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Undergraduate Research in Math

An Undergraduate Director's View

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1. Introduction: what is "math research"?

By this I mean any form of mathematical discovery undertaken outside a formal class structure. Working mathematicians typically do *original* research – proving new theorems (ie. mathematical facts) that were not already known. This can describe undergraduate research, too! But math is a hierarchical subject, and it's not always easy to find interesting open problems that can be taken on (or even understood) with undergraduate-level background knowledge.

However, there are many other forms of research that are worth doing. This can include further exploring topics first encountered in class, eg. by reading a textbook or journal article, or coding and/or running computer simulations. Fundamentally, the payoff is the joy of discovering something new, even if only to you. But doing undergraduate research has many other benefits: as a resumé line; as an introduction to new topics, techniques, and people; as a way of testing whether you enjoy the process; and in giving you interesting things to present (eg. at conferences) or just discuss with other smart people.

Doing math research typically requires significant individual initiative. But at the undergraduate level (and even at the graduate level and beyond), it's also really useful to have direction from someone who knows the field—a faculty member—and has well-developed judgement on what's interesting to do and how one might approach it. Many Math Department faculty members are interested in including undergraduates in their research, or introducing undergraduates to research. These faculty often have projects that are suitable for undergraduates with the right background.

2. Getting started; getting paid

During the school year, most undergraduate research in math is unpaid—as a rule, individual mathematicians don't have labs or money to support undergraduate researchers. However the Chancellor's Undergraduate Research Fellowship does offer in-term research

funding across disciplines for selected Pitt students. Less-exclusive math-related employment is available in-term and in the Department through our Math Assistance Center, which hires qualified undergraduates as TAs and tutors for some of our courses. Faculty-mentored research can be either informal or for course credit – in the latter case coming from Math 1902, "Directed Study".

A great way to get started with research is to approach a faculty member with whom you have some connection, for instance if they taught a course that you enjoyed and did well in, and ask if they are willing to mentor you through a research experience. As the Undergraduate Director, I am also happy to facilitate undergraduate research by matching students with faculty based on interests and skills. You are always welcome to reach out for my help.

During the summer there are several potential sources for financial support to do research, some of which I'll describe below. First, some programs that offer stipends to perform research *at Pitt* during the summer:

- The **Painter Fellowships**, offered by the Math Department thanks to a generous gift from the Painter family, provide two months of support for a summer undergraduate research project supervised by a Math Department faculty member. Applications do not require a project proposal or faculty member support.

- **SURA** (Summer Undergraduate Research Awards), offered by Pitt's Office of Undergraduate Research, offers support similar to the Painter Fellowships. Applications do require a project proposal and the support of a faculty member.

- The **Brackenridge Fellowship**, offered by the Frederick Honors College, has a similar application and support structure to SURA.

Having in-term research experience is a great way to increase the competitiveness of your applications for such support. I will post application links and deadlines (late winter/early spring) to the math majors listserv.

Many colleges and universities across the U.S. also host **REU**s (Research Experiences for Undergraduates) over the summer. These programs offer a stipend for students to come to campus for a fixed period to work on a preselected research project. The NSF (National Science Foundation) funds many of these, in different subject areas not limited to math; here is a link to a page with all of these:

`https://www.nsf.gov/crssprgm/reu/reu_search.jsp`

Funding from the NSF is only available to U.S. citizens, nationals, and permanent residents. However, there do exist REU-type programs funded from other sources (eg. the RIPS program at UCLA—google it), so if you are an international student, take heart and keep looking!

3. Presenting your work

So you did some work and learned some stuff—now what? Mathematicians usually write up their research results in papers and publish them in peer-reviewed journals, often posting them as preprints first. "The arXiv", `https://arxiv.org`, is a great way to get an unfiltered look at what research mathematicians are posting right now. If you scroll down that page to "Mathematics" and click on one of the subject headings there, you will see everything posted with that subject heading in the past five days.

Most undergraduate research papers do not meet the standards of significance and originality required by standard peer-reviewed math journals, however. This is no knock on undergraduate research but reflects the reality that math is a hierarchical subject. There are journals devoted to undergraduate research—*Involve* is a prominent example—but not enough. I understand that the current journal was conceived in part to address this shortfall. Send them your work!

Other opportunities to publicize your work are talks and poster presentations. Within the department, the **Undergraduate Research Colloquium** near the end of Fall semester is an opportunity to speak. **MathFest**, near the end of spring semester, features a poster presentation contest with prizes for the top posters. Another on-campus forum for a poster presentation is the **Undergraduate Research and Creative Expression Fair**, offered every Fall and Spring semester by the Provost's Office and the Student Success hub.

Regional conferences offer the opportunity to speak on your work without going too far from home. The **Young Mathematicians Conference** at Ohio State, taking place yearly in mid-August, features 20-minute talks by students as well as a few longer "plenary talks" by senior mathematicians. Students in MATH 1103, Mathematical Problems in Business, Industry and Government frequently attend and speak at **MAA**'s (Mathematical Association of America) Allegheny Mountain Section meeting.

National meetings of the major mathematical organizations have undergraduate research sessions alongside a myriad of other valuable opportunities to network and learn more about the field. Math majors Lark Song and Sasha Sluis-Cremer won an Honorable Mention for their poster presented at the MAA's national meeting (also titled "MathFest") this past August, for example. There are also student presentation and poster sessions at the Joint Meetings (a national meeting of the **AMS** (American Mathematical Society) and **SIAM** (Society for Industrial and Applied Mathematics), among other organizations) in January. The AMS offers some funding to support undergraduate travel to this event.

4. Conclusion

This article has shared some tips about the resources that exist to help you pursue mathematical research as an undergraduate. In a broader sense, the only true prerequisite for math research is curiosity and interest; and by reading this journal, and to this point in this article, you've already satisfied that. In that spirit I encourage you to continue pursuing the aspects of mathematical learning that most interest you, for as long as they continue to do so. And as I mentioned above, you are always welcome to reach out at any point where you would like help with that.