Sample Syllabus

ME 480
Mechanism Design and Analysis
Spring 2025

Time: MWF 11:15 AM – 12:05 PM / **Location:** Electrical Engineering West 103

INSTRUCTOR: Dr. Joseph S. Najem
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Office Hours: 12:15-11:15 MWF

TA: XXX

**Meetings outside office hours are by appointment only and upon availability.*

**Office hours can be in person or via Zoom.*

**I will respond to your emails between 8 am and 5 pm M-F.*

Textbook: Design of Machinery, An Introduction to the Synthesis and Analysis of Mechanisms and Machines, 6th Edition, by Robert L. Norton; McGraw Hill.

a. Other supplemental material: None

Course Description: Design and analysis of mechanical linkages, including kinematic synthesis and dynamic analysis. Linkages for a variety of applications are considered. M E 480 Mechanism Design and Analysis (3) The student taking this course will develop a basic understanding of planning and synthesizing planar linkage mechanisms. Students will develop the ability to model real linkage mechanisms using kinematic diagrams, including identifying links and joints. Based on the kinematic diagram, they will also learn to use Gruebler's equation to calculate the mobility or number of degrees of freedom of linkages. Students will also become familiar with real mechanism applications in the context of mechanism synthesis, where they will learn to determine the required mechanism dimensions for a specific application. Students will apply these dimensional synthesis methods in a design project, including building a simple linkage prototype. They will learn kinematic analysis methods, i.e., analysis of position, velocity, and acceleration of planar linkages. These methods consist of graphical, algebraic, and complex number approaches. Students will also learn to use commercial software packages, e.g., Working Model, to predict the position, velocity, and acceleration of planar linkages and will compare their predictions to those using analytical approaches. Finally, students will learn to do dynamic force analysis of planar linkages to predict joint forces and motor torques. They will use commercial software packages to predict joint forces and motor torques of planar linkages and will compare their predictions to those using analytical approaches

Prerequisites: EMCH 212, CMPSC 200, 201, or 202, MATH 220 and 251

Computer requirements: MATLAB will be used to obtain numerical solutions and for plotting

Goals and Objectives:

Objectives	Outcomes
Apply kinematic modeling techniques	Develop kinematic diagrams of real linkage mechanisms
Apply Gruebler's Equation	Determine degrees of freedom of planar linkages
Apply dimensional synthesis techniques to a design project	Determine the required dimensions of a planar linkage for a specific application; Build a simple prototype linkage
Apply graphical, algebraic, and complex number kinematic analysis methods	Predict positions, velocities and accelerations of planar linkages
Apply dynamic analysis techniques	Predict joint forces and motor torques of planar linkages
Develop proficiency at using commercial software packages for kinematic and dynamic analysis	Compare predictions from commercial software to those using analytical approaches

Resources:

Canvas

Course Topics and Tentative Schedule:

Lecture	Topic
1	Introduction and Overview
2	**Chapter 2: Kinematics Fundamentals.** Degrees of Freedom; Links, Joints, and Kinematic Chains; Grashof Condition; Limiting Conditions
3	**Chapter 3: Graphical Linkage Synthesis.** Dimensional Synthesis Quick-Return Mechanisms; Coupler Curves, Straight-Line and Dwell Mechanisms;
4	**Chapter 4: Position Analysis.** Algebraic Position (Vector Loop) Analysis of Linkages, pin jointed four bar mechanism
5	Crank slider mechanism
6	Slider crank mechanism, transmission angle and toggle positions
7	Position analysis examples
8	Position analysis examples
9	Position analysis examples
10	**Chapter 6: Velocity Analysis.** Analytical Solutions for Fourbar Pin-Jointed Linkage
11	Analytical Solutions for Slider-Crank Linkage
12	Velocity of any Point on a Linkage
13	Velocity examples on Fourbar Pin-Jointed Linkage
14	Velocity examples on Fourbar Pin-Jointed Linkage
15	Velocity examples on Slider-Crank Linkage; Instant Centers of Velocity;
16	**Exam 1**
17	**Chapter 7: Acceleration Analysis**. Analytical Solutions for Fourbar Pin-Jointed Linkage

