Summer Undergraduate Research in Mathematics at UNI

UNI Mathematics has funding for two undergraduate students to work on research projects under the direction of a faculty member during the summer of 2019. Each student will receive a stipend of $3,000 and the research is to be conducted over an eight week period. Student researchers are required to present a poster on their work at a poster symposium at the end of July.

The program is open to all students with a declared major or minor in a program offered by the Math Department, and who will still be in residence (including student teaching) in the fall of 2019. Interested students must submit their application materials to the Math Department office in WRT 220 by 5 pm on March 6th, 2018.

A complete application consists of all of the following documents:

- Applicant Information Form, including names of references
- Unofficial transcript
- Letter of application

Your letter of application should be a short statement (one page or less) explaining why you are interested in doing research this summer and why the project(s) you listed appeal to you. You are also welcome to describe a project (other than one of those listed) that you would like to work on this summer with a faculty mentor in the Math Department.

A copy of the Applicant Information Form is available at

https://sites.uni.edu/theron/SURP/index.html

For more information about the program, contact Prof. TJ Hitchman: *theron.hitchman@uni.edu*

Possible Research Projects:

This is a partial listing of possible research projects available to students in the summer of 2019. For more information on a particular project, contact the faculty member listed. If you want advice or information on the general program structure, please contact Professor Hitchman.

Project 1: Exploring PreService Elementary Teachers' Beliefs and Knowledge of Mathematics (Prof Hughes & Prof Steinthorsdottir)

Abstract: In the UNI elementary educator preparation program, pre-service teachers (PST) are required to take three mathematics content courses. These courses are structured to extend PSTs' mathematical content knowledge (MCK) and offer PSTs an opportunity to engage with mathematics in a different way than they have previously experienced. Dr. Hughes & Dr. Steinthorsdottir have designed a study to gain insight into (1) our pre-service teachers' MCK, and (2) our pre-service teachers' beliefs about mathematics and mathematics learning. By this summer, we will have collected data in the form of surveys, short answer mathematics problem solving sets, video recordings of problem-solving interview sessions, and audio recordings of interviews about PSTs' experiences in learning mathematics. This summer, we want to work as a research team to analyze this data. No prior experience is required. Applicants should be interested in and willing to work with a team of researchers to engage in mathematics education research.

Project 2: Proportional Reasoning and Middle School Students' Work (Prof Riehl)

Abstract: We will use a database of student solutions to missing value problems and explore. Possible directions include comparing solution strategies on direct and indirect proportion problems or investigating how the context of a problem affects the success rate. Another possibility is to look at how particular students perform on a sequence of problems ranging in difficulty. Can we figure out what the student understands and what s/he still needs to learn? A third possibility, more appropriate for applicants with statistics background, is to investigate how item response theory may be used to help make sense of the data.

Project 3: Finding Donuts Statistically (Prof Shaw)

Abstract: You exit the highway, because you want to go to the new bakery. But you don't know whether you should turn left or right. So you guess "right". You go on for a while, and then are thinking "Maybe I turned the wrong way?" Now - if you turn around too soon, that may be a disaster, because you have to retrace your path, go all the way back, go the other direction for a while, and eventually have to turn around again and find the bakery. If you turn around too late, you are getting farther and farther away from the bakery before you turn.

So using stats and calculus you… what? That's the issue!

I have some work that a previous student did on the problem, and need a self-starter to run with it. I will be out of town, so you have to be okay with working independently, and we will check in every day with a video chat. You also need to have some research skills, to see what has been done with the problem previously!

Project 4: Indices of Graphs (Prof Somodi)

Abstract: We will calculate several indices for all the graphs on up to *n* vertices (*n* will be fairly small) and look for pairs of non-isomorphic graphs for which these indices are equal. This is a computational project for a student who has taken (or is currently taking) Linear Algebra and Combinatorics and who is familiar with one mathematical software (e.g. Sage, Maple, etc).

Project 5: Curves in the p-norm (Prof Wood)

Abstract: There are plenty of curves that are defined by their special geometric properties. For example, an ellipse is a set of points whose sum of the distances to two fixed points is constant. Change "sum" to difference or product and you get hyperbolas and lemniscates. These and many other curves inherit various nice properties from these definitions. We will explore what happens when we keep the definitions of the curves the same but change the geometry. For example, what if we take the distance function to be the "taxicab metric" where the unit circle has equation $|x|+|y|=1$ instead of $x^2+y^2=1$? More generally, what if we use $|x|^p+|y|^p = 1$ for any p greater than or equal to 1? This is called the p-norm. What does an ellipse or a lemniscate or an Euler spiral look like now? We will explore these curves and in particular seek relationships among curves in dual norms, wherein we compare p-norm and q-norm curves where $1/p+1/q = 1$. This project requires only calculus, but some geometry, differential equations, or advanced calculus would be helpful. Experience in or willingness to work with computer algebra systems will be required.

Project 6: Knots and Covering Spaces (Prof Hitchman)

Abstract: To a mathematician, a *knot* is a smooth, closed loop in space… or a special kind of diagram drawn on a piece of paper. A secret trick mathematicians have is to imagine that piece of paper is part of a (very large) sphere. The sphere is the simplest example of a *surface*, and we could just decide to draw our diagrams on other surfaces. We'll investigate the relationships between these types of diagrams using a tool called a *branched cover*, and try to design a complexity measurement for knots. There will be some reading to do ahead of time about the basics of knots, but mostly you have to be ready to draw a LOT of pictures, in your head and on paper.

Project X: *Choose your own adventure* (Prof *Arranged*)

Have an idea for some summer research? Or a professor you would really like to work with? Suggest an idea for summer research and we can try to help you work out the details.

Contact Prof. Hitchman if you are unsure how to get started: *theron.hitchman@uni.edu*