

## **Stability Analysis of Non Linear Systems– Prof Tushar Jain, IIT Mandi**

**Relevant course:** Control System

**Relevant department:** B.Tech (all branches) 3rd and 4th year - interested in control systems and stability analysis

**Pre requisite:** Network theory / Control systems intended for: B.Tech (all branches) 3rd and 4th year - interested in control systems and stability analysis

**Course outline:**

### **Preamble:**

Most systems are nonlinear, and therefore, it is of general interest to investigate possible behaviors of nonlinear systems, investigate their stability, and to design control schemes. For example, there are many situations in Power systems where linear controllers are used. For these one would like to investigate behavior under “large signal conditions” when nonlinearities cannot be ignored. And there are areas like Robotics where designs based on linear models do not work well.

### **Intended learning outcomes:**

- Get a feel for the qualitatively different trajectories possible in nonlinear systems.
- Understand when and how linearized models can be useful for studying behavior around equilibrium points, and near limit cycles.
- Master Lyapunov stability theory and its modern control theoretic extensions.

### **Course Outline:**

Linear and nonlinear system behaviors - Quick recapitulation of linear differential equations, and their solutions. Qualitative properties of nonlinear systems. Existence and uniqueness of solutions to Ordinary differential equations. Linearizations. Phase portraits, limit cycles.

Lyapunov’s stability theory - Notions of stability. Lyapunov’s stability theorem. Lasalle’s invariance principle. Circle criterion, Popov criterion. Lyapunov-Krasovskiifunctionals.

### **References:**

1. Nonlinear Systems H. Khalil, 3rd edition, 2014, Pearson
2. Nonlinear Dynamical Systems and Control, W. Haddad, and V. Chellaboina, 2008, Princeton University press
3. Stability and Stabilization: An Introduction, W. J. Terrell, 2009, Princeton University press