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Professor creates introductory book to advanced computational mathematics

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The Lockheed F-117 Nighthawk stealth plane cuts through the air at a top speed of 617 miles per hour. Part of its incredible speed is a function of the aircraft's shape, deriving from both human ingenuity and computerized shape optimization.

University assistant professor Shawn W. Walker studies shape optimization and recently authored rare to nearly nonexistent textbook material — an introduction to shape optimization and surface geometry, the building blocks for the industrial science that optimizes the speed of cars, boats and planes.

"All the other books that deal with shape derivatives are really advanced and are meant for minimum grad students," Walker said. "This, as far as I know, is the only undergrad level book on this stuff at all and should definitely be useful for grad students or students in other fields without getting bogged down in enormous details of the math."

The textbook, "The Shapes of Things: A Practical Guide to Differential Geometry and the Shape Derivative," introduces readers to learning simulation with differential geometry, a more advanced mathematical field usually taught in graduate schools.

"I would like to do a follow up book that is a little more advanced and goes into how you actually apply this on a computer such as developing algorithms to do optimization," Walker said.

Walker, who just finished his fifth year at the University, holds a joint appointment with the Department of Mathematics and the Center for Computation & Technology. He said the idea for a textbook stemmed from his lecture notes. After showing the notes to a few individuals, Walker decided the notes would serve well as an introduction for undergraduates and professionals in different fields.

The textbook took about a year to go through the publishing process, going through peer reviews, multiple edits and re-edits and finally becoming available through the Society for Industrial and Applied Mathematics in late June.

Walker said his research specifically focuses on moving boundary theories and shape optimization as it relates to fluids. He said shape optimization can be used for boats, cars or even the shape of a curve in a pipeline to diminish the amount of turbulence the water creates at the bend.

"What's the optimal shape of the boat so that it goes through the water faster? What's the optimal shape of the propeller to get as much thrust out?" Walker said.

The Virginia-born professor teaches numerical analysis courses and computational mathematics, which deals with modeling physics on a computer and how to develop simulation methods for recreating fluid dynamics.

"Learn a simulation to predict the process you are trying to run that way you can use the simulation to tweak the process," Walker said. "In other words you are trying to optimize your industrial process."

University students may first get the opportunity to use Walker's new textbook as supplemental reading in a graduate course Walker hopes to teach next spring.

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