IDETC/CIE 2009 Workshops and Tutorials
Sunday, August 30, 2009
San Diego Convention Center

TU 1:	Numerical Methods Using Excel/VBA for Engineers
Location:	San Diego Convention Center
Date:	Sunday, August 30, 2009
Time:	1:00 PM – 5:00 PM
Fee:	$75 Early / $100 Late
Student Fee:	$50 Early / $75 Late

Instructor(s):
Prof. David G. Lilley, PhD (Lilley@okstate.edu)

Abstract and Benefits:
The tutorial is intended for newcomers to the field, like senior undergraduate and graduate students, educators wanting to learn about the approach for subsequent teaching purposes, and application engineers who want to understand and apply the methods to their particular applied problems. The objective is to provide attendees with the knowledge and ability to solve basic engineering problems using the Excel/VBA environment. Visual Basic for Applications VBA is the computer programming facility that resides behind the Excel spreadsheet. Benefits and drawbacks of this approach versus alternative approaches will be addressed. Participants will appreciate how numerical methods can be used in basic engineering applications, for the simulation and solution of problems. Emphasis is on the methods and applications, using Excel as the interface for data input and output, tables and figures, and VBA as the programming language for computations. The tutorial covers the fundamental topics of solving nonlinear equations and sets of linear equations, differentiation and integration from tabulated data, and applications to the solution of ordinary and partial differential equations, together with auxiliary topics of graphics and curve fitting, including various types of parametric curves. Participants will learn how to develop the expertise and confidence to apply the techniques. A set of working Excel/VBA computer programs will be supplied, and these can be modified later by participants to solve similar but different problems.

Tutorial Outline:
The Numerical Methods tutorial is designed as an introductory course in numerical methods using Excel/VBA for engineers. It includes computer methods in analysis and design, and the simulation and solution of engineering problems that may or may not have analytical exact mathematical solutions. Emphasis is on the methods and applications, using Excel as the interface for data input and output, tables and figures, and Visual Basic for Applications VBA as the programming language for computations. The tutorial covers fundamental topics and sample Excel/VBA codes covering:

- Fundamentals of Excel and VBA
- Nonlinear Equations and Sets of Linear Equations

- Interpolating Polynomials, Differentiation and Integration
- Solution of ODEs – Initial and Boundary Value Problems
- Solution of PDEs – Elliptic, Parabolic and Hyperbolic
- Graphics, including Plotting and Data Presentation, Various Types of Parametric Curves

Connections will be made between each topic and a variety of engineering problems and applications. In this course, it is emphasized how to develop and apply numerical techniques to solve engineering problems. En route, participants learn how to develop the expertise and confidence to apply the techniques to problems and projects with hitherto unknown solutions. The text is imbued with fundamental and applied examples, fully worked out and illustrated. A set of working Excel/VBA computer programs will be supplied electronically to participants. These fully illustrate the worked examples discussed in the tutorial, and can be modified later to solve similar but different problems of special interest to participants.

TU 2: Design of Precision Structronic and Mechatronic Devices with Smart Materials
Location: San Diego Convention Center
Date: Sunday, August 30, 2009
Time: 1:00 pm-5:00 pm
Fee: $75 Early / $100 Late
Student Fee: $50 Early / $75 Late

Instructor(s):
Prof. Horn-Sen (H.S.) Tzou

Abstract and Benefits:
Modern precision and ultra-precision systems often integrate both mechanical and electronic components to achieve their performance requirements. Development of the emerging technology of smart structures and structronic systems has been evolving for over two decades. Sophisticated multi-field and control coupling theories have been developed and numerous applications have also been proposed. This tutorial focuses on the design aspects of the technology. Histories, fundamental characteristics, material varieties, design principles, micro-/nano-actuations, and practical applications are emphasized.

The synergistic integration of smart materials, structures, machines, sensors, actuators, and control electronics can transform conventional passive structures and machines to active, adaptive, and "smart" structronic (structure + electronic) or mechatronic systems with inherent self-sensing, diagnosis, and control capabilities. This lecture covers smart materials (e.g., piezoelectrics, electro- and magneto-strictive materials, shape memory materials, electro- and magneto-rheological fluids, photostrictive materials, polyelectrolyte gels, pyroelectric materials, magneto-optical materials, superconductors, etc.), precision devices (sensors and actuators), micro-/nano-actuations, smart structures, mechatronic and structronic systems, and photo-thermo-electro-magneto-mechanical systems encompassing elastic, temperature, electric, magnetic, light, and control interactions. Modern research issues are also discussed.

Tutorial Outline:

1. Introduction and overview;
2. Smart materials: piezoelectrics, electro/magneto-strictive materials, shape memory materials, electro/magneto-rheological materials, polyelectrolyte materials, photostrictive materials, pyroelectric materials, magneto-optical materials, superconductors, etc.;
3. Design principles, micro-/nano-actuations, precision devices and control;
4. Case studies; and
5. Design clinic: Special and customized applications.

TU 3:	Tensegrity Systems
Location:	San Diego Convention Center
Date:	Sunday, August 30, 2009
Time:	1:00 PM – 5:00 PM
Fee:	$75 Early / $100 Late
Student Fee:	$50 Early / $75 Late

Instructor(s):
Prof R. E. Skelton and M. de Oliveira, UCSD (bobskelton@ucsd.edu)

Abstract and Benefits:
Traditionally structures were designed first and then control systems were added to force the structure to do what you needed it to do. This wastes both material and control resources, since the two design steps were not coordinated. This course provides some new analytical machinery to integrate structure and control design. Such cooperation between the static and dynamic properties of the structure and the control system can only be accomplished by a structure design paradigm that maintains a high degree of "controllability" during all phases of the structure design. Tensegrity solves some mathematical problems that are important in structure and control design. We will determine the optimal complexity of the minimal mass structure, and show that this optimized structure has a finite complexity, and has a topology we call tensegrity. Indeed, we will show that the material topology that minimizes mass subject to a strength and stiffness constraint is a tensegrity topology for both the cases for bending loads and for compressive loads. One can control the shape of such a system with minimal control energy, by controlling the strings to move the system from one equilibrium to another. New dynamic models and new control strategies are introduced for the first time in this course. Since the minimal mass structure is tensegrity, and the tensegrity paradigm for structures (an assembly of "sticks" and "strings") easily allows one to modify the equilibrium of the structure to achieve a new desired shape (so that power is not required to hold the new shape), it is important to develop design tools to use the tensegrity paradigm to integrate structures and controls..

Tutorial Outline:
Tensegrity systems that occur in nature are described, and the participants will build simple tensegrity structures with sticks and rubber bands. Dynamic models for tensegrity systems will be given in simple form (the new matrix forms introduced have the simplest form). From these dynamic equations, we can analyze the static behavior to determine the necessary and sufficient conditions for an equilibrium, and determine that the forces in all members are solutions of a linear algebra problem. We also determine the formulas for stiffness of any tensegrity structure, and techniques to analyze stability properties. Self-similar structural topologies are examined for minimal mass. Tensegrity fractals are generated by taking these self-similar iterations toward infinity, but the minimal mass solution for a given loading condition, yields a specific finite complexity (number of parts). Optimal structures in compression and bending are computed. These tensegrity structures also involve self-similar iterations. Finally, The differential equations are developed for the dynamics of constrained systems. A final study of control strategies will be discussed. Proofs of all results in the course may be found in the book {TENSEGRITY SYSTEMS, Skelton and de Oliveira, by Springer Verlag 2009, **ISBN:** 9780387742410} (book not included)