CARLETON UNIVERSITY
DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

MECH 5507
Advanced Kinematics

WINTER 2018 FINAL OUTLINE

Fall term: Lectures three hours per week.

Instructor: M.J.D. Hayes, 2184 ME, and invited speakers.

Course Objective:

To give a broad overview of elementary issues related to the kinematics of mechanisms and robot mechanical systems from an advanced standpoint. A major component of the course will be to rediscover geometric tools and insight from the 19th and early 20th centuries, which were abandoned because practical application required numerical application leading to seemingly impossibly large numbers of computation steps, considering they had to be done by hand. However, the methods are elegant and compact, and lead to numerically efficient implementation. The computation issues are insignificant given the computational speed of modern desktop PC's. Emphasis will be placed on algorithm development and implementation through practical application.

Topics (due to time constraints, some topics may not be covered):

1 Kinematic chains:
simple and complex chains; DOF and mechanical constraints; kinematic pairs; elementary group theory; CGK formula.

2 Rigid body displacements and the Isometry group:
reflections; translations; rotations; glide reflections; product theorems; pole of a displacement.

3 Geometry:
homogeneous coordinates; duality; line, point, and plane coordinates; the Erlangen Programme; transformation groups; invariants; metric spaces; Cayley-Klein spaces and geometries; applications (algebraic geometry, geometric algebra).

4 Descriptions of position and orientation (pose):
Euler-Rodrigues parameters; Plücker coordinates; Study's soma coordinates; kiematic mapping of planar kinematics.

5 Kinematic synthesis of linkages:
type, number, and dimensional synthesis; function generation; rigid body guidance; trajectory generation; design and structural error.

6 Differential kinematics:
Jacobians; velocity level kinematics; static forces; equivalent joint torques.

7 Singularities:
representational (formulation); configurational; architectural.

8 Self motions of parallel robots:
planar; spherical; spatial.

9 Topics in kinematic calibration.

10 Topics in kinematic synthesis of mechanisms.

Textbook: Course handouts. Students will be required to use literature found in the library.

Grading:	Project 1	40%
	Project 2	60%

Projects: Two open-ended problems in kinematics will be assigned in the 1st and 5th weeks of the course. The solution algorithms will be implemented using Maple and MATLAB, or any other combination of symbolic and numerical algebra software. Results will be presented in either one, or two-column archival journal paper format (e.g. Abstract, Introduction, …, Conclusions, References), graded as follows:

- Interpretation of results: 50%
- Originality and resourcefulness in implementation: 25%
- Awareness of importance of results: 15%
- Presentation (second project only): 10%

Arrangements will be made to submit any useful and/or novel results for publication in archival journals, or conference proceedings.

NOTICE: this final version of the outline supersedes all earlier versions.

M.J.D. Hayes
January 9, 2018