18	Analytical Solutions for Slider-Crank Linkage
19	Acceleration of any Point on a Linkage
20	Acceleration examples on Fourbar Pin-Jointed Linkage
21	Acceleration examples on Slider-Crank Linkage
22	**Chapter 10: Dynamics Fundamentals.** Mass Moment and Center of Gravity, Mass Moment of Inertia
23	Radius of Gyration, Modeling Rotating Links, Lumped Parameter Dynamic Models
24	**Chapter 11 Dynamic Force Analysis.** Single Link in Pure Rotation
25	Force Analysis of a Fourbar Linkage
26	Examples on Force Analysis of a Fourbar Linkage
27	Shaking Forces and Shaking Torque
27	Force Analysis of a Fourbar Slider-Crank Linkage
28	Examples on Force Analysis of a Fourbar Slider-Crank Linkage
29	Case study: Oil pump
30	**Exam 2**
31	**Chapter 9: Gear Trains.** The Fundamental Law of Gearing, Gear Tooth Nomenclature, Contact Ratio, Gear Types
32	Compound Gear Trains
33	Epicyclic or Planetary Gear Trains
34	Examples on planetary system design
35	Differentials
36	**Chapter 8: Cam Design,** Cam Terminology
37	SVAJ Diagrams
38	SVAJ Diagrams
39	Polynomials for cams
40	Cam sizing
41	Cam dynamics, spring design

Grading Policies:

This course will follow all policies and rules outlined in Senate Policy 47-20. Occasionally, a disagreement arises in the assignment of a grade. A student who wishes to question or challenge the grade assigned must email a request for a grade change, including a copy of the question, the original answer, and a paragraph explaining why a grade change is warranted.
On the rare occasion that a student and instructor fail to resolve the course grade dispute through informal means, the student may request that the head of the academic program offering the course review the issue and take appropriate action to mediate and seek resolution. If this does not resolve the dispute, the student may seek further review from the associate dean for undergraduate or graduate education or the director of academic affairs for the college offering the course. The student may initiate this process by completing the Grade Adjudication Petition Form (available at http://www.psu.edu/oue/aappm/grademed.pdf) and returning it to the associate dean or director of academic affairs responsible for undergraduate education or the associate dean for graduate studies. The request form must be submitted ten weeks after the course's end date (as it appears in the schedule of classes).

Evaluation & Grading:
Students will earn points for weekly homework and quizzes, two tests, and a final examination. Homework should be submitted at the start of class on the due date. Your homework must be a printed, word-processed document, as this will be expected of you when you go to work. If you do not know how to use an equation editor and MATLAB, it is time to learn how, as these will be invaluable tools for you once you graduate.

Formulas and weights for assignments, quizzes, and exams:

Homework (Assigned every Friday and due the Friday after)	25 %
Tests (25% will go to the highest grade)	45 %
Test 1: TBD | 11:15 am- 12:05 pm | In-class	
Test 2: TBD | 11:15 am- 12:05 pm | In-class	
Final	30 %

Grading Scale:

Final Course Average	Grade
<65.00	F
65.00≤avg≤75.00	D
70.00≤avg≤77	C
77.00≤avg≤80	C+
80.00≤avg≤83	B-
83.00≤avg≤87	B
87.00≤avg≤90	B+
90.00≤avg≤93	A-
93.00≤avg≤100	A

Policies for missed projects/assignments:

Students can only make up missed work for legitimate, unavoidable reasons, such as illness, injury, military service, family emergency, or religious observance.
Non-legitimate missed work will receive a zero.

Policies for make-up quizzes and exams:

Suppose an evaluative event is missed due to an unavoidable absence. In that case, the student should contact the instructor as soon as possible to discuss ways to make up the exam.
44-35 CONFLICT OF NON-FINAL EXAMINATIONS

1. Evening Conflict. In the case of conflict between an evening examination or quiz and other scheduled University activities, or in the case of more than one evening examination in any one evening, each student is permitted to make up the examination without penalty.
2. Non-Evening Conflict. If a non-evening examination or previously announced quiz conflicts with participating in scheduled University-approved activities, the student can make up the examination or quiz without penalty.

Attendance and late policies:

Religious observances are not counted as absences, though observing students must inform the instructor during the first week of the course of any planned absences. Official university activities are excused absences if the student notifies the instructor in advance and provides appropriate paperwork. Absence due to sickness does not require a doctor's note. Still, the student must inform the instructor promptly and bring extended medical absences to the instructor as soon as possible. The absent student is responsible for catching up on any missed material and doing any make-up work required by the instructor.

Academic Integrity:

The University defines academic integrity as the pursuit of scholarly activity in an open, honest, and responsible manner. All students should act with personal integrity, respect other students' dignity, rights, and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts, refer to Senate Policy 49-20. Dishonesty of any kind will not be tolerated in this course. Students found to be dishonest will receive academic sanctions and be reported to the University's Office of Student Conduct for possible further disciplinary sanctions (refer to Senate Policy G-9).

