MECH541 Kinematic Synthesis
Course Information–Winter 2014
Lecture Time & Room: Mon & Wed 10:05 to 11:25 ENGTR1080

Prof. J. Angeles, MC455
angeles@cim.mcgill.ca

Office Hours: Mondays & Thursdays 4:00–5:00
www.cim.mcgill.ca/~rmsl/Index/index.htm

Course Outline

Objective

To learn techniques enabling the mechanical designer to dimension geometrically a mechanical system intended to accomplish a specified motion task.

Topics

1. The role of kinematic synthesis in mechanical design. Kinematic analysis vs. kinematic synthesis. Algebraic and computational tools.

2. The qualitative synthesis of kinematic chains; displacement groups; kinematic bonds; the Chebyshev-Grübler-Kutzbach-Hervé formula. Series and parallel arrays of kinematic subchains: applications to the qualitative synthesis of parallel-kinematics machines.

3. Function-generation: planar, spherical and spatial four-bar linkages. The synthesis matrix and its condition number; exact and approximate synthesis. Application of dual algebra to the synthesis of spatial function generators.

   Class Test: Open book, in class, one week after completing the foregoing topics

4. Function-generation (cont'd): design vs. structural error. Transmission angle. Linkage discriminant. Link-rotatability conditions. Transmission quality (defect) and its maximization (minimization). Zero-mean linkages: application to quick-return and drag-link mechanisms.

5. Motion generation, a.k.a. rigid-body guidance: the planar Burmester problem for three, four, and five poses of the guided body. The centre-point and the circle-point curves for four poses. The spherical and spatial Burmester problem. Application of dual algebra to the synthesis of spatial motion generators. Semigraphical solutions to the Burmester problem. Approximate synthesis.

6. Path generation: the coupler curves of planar four-bar linkages. The Theorem of Roberts-Chebyshev. Special loci of the coupler link: the cubic of stationary curvature and the inflexion circle. Applications to the synthesis of six-bar mechanisms with dwell. Spherical and spatial path-generating linkages.

Marking Scheme: Three mini-projects, each worth 25% of the final mark, will be assigned, according to the schedule of Table 1. The balance 25% will come from the Class Test. **Project reports are to be submitted at the end of the lecture of the due date. Late submissions will be penalized at the tune of 20% of the mark received for every 24h.**

The projects will require numerical and symbolic computations using commercial software: Maple/Mathematica and Matlab. Visualization of the results will require computer animations

Report ID	Deadline	Description	% Mark
MP1	Feb. 10th	Qualitative synthesis	25%
MP2	March 17th	Function generation	25%
MP3	April 11th	Motion generation	25%

Table 1: Schedule of Project Reports

using, e.g., SolidWorks, ADAMS, Pro/E, Unigraphics, or similar packages. Rapid prototypes of the synthesized mechanisms are encouraged (consult the schedule of the repid-prototyping machine at the Machine-Tool Shop).

Policy for project-marking: 2/3 for technical content and 1/3 for presentation. Guidelines on report organization are found in `rprt-gdlns140106.pdf` on *myCourses*.

Course is based on

Angeles, J., 2014, *MECH 541 Kinematic Synthesis Lecture Notes*, Department of Mechanical Engineering, McGill University, Montreal.

Otherwise, reading assignments will be posted. Useful references:

- Chiang, C.H., 1988, *Kinematics of Spherical Mechanisms*, Cambridge University Press, Cambridge.

- Hartenberg, R.S. and Denavit, J., 1964, *Kinematic Synthesis of Linkages*, McGraw-Hill Book Inc., New York.

- Kimbrell, J.T., 1991, *Kinematics Analysis and Synthesis*, McGraw-Hill Book Inc., New York.

- McCarthy, J.M. and Soh, G.S., 2011, *Geometric Design of Linkages*, Springer, New York.

Important Notes:

1. **Lecture attendance is mandatory. Not all announcements in class will be posted on the course website. Students missing one lecture are responsible for obtaining course information from fellow students.**

2. McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offenses under the code of student conduct and disciplinary procedures. See `www.mcgill.ca/integrity` for more information.

3. If you have any disability please contact the instructor to arrange a time to discuss your situation. It will help if you contact the Officer for Students with Disabilities at 398-6009 before you do this.

4. Every student has the right to write term papers, examinations and theses in English or in French, except in courses where knowledge of a language is one of the objectives of the course.