



# FRISPIES with MATH

H. Barton Excellence Professor Ratnasingham Shivaji was awarded the 2022 UNCG Senior Research Excellence Award for his accomplishments in differential equations research as well as his lengthy record as a teacher and academic mentor. He is known as a passionate educator who burns the midnight oil working with students. This year, he also received UNCG's Excellence in Graduate Mentoring Award.

Over more than four decades as a mathematician, Dr. Shivaji has conducted research in partial differential equations, with a focus on reaction-diffusion systems. The work has applications in nonlinear heat generation, combustion theory, chemical reactor theory, population dynamics, and ecology.

An internationally renowned authority on positone and semipositone problems, Shivaji has 180 publications with over 4,000 citations, has given 24 plenary talks across the world, and is a Fellow of the American Mathematical Society. His successful funding record includes six major NSF research grants as well as a host of conference grants.

## **MATH IS FUN**

"Students are my research collaborators and friends. We often form teams of PhD students, master's students, and undergraduates to work on a project. I love to see undergraduates experience the excitement of discovery. They often do not get this adventure in their classes.

"We all get together either in the department or in the coffee shop – we don't need labs. We will have coffee, have lunch, and we'll continue to have fun working on research problems.

"That's what I always emphasize for my students: 'Let's have fun doing research.'"

## **MATH AND SCIENCE INTERACTIONS**

"I have worked with combustion theory problems. Now I'm working quite a bit in population ecology. I have a co-investigator who is a renowned ecologist at Louisiana State University. We're trying to model mathematically what his team discovers through field research.

"We're looking at competing and cooperating species inside a certain region – things like that. How the two species interact is complicated – they might cooperate in the interior of the region, but when they come to the boundary they might compete. In the past, mathematical ecology was more focused only on the interior of a region. Now we're looking at how exterior regions can also impact what's happening in the interior. We build mathematical models and analyze them to provide answers."

## **REACTION DIFFUSION SYSTEMS**

"A region could be anything – a lake, a metal plate, or whatever. Then comes the issue that I'm very interested in: measuring a quantity – like population density or temperature – at a specific

position at a specific time. The quantity changes due to reactions – like births and deaths and external forces, due to diffusion – like the effects of crowding, and due to the nature of the boundary. For example, if you’re looking at a lake as the region and the exterior is land, that’s a hostile boundary because crossing is impossible for many species. With other kinds of boundaries, an animal population might come into a region and then go back out more easily.”

### SOLUTIONS

“In these systems, I’m looking for long-term, steady state measures of a particular quantity – this happens when the quantity in a certain position essentially stops changing over time. That may or may not happen. We attempt to determine if there is a unique steady state, multiple steady states, or no steady states. Identifying steady states is very important to understanding time-dependent dynamics in a system.

### UNCG EDGE

“One of the things I like about our program is that, even though I’m not a computational expert, all my PhD students are now experts in both analytical plus computational mathematics, thanks to fantastic colleagues in my department, like Dr. Tom Lewis and Dr. Yi Zhang. They are on my students’ committees and work with them

on the computational components. So we’re graduating students competent on both sides. That’s a big plus. They have a different flavor when they go into the mathematics job hunt.”

### CAREER PHILOSOPHY

“I served as head of UNCG’s Department of Mathematics and Statistics from 2011 to 2019. A department head, for me, is a servant leader. That was my model. But I don’t want to go beyond the department because I need to stay close to mathematics. That’s where my love is. Mathematics is the universal language that we all need to speak – it’s important for logical reasoning.

“When it comes to teaching students, I want to share the beauty and power of mathematics. To help prepare the next generation of mathematicians who love research and teaching. And to expand my group of research buddies.”

*Interview by Mark Toczak • learn more at [mathstats.uncg.edu](http://mathstats.uncg.edu)*

**WHEN  $f(0) < 0$**  Shivaji and his collaborators pioneered the study of semipositone problems. On the board below, Shivaji writes out the beginning of the equation on which his landmark paper is based.


$$\left\{ \begin{array}{l} \Delta u = \lambda f(u) : \Omega \\ u = 0 : \partial\Omega \end{array} \right.$$

