Beni Suef Technological University

Computer-Aided Kinematics

Syllabus

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Course Title: Computer-Aided Kinematics

Course Code: N/A

Course Followers:

Students of Mechatronics Department in 2nd semester of 1st year

Course Meeting Times

Lectures: 1 session / week, 1 hours / session

Labs: 1 session / week, 3 hours / session

Course Introduction

This course gives mechatronics students ability to understand basic concepts of mechanisms and develop their ability to interpret and design mechanisms. First parts deal with the basic theory of kinematics explained by lecture and together assisted by computer-aided design tool (e.g. SolidWorks) to better interpret and finally design the functions. The main contents are as follows: Mechanism and Kinematics, Vectors, Numerical Analysis, Position Analysis, Velocity Analysis, Acceleration Analysis, Mechanism Design.

Course Objectives

After successfully studying this course, students will learn:

1. The need for kinematic analysis and basic components & terms of mechanisms.
2. The degrees of freedom of mechanisms.
3. Graphic linkage synthesis method using computer-aided design tool, SolidWorks.
4. How to design the rocker and the coupler.
5. How to analysis the position of the slider-crank, the four-bar linkage, the inverted slider-crank, and the geared five bar linkage.
6. How to determine the instant of centers
7. How to analysis the velocity of the slider-crank, the four-bar linkage, the inverted slider-crank, and the geared five bar linkage.
8. How to calculate the acceleration on a moving point on a moving link.
9. How to analysis the acceleration of the slider-crank, the four-bar linkage, the inverted slider-crank, and the geared five bar linkage.
10. How to design cams and followers.
11. How to design gear trains

Learning Outcomes

1. The method of the design and analysis of mechanisms using computer-aided design tool, SolidWorks, can be understood and be utilized.
2. The degrees of freedom of mechanism can be calculated.
3. The position of the slider-crank, the four-bar linkage, the inverted slider-crank, and the geared five bar linkage can be analyzed.
4. The velocity of the slider-crank, the four-bar linkage, the inverted slider-crank, and the geared five bar linkage can be analyzed.
5. The acceleration of the slider-crank, the four-bar linkage, the inverted slider-crank, and the geared five bar linkage can be analyzed.
6. The mechanism of cams and followers can be designed.
7. The mechanism of gear trains can be designed.

Prerequisites

Mathematics for Technicians

Application of Math and Science in Technology

Physics for Technicians

SolidWorks (Computer-aided design tool)

Textbooks

The course textbooks are:

1. Eric Constans and Karl B. Dyer, Introduction to Mechanism Design with Computer Applications, CRC Press, 2019, New York, USA. ISBN: 978-1-138-74065-5.
2. Naguib G. Naguib, Computer-Aided Kinematics (Practice Manual), BST, 2020.

Homework

- Homework will be issued in lectures and collected a week later in recitation.
- Corrected homework with solutions will be returned in labs the week after it is collected. You are welcome and encouraged to discuss the homework among your colleagues. However, the final formulation and write up of your homework answers must be your own.
- Submitting homework copied from someone else is a breach of ethics, and will be handled by the Committee on Discipline. More importantly, although homework counts for only 5 percent of the grade, they are critical to learning the material and to doing well on the quizzes and final exam. **One homework problem will appear in each of the tests**, and homework performance will be taken into account during grade assignment for cases that are on letter-grade boundaries.
- **Late homework will not be accepted for grading**. However, total homework grades will be based on the best nine out of eleven individual homework grades. Thus, with one exception, two homework assignments may be missed without a grading penalty.
- All homework will be graded on a coarse scale of 0 to 3 points. 3 points if all or nearly all problems are correct, 2 points if homework is approximately half correct, 1 point if mostly incorrect, and 0 points if late or not submitted.

Labs (or Tutorials/Exercise, Workshop)

- Labs will be conducted during the weeks shown in the schedule. Each lab assignment involves one or more accomplishments which must be checked off by an instructor in the lab. The instructor will be available for help and lab check-off during those weeks in which a lab is in progress.
- No written work will be due for the last lab.
- You are welcome and encouraged to discuss the labs among your colleagues. You are also welcome to team up in pairs to execute a lab. However, the write up of your lab must be done on your own. Skipping the lab and submitting work copied from someone else is a serious breach of ethics, and will be handled by the Committee on Discipline.
- Lab assignments will be graded on a scale of 0 to 3 (3: lab complete, works, good job on pre- and post-lab; 2: lab mostly complete, reasonable job on pre and post lab; 1: lab partially done, marginal to poor job on pre- and post-lab; 0: lab not done, poor job on pre- and post-lab).

Lab Books

- You must obtain the contents of a few pages for every lab (from Lab #1 to lab #15) for recording measurements, observations and graphs of data taken during the in-lab exercises.
- Written pre-lab and post-lab exercises are also to be completed in your own papers.

