Basics of Nonlinear Dynamics

All physical systems are nonlinear, time-varying and also uncertain due to many factors e.g. clearances in moving parts, input / output limits such as physical stops, inelastic / plastic deformations, losses due to heating, friction, change in inertia due to fuel burn / mass aggregation, and various environmental parameters etc.

In this regard, we note that in most studies involving the dynamics of such systems, we assume a linearized time-invariant form in order to simplify the analysis procedures for predicting a large number of responses in lesser time, with reasonable accuracy, during the design process.

However, once such systems are designed and built, there is a need to carry out a full-fledged dynamic analysis, considering all the real system effects, in order to correctly assess the quality of the design. In this context, while there are standard numerical solution techniques, which can address the issues of time variance and Monte' Carlo technique, which can provide the impact of uncertainties, the nonlinear effects significantly impact the nature and extent of the responses, and, hence, need greater attention.

The present short course aims to present a basic perspective on the dynamics of some of the typical nonlinearities that are present in the systems and brings out the nature of the behaviour that one can expect from such systems under operational conditions. In particular, the focus of the short course to discuss the phenomena of Multiple Equilibria, Periodic and Chaotic Attractors, Basins of Attractions and Bifurcations. The above behaviours are demonstrated through suitable physical examples such as limit cycles, large departures, snap-through buckling etc.

Participants to the course can expect to acquire a basic understanding of the nonlinear dynamical phenomena and their implications in the context of practical systems where such nonlinear effects are present. The course is of twelve hours duration and is delivered over six weeks.