

# Publications

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*Modified November 2014*

## DOCTORAL THESIS

### **Mathematical Model of a Protein-Protein Interaction Network**

The University of Connecticut (2001).

<http://proquest.umi.com/pqdweb?did=728955001&sid=19&Fmt=2&clientId=48996&RQT=309&VName=PQD>

Multicellular organisms have a complex signaling system that allows for efficient intercellular crosstalk. This requires that each cell has a mechanism to read and understand the information coming from other cells. In this paper, we analyze a theoretical model of protein-protein interaction with respect to cell signalling.

## REFEREED PUBLICATIONS

### **Publications in Press.**

#### **Mathematical Model of a Protein-Protein Interaction Network**

Nonlinear Studies, 10 (2003), no. 3, 201-220.

<http://nonlinearstudies.com/index.php/nonlinear/article/view/148>

A spatial-temporal model of theoretical protein-protein interactions is developed to analyze the behavior of a network of proteins that exist in two states: active and inactive. After given an initial protein concentration, the proteins activate and inactivate proteins in the network. After the proteins interact with each other, the concentrations of the proteins reach a unique steady state. This model mathematically explains how a network of proteins generates a specific protein concentration.

#### **A Mathematical Model for LH Release in Response to Continuous and Pulsatile Exposure of Gonadotrophs to GnRH**

With J. Joseph Blum, Michael C. Reed, and P. Michael Conn. Theoretical Biology and Medical Modeling, 1 (2004), no. 9, pgs. 1-17.

<http://www.tbiomed.com/content/1/1/9>

In a previous study, a model was developed to investigate the release of luteinizing hormone (LH) from pituitary cells in response to a short pulse of gonadotropin-releasing hormone (GnRH). The model included: binding of GnRH to its receptor (R), dimerization and internalization of the hormone receptor complex, interaction with a G protein, production of inositol 1,4,5-trisphosphate (IP3), release of calcium from the endoplasmic reticulum (ER), entrance of calcium into the cytosol via voltage gated membrane channels, pumping of calcium out of the cytosol via membrane and ER pumps, and release of LH. The extended model, presented in this paper, also includes the following physiologically important phenomena: desensitization of calcium channels; internalization of the dimerized receptors and recycling of some of the internalized receptors; an increase in  $G_q$  concentration near the plasma membrane in response to receptor dimerization; and basal rates of synthesis and degradation of the receptors. With suitable choices of the parameters, good agreement with a variety of experimental data of the LH release pattern in response to pulses of various durations, repetition rates, and concentrations of GnRH were obtained. The mathematical model allows us to assess the effects of internalization and desensitization on the shapes

and time courses of LH response curves.

### **Mathematical Modeling of the Chemical Vapor Infiltration Process**

With Andrew D. Jones, Pierre Ngnepieba, and Derrick K. Rollins. Proceedings of the International Conference on Carbon (2007).

The Chemical Vapor Infiltration (CVI) process produces high performance ceramic composite materials. This process involves running a gas into a pyrolysis chamber at high temperatures to cause desired reactions within preforms of various shapes and chemical compositions. Achieving the desired pore filling in the least amount of time requires modeling and subsequent optimization of the reaction parameters such as temperature, pressure, and initial porosity of the preform. In this paper we present a model that describes gas transport phenomena, reaction kinetics and pore filling. With very few assumptions, the model predicts the concentration of gas molecules and the void in the preform. The proposed mathematical model yields a straight forward numerical algorithm that accurately simulates the process.

### **Evansville Honors the First Black Ph.D. in Mathematics and His Family**

The Notices of the American Mathematical Society, 55 (2008), no. 5, pgs. 588-589.

