ME 451
Kinematics and Dynamics of Machine Systems
Spring 2009

Time: 11:00 – 12:15 PM Tu & Th
Room: 3345EH before Feb. 1 and 3126ME starting on Feb. 1.
Instructor: Dan Negrut
Office: 2035ME
Phone: 608 890 0914
E-Mail: negrut@engr.wisc.edu
Course Page: learnuw.wisc.edu (for grades), and www.sbel.wisc.edu/Courses/ME451/2009/index.htm
Graders: Justin Madsen (jcmadsen@wisc.edu) – ask ADAMS related questions
Naresh Khude (khude@wisc.edu) – ask non-ADAMS related questions

Office Hours:

Monday, 2 – 4 PM
Wednesday, 2 – 4 PM
Friday, 3 – 4 PM
Other times by appointment (please call or email to arrange)

Text: The books below have been placed on reserve at Wendt library in conjunction with this course. The first book will be the one that comes closest to the material covered in the class. The author provided a pdf of the entire book and gave me permission to distribute it for free.

1. Computer-Aided Kinematics and Dynamics of Mechanical Systems, Volume I: Basic Methods, by Edward J. Haug, Allyn and Bacon, 1989
2. Theory of Machines and Mechanisms, by J. J. Uicker, Jr., G. R. Pennock, and J. E. Shigley, 3rd ed., Oxford University Press, 2003.
3. Dynamics of Multibody Systems, by Ahmed A. Shabana, 3rd ed., 2007
4. Scientific Computing, An Introductory Survey, by Michael T. Heath, 2nd ed., 2002

Prerequisites: ME 240 or equivalent

Recommended Supplemental Text: *MATLAB & Simulink Student Version Release 14*
Available for purchase at bookstore and at www.mathworks.com/academia/student_version/index.html

Course Objectives: This course reviews and reinforces the student's understanding of Kinematics and the Dynamics of multibody systems with immediate application to the study of machines. All aspects of multi-body kinematics and dynamics are covered making the course good as a Junior/Senior elective course or as a graduate level review for the PhD qualifying exam. This course assumes knowledge of elementary vector algebra and the concepts of time and partial derivatives. An elementary Physics course covering Newton's laws or course(s) on Statics and Dynamics will prove very helpful in understanding the material covered in ME451. More precisely, the course reviews these topics and then applies them to more complex problems. The course will place equal emphasis on gaining both an analytical understanding and insight/intuition on the subject. The material presented in the class will emphasize the analytical component of the subject, while the homeworks, particularly through the coding and ADAMS modeling assignments, will encourage you to see beyond equations and abstract constructs. It is also anticipated that this course will improve your MATLAB programming skills and help you learn how to model/simulate/analyze mechanical systems in ADAMS, the most widely used mechanical system simulation software package.

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Course Grading

Grades will be based on your performance on written homework, two midterm exams, and one final exam. All homework and exam scores will be maintained on the Learn@UW course website. This will allow you to monitor your performance and see aggregate scores for the rest of the class, which should give you a continuous idea of your performance. Should you have questions about your score, please contact the instructor. Specific score-related questions about homeworks and exams must be raised prior to the next class period after receiving the score. If homework that is turned in does not appear to be graded (missing) on the Learn@UW course website please point that out to me within one week after the return of the corresponding set of graded homeworks.

Percentage participation to the final grade shall be distributed in the following manner:

Homework	**=**	**40%**
Exam I	**=**	**15%**
Exam II	**=**	**15%**
Final Exam	**=**	**30%**

The PowerPoint notes used in class, handwritten notes, and examples covered in class will be made available on the course web-site at www.sbel.wisc.edu/Courses/ME451/2009/index.htm. Solutions to homework problems will be posted at learnuw.wisc.edu.

Homework: Problems will be assigned regularly during the semester. All assigned homework will be collected at the beginning of class on the date due. No late homework will be accepted. Homework solutions should be *neat and well organized*. All necessary diagrams and calculations must be clearly shown. Homework solutions will be made available. The homework with the lowest score will be dropped when computing the final homework average. NOTE: There will be one bonus ADAMS project that will be worth two homeworks. You will get to choose the topic of the project that you work on after the topic gets ok'ed by the instructor.

