# **Summer Research Opportunities in Mathematics at CSB/SJU**

 The Mathematics Department has funding for at least two continuing CSB/SJU students to engage in undergraduate mathematics research in cooperation with faculty here this summer. (We applied for additional student research positions and will find out about them in February.) Students interested in summer research should find a faculty sponsor in the Mathematics Department willing to work with the student. The student and faculty sponsor will choose one of the topics given below or propose another topic. The student then fills out the application on the last page and submits it electronically with a supporting e-mail from the sponsoring mathematics professor to Tom Sibley by February 15, 2019. The department will contact the students chosen to receive funding by February 27, 2019. Chosen students are asked to accept or decline by March 15, 2019. If you have further questions, contact Tom Sibley (e-mail: tsibley@csbsju.edu.)

**Logistical Information**

Students will be employed full time (40 hours per week) for 10 weeks. Last year students earned $10.09 per hour for a total of $4396 plus $1600 for room and board. (This coming summer’s rate isn’t yet known.) Note: Social Security and withholding taxes must be deducted. Both CSB and SJU will provide a summer meal plan and housing, although the meal plans may be different. Students should not have any other employment while they are doing the summer research. Students will meet regularly with their faculty advisors. The students and their advisors will decide the starting dates and ending dates, subject to the ten weeks of work, the constraints of the general research program and availability of rooms and meal plans. Because of the shift of the Mathematics Department to the Main building at CSB, students and faculty will be in the Main building and will have access to library resources, computers and office space. (Students can live on either campus or off campus, but transportation between campuses in the summer is not overly frequent. Students receive the board and room stipend whether or not they live on campus.) They are encouraged and expected to participate in all activities organized for summer research students. They will share the results of their research in writing and at suitable forums, including a summer research seminar and, if appropriate, at Mathfest/national Pi Mu Epsilon Conference from July 31 to August 3, 2019 in Cincinnati, Ohio and possibly other conferences later, including the Pi Mu Epsilon conference at St. Norbert College in November 2019 and our own Pi Mu Epsilon conference in April 2020. Travel funds to any conferences would be arranged.

**Descriptions of Possible Research Topics**

**Modeling Ecosystems via Flow-Kick Dynamics with Bob Hesse.** Work with real data to develop a mathematical model to try to depict past changes and predict future changes in a fish species population, including the effects of harvesting (fishing) and interactions with other species. Flow-kick dynamics are a new mathematical model for ecology. Pre-requisite: Math 239; Preferred: Math 337 or 339.

**“Lights Out” on Graphs with Travis Peters.** We generalize the game LIGHTS OUT! to different graphs. The vertices of the graph are the lights that can be on or off and the edges determine how neighboring vertices turn on or off as a vertex switches. Given an initial configuration of vertices that are on, the object of the game is to turn all the lights out. We will use topics from graph theory and linear algebra to help us investigate the game applied to Cartesian Product graphs and other types of graph products. Pre-requisite: Math 239.

**Permutation Bases with Bret Benesh.** People are working developing a way to send internet signals through power lines. This would have to the advantage of providing faster internet service than one can get from wireless while doing something they need to do anyway (charge their computer). This is based on "permutation bases," which are (very) roughly the smallest amount of information that one needs to know in order to rearrange an object symmetrically. See <https://www.youtube.com/watch?v=RJgxMUoX_ZE> for more information. Pre-Requisites: Math 239, preferred: 331.

**Games with Group Actions with Bret Benesh.** We will study how to come up with winning strategies for a variety of games involving permutations. A very simple example is the following game: Suppose that there is a "game board"

consisting of the numbers "1" and "2," and the game starts on "1." There are two moves that a play can do: stay where you are, or move to the other number. Each move can only be used once total. If the first player to move wants the game to end on the "1," what should the first player do? In this case, Player 1 cannot win. If Player 1 stays on "1," then Player 2 (necessarily) will switch to "2." If Player 1 switches to "2," then Player 2 will (necessarily) stay on "2." In either case, Player 1 loses. See <https://www.youtube.com/watch?v=dzBjXKaL0UQ> for more information. Pre-requisites: Math 239, preferred: 331.

**Groups with only cyclic quotients with Sunil Chetty.** We search for non-cyclic groups with only cyclic quotients G/N, where N is a nontrivial normal subgroup. For instance, **Z2 x Z2** is not cyclic, but its factor groups besides itself are all cyclic. Pre-requisite: Math 331.

**Generating Pythagorean triples of a given form with Sunil Chetty.** A Pythagorean triple consists of three integers x, y and z satisfying $x^{2}+y^{2}=z^{2}$. We investigate triples of special forms. (For instance, others have found infinitely many triples of the form x, y, y+1. For other forms we seek to prove whether there are infinitely many Pythagorean triples of that form. Also, we will look for algorithms to generate all Pythagorean triples of that form. If time we will try to generalize this problem. Pre-requisite: Math 241.

**Optimal Strategy for Machi Koro with Rob Campbell.** Machi Koro is a competitive board game where players are developing a town. On their turn, players will roll dice and purchase a building to add to their city. The dice rolls have effects based on the buildings in each player’s town. The goal for each player is to build all of their town’s landmarks first. See

<https://boardgamegeek.com/boardgame/143884/machi-koro> for more information on Machi Koro. Prerequisite: MATH 239, Preferred: also MATH 124, 318, or 345.

**Other Topics.** Contact a professor with whom you’d like to work, either with your own idea or ask her or him for suggestions.

**APPLICATION FORM**

DUE: February 15, 2019 electronically to Tom Sibley

NAME: \_\_Michael Klonowski\_\_\_\_\_\_\_\_ e-mail: \_mklonowsk001@csbsju.edu\_\_

YEAR: \_Sophomore (Junior credit-wise)

Name of sponsoring professor: \_\_Bret Benesh\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Have your sponsoring professor e-mail Tom Sibley confirming this sponsoring.

Do you have a work study grant? \_\_Yes\_\_\_\_\_\_\_

Do you wish to live at SJU? \_\_\_\_\_\_\_\_ OR at CSB? \_\_\_\_X\_\_

Do you wish to use the meal plan? \_\_No thanks\_\_\_\_\_\_\_\_

Please list any times in the summer where you would NOT be able to do research due to travel/events/etc.

Unknown at this time.

Check this line to indicate your commitment that, if chosen for summer research, you will write a report and give a presentation on your research \_\_\_X\_\_\_

For each mathematics course you have finished at CSB/SJU, list its number, professor and the grade you received:

Linear Algebra 239, Phil Byrne, A

Applied Statistical Models 318, Phil Byrne, A

Differential Equations 337, Michael Tangredi, A

Multivariable Calculus 305, Travis Peters, A

List all mathematics courses you are currently enrolled in here:

Fourier Analysis with Michael Tangredi

Describe the project you wish to do. (If it is one of those described in the announcement, you may refer to that description. For your own proposal, consult with your sponsoring professor to develop a description.)

 I would like to work on Permutation Bases with Bret Benesh as described in the announcement.

Describe why you would like to do this research.

I have always been interested in research in mathematics. One of the main reasons I came to CSB/SJU was the easy access to research opportunities. Last summer, I applied to numerous physics REU’s. Unfortunately, I was not accepted in any program. However, my passion for research has not dwindled, and the more math and physics classes I take, the more I am interested in participating in a research project. As a double physics and mathematics major, Bret’s proposal peaked my interest due to its application to a real-life engineering problem. This research opportunity fits perfectly with my double major, and will allow me to apply both physics and mathematical concepts to effectively research the topic. I am excited for the opportunity to use my skills to research an interesting mathematical topic.