Midterm Exam

- One closed-book midterm exam will be given in this term. The exam will take place few days after Lab #7 for a one-hour duration.
- There will be no lecture or lab on the day. **You may bring one two-sided sheet of notes written by your own hands to the exam**. You may also bring a calculator, eraser, pencil or ball pens.

Final Exam

- A two-hour final exam will be given during the end-of-term exam week. Timing and room assignments will be announced later. **You may bring three two-sided sheets of notes written by your own hands to the exam**.

Calendar

The calendar provides information on the course's lecture class (L), lab (Lab #), and exam (E) sessions.

SES #	TOPICS	KEY DATES
L1	Introduction to Mechanical Design Fundamentals of Kinematics	Homework #1 in
Lab #1	Degrees of Freedom Example Problems Practice Problems	Lab report #1 in
L2	Degree of Freedom	Homework #1 out Homework #2 in
Lab #2	Introduction to Graphical Linkage Synthesis Two Specified Positions of the Rocker Practice Problems	Lab report #1 out Lab report #2 in
L3	Classifications of the Fourbar Linkage	Homework #2 out Homework #3 in
Lab #3	Two Specified Positions of the Coupler Three Specified Positions of the Coupler Practice Problems	Lab report #2 out Lab report #3 in
L4	Introduction to Position Analysis Review of Vectors and Matrices Position Analysis of the Slider-Crank	Homework #3 out Homework #4 in
Lab #4	Vectors and Matrices Exercises Position Analysis of the Threebar Slider-Crank Position Analysis of the Slider-Crank Practice Problems	Lab report #3 out Lab report #4 in
L5	Position Analysis of the Fourbar Linkage	Homework #4 out Homework #5 in
Lab #5	Position Analysis of the Fourbar Linkage Position Analysis of the Inverted Slider-Crank	Lab report #4 out Lab report #5 in

SES #	TOPICS	KEY DATES
	Practice Problems	
L6	Position Analysis of the Geared Five bar Linkage	Homework #5 out Homework #6 in
Lab #6	Position Analysis of the Geared Five bar Linkage Practice Problems	Lab report #5 out Lab report #6 in
L7	Introduction to Velocity Analysis The Method of Instant Centers	
Lab #7	Instant Centers of the Four bar Linkage Velocity Analysis of the Four bar Linkage by SolidWorks Instant Centers of the Slider-Crank Linkage Instant Centers of the Inverted Slider-Crank Linkage Practice Problems	Lab report #6 out Lab report #7 in
E1	**Midterm Exam**	
L8	Velocity Analysis of the Slider-Crank	
Lab #8	Velocity Analysis of the Three bar Slider-Crank Velocity Analysis of the Slider-Crank Practice Problems	Lab report #7 out Lab report #8 in
L9	Velocity Analysis of the Four bar Linkage	
Lab #9	Velocity Analysis of the Four bar Linkage Velocity Analysis of the Inverted Slider-Crank Practice Problems	Lab report #8 out Lab report #9 in
L10	Velocity Analysis of the Geared Five bar Linkage	
Lab #10	Velocity Analysis of the Geared Five bar Linkage Practice Problems	Lab report #9 out Lab report #10 in
L11	Introduction to Acceleration Analysis Acceleration Analysis of the Slider-Crank	Homework #10 out Homework #11 in

SES #	TOPICS	KEY DATES
Lab #11	Acceleration on a Moving Point on a Moving Link Acceleration Analysis of the Three bar Slider-Crank Acceleration Analysis of the Slider-Crank Practice Problems	Lab report #10 out Lab report #11 in
L12	Acceleration Analysis of the Four bar Linkage	Homework #11 out Homework #12 in
Lab #12	Acceleration Analysis of the Four bar Linkage Acceleration Analysis of the Inverted Slider-Crank Practice Problems	Lab report #11 out Lab report #12 in
L13	Acceleration Analysis of the Geared Five bar Linkage	Homework #12 out Homework #13 in
Lab #13	Acceleration Analysis of the Geared Five bar Linkage Practice Problems	Lab report #12 out Lab report #13 in
E2	**Final Exam**	

Grading (or Assessment) Policy

Initial grading will be based on the following weighting:

ACTIVITIES	PERCENTAGES
Homework	5%
Labs (performance & reports)	50%
Midterm	20%
Final exam	25%

- Lab assignments will be graded on a scale of 0 to 3
  - i) 3: lab complete, works, good job on pre- and post-lab;
  - ii) 2: lab mostly complete, reasonable job on pre and post lab;
  - iii) 1: lab partially done, marginal to poor job on pre- and post-lab;
  - iv) 0: lab not done, poor job on pre- and post-lab.
- All homework will be graded on a coarse scale of 0 to 3 points,
  - i) 3 points if all or nearly all problems are correct,
  - ii) 2 points if homework is approximately half correct,
  - iii) 1 point if mostly incorrect, and
  - iv) 0 points if late or not submitted.

