of algorithms in **SAGE**, which is an open source mathematics software project started by the PI for research in algebra, geometry, number theory, cryptography, numerical analysis, statistics, and other areas (<http://sage.math.washington.edu/sage>). Student work would be done in conjunction with Jim Morrow's highly successful REU.

By joining the SAGE project, the PI hopes that participants will become involved in mathematical research, gain extensive knowledge about mathematical software, make long-term connections with a vibrant research and development community, and contribute tools that will be used by teachers and expert researchers in numerous fields. They will also learn presentation and writing skills, and really understand some part of mathematics deeply, which will prepare them to apply computational mathematics in graduate school and industry.

**The PI's involvement in Undergraduate Research:**

The PI, William Stein, has supervised over 20 undergraduate student research projects, ranging from deep theoretical work on the Birch and Swinnerton-Dyer conjecture and ranks of elliptic curves to difficult software engineering projects involving mathematical computation. One of his students, Yi Qiang, recently received the prestigious Mary Gates Research Grant, and gave an invited talk at an international workshop in Berkeley on his work with Stein on parallel computation.

**Intellectual Merit:**

Students will research and implement algorithms, write proposals, and give presentations to other REU students. They will design and implement algorithms for computing with mathematical structures such as groups, rings, fields, graphs, matrix spaces, varieties, manifolds, etc. Their work will be reviewed, commented on, and used by the growing worldwide community of SAGE users.

**Broader Impact:**

In addition to designing new algorithms, students will create freely available implementations of algorithms that have been developed over many years by work of dozens of Jim Morrow's REU students.

Another impact is that instead of students (e.g., in future REU's) having no choice but to pay to buy mathematics software, they will have the option to use SAGE for free. At many institutions and US high schools, purchasing computer software is a significant burden. SAGE could help address this problem.