Exams: Exams will include short-answer questions and problems, and may include both take-home and in-class portions. In-class portions will be given during the lecture sessions shown on the schedule. Take-home problems will be more involved and may require the use of computational tools (MATLAB and/or ADAMS). The best way to prepare for exams is to participate in class, learn the fundamental concepts, and redo homework and example problems. The first exam will be given on March 10. The second exam will be given on April 23. Reviews will be held for each of these two exams, the day before the exam, starting at 7:15 PM in room 3126ME. The ME451 final exam will be a comprehensive exam, scheduled for Friday, May 15 at 12:25PM.

Disability requests: I must hear from anyone who has a disability that may require some modification of seating, testing or other class requirements so that appropriate arrangements may be made. Please see me after class or during my office hours.

Complaints: If you have a complaint regarding the course and if you are unsatisfied with the response of the instructor, then you should contact the Chair of the Department of Mechanical Engineering. The Chair's office is in 3065 Mechanical Engineering Building, and an appointment to see the Chair can be made by contacting the Department Office at 263-5372.

Letter Grades: Final letter grades will be based on the total score accumulated on homework and exams throughout the semester using the following scale:

Score	Grade
≥94	A
87-93	AB
80-86	B
73-79	BC
66-72	C
55-65	D
Below 55	F

ME 451[1]: Kinematics and Dynamics of Machine Systems

Spring 2009

Date	Topic	Details regarding learning objectives	HW
01/20	Scope of Kinematics and Dynamics Analysis Overview of Existing Methodologies	Understanding the scope of the course. Understanding the goals of the course.	
01/22	Matrix Algebra	Concept of geometric vector Concept of algebraic vector and reference frame Matrices and matrix-vector operations Transformation of coordinates	ADAMS[2], 2.2.5, 2.2.8, 2.2.10 h1_jan22
01/27	Vector Calculus	Vector and matrix differentiation Velocity and acceleration of a point fixed in a moving reference frame	2.4.4, 2.5.1, 2.5.2, 2.5.3 2.5.7, ADAMS[2] h2_jan27
01/29	Matrix Notation Vector Partial Derivatives Chain Rule of Differentiation		
02/03	Basic Concepts of Planar Kinematics	Generalized and Cartesian coordinates Kinematic constraints Degrees of Freedom Reference frames	2.6.1, 3.1.1, 3.1.2, 3.1.3 h3_feb03
02/05	ADAMS Tutorial	Location: 2324EH	
02/10	Absolute Kinematic Constraints	Kinematic constraints involving one body: position and angular constraints	3.3.2, 3.3.4, 3.3.5, MATLAB[2] h4_feb10
02/12	Basic Relative Kinematic Constraints	Kinematic constraints involving pairs of bodies	
02/17	Relative Kinematic Constraints (Cntd.)	Kinematic constraints involving pairs of bodies: distance constraint, revolute joint, translational joint	3.4.2, 3.4.7, 3.4.9, ADAMS[2] h5_feb17

[1] Tentative schedule; changes might occur during the semester. Document will be updated to reflect these changes.
[2] Emailed to you.

02/19	Composite joints Cam-Follower Constraints		
02/24	End, Kinematic Constr. Driving Constraints	Cam/Flat Follower; Point-Curve Constraints Absolute driving constraints	
02/26	Driving Constraints	Relative driving constraints	3.5.1, 3.5.4, 3.5.5, 3.5.6, ADAMS[2] h6_feb26
03/03	Position, Velocity, and Acceleration Analysis	Formulating and solving the kinematic problem Implicit Function Theorem Wrecker Boom Example	Take-home part of Exam 1 assigned
03/05	Elements of the Solution of Kinematic Analysis of Mechanisms	Newton-Raphson method Gaussian Elimination	3.5.5 (done in ADAMS) h7_mar05
03/10	EXAM 1[3]		
03/12	Singular Configurations of Mechanisms	Mechanism lock-up Bifurcations Redundant constraints	MATLAB assignment, solving IVPs h8_mar12
03/17	SPRING	RECESS	
03/