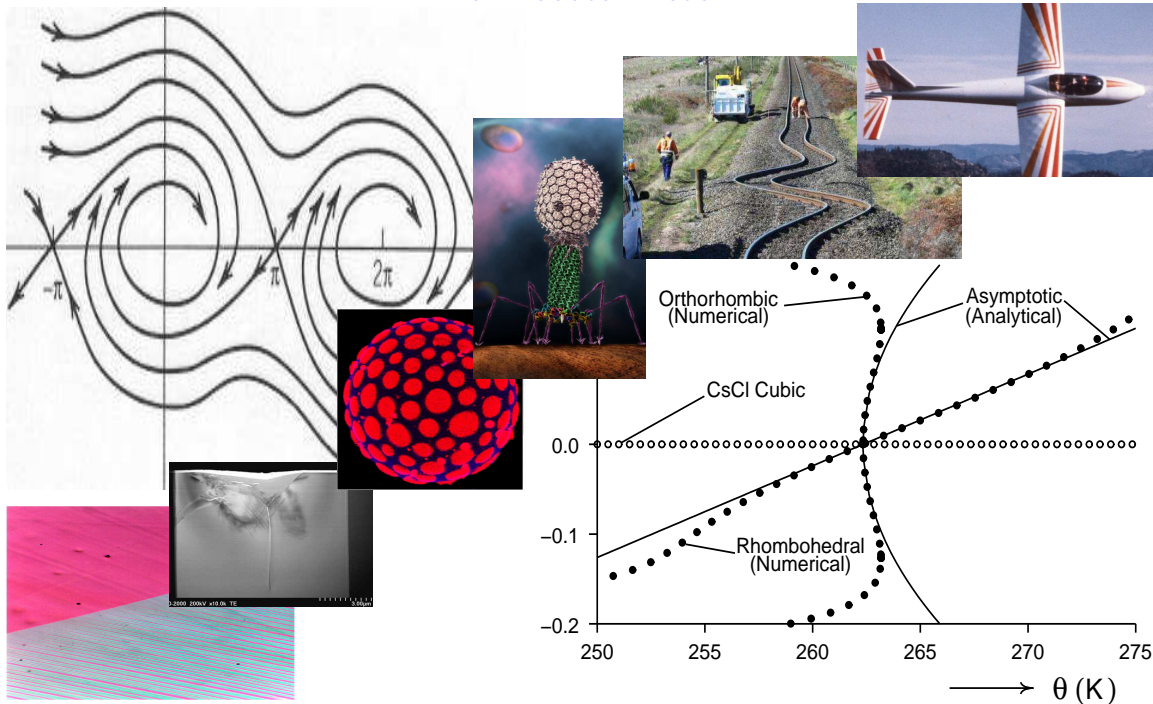Short Course on

Stability and Bifurcation Theory and Its Systematic Application

Instructor:

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This is an intensive 3–5 day short course appropriate for participants in the engineering, science, or mathematics disciplines at the graduate, professional, or university faculty level. The course presents an introduction to stability and bifurcation theory and its systematic application to science and engineering problems. The topics covered in the course are tailored to the audience, and the content (covering basic concepts, theory, numerics, and examples) is delivered primarily in an interactive and lively lecture format. In-class exercises provide an opportunity for becoming familiar with new concepts through hands-on problem solving. The cost per student depends on the course duration, number of students, and location. Participants receive a comprehensive set of materials (lecture notes and presentations) in electronic form. Depending on the topics to be covered, a copy of "Methods of Analytical Dynamics" by Leonard Meirovitch, Dover 2010 will also be provided. Registered participants will receive a "Certificate of Completion" for the short course.