<http://www.ams.org/notices/200805/tx080500588p.pdf>

Elbert Frank Cox is the first black to earn a doctorate in mathematics. In 2007, I coordinated the installation of a plaque at the 600 Block of Cherry Street in Evansville, Indiana that gives honor to Johnson Duncan Cox and his son, Elbert Frank Cox. I joined the Evansville-Vanderburgh School Corporation, University of Evansville, University of Southern Indiana, and Ivy Tech Community College to support the plaque. This is an effort that I led out of my personal obligation to remember our past as I am the second African American from Evansville to earn a doctorate in mathematics.

### **A Tasty Combination: Multivariable Calculus and Differential Forms**

With Edray Herber Goins. The Pentagon, 69 (2009), no. 1, pgs. 11-28.

<http://arxiv.org/abs/0910.0047>

Differential Calculus is a staple of the college mathematics major's diet. Eventually one becomes tired of the same routine, and wishes for a more diverse meal. The college math major may seek to generalize applications of the derivative that involves functions of more than one variable, and thus enjoy a course on Multivariate Calculus. We serve this article as a culinary guide to differentiating and integrating functions of more than one variable using differential forms which are the basis for de Rham Cohomology.

### **Sphere-of-Influence Graphs**

With Edray Herber Goins. Wolfram Demonstrations Project (2010).

<http://demonstrations.wolfram.com/SphereOfInfluenceGraphs/>

Let  $S$  be a set of vertices chosen from a grid. Given a vertex  $V$  in  $S$ , let  $N(V)$  be the closest neighbor to  $V$  in  $S$ . Draw a circle with center  $V$  and radius  $|V - N(V)|$ , then draw an edge between two vertices  $U$  and  $V$  if their circles intersect in more than one point. This gives the "sphere-of-influence" graph for the given set of vertices. This demonstration provides a graphical representation of such graphs.

### **A Note on Fixed Points of Iterations of Real-Valued Functions**

International Journal of Pure and Applied Mathematics, 61 (2010), no. 3, pgs. 297-300.

<http://www.ijpam.eu/contents/2010-61-3/5/5.pdf>

In this paper we consider the fixed points of both real- and complex-valued continuous functions. We provide clarification of a result by Mohammad K. Azarian. In particular, we discuss how the fixed points of a given function  $f$  are related to the fixed points of its iterates

$$f^n(x) = \underbrace{f(f(\dots f(x)\dots))}_{n \times}$$

where  $n \geq 1$ .

### **Building Better Scientists Through Cross-disciplinary Collaboration in Synthetic Biology: A Meeting Report from the Genome Consortium for Active Teaching Workshop 2010.**

With Michael J. Wolyniak, Consuelo J. Alvarez, Vidya Chandrasekaran, Theresa M. Grana, Andrea Holgado, Christopher J. Jones, Robert W. Morris, Anil L. Pereira, Joyce Stamm, and Yixin Yang. CBE-Life Sciences Education, 9 (2010), no. 4, pgs. 399-404.

<http://www.lifescied.org/cgi/content/full/9/4/399>

Synthetic biology is the application of engineering and mathematical principles to develop novel biological devices and circuits. It is a newly emerging field in which costs are relatively low and the value of student input can be high. It rewards tackling the sort of interdisciplinary problems that are increasingly important for students' professional futures but are often difficult to undertake from traditional disciplinary towers. This paper summarizes GCAT Workshop 2010, and presents an introduction to synthetic biology for those who want to explore this exciting new field.

### **A Note on an NSFD Scheme for a Mathematical Model of Respiratory Virus Transmission**

With Ronald E. Mickens. Journal of Difference Equations and Applications, 18 (2012), no. 3, pgs. 525-529.

<http://arxiv.org/abs/1008.2314>

We construct a nonstandard finite difference (NSFD) scheme for an SIRS mathematical model of respiratory virus transmission. This discretization is in full compliance with the NSFD methodology as formulated by R. E. Mickens. By use of an exact conservation law satisfied by the SIRS differential equations, we are able to determine the corresponding denominator function for the discrete first-order time derivatives. Further, the scheme is shown to satisfy a positivity condition for its solutions for all values of the time step-size.