Dishonesty Examples:

CHEATING is a general category of academic misconduct that, in the context of an educational course, involves dishonesty in completing work in the course, whether an examination or other kind of assignment. Assisting another student dishonestly is also cheating. Note that plagiarism, fabrication of research results, and other such violations of academic integrity may correctly be identified as particular kinds of cheating. Examples of cheating include, but are not limited to, the following:

- Knowingly discovering or attempting to discover the contents of an examination before the instructor releases the contents
- Taking a picture of or otherwise copying an examination without permission to do so
- Providing such a picture/copy to another person
- Obtaining, using, or attempting to obtain or use any material or device dishonestly
- Supplying or attempting to supply any material or device to another person dishonestly
- Obtaining or attempting to obtain unauthorized information during an examination from another student or another student's test materials
- Unauthorized possessing, taking, copying, or sharing of solutions manuals or computerized solutions (example, CHEGG) for assigned homework or research problems
- Taking a quiz, an exam, performing a laboratory exercise, or similar evaluation in place of another.
- Altering an exam, quiz, project, or lab by changing incorrect answers and seeking a grade adjustment asserting the instructor made a mistake in grading.

- Facilitating acts by others, unauthorized collaboration of work, permitting another to copy, writing a paper for another, or inappropriately collaborating on home assignments or exams without permission or when prohibited.

PLAGIARISM is that kind of cheating that involves using someone else's words, ideas, or other intellectual property as if they (the words, ideas, or other intellectual property) were one's original work. Some common kinds of plagiarism are listed here:

- Because the Internet's richly varied resources make copying the work of others easy, a particularly common kind of plagiarism occurs when someone reproduces or closely imitates one or more documents from the Internet and claims that the resulting essay or research paper is the copier's own work.
- Similar issues of dishonesty are raised by term paper sites or custom term paper writing services where one can purchase a term paper, research paper, or essay.
- Submitting an assignment prepared by another student as one's own is an obvious form of plagiarism.
- At other times, plagiarism occurs because a student needs help understanding the necessity or the mechanisms for acknowledging the words, ideas, or other intellectual property of others.

FABRICATION is cheating by faking results, as of an experiment, or otherwise "making up" something that one presents as true, factual, or accurate. Fabrication in an academic context may occur in several forms, including these:

- falsifying research results or a report of research processes
- falsifying reports or records related to a field, practicum, or clinical experience

Disability Resources:

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. The Student Disability Resources (SDR) website provides contact information for every Penn State campus: http://equity.psu.edu/sdr/disability-coordinator. For further information, please visit the SDR website: http://equity.psu.edu/sdr/.

To receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation. See documentation guidelines (http://equity.psu.edu/sdr/guidelines). If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

Counseling & Psychological Services (CAPS):

Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional well-being. The university offers confidential services to help you through tricky times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a

philosophy that is respectful of clients' cultural and religious backgrounds and sensitive to differences in race, ability, gender identity, and sexual orientation.

- Counseling and Psychological Services at University Park (CAPS) (http://studentaffairs.psu.edu/counseling/): 814-863-0395
- Penn State Crisis Line (24 hours/7 days/week): 877-229-6400
  Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741

Educational Equity/Report Bias

Penn State University has adopted a Protocol for Responding to Bias Motivated Incidents http://equity.psu.edu/reportbias/reports/protocol-for-responding-to-bias-motivated-incidents that is grounded in the policy that the "University is committed to creating an educational environment which is free from intolerance directed toward individuals or groups and strives to create and maintain an environment that fosters respect for others." That policy is embedded within an institution traditionally committed to academic freedom https://guru.psu.edu/policies/OHR/hr64.html Bias-motivated incidents include conduct that is defined in University Policy AD 91: Discrimination and Harassment, and Related Inappropriate Conduct https://guru.psu.edu/policies/ad91.html. Students, faculty, or staff who experience or witness a possible bias-motivated incident are urged to report the incident immediately by doing one of the following:

- Submit a report via the Report Bias webpage (http://equity.psu.edu/reportbias/)
- Contact one of the following offices:

  University Police Services, University Park: 814-863-1111

  Multicultural Resource Center, Diversity Advocate for Students: 814-865-1773

  Office of the Vice Provost for Educational Equity: 814-865-5906

  Office of the Vice President for Student Affairs: 814-865-0909

  Affirmative Action Office: 814-863-0471

  * Dialing 911 in cases where physical injury has occurred or is imminent