ME 3011 Kinematics & Dynamics of Machines and Vibrational Modeling

Learning Outcomes

Dr. Bob Williams

The objectives of this course are to cover the kinematics and dynamics of planar single degree-of-freedom mechanisms. After this course, the student should have general mathematical and computer skills to enable high-fidelity kinematics and dynamics analysis of machine elements including linkages, cams, and gears, within the general machine design context. The methods used in this course are general vector/matrix analysis techniques that can be applied in the future to any planar mechanism, not only the example mechanisms presented in class. A side-objective is to introduce the use of MATLAB as a powerful software tool in programming analysis equations. The course project is intended to have each student team apply the class principles in real-world mechanisms. This course provides practice in technical writing (weekly homework memos and final project report) and practice in technical presentation (final project presented orally to the class). Specific topics include:

1. Students will be able to identify common mechanisms used in machines and everyday life.

2. Students will be able to calculate the mobility (number of degrees-of-freedom) of planar structures, mechanisms, and robots.

3. Students will be able to perform complete translational and rotational mechanism position analysis.

4. Students will be able to perform complete translational and rotational mechanism velocity analysis.

5. Students will be able to perform complete translational and rotational mechanism acceleration analysis.

6. Students will be able to perform complete translational and rotational mechanism inverse dynamics analysis via the matrix method.

7. Students will be able to classify cam mechanisms, and design cam motion profiles.

8. Students will be able to classify gear mechanisms, and calculate gear motion and torque given the gear ratio.

9. Students will be able to perform linearized dynamic modeling for vibrational systems.

10. Term project: complete kinematics and inverse dynamics analysis of a real-world mechanism. Done by teams of two students, all teams choose a unique mechanism. Must be presented orally to the class and in a formal written technical report.

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ABET Outcomes

[ABET-e] OU ME graduates will demonstrate an ability to identify, formulate, and solve engineering problems

i. Kinematic/Dynamic analysis skills, including:

1) Analysis of position, velocity and acceleration kinematics of mechanisms (Competence)

2) Analysis of inverse dynamics of mechanisms (Competence)

3) Basic analysis of cams and gears (Awareness).

[ASME/ABET-a] OU ME graduates will demonstrate an ability to apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations) to model, analyze, design, and realize physical systems, components or processes; and work professionally in both thermal and mechanical systems areas.

a.1) An ability to apply knowledge of Linear Algebra

a. The ability to complete standard matrix manipulations. (Mastery)

b. The ability to use matrices for solving systems of linear equations (Mastery)

ME 3011 Kinematics & Dynamics of Machines and Vibrational Modeling
Syllabus and Policy

Dr. Bob Williams 262 Stocker, 740-593-1096 williar4@ohio.edu	Fall 2024 Class # 7047 people.ohio.edu/williams

Time & Venue

9:40 – 10:35 a.m. M W F 3 credit hours ARC 212

Prerequisites

C or better in ET 2240

Description

Analytical and graphical solutions of kinematic and dynamic motion problems involving mechanical elements: linkages, gears, cams, mechanical trains, etc. Modeling and characteristic phenomena of one degree-of-freedom mechanical vibrations encountered in machines and structures.

Office Hours

12:00 – 1:30 p.m. M W and by appointment

Required NotesBooks

Mechanism Kinematics & Dynamics, Dr. Bob Productions, ©2024
Mechanism Kinematics & Dynamics (lulu.com)

Mechanical Vibrations, Dr. Bob Productions, ©2024 (also used in ME 3012)
Mechanical Vibrations (lulu.com)

I would NOT use all your Stocker prints for hardcopies of these two required NotesBooks.

Required Textbook

none

ME 3011 Course Website

https://people.ohio.edu/williams/html/Courses.html

ME 3011 NotesBook Supplement

https://people.ohio.edu/williams/html/PDF/Supplement3011.pdf

Dr. Bob's MATLAB Primer and Matrices Review

https://people.ohio.edu/williams/html/PDF/MATLABPrimer.pdf
https://people.ohio.edu/williams/html/PDF/MatricesLinearAlgebra.pdf

Dr. Bob's Mechanisms Atlas

https://people.ohio.edu/williams/html/PDF/MechanismAtlas.pdf

Mechanism and Robot Animations developed at Ohio University

https://people.ohio.edu/williams/html/MechanismAnimations.html

Homework

Six homework assignments will be collected via hardcopy at the start of class as shown in the schedule on the following two pages. Each homework will be assigned via email two weeks before it is due. A **Memo** (see sample memo) summarizing the work must be the first page of each homework submission.

Quizzes

Six quizzes will be given in class as shown in the schedule on the following two pages. All quizzes are closed notes and closed NotesBook. Quiz 3 is the Midterm (20 pts), and Quiz 6 is the Final (30 pts).

Homework/Quiz Makeup Policy

You can make up any quiz, with a valid written OU excuse, before the next class. For planned absences with a valid OU excuse, please turn in the homework early. For unplanned absences with a valid OU excuse, you can turn in the homework ASAP afterwards. You must turn in the homework early if you have an unexcused absence on one of those HW due dates.

Capstone Term Project

The term project, with a standard team size of two students, is assigned here: https://people.ohio.edu/williams/html/PDF/Proj3011.pdf. One final report will be submitted per pair and both partners earn the same grade, in general. The project will be evaluated via an interim report, a final oral presentation, and a final report.

Academic Dishonesty

Cheating in any form will not be tolerated. A grade of zero will be registered for any infraction, and the matter will be referred to University Judiciaries. There will be a zero-tolerance punishment of plagiarism in any form – the assignment in question will receive a zero and you will be referred to University Judiciaries. Cite all references properly and do not copy ANY text (with the exception of an important short quote, in quotation marks, and attributed and referenced properly).

Attendance

Full attendance is required. Class participation is expected. No homework, quiz, or exam can be made up without a valid written OU excuse.

Grading

Homework 30%	Quizzes 35%	Project 35%

93.3-100	90-93.3	86.7-90	83.3-86.7	80-83.3	76.7-80	73.3-76.7	70-73.3	66.7-70	63.3-66.7	60-63.3	< 60
A	A–	B+	B	B–	C+	C	C–	D+	D	D–	F

ME 3011 Fall Semester 2024 Schedule

Week	Date	Day	Topic	Notes	HW	Quiz	Proj
1	26-Aug	Mon	Syllabus, intro, videos	1.1			
		Wed	Vectors overview	1.3			
		Fri	MATLAB intro	1.4			
2	2-Sep	Mon	Labour Day Holiday				
		Wed	Mobility	1.5			
		Fri	4-bar position analysis	2.1.1			
3	9-Sep	Mon	Quiz 1			Q1	
		Wed	4-bar position analysis	2.1.1			
		Fri	4-bar graphical, mu, Pt C, MATLAB	2.1.1			
4	16-Sep	Mon	Trig uncertainty, 4-bar irregularities	2.1.2-3	HW1		
		Wed	Grashof's Law, Project signup	2.1.4			Sign
		Fri	Slider-crank position analysis	2.2			
5	23-Sep	Mon	Quiz 2			Q2	
		Wed	3-part velocity equation	3.1-2			
		Fri	4-bar velocity analysis, Vc	3.3			
6	30-Sep	Mon	4-bar velocity, matrix, singularity	3.3	HW2		
		Wed	Slider-crank velocity analysis	3.4			
		Fri	5-part acceleration equation	4.1-2			
7	7-Oct	Mon	Quiz 3 Midterm			Q3	
		Wed	4-bar accel, Ac, matrix, singularity	4.3			
		Fri	Wellness Day Holiday				
8	14-Oct	Mon	Slider-crank acceleration analysis	4.4	HW3		
		Wed	Link extension, Input motion spec	5.1-2			
		Fri	Dynamics intro, m CG Ig	6.1-2			

ME 3011 Fall Semester 2024 Schedule (continued)

Week	Date	Day	Topic	Notes	HW		Proj
9	21-Oct	Mon	Quiz 4			Q4	
		Wed	Single-rotating-link inverse dynamics	6.3			Int
		Fri	Single-rotating-link inverse dynamics	6.3			
10	28-Oct	Mon	4-bar inverse dynamics, matrix, shake	6.4	HW4		
		Wed	4-bar inverse dynamics link details	6.4			
		Fri	Slider-crank inverse dynamics	6.5			
11	4-Nov	Mon	Quiz 5			Q5	
		Wed	Gears intro	7.1.1			
		Fri	Gear ratio	7.1.2			
12	11-Nov	Mon	Veteran's Day Holiday				
		Wed	Cam Intro	7.2	HW5		
		Fri	Capstone project work day				
13	18-Nov	Mon	Capstone project presentations				Pres
		Wed	Capstone project presentations				Pres
		Fri	Intro to Vibes, Review of trig fns, Report due	V1.1-1.3			Final
14	25-Nov	Mon	Thanksgiving Holiday				
		Wed					
		Fri					
15	2-Dec	Mon	2nd-ord sys mck, vert, subsets	V2.1.2			
		Wed	Equivalent springs, pendulum, J-cR-kR	V2.1.2	HW6		
		Fri	Quiz 6 Final			Q6	

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Homework Policy

Dr. Bob Williams

Homework assignments will be collected via hardcopy at the start of class as shown previously in the schedule, every other Monday. Each will be assigned via email two weeks before it is due. A **Memo** (see sample memo next page) summarizing the work must be the first page of each HW submission.

Please see the Homework/Quiz drop and makeup policies already presented in this syllabus.

1) No late homework assignments will be accepted. Each homework assignment is due as assigned.

2) No computer excuses will alter deadlines. In the event of problems, do your best.

3) Each assignment must be neat, with answers clearly noted and supporting information provided.

4) One complete hand calculation must be provided (if the computer is used to solve multiple problems) to verify your results.

6) MATLAB software is required. I am available to help during office hours or by appointment. For an extensive introduction to the MATLAB software, please see Dr. Bob's MATLAB Primer:

www.ohio.edu/mechanical-faculty/williams/html/PDF/MATLABPrimer.pdf

MEMO-WRITING. A MEMO MUST BE INCLUDED WITH YOUR HOMEWORK RESULTS EACH TIME. An example is given on the next page. This should be a *brief* technical communication addressed to me, summarizing the week's homework assignments and bottom-line results. Your single memo must summarize all assignments each week. LENGTH LIMIT: *one single-sided page, 12 pt font*. Without a MEMO your HW score will be entered as zero. If the MEMO is not clear, credit can also diminish. A memo is required from the first HW assignment through the last, and for the Capstone Term Project reports.

For maximum credit, you must focus on **Good Graphical Communication**, **Validation**, and **Discussion**.

OHIO UNIVERSITY

Russ College of Engineering & Technology
Department of Mechanical Engineering

DATE: August 31, 2024

TO: Dr. Bob

FROM: Ima Student

SUBJECT: ME 3011 Homework Assignment #1

Dr. Bob,

The purpose of this memo is to present the basic results for HW Assignment #1. You assigned a total of two problems: (*enumerate briefly here*).

The answers to problem 1 are: (*give answers; not always appropriate here*). My sketches appear on p. 2 (*if appropriate*). I obtained the answers using MATLAB file **bob.m**, which appears on p. 3. Sample calculations are presented on p. 4 to demonstrate that the computer code generates the correct results. (*Brief summary of roadblocks, issues, or learning here, if appropriate*).

For problem 2, (*similar to above paragraph*).

If you have any questions on my work, please contact me.

Sincerely,

Ima Student
AlmostTotallyUnintelligibleUsername@ohio.edu