SPRING 2019

ENME665: ADVANCED TOPICS IN VIBRATIONS

Instructors: B. Balachandran, Professor of Mechanical Engineering
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Textbooks:

- Nayfeh, A. H. and Mook, D. T. (1979). *Nonlinear Oscillations*, Wiley, New York (Available in EPSL Library).
- Nayfeh, A. H. and Balachandran, B. (1995, 2006). *Applied Nonlinear Dynamics*: *Analytical, Computational, and Experimental Methods*, Wiley, New York.

Other Material: Other books in the field of nonlinear oscillations and nonlinear dynamics will also be used to illustrate concepts and ideas. Articles such as the following will also be used in this course:

i) Turner, K. L. *et al*. (1998). ``Five parametric resonances in a microelectromechanical system,'' *Nature*, Vol. 396, pp. 149—152

ii) Voth, G. A. *et al*. (2002). ``Experimental measurements of stretching fields in fluid mixing,'' *Physical Review Letters*, Vol. 88(25), pp. 254501-1-254501-4.

iii) Shaw, S. W. and Balachandran, B. (2008). ``A review of nonlinear dynamics of mechanical systems in Year 2008," *Japanese Society of Mechanical Engineers*, Vol. 2(No. 3), pp. 611-640.

Class Notes: Copies of certain lectures will be provided on Canvas

Time and Place: Tu, Th, 3.30 P.M. to 4.45 P.M.; EGR 3114

Office Hours: Tu, Th: 5:00 P.M. to 6.00 P.M. or by appointment

Grading: Assignments: 20%; One Mid-Term Exam (Date TBA): 40%; and Project: 40 %

Course Description: The theme of the course will be nonlinear oscillations and dynamics of structural and mechanical systems. Starting with classical methods, a blend of computational, geometrical, and analytical methods will be used to provide a unified treatment of nonlinear oscillations and nonlinear dynamics. Bifurcations (qualitative changes) with respect to quasi-stationary variations of one or more control parameters will be considered and instabilities such as flutter and divergence will be discussed. The phenomenon called chaos will be explored. Specific topics to be considered include the following: 1) nonlinear oscillations of pendulum and structural systems; 2) perturbation methods such as the method of multiple scales; 3) phase plane analysis and Poincare' maps; 4) external, parametric, and internal resonances; 5) stability notions and instabilities such as saddle-node, pitchfork, and Hopf bifurcations of equilibria and periodic solutions; and 6) tools such as dimension calculations and Lyapunov exponents for analyzing nonlinear motions.

Course Pre-requisites: ENME662 and ENME700 or equivalent set