ME 5233 Multi-body Dynamics & Applications

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Class Hours	Wed 14:00 -15:15; Thur 15:30-16:45
Teaching Associate	Mr. Paras Saini (me22s069@smail.iitm.ac.in)
Grading	Quizzes 20% ; End Semester 40% Assignments 35% (ADAMS Based Also); Professionalism 5%

If you are allergic to computers and/or mathematics, then this course is probably not suitable for you. The course focuses on the dynamics of rigid-bodies connected to each other (mechanisms and open chains). The background assumed would be an undergraduate course on "Theory of Machines" or "Dynamics of Machinery" as it is called here at IIT Madras and linear algebra exposure. Matrix based formulations will be used to study kinematics and dynamics of connected bodies, since it is easier to implement it on a computer. I suggest that you use GNU Octave (Opensource platform free to download) for computer assignments and hence you need to spend some time familiarizing yourself with the software. We will also be using ADAMS software for 2 assignments for which there will be tutorial classes by Dr. Rameshkumar of MDS.

The objective of this course is to build your capability to carry out multi-body dynamic analysis of complex mechanisms and enable intelligent use of commercial packages used by industry.

Course Outline

1. **Review** Overview of Kinematics & Dynamics; Defining orientation for 3D spatial motion; Parallelism in vectors and matrix representation of cross-product (**3 lectures**)
2. **Multi-body formalism for planar motion** Transformation from body to global coordinate systems; Joint constraints; computational kinematic analysis - 4 bar and slider-crank examples (**8 lectures**)
3. **Virtual Work and Lagrangian Dynamics** Classical mechanics overview; Workless constraints and Virtual work for dynamics; Gibbs-Appell equations; Lagrangian and Hamiltonian formulation; non-conservative systems (**4 lectures**)
4. **Constrained Multi-body dynamics** Inertia matrix and elimination of constraints (embedded formulation); Lagrange multipliers and joint forces; Augmented formulation (**9 lectures**)
5. **Three-dimensional Rotational Kinematics** SO(3) group, Axis-angle, Euler Angles and Quaternion representation (**4 lectures**)
6. **General Three-dimensional Motion** SE(3) group, 4-component representation of position and velocity vectors, transformation of position and velocity vectors using Lie theory, Applications in Robot Kinematics (**8 lectures**)
7. **General Three-dimensional Motion** Inertia Tensor, Kinetic Energy, Newton-Euler equations and Gyroscopic Couple (**4 lectures**)

Books

1. A. A. Shabana, 2010, *Computational Dynamics*, Third Edition, John Wiley & Sons: New York.
2. R. M. Murray, Z. Li and S. Sastry, 1994, *A Mathematical Introduction to Robotic Manipulation*, CRC Press: Boca Raton.
3. P. E. Nikravesh, 2007, *Planar Multibody Dynamics: Formulation, Programming and Applications*, CRC Press: Boca Raton.