BITS, PILANI K. K. BIRLA GOA CAMPUS
INSTRUCTION DIVISION
SECOND SEMESTER 2018-2019

Course Handout (Part II)

Course No. : BITS F316 8/1/2019
Course title : Nonlinear Dynamics and Chaos (NLD)
Instructor-in-charge : Chandradew Sharma

1. **Scope and Objective of the course**
   This is an introduction to Chaos. The student will be introduced to bifurcations, fixed points, limit cycles, chaos & quasiperiodic behaviors in nonlinear system. Fractal geometry of chaotic attractors will be discussed. These will be applied to understand the dynamics of various natural systems.

2. **Textbook**
   1) TB: Steven H. Strogatz, "Nonlinear dynamics and Chaos" West view Press

   Reference Books
   1) RB1: Robert C. Hilborn, "Chaos and Nonlinear dynamics – An introduction for scientists and engineers" Oxford University Press
   2) RB2: G. L. Baker and J. P. Gollub, "Chaotic dynamics – an introduction", Cambridge university press
   3) RB3: Edward Ott, "Chaos in dynamical systems" Cambridge university press

   Popular science book
   4) PB: James Gleick, "Chaos: Making of a new science" Penguin

3. **Course Plan**

Lecture Number.	Learning objective	Topics to be covered	References	Self-Study
1	Understanding Nonlinearity.	Introduction to nonlinear systems,	Lecture Notes, PB	
2-4	First Order nonlinear system	Fixed Points and Stability, Linear Stability Analysis, Existence and Uniqueness Theorem, Impossibility of Oscillations, Potentials, Solving ODE using numerical methods	TB Chapter 2	2.1, 2.2.3, 2.2.7, 2.3.1, 2.4.2, 2.4.3, 2.8.2
5-8	One dimensional Bifurcation	Saddle-Node Bifurcation, Transcritical Bifurcation, Pitchfork Bifurcation, Dimensional Analysis and Scaling, Imperfect Bifurcation.	TB Chapter 3	3.1.2, 3.1.3, 3.2.2, 3.4.2, 3.4.3, 3.6.2
6-10	One dimensional Periodic System	Uniform Oscillator, Nonuniform Oscillator, Ghosts and Bottlenecks, Phase Locking.	TB Chapter 4	4.1.2, 4.1.3, 4.3.3, 4.6.2
11-14	Two Dimensional Flows	Classification of the Stability of Linear Systems,	TB Chapter 5	5.1.2, 5.2.2, 5.3.2
15-18	Phase Portraits	Lotka-Voltera Model, Conservative System, Reversible Systems, Index Theory	TB Chapter 6	6.1.2, 6.1.6, 6.3.2, 6.3.3, 6.5.2, 6.6.2, 6.8.2, 6.8.4

18-24	Limit Cycles	Ruling Out Closed Orbits: Gradient Systems, Liapunov Functions, Dulac Criterion, Poincare-Bendixon Theorem, Lienard Systems, Relaxation Oscillations, Regular Perturbation Theory: Weakly Nonlinear Oscillators (Relaxation time)	TB Chapter 7	7.1.2, 7.2.2, 7.2.9, 7.2.12, 7.3.3, 7.4.2, 7.5.2, 7.6.2
25-26	One Dimensional Maps	Cobwebs, Stability of Fixed Points, Periodic Points, Liapunov Exponents, Poincare Maps,	TB 10.1, 10.2, 10.3, 10.4, 10.5, 8.7	10.1.2, 10.2.4, 10.3.4, 10.4.2, 10.5.2, , 8.7.2
27-31	Two Dimensional Maps	Linear Maps, Nonlinear Maps, Stable and Unstable Manifolds, Lorenz Maps, Henon Maps, Baker's Map, Tent Map	Lecture Notes	
32-34	Fractals	Countable and Uncountable Sets, Cantor Set, Self-Similar Fractals, Similarity Dimension, Box Dimension, Pointwise and Correlation Dimensions, Multifractals	TB Chapter 11	11.2.5, 11.3.2, 11.3.7, 11.3.8, 11.4.1, 11.4.2, 11.4.3,
35-37	Two Dimensional Bifurcations	Saddle-Node, Transcritical, Pitchfork and Hopf Bifurcation, Global Bifurcation of Cycles, Coupled Oscillators and Quasiperiodicity, Phase Locking	TB Chapter 8	8.1.2, 8.1.3, 8.1.4, 8.2.2, 8.4.3, 8.6.2
38-42	Chaos	Lorenz equations, Strange Attractor, Rossler System, Logistic Map, Periodic doubling route to Chaos, Periodic Window, Universality, Renormalization	TB Chapter 9	

4. Evaluation Scheme

EC No.	Evaluation component	Duration	Weightage (100)	Date	Nature of component
1.	Attendance		5 (if attendance > 85%) 2 (70% < attendance <=85%) 0 (if attendance <70%)		
2.	Quizzes (10)		20	TBA	O/C
3.	Projects (2)	-	5	TBA	Open Book
4.	Mid Sem Exam	1.5 Hours	30	16/3/2019 (4-5.30 PM)	Open Book
5.	Comprehensive Exam	3 Hours	40	05/05/2019 (FN)	Closed Book

5. Chamber consultation Hours To be announced in the class

6. Notices To be displayed on Moodle.

Instructor-in-charge