Summer Math Integrated Learning Environment
SMILE@LSU
The Vigre Summer Program 2009

The following four courses are being offered for summer 2009

1. **Instructor**: Professor Mark Davidson (**MD**), Louisiana State University.

   The Surprising Roles of the Laplace transform in Analysis and Algebra: This short course explores the surprising roles that the Laplace transform has in analysis and algebra. The first part of the course would provide coverage of the basic Laplace transform principles. Then we pursue a non-standard approach to linear and systems of differential equations. Further lectures would be designed to support the projects listed below.

   Projects

   (a) Applications in Linear algebra such as the Cayley-Hamilton Theorem, Diagonalization of self adjoint operators, The Jordan canonical form.

   (b) Finite Difference equations.

   Textbook: Notes will be provided.

2. **Instructor**: Professor Keng Deng (**KD**), University of Louisiana, Lafayette.

   Differential Equations with Applications to Mathematical Biology: This course focuses on ordinary differential equations and their applications to many models of biological systems. It will present theory and methods such as well-posedness, local stability in first order equations, phase plane analysis, Poincare-Bendixson Theorem, global stability, and Lyapunov functions. It will also discuss some well-known mathematical models in biology including Logistic equation, harvesting a single population, predator-prey models, and SIR epidemic model. The mathematical and biological background required is kept to a minimum so that the topics are accessible to students in mathematics, biology, and engineering.

   Projects:

   (a) Consider any biological system with three or more interacting populations. Such a system can be composed of one population that has been divided into three or more stages (subpopulations); Develop a set of differential

equations which describes the dynamics of the biological population system; State clearly what questions you are interested in answering or what hypotheses you are interested in testing with this biological population using the set of differential equations you developed; Perform the necessary analysis to answer these questions.

Text: recommended but not required, 'An introduction to Mathematical Biology' by Linda J. B. Allen.

3. **Instructor**: Professor Walfredo Javier (**WJ**), Southern University

   Probability Models: This course explores the application of elementary probability theory and stochastic processes to mathematical modeling. Topics covered are: Probability theory; Random Variables; Conditional Probability and Conditional Expectation; Markov Chains.

   Projects

   (a) Queen Dido's Hide and the Minimal Arc-Length Problem

   (b) Confidence Interval for Population Variance

   (c) Information Measure for a mixture of two bivariate normal distributions

   Text: Sheldon Ross, Probability Models

4. **Instructor**: Professor Bob Lax (**BL**), Louisiana State University.

   Systems of Polynomial Equations and Groebner Bases: Groebner Bases provide an algorithmic method for solving systems of polynomial equations, and they are used in symbolic software such as Mathematica and Maple. In certain circumstances, this method may be viewed as a generalization of Gaussian elimination for solving systems of linear equations. We will use

   Textbook: "Ideals, Varieties, and Algorithms" by Cox, Little, and O'Shea

   to present an introduction to Groebner Bases and Affine Algebraic Geometry. We will also be using Mathematica in the course.

   Prerequisite: Linear Algebra.

   Projects:

   (a) Investigate how a Groebner basis changes as the monomial ordering changes: FGLM algorithm, Groebner Walk.

   (b) Groebner Bases and Robotics: Chapter 6 of the text.

(c) Error-correcting codes and Groebner Bases: This involves Groebner Bases over finite fields and their use in decoding.

(d) Groebner Bases and public-key crytptosystems: The Buchberger algorithm for finding a Groebner basis can be very time-consuming, which has prompted some people to propose using Groebner bases in cryptography.