Syllabus for EE 714: Behavioural Theory of Systems

- **Introduction:** Motivation, Mathematical modeling as exclusion laws, universum and behaviour. Dynamical Systems: linearity, time invariance.
- **Description of LTI systems in terms of differential equations:** Kernel representation, weak solutions versus strong solutions, calculus of equations, unimodular matrices, upper triangular form, Smith canonical form, Aryabhatta/Bezout identity.
- **Equivalence of representations:** Time domain description of behaviours specified by kernel representations, input/output cardinality, the equation module, the quotient module, module-behaviour duality: Oberst's theorem, Malgrange's theorem.
- **Elimination theory:** Hybrid representation, image representation, fundamental principle, elimination of latent variables.
- **Controllability and observability:** Definition of behavioural controllability, equivalent conditions as tests of controllability, controllability and torsion elements, autonomous systems. Definition of observability, equivalent conditions as tests of observability, observable image representations.
- **State representation:** Axiom of states, obtaining state representation from kernel representation, trim-ness and minimality, McMillan degree.
- **Multi-dimensional systems:** Description, controllability, observability, conic stability.
- **Dissipative Systems:** Quadratic differential forms (QDFs), path independence, dissipativity, dissipation inequality, storage functions, half-line dissipativity. Applications of QDFs: $\mathcal{H}_\infty$ gain, KYP Lemma, LQR control problem.