### **The Area of the Surface Generated by Revolving a Graph About Any Line**

With Edray Herber Goins. PRIMUS, Vol. 23, Iss. 2 (2013), pgs. 121-132.

<http://arxiv.org/abs/1108.2624>

We discuss a general formula for the area of the surface that is generated by a graph  $[t_0, t_1] \rightarrow \mathbb{R}^2$  sending  $t \mapsto (x(t), y(t))$  revolved around a general line  $L : Ax + By = C$ . As a corollary, we obtain a formula for the area of the surface formed by revolving  $y = f(x)$  around the line  $y = mx + k$ .

## **A Note on Exact Finite Difference Schemes for the Differential Equations Satisfied by the Jacobi Cosine and Sine Functions**

With Ronald E. Mickens. *Journal of Difference Equations and Applications*, Vol. 19, Iss. 2 (2013), pgs. 1042-1047.

<http://dx.doi.org/10.1080/10236198.2012.754020>

We construct the exact finite difference equation discretizations for the nonlinear differential equations whose solutions are the Jacobi cosine and sine functions. Our derivations clarify and extend previous work done on this topic.

## **NSFD Representations for Polynomial Terms Appearing in the Potential Functions of 1-Dimensional Conservative Systems**

*Computers & Mathematics with Applications*, Vol. 66, Iss. 11 (2013), pgs. 2251-2258.

<http://dx.doi.org/10.1016/j.camwa.2013.06.017>

We provide a methodology for the construction of nonstandard finite difference (NSFD) schemes for 1-dim conservative dynamical systems. Such systems are used to model a broad range of nonlinear oscillators. To obtain the desired representations, we imposed conditions following from the constraints of parity invariance and the conservation of energy. A further, practical computational requirement is that these schemes be explicit and linear in the dependent variable evaluated at the upper discrete-time level. The current work extends previous studies by Mickens et al. Finally, we present an example of a non-polynomial potential and indicate how it can be treated within the NSFD method.

## **NSFD Discretizations of Interacting Population Models Satisfying Conservation Laws**

With Ronald E. Mickens. *Computers & Mathematics with Applications*, Vol. 66, Iss. 11 (2013), pgs. 2307-2316.

<http://dx.doi.org/10.1016/j.camwa.2013.06.011>

We consider the roles conservation laws can play in providing restrictions on the construction of finite difference discretizations of interacting population systems, modeled by coupled ordinary differential equations. Our analysis is formulated within the nonstandard finite difference (NSFD) methodology of Mickens. A major feature of this paper is the recognition that several distinct types of conservation laws exist. Using a number of well-known population models, we illustrate the details of our procedures by constructing appropriate NSFD discretizations. The relevance of these results to various issues associated with the numerical integration of the original population system differential equations is also presented, especially the role of positivity of the solutions.

## **On the Generalized Climbing Stairs Problem**

With Edray Herber Goins. *Ars Combinatoria*, Vol. 117 (2014), pgs. 183-190.

<http://arxiv.org/abs/0909.5459>

Let  $\mathcal{S}$  be a subset of the positive integers and  $M$  be a positive integer. Mohammad K. Azarian, inspired by work of Tony Colledge, considered the number of ways to climb a staircase containing  $n$  stairs using “step-sizes”  $s \in \mathcal{S}$  and multiplicities at most  $M$ . In this exposition, we find a solution via generating functions, i.e., an expression that counts the number of partitions of  $n = \sum_{s \in \mathcal{S}} m_s s$  satisfying  $0 \leq m_s \leq M$ . We use this to answer a

series of questions posed by Azarian and we conclude by posing an open problem.

### **Submitted Publications.**

#### **A Note on Exact Discretization for a Cauchy-Euler ODE: Application to the Black-Scholes Equation**

With Ronald Mickens and Justin Munyakazi.

### **Publications in Progress.**

#### **Ordinary Differential Equations**

With Edray Herber Goins.

This textbook will cover the theory of ordinary differential equations by focusing on applications to various branches of science, including applied mathematics, biology, chemistry, and physics. It is meant to be used for advanced undergraduates or as a reference manual for graduate students. (The first 60 pages concerning first order differential equations has been completed. The authors have discussed publication deals with two book companies.)

#### **Ordinary Differential Equations: Worked Examples with Solutions**

With Edray Herber Goins.

This textbook is meant to be a companion to “Ordinary Differential Equations.” Each of the exercises in the aforementioned book will contain a detailed solution. (Some 100 pages have been completed in this solution manual; the exercises concerning first order differential equations have already been written up.)

### **Supervised Undergraduate Students.**

#### **Improving the Mathematical Model of the Tacoma Narrows Bridge**

Brian Fillenwarth. *Rose-Hulman Undergraduate Math Journal*, 8 (2007), no. 2.

<http://www.rose-hulman.edu/mathjournal/archives/2007/vol8-n2/paper7/v8n2-7pd.pdf>

In this paper, we investigate the mathematical model for the torsional rotation of the Tacoma Narrows Bridge derived by P.J. McKenna. Through modifying this model and programming various cases of these modifications using MATLAB, we explore how the Tacoma Narrows Bridge would respond to different loading conditions that may have occurred the day the bridge collapsed. From this we are able to gain a better understanding of how the bridge actually behaved prior to its collapse, and can see possible reasons for the ultimate collapse.

### OTHER

### **Editorship.**

From 2010 to 2012, I was the Editor of the National Association of Mathematicians (NAM). NAM is a professional organization that serves under-represented minorities in the mathematical sciences. The following editions of the *Newsletter* can be found at <http://nam-newsletter.org>.

### **Young Gifted and Black**

*NAM Newsletter*, 41 (2010), no. 1, 12 pages.

**Education, Empower and Create New Frontiers**

*NAM Newsletter*, 41 (2010), no. 2, 12 pages.

**Strength in Numbers**

*NAM Newsletter*, 41 (2010), no. 3, 20 pages.

**Black, Brown and Beige Together**

*NAM Newsletter*, 41 (2010), no. 4, 20 pages.

**The Next Generation of Scholars**

*NAM Newsletter*, 42 (2011), no. 1, 12 pages.

**Mathematical Inspiration**

*NAM Newsletter*, 42 (2011), no. 2, 12 pages.

**It's Math**

*NAM Newsletter*, 42 (2011), no. 3, 16 pages.

**We Math So Hard**

*NAM Newsletter*, 42 (2011), no. 4, 20 pages.

**Mathematical Light**

*NAM Newsletter*, 43 (2012), no. 1, 16 pages.

**Non-technical Publications.**

Activities outside the university include writing articles for non-technical publications. These include educational and social topics of interest to the local community.

**Evansville Man Led Inspiring Life as Math Pioneer**

Evansville Courier & Press, April 18 (2006), A7.

<http://www.courierpress.com/news/2006/apr/18/evansville-man-led-inspiring-life-as-math/>

**Low Dropout Rate Helps Us All**

Evansville Courier & Press, July 17 (2006), A9.

[http://faculty.evansville.edu/tw65/low-dropout-rate-helps-us-all\\_July\\_17\\_2006.pdf](http://faculty.evansville.edu/tw65/low-dropout-rate-helps-us-all_July_17_2006.pdf)

**Cyclists Do More Than Spin Wheels**

Evansville Courier & Press, July 29 (2008), A6.

<http://www.courierpress.com/news/2008/jul/29/cyclists-do-more-than-spin-wheels/>

**New Definition of 'American' Has Arisen**

Evansville Courier & Press, November 9 (2008), A15.

<http://www.courierpress.com/news/2008/nov/09/new-definition-of-american-has-arisen/>