


NONLINEAR SYSTEM ANALYSIS

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TYPE OF COURSE : Rerun | Elective | UG/PG
COURSE DURATION : 12 weeks (24 Jan' 22 - 15 Apr' 22)
EXAM DATE : 24 Apr 2022

PRE-REQUISITES : Undergrad control engineering, basic knowledge of differential equations and linear algebra is highly desirable.

INTENDED AUDIENCE : PhD, MS/M. Tech/ ME, Senior Undergraduate students from EE, ME, AE, PH

INDUSTRIES APPLICABLE TO : Any robotics, space and defence related industries.

COURSE OUTLINE :

All systems are inherently nonlinear in nature. This course deals with the analysis of nonlinear systems. The need for special tools to analyze nonlinear systems arises from the fact that the principle of superposition on which linear analysis is based, fails in the nonlinear case. The course exposes the students to various tools to analyze the behaviour of nonlinear systems, culminating in the stability analysis, which is of paramount importance in control systems.

ABOUT INSTRUCTOR :

1. Prof. Arun Mahindrakar is an Associate Professor in the Department of Electrical Engineering, IIT Madras. He received his Ph.D. in Systems and Control from IIT Bombay, Mumbai, India, in 2004. He was a Postdoctoral Fellow with the Laboratory of Signals and Systems, Supelec, Paris, France, from 2004 to 2005. His research interests include nonlinear stability, geometric control, and formation control of multiagent systems.

2. Prof. Ramkrishna Pasumarthy is an Associate Professor at the Dept. of Electrical Engineering, IIT Madras. He obtained his PhD in Systems and Control at the University of Twente, The Netherlands and held postdoc positions at the University of Melbourne and UCLA. He held visiting positions at Stanford University. His research interests are in the areas of network science with applications to power, traffic cloud and brain networks. He is also associated with the Robert Bosch Center for Data Sciences and Artificial Intelligence at IIT Madras. He has interests in medical wearable devices and is a co-founder of a start up iMov Motion Tech pvt. ltd. incubated at IITM Research Park.

COURSE PLAN :

Week 1: Why nonlinear systems? - Non-linear Models of Physical Systems

Week 2: Mathematical Preliminaries: Finite dimensional normed spaces, Euclidean space and its topology

Week 3: Infinite dimensional Banach spaces - Contraction mapping theorem

Week 4: Existence and Uniqueness results for solutions to non linear ODEs

Week 5: ODEs as vector fields - One dimensional systems - Phase portrait of second order linear systems - Equilibrium points, linearization and their classification

Week 6: Examples: Simple pendulum, Bead on a hoop, Lotka-Volterra models for predation and competition, biological transcriptional system, van der Pol oscillator and conservative systems, non linear circuits - Limit cycles

Week 7: Bifurcations of two dimensional flows: Saddle-node, pitchfork, transcritical and Hopf - their normal forms

Week 8: Notions of stability - Lyapunov and LaSalle's theorems

Week 9: Finding Lyapunov functions: Linear systems, variable gradient method - Center Manifold Theorem

Week 10: Physical Non-linearities - Interconnections and feedback - Aizermann's conjecture - Passivity

Week 11: PR systems - Dissipation equality - Passive filters

Week 12: KYP Lemma - Popov and circle criterion