

Design of Mechanisms

1. **Course number and name:** 020CPMES3 Design of Mechanisms
2. **Credits and contact hours:** 4 ECTS credits, 2x1:15 contact hours per week
3. **Name(s) of instructor(s) or course coordinator(s):** Hussein Farroukh
4. **Instructional Materials:** PowerPoint slides

Textbooks/References:

- Kinematics of Mechanical Systems – Fundamentals, Analysis and Synthesis, Jorge Angeles and Shaoping Bai, Springer © 2022. ISBN 978-3-031-09543-6.
- Design of Machinery – An Introduction to the Synthesis and Analysis of Mechanisms and Machines, Robert L. Norton, fourth edition, Mc Graw Hill, ISBN 978-0-07-312158-1.
- Theory of Machines and Mechanisms, Uicker, Pennok, Shigley. Willey, 3rd edition. ISBN13: 9780195155983.

5. Specific course information

a. Catalog description:

This course focuses on the graphical and analytical synthesis of linkage mechanisms to one or more loops for the generation of movements, trajectories and generation of functions from 2-3-4 and 5 precision positions; optimal synthesis of linkage mechanisms; synthesis of cam-follower mechanisms; synthesis of gear trains.

b. Prerequisite: Mechanical Systems (020SMEES1).

c. Selected Elective for ME students.

6. Educational objectives for the course

a. Specific outcomes of instruction:

A student who successfully fulfills the course requirements will have demonstrated an ability to:

- Design of bar linkages using graphical synthesis for two positions, three positions with specified moving pivots, three positions with alternate moving pivots, three positions with specified fixed pivots, and quick return mechanisms.
- Design of bar linkages based on the coupler motion to produce a specified motion such as straight line, parallel motion, single and double dwell motion in addition to using cognates for multiple or alternative solutions.
- Design of bar linkages using analytical synthesis of precision type and based on position analysis for two, three, four, and five positions.
- Compare between graphical and analytical syntheses for two and three positions.

- Evaluate a linkage performance throughout the transmission angle and the transmission quality.
- Design of cam-follower mechanisms to generate a function with specified boundary conditions using “SVAJ” functions.
- Design of gear trains mechanisms to obtain a specific change in the speed or torque of a rotating device.

b. PI addressed by the course:

PI	1.1	1.2	1.3	2.1	7.1	7.2
Covered	x	x	x	x	x	x
Assessed	x	x	x	x	x	x

7. Brief list of topics to be covered

- **Chapter 1: Introduction to Kinematic Synthesis:** The role of kinematic synthesis in mechanical design – Glossary – Analysis versus kinematic synthesis – Kinematic pairs – Graph representation of kinematic chains – Groups of displacements – Kinematic bonds – Synthesis number – Inversion – Four bar linkages – Grashof condition – The Chebyshev-Grübler-Kutzbach-Hervé formula (Degree of mobility/freedom) – Applications to robotics. (3 Lectures).
- **Chapter 2: Graphical linkage Synthesis:** Function, path and motion generation – Limiting conditions (Toggle positions and Transmission angles) – Dimensional synthesis – Two-position synthesis – Three-position synthesis with specified moving pivots – Three-position synthesis with specified fixed pivots – Quick-return mechanisms – Coupler curves of four bar linkages – Cognates – Straight line and parallel motion mechanisms – Single and double-dwell mechanisms. (4 Lectures).
- **Chapter 3: Analytical Linkage Synthesis:** Types of kinematic synthesis – Precision points – Two-position motion generation by analytical synthesis – Comparison of analytical and graphical two-position synthesis – Three-position motion generated by analytical synthesis – Comparison of analytical and graphical three-position synthesis – Synthesis for a specified fixed pivot location – Center-point and circle-point circles – Four-and-five-position analytical synthesis – Analytical synthesis of a four-bar function generation – Other linkage synthesis methods. (5 Lectures).
- **Chapter 4: Linkage Synthesis for Function Generation:** Input-Output (IO) functions – Exact synthesis – Analysis of the synthesized linkage – Approximate synthesis – Linkage performance evaluation – Design error versus structural error – Synthesis under mobility constraints. (4 Lectures).
- **Chapter 5: Motion Generation:** Spherical four-bar linkages – Spatial four-bar linkages. (3 Lectures).
- **Chapter 6: Trajectory Generation:** Trajectory generation for spherical four-bar linkages – Path generation for RCCC linkages. (3 Lectures).
- **Chapter 7: Cam Design:** Cam terminology – Type of cams – Type of motion – SVAJ diagrams – Single and double dwell cam design – Critical path motion – Sizing the cam (Pressure and radius of curvature) – Practical design considerations. (3 Lectures).

- **Chapter 8: Gear Trains Design:** Contact ratio – Design of simple gear trains – Design of compound gear trains – Design of epicyclic or planetary gear trains– Efficiency of gear trains. (3 Lectures).