Astronomy, Mathematics and Physics
(Including **Materials Science**)

STOCHASTIC STIFFINESS MATRIX AND MODAL ANALYSIS IN NON-DESTRUCTIVE DAMAGE DETECTION IN STRUCTURES. Anthony A. Teate, Department of Integrated Science and Technology, James Madison University, 800 S. Main St., Harrisonburg, VA 22807. We examine from first principles the effects of stochasticity in the stiffness matrix on the modal differential equations for a vibrating structure. We construct generalized stochastic model equations which describe the dynamical properties of the structure. The stochastic stiffness matrix is statistically described as a stationary, random, Gaussian stochastic process with zero mean. Closed form solutions of the equations are developed through calculation of all necessary moments. It is shown that a fluctuating stiffness matrix, and concomitantly the fluctuating frequency, can lead to an incorrect estimation of the frequency bandwidth of the frequency response function. This can result in an erroneous estimation of the damping and associated deformation in a structure. Similarly, the experimentally determined phase is shown to be in error when the effects of stochasticity in the frequency are neglected. We discuss the implications of these results on modal analysis when used in nondestructive testing and evaluation of damage in structures.

EVIDENCE OF A LONG-TERM WARMING TREND IN CHESAPEAKE BAY, VIRGINIA. William C. Coles[1], Thomas C. Mosca III[2], & Yohana K. Flores[3], [1]Division of Fish and Wildlife – Department of Planning and Natural Resources – U.S. Virgin Islands, [2]Rappahannock Community College, Dept of Mathematics, 52 Campus Drive, Warsaw, VA 22572, & [3]Rappahannock Community College, 52 Campus Drive, Warsaw, VA 22572. Water temperature data collected on the York River at Gloucester Point, Va. from 1954 until the 2002 were analyzed for trend. Water temperature is a sum of many functions, some periodic and some not. By collapsing the data into annual summer and winter means, the long-term trend was exposed. The trend was established to exist in the entire Virginia portion of the Chesapeake Bay by comparison with similar means of data collected on the tidal portions of the James, York, and Rappahannock Rivers, and the Chesapeake Bay over the years 1984 through 2008. The long-term trend indicates increasing temperatures, with a recorded change of 1.5 ºC over the period of record. The warming trend is persistent across every location and time period examined. We thank Virginia Institute of Marine Science, Old Dominion University, and Virginia Department of Environmental Quality for the data used in this study.

ALGEBRAIC TORSION AND GENERAL RELATIVITY. Joseph D. Rudmin, Dept. of Integrated Sci. and Tech., James Madison Univ., Harrisonburg VA 22807. Ed Parker and James Sochacki have discovered a powerful way of finding polynomial approximations to systems of differential equations. This "Parker-Sochacki" or "Power-Series" method always finds the Taylor Series approximation to a given order, if such approximation exists, and has absolute error limits. For most practical applications, a Padé approximant derived from the Taylor Series provides better fit than the Taylor Series. However, both Taylor Series and Padé Approximants have difficulty modeling poles in the solution. Often one can best model a pole by a change of variable, where the variable explicitly contains the pole. The change of variable can be found from the differential equations by eliminating the highest order feedback loop in the Parker Sochacki approximation, thereby simplifying those equations.

ALGEBRAIC TORSION AND GENERAL RELATIVITY. Joseph D. Rudmin, Dept. of Integrated Sci. and Tech., James Madison Univ., Harrisonburg VA 22807. Algebraic torsion offers a compact representation of Lorentz transformations, and contains the same symmetry as Dirac Spinors of quantum relativity, in a context that might be extended to general relativistic tensors, unifying the two theories. This talk elaborates on algebraic torsion as discussed in the book *Geometric Algebra and Applications to Physics* by Venzo De Sabbata and Bidyut Kumar Datta.

