ME 312
Analysis and Synthesis of Mechanisms
Fall 2020

**Course Information**

**Time:** Monday 12:40pm – 1:30pm and Tuesday 12:40pm – 2:30pm

**Location:** Synchronous Zoom Sessions

**Recitation:** Thursday 8:40am – 10:30am @ Synchronous Zoom Sessions

No recitation during the first week of classes.

**Credit:** 3 credit hours

**Synchronous Zoom Sessions**

Monday 12:40pm – 1:30pm
https://sabanciuniv.zoom.us/j/97412850862?pwd=SUY0NWc0eG40RU9aMVZMkFzdZWGRzUT09

Tuesday 12:40pm – 2:30pm
https://sabanciuniv.zoom.us/j/91417346322?pwd=aWFVVGVSTVIWHZVYWkvcFBWZbCUT09

**Instructor**

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**TAs:** Ali Khalilian Motamed Bonab and Uğur Mengilli

**Resources**

**Web Site:** Available through SUCourse+. Please check regularly for announcements and updates.


**Reference Books:**


**Prerequisites**

Students are expected to have a working knowledge of differential equations and linear systems. Familiarity with statics, kinematic and dynamics is expected. Programming skills, especially familiarity with Matlab, is a plus.

**Purpose**

This course is designed to equip students with fundamental theories and methodologies that are used in kinematic analysis, dynamic analysis, and synthesis of mechanisms commonly encountered in machine design. Students will learn analytical and computational techniques for displacement, velocity, and acceleration analyses of mechanisms, as well as methods for force analysis using static and dynamic approaches. Kinematics (and time permitting dynamics) of gear trains, screw mechanisms, and belt/chain drive mechanisms will be discussed. Students will be introduced to the mechanism design process. Synthesis of mechanisms for the generation of a prescribed path and motion will be covered. Throughout the course, vector-based approaches will be emphasized. Analytical and computational methods for mechanism synthesis will also be exercised.
COURSE OBJECTIVES

The goal of this course is to introduce juniors and seniors to basic methods in the synthesis, kinematic, and dynamic analysis of mechanisms commonly encountered in machine design. By the end of the course, each student should be able to do the following:

1. Demonstrate an understanding of fundamental concepts in mechanisms (linkages, cams, gears, etc.).
2. Identify basic types of mechanisms, joints, and motion.
3. Determine degree of freedom (mobility) of mechanisms and equivalent linkages.
4. Perform position, velocity, and acceleration analyses using analytical and computational methods.
5. Perform force analysis of linkages using static (and dynamic) methods.
6. Describe the mechanism design process.
7. Synthesize mechanisms for prescribed path and motion generation using analytical and computational methods.
8. Analyze (and design) gear trains, cam-followers, belt and chain drives, and screw mechanisms.

HOMEWORK SETS

Homework sets will be assigned regularly and posted on the course website.

EXAMS

There will be one mid-term exam and one final exam. Since the course continually builds upon previous material, all exams will be comprehensive. All exams are closed book and closed notes. A cheat sheet containing relevant formulas is provided. By registering to this course, students consent that they will secure a reliable internet connection, a camera and a audio recorder and will follow the detailed instructions to be provided for the online exams.

PROJECT

Students will be assigned a course project. Students may be given the freedom to choose a project topic of their interest subject to instructor’s approval. A candidate project topic should address a real life problem and should involve sufficient complexity to let students demonstrate their proficiency at a technical level.

LECTURE

The lecture format will be loose. There may be a short break during the two hour lecture period. Extra lectures and problem solving sessions may be scheduled when necessary. Class participation and cooperation among students are highly encouraged. Student feedback will be collected throughout the semester and adaptation will be undertaken accordingly.
Grading Policy

Your course grade is determined from the total points you receive from attendance, homework, midterm, project, and the final exam. Borderline grades are determined by class participation.

Homework sets must be submitted to SUCourse+ by the deadline. **No late problem sets will be accepted.** (Extensions may be granted for special circumstances and only when requested at least one day in advance.)

You are responsible for all information given in class verbally and/or in writing. Any information about the course on the web may be replaced by the information announced in the class.

Cooperative efforts at understanding the material and the assignments of the course are encouraged. You may also use the assignments of the previous years as exercised. However, you may only submit work that you have completed individually. For example, you may communicate verbally about methods for solving the assigned problems, but sharing of written work is not permitted. Copying solutions from the assignments of the previous years is also strictly forbidden. Submitting any work that is not the result of a student’s own effort is considered cheating and will result in disciplinary action.

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<tr>
<th>Component</th>
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<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
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<td>Midterm Exam</td>
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<td>Project</td>
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Other Notes

Any student with a disability requiring accommodation in this course is encouraged to contact the instructor during the first two weeks of the semester.

Additional Reading


Tentative Schedule and Topics

Fundamentals

Week 1 – 4
- Vector Algebra
- Reference Frames and Rotations in Space
- Angular Velocity
- Vector Calculus
- Nomenclature on Machines and Mechanisms
- Kinematic Diagrams and Kinematic Inversion
- Degrees of Freedom/Mobility and Grashoff Criteria

Displacement and Velocity Analyses

Weeks 5 and 6
- Displacement Analysis: Analytical Methods
- Displacement Analysis: Computational Methods
- Velocity Analysis: Analytical Methods
- Kinematic Analysis of Gear Mechanisms

Acceleration Analysis

Week 7
- Coriolis Acceleration
- Equivalent Linkages

Force Analysis

Weeks 8 and 9
- Static Force Analysis of Mechanisms
- Mass Moment of Inertia, Center of Gravity
- Inertia Forces and Torques in Linkages
- Dynamic Force Analysis

3D Dynamics

Weeks 10 and 11
- Newton-Euler Equations of Motion
- Dynamic Simulation and Time Response of Mechanisms

Kinematic Synthesis

Weeks 12 – 14
- Mechanism Design Process
- Type Synthesis
- Number Synthesis
- Dimensional Synthesis
- Synthesis for Function Generation
- Synthesis for Prescribed Path and Motion Generation