· This will be followed by considerable discussion among the entire teaching staff to factor in your diligence on the homework and labs, and your participation in class and labs. This discussion can affect your letter grade for the course, particularly if your initial grade is on a letter-grade boundary.

· Furthermore, failure to complete the labs in this subject will result in an overall grade that is one letter grade lower (not an Incomplete).

· This subject has been designed so that lectures, homework and labs are integral and essential parts of the learning process. Although there is no specific reward for participation, there is a clearly defined penalty for not participating. Students who consistently miss lectures, homework and labs will not be included in the grading discussions.

Lecture notes

This section contains lecture notes from some chapters of the following book,

Eric Constans and Karl B. Dyer, Introduction to Mechanism Design with Computer Applications, CRC Press, 2019, New York, USA. ISBN: 978-1-138-74065-5.

LEC #	TOPICS	LECTURE NOTES (BOOK)
L1	Introduction to Mechanical Design Fundamentals of Kinematics	Chapter 1: Introduction to Kinematics
L2	Degree of Freedom	Chapter 1: Introduction to Kinematics
L3	Classifications of the Four bar Linkage	Chapter 1: Introduction to Kinematics
L4	Introduction to Position Analysis Review of Vectors and Matrices Position Analysis of the Slider-Crank	Chapter 4: Position Analysis of Linkages
L5	Position Analysis of the Four bar Linkage	Chapter 4: Position Analysis of Linkages
L6	Position Analysis of the Geared Five bar Linkage	Chapter 4: Position Analysis of Linkages
L7	Introduction to Velocity Analysis The Method of Instant Centers	Chapter 5: Velocity Analysis of Linkages
L8	Velocity Analysis of the Slider-Crank	Chapter 5: Velocity Analysis of Linkages
L9	Velocity Analysis of the Four bar Linkage	Chapter 5: Velocity Analysis of Linkages
L10	Velocity Analysis of the Geared Five bar Linkage	Chapter 5: Velocity Analysis of Linkages
L11	Introduction to Acceleration Analysis Acceleration Analysis of the Slider-Crank	Chapter 6: Acceleration Analysis of Linkages
L12	Acceleration Analysis of the Four bar Linkage	Chapter 6: Acceleration Analysis of Linkages
L13	Acceleration Analysis of the Geared Five bar Linkage	Chapter 6: Acceleration Analysis of Linkages

Lab notes (or Practice Manual)

This section contains lab notes from every chapter of the practice manual, "2. Naguib G. Naguib, Computer-Aided Kinematics (Practice Manual), BST, 2020"

LAB #	TOPICS	LAB NOTES (PRACTICE MANUAL CHAPTER)
Lab #1	Fundamentals of Kinematics Degrees of Freedom Example Problems Practice Problems	Module 1 Chapter 1
Lab #2	Introduction to Graphical Linkage Synthesis Two Specified Positions of the Rocker - Without Specified Ground Pin - Quick-Return Mechanisms Practice Problems	Module 2 Chapter 1
Lab #3	Two Specified Positions of the Coupler Three Specified Positions of the Coupler Practice Problems	Module 2 Chapter 2
Lab #4	Vectors and Matrices Exercises Position Analysis of the Three bar Slider-Crank Position Analysis of the Slider-Crank Practice Problems	Module 3 Chapter 1
Lab #5	Position Analysis of the Four bar Linkage Position Analysis of the Inverted Slider-Crank Practice Problems	Module 3 Chapter 2
Lab #6	Position Analysis of the Geared Fiver bar Linkage - Position of Any Point on the Linkage Practice Problems	Module 3 Chapter 3
Lab #7	Instant Centers of the Four bar Linkage Velocity Analysis by SolidWorks Instant Centers of the Slider-Crank Linkage Instant Centers of the Inverted Slider-Crank Linkage Practice Problems	Module 4 Chapter 1

LAB #	TOPICS	LAB NOTES (PRACTICE MANUAL CHAPTER)
Lab #8	Velocity Analysis of the Three bar Slider-Crank Velocity Analysis of the Slider-Crank Practice Problems	Module 4 Chapter 2
Lab #9	Velocity Analysis of the Four bar Linkage Velocity Analysis of the Inverted Slider-Crank Practice Problems	Module 4 Chapter 3
Lab #10	Velocity Analysis of the Geared Five bar Linkage - Example Five bar Linkage Practice Problems	Module 4 Chapter 4
Lab #11	Acceleration on a Moving Point on a Moving Link Acceleration Analysis of the Three bar Slider-Crank Acceleration Analysis of the Slider-Crank Practice Problems	Module 5 Chapter 1
Lab #12	Acceleration Analysis of the Four bar Linkage Acceleration Analysis of the Inverted Slider-Crank Practice Problems	Module 5 Chapter 2
Lab #13	Acceleration Analysis of the Geared Five bar Linkage Practice Problems	Module 5 Chapter 3