CALCULATING THE EXACT POOLED VARIANCE. Joseph W. Rudmin, Dept. of Physics and Astron., James Madison University, Harrisonburg VA 22807. An exact method of calculating the variance of a pooled data set is presented. Its major advantages over the many other methods are that it is simple, involves no assumptions, and is exact. The Exact Pooled Variance is the mean of the variances plus the variance of the means of the component sets." In this calculation, all means are averages weighted by the number of points in each data set. The statement will be proven, and the practical significance discussed. Please refer to this method as "the Exact Pooled Variance". This paper is available at:
http://csma31.csm.jmu.edu/physics/rudmin/PooledVariance.htm

COUPLED AND UN-COUPLED ORDINARY DIFFERENTIAL EQUATIONS: WHAT IS THE IMPLICATON? James S. Sochacki, Dept. of Math, James Madison Univ., Harrisonburg VA 22807. Let n, m be natural numbers. Let xÎ$\mathbf{R}^n$ be a function depending on t and let $f : \mathbf{R}^n m \rightarrow \mathbf{R}^n$ be a function on $\mathbf{R}^n$. Consider the autonomous system of n ordinary differential equations (ODEs) of order m given by $x^m = f(x, x', x'', \ldots, x^{m-1})$. If $n=1$ then we only have one ODE depending on the single variable x and we say the ODE is uncoupled from any other ODE. If $n>1$, but we can write the n ODEs as n uncoupled ODEs, then we say the system is uncoupled. Otherwise, we say the system is coupled. In this talk I will show how to uncouple a large class of ODES that are coupled. I will also discuss the mathematical, physical, and philosophical consequences of this surprising result.

DESIGN AND CONSTRUCTION OF A TWO-BEAM ASTRONOMICAL POLARIMETER. Gregory A. Topasna, Daniela M. Topasna, Gerald B. Popko, Department of Physics and Astronomy, Virginia Military Institute, Lexington, VA 24450. We present the progress made on the two-beam optical polarimeter that was designed and constructed at Virginia Military Institute. We discuss the transition from laboratory testing and design to the construction of a portable working prototype currently being evaluated at the 20-inch telescope at the VMI observatory. Current results and capabilities of the instrument, as well as planned observations, will be presented

EXPLORING "THE GAME OF LIFE" IN SMALL WORLDS. Richard L. Bowman, Dept. of Physics, Bridgewater College, Bridgewater, VA 22812. While Conway's "Game of Life," an example of 2-D cellular automata, has been shown to have parallels with the biological world, researchers debate the role of boundary conditions in large universes on the patterns and behaviors observed there. This paper examines the effects of various boundary conditions on small worlds, 25 X 25 cells or smaller, and illustrates the dramatically different behavior resulting from an identical starting arrangement of cells (seed), the R-pentamino. The boundary conditions are referred to by their geometric analogs: torus, box, loop, and Möbius strip.

WHEN STEVEN HAWKING'S ALIENS ATTACK, A MATHEMATICAL MODEL. Yooryeon "Eddy" Jeon and Kristopher M. Kalish, Dept. of Mathematics and Statistics, James Madison University, Harrisonburg, VA 22807. This project is a model of a hypothetical extraterrestrial biological attack on the planet earth. The model used is a modified Kermack-McKendrick S-I-R model for infectious diseases. The model itself tracks the progression of a zombie outbreak throughout the population of the Earth. It takes into account three primary factors: susceptible humans in the population, the number of zombies created in relation to the population, and the process of reanimation. Each equation also has several factors that are used to judge the spread of infection throughout the population: a birth rate that is consistent with the population, natural death, reanimation, and contact with an infected individual. A Zombie attack presented several challenges due to the fact that there is no known natural immunity or cure, and that the members of the population who die either naturally or by contact with a zombie, will reanimate and become a zombie. The method used to solve the S-I-R differential equations is the Parker-Sochacki method, developed by Dr. Edgar Parker and Dr. James S. Sochacki of James Madison University's Dept. of Mathematics and Statistics. The software programs Maple 13 and MatLab were used to model the progression of the attack through the population once the equations were set up. This was a group project between the presenters' Math 441 class at James Madison University.

Biology
(including **Microbiology and Molecular Biology**)

CORRELATION OF CHRONIC DISEASES WITH THE PRESENCE OF *TROPHERYMA WHIPPLEI* DNA IN SALIVA. Muhammed Faizan Casim & Lynn O. Lewis, Department of Biological Sciences, University of Mary Washington, Fredericksburg VA 22401. Whipple's disease is a rare systemic infection caused by the