Selected Topics:

- Example applications of the theory of stability and bifurcation
- Intro./Review of analytical dynamics (Lagrangian dynamics)
- General stability definitions for dynamical systems
- Lyapunov's First Method (indirect) for evaluating stability
- Characterization of 2D linear system equilibrium stability
- Lyapunov's Second Method (direct) for evaluating stability
- Double inverted pendulum example
- Hamiltonian dynamics and the proof of the Principle of Minimum Potential Energy (PMPE)
- Quasi-static loading in Finite DOF systems: Equilibrium paths
- Equilibrium path stability: Limit-loads, (simple) Bifurcations, and imperfection sensitivity
- Two-bar truss example (snap-through)
- Water liquid-vapor phase transition example (material instability)

- Solid-solid phase transitions in bars; Nano-slab example (including qualitative discussion of "small vs. large" perturbation)
- 2nd-order phase transition in H_2O system; Landau theory
- Numerical Path Following and (simple) Bifurcation Identification
- Lyapunov-Schmidt-Koiter decomposition (simple bifurcation)
- Non-elastic problems: Hopf bifurcation example (flutter)
- Review of elasto-dynamics of (infinite dimensional) continua
- Extension and discussion of stability concepts to continua
- Lyapunov's Second Method and the PMPE for continua
- Euler's elastica examples
- Multiple Bifurcation: Shanley plate, Lyapunov-Schmidt-Koiter for multiple bifurcation
- Multiple Bifurcation Example: uniform deformation of crystals
- Symmetry theory and its connection to bifurcation problems

Three to five 8-hour days give a total of 24–40 hours of instruction. This is on par with a typical 14-week semester course that meets for 3 hours per week. Thus, the short course is roughly equivalent to a full 2–3 credit university course's worth of content and work.

Interested in having a short course near you? Send a message to relliott@umn.edu for details.

Brief Biographical Sketch

Ryan S. Elliott

Ryan S. Elliott received his B.S. in Engineering Mechanics from Michigan State University, East Lansing. He received a M.S.E. in Aerospace Engineering, a M.S. in Mathematics, and a Ph.D. in Aerospace Engineering and Scientific Computing, all from The University of Michigan, Ann Arbor. In 2004 he was a Research Fellow at The University of Michigan. Elliott was appointed, as an Assistant Professor, in January 2005 to the faculty of the Aerospace Engineering and Mechanics Department at The University of Minnesota, Minneapolis and in 2011 he was promoted to Associate Professor with tenure. Prof. Elliott has been an Associate Fellow of the Minnesota Supercomputing Institute since 2009. In 2010 he held the position of Visiting Researcher at the Laboratoire de Mécanique des Solides (LMS) of The École Polytechnique, Palaiseau, France. In 2012 Elliott was appointed as the first *KIM Editor* for the Knowledgebase of Interatomic Models (KIM) (http://openKIM.org).

Dr. Elliott's research interests are in the areas of stability and non-uniqueness in nonlinear systems, active materials and shape memory alloys, and the accuracy or "transferability" of interatomic force laws for atomistic simulations. He also has significant interest in the general areas of scientific computing and software engineering. He applies all of these interests to study the detailed post-bifurcation behavior of periodic architectured materials (such as honeycombs), as well as the detailed atomic scale behavior of martensitic phase transformations, and defects in crystalline solids. Elliott is co-author (with E.B. Tadmor and R.E. Miller) of the book *Continuum Mechanics and Thermodynamics: From Fundamental Concepts to Governing Equations*, Cambridge University Press, 2011. He has received numerous awards, including: the *Tau Beta Pi Matthews Fellowship* (1998), the *U.S. D.O.E. Computational Science Graduate Fellowship* (2000), the *Ivor K. McIvor Award in Applied Mechanics*, the *Frederick A. Howes Scholar in Computational Science* award (2005), a *National Science Foundation* CAREER *grant* (2007), a *University of Minnesota McKnight Land-Grant Professorship* (2009), the *Russell J. Penrose Faculty Fellowship* (2012), and the *Thomas J.R. Hughes Young Investigator* award (2014). Elliott's research has been presented at numerous national and international conferences.