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.

ME 3011 Kinematics & Dynamics of Machines and Vibrational Modeling

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	Spring 2022 Class # 1708 ohio.edu/mechanical-faculty/williams

Time & Venue

3:05 – 4:25 p.m. Tu Th 3 credit hours ARC 321

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

1:30 – 3:00 p.m. Tu Th and by appointment

Required NotesBooks

Mechanism Kinematics & Dynamics, Dr. Bob Productions, ©2022
www.lulu.com/content/e-book/mechanism-kinematics-dynamics/20797952
Mechanical Vibrations, Dr. Bob Productions, ©2017 (also used in 3012)
www.lulu.com/content/e-book/mechanical-vibrations/20853410
I would NOT use all your Stocker prints for hardcopies of these two required NotesBooks. You must first purchase from lulu.com before making a hardcopy locally.

Required Textbook

none

ME 3011 Course Website

www.ohio.edu/mechanical-faculty/williams/html/Courses.html

ME 3011 NotesBook Supplement

www.ohio.edu/mechanical-faculty/williams/html/PDF/Supplement3011.pdf

Dr. Bob's MATLAB Primer and Matrices Review

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

Dr. Bob's Mechanisms Atlas

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

Mechanism and Robot Animations developed at Ohio University

www.ohio.edu/mechanical-faculty/williams/html/MechanismAnimations.html

Homework

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

Quizzes

Five quizzes will be given in class as shown in the schedule on the following page. All quizzes are closed notes and closed NotesBook.

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 to Dr. Bob. You must turn in the homework early to Dr. Bob if you have an unexcused absence on one of those HW due dates.

Capstone Term Project

The Capstone Term Project, with a standard team size of two students, is assigned here: www.ohio.edu/mechanical-faculty/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

Turn off all cell phones and other portable electronic devices before entering the classroom!

ME 3011 Spring Semester 2022 Schedule

Week	Date	Day	Topic	Notes	HW	Quiz	Proj
1	1/11	Tu	Syllabus and Policy, Intro, History	1.1			
		Th	Vectors Overview and MATLAB Intro	1.3-4			
2	1/18	Tu	Mobility	1.5			
		Th	Four-Bar Position Analysis	2.1			
3	1/25	Tu	Quiz 1			Q1	
		Th	Four-Bar Graphical, mu, Point C, MATLAB	2.1			Sign
4	2/1	Tu	Trig Uncertainty, Grashof's Law	2.1	HW1		
		Th	Slider-crank position analysis	2.2			
5	2/8	Tu	Quiz 2			Q2	
		Th	3-part velocity equation	3.1-2			
6	2/15	Tu	4-bar velocity analysis, Vc, matrix, singularity	3.3	HW2		
		Th	Slider-crank velocity analysis	3.4			
7	2/22	Tu	Quiz 3			Q3	
		Th	5-part Acceleration Equation	4.1-2			
8	3/1	Tu	4-bar acceleration analysis, Ac, matrix, singularity	4.3	HW3		
		Th	Slider-crank acceleration, Link Ext, Input Motion Spec	4.4-5.2			
9	3/8	Tu	Spring Break				
		Th					
10	3/15	Tu	Quiz 4			Q4	
		Th	Dynamics Intro, m CG I	6.1-2			Inter
11	3/22	Tu	Single-Rotating-Link Inverse Dynamics	6.3	HW4		
		Th	Four-bar Inverse Dynamics	6.4			
12	3/29	Tu	Slider-Crank Inverse Dynamics	6.4			
		Th	Quiz 5			Q5	
13	4/5	Tu	Gears and Cams	7.1-2	HW5		
		Th	Vibes Intro, Trig, Zeroth	V1.1-3			
14	4/12	Tu	Capstone term project presentations				Pres
		Th	Capstone term project presentations, Final report due				Final
15	4/19	Tu	Second-Order Modeling, Vertical, Equivalent Springs	V2.1			
		Th	Pendulum, J-cR-kR, First-Order	V2.1			

ME 3011 Kinematics & Dynamics of Machines and Vibrational Modeling

Homework Policy

Dr. Bob Williams

Homework assignments will be collected in hardcopy at the start of class, as shown previously in the ME 3011 schedule, roughly every other Tuesday. Each will be assigned via email about 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.

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: January 1, 2022

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