23MA809 **Dynamical Systems** **4 0 0 4**

Course outcomes (COs):

1. Students will be able to analyse the behaviour of dynamical systems (e.g. find periodic orbits and assess their stability, draw phase portraits, etc.) expressed as either a discrete-time mapping or a continuous-time flow.
2. Students will be able to analyse changes (i.e. bifurcations) to dynamical systems as system parameters are varied.
3. The student will have an understanding of how and why a dynamical system becomes chaotic. He/she will understand fundamental characteristics of chaotic systems.
4. Students will be able to apply the techniques of nonlinear dynamics to physical processes drawn from a variety of scientific and engineering disciplines.

Syllabus:

One Dimensional flows:
Flows on the line-A Geometric Way of Thinking, Fixed Points and Stability, Population Growth, Linear Stability Analysis, Existence and Uniqueness, Solving Equations on the Computer. Bifurcations-Saddle-Node Bifurcation, Transcritical Bifurcation, Pitchfork Bifurcation.

Two-Dimensional Flows:
Linear Systems-Definitions and Examples, Classification of Linear Systems. Phase Plane-Phase Portraits, Fixed Points and Linearization, Index Theory. Limit Cycles- Ruling Out Closed Orbits, Poincare-Bendixson Theorem, Lienard Systems, Relaxation Oscillators, Weakly Nonlinear Oscillators. Bifurcations Saddle-Node, Transcritical, and Pitchfork Bifurcations, Hopf Bifurcations Oscillating Chemical Reactions, Global Bifurcations of Cycles, Hysteresis in the Driven Pendulum and Josephson Junction, Coupled Oscillators and Quasi-periodicity, Poincare Maps.

Chaos
Lorenz Equations-Simple Properties of the Lorenz Equations, Chaos on a Strange Attractor, Lorenz Map, Exploring Parameter Space. One-Dimensional Maps- Fixed Points and Cobwebs, Logistic Map: Logistic Map: Analysis, Periodic Windows, Lyapunov Exponent, Universality and Renormalization.

Text Book / Reference Book:

1. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering by Steven H. Strogatz (CRC Press; 2nd Edition), 2015.
2. Chaos: An Introduction to Dynamical systems by K. T. Alligood, T. D. Sauer, J. A. Yorke (Springer Verlag), 1996.