Course Number: 28052

Course Name: Advanced Kinematic Synthesis and Mechanisms Design

Course Type: Theory	Type & Max Unit: Constant 3
Prerequisite: Nothing	Corequisite: Nothing.
Level: Graduate	First Presentation: 2003-1
Group: Applied mechanics	Last Edition: 2018-1

Objectives:

This course is deigned to introduce basic concepts in Kinematic Synthesis and Mechanisms design for graduate students including M.Sc. and Ph.D. students. Planar mechanisms and spatial ones are considered here using vector kinematics and graphical methods in planar mechanisms and then completing and introducing matrix methods in kinematics to be applicable for both planar and spatial mechanisms.

Topics:

- Basics and definitions, Machines and Mechanisms, different type of industrial mechanisms, definitions for type synthesis, number synthesis, and dimension synthesis for mechanisms. Link types, simple and compound, kinematic pair, lower and higher, connectivity for kinematic pair and mobility of mechanisms, Degree Of Freedom, Grubler and Kutzbach formulas, kinematic chains and inversions for a mechanism, different possibilities for mechanisms and inversions by graphical and network methods such as Graph Theory etc., mobility for links such as Crank type and Rocker type and Grashoff criteria and other graphical methods.
- Kinematic Synthesis for Two accuracy positions in planar motion of linkages using geometric and graphical theorems by 4-Bar Mechanism and Slider Crank Mechanism or Double Slider Mechanism. Rotational Poles and their specifications and theorems, Pole Triangle and its theorems, Cardinal point and Center point and graphical-geometric techniques to solve Three accuracy positions problems in planar motion using coupler of a 4-Bar Linkage, Relative poles and Image poles and finding a way for Four accuracy positions in planar kinematics, opposite poles and opposite quadrilaterals and theorems, Center point curve and Circle point curve and how to find solution for Four accuracy positions and then extension to Five accuracy positions and limited number of solutions, Brumester points. Coupler curve and double tangent points, Foci circle and complementary discussions.
- Plane kinematics analysis for planar mechanisms, Complex Polar Vectors, Cartesian Vectors, Computer Aided Kinematic Analysis for plane mechanisms using Rigid Body motion, Two Link Dyad, Oscillating Slider, and Rotating Guide.
- Matrix Methods in Kinematics, Rigid Body Rotation Matrix, rotation about fixed Cartesian axes, rotation about varying Cartesian axes, rotation about arbitrary spatial axis. Displacement Matrix in planar motion and Rotational Pole and Displacement Matrix for spatial motion and Screw Parameters. Coordinate Transformations and Denavit-Hartenberg parameters. Differential Rotation Matrices and Differential Displacement Matrices, Angular Velocity and Angular Acceleration Matrices and Velocity and Acceleration Matrices.

- Kinematic Analysis of Spatial Mechanisms using link to link relative velocity and relative acceleration by Matrix Kinematics. Introducing different joint connection between links in spatial mechanisms, such as revolute, prismatic, cylindrical, and spherical and using closure equation and constraint equation to solve different examples.
- Rigid Body Guidance, plane rigid body guidance using analytic kinematics by constraint equation for Crank motion and Slider motion and extending for velocity and acceleration constraints to solve Three, Four accuracies problems, Poles and Center Point curve in analytic form. Crank-Crank, Slider-Crank, and Double Slider mechanisms, solving linear and nonlinear systems of equations. Some planar examples and extension to spatial mechanisms.
- Path Generation and Function Generation and introduction to Mechanisms Optimizations and introduction to Force-Torque analysis in mechanisms and some examples.

References:

1- Richard S. Hartenberg and Jacques Denavit, “Kinematic Synthesis of Linkages”, First Edition, McGraw-Hill, 1964.
2- C.H.Suh and C.W. Radcliffe, “Kinematics and Mechanisms Design”, First Edition, John Wiley & Sons, 1978.
3- Hassan Sayyaadi, “Personal Notes and Comments”, Professor of the School of Mechanical Engineering, Sharif University of Technology, Tehran, Iran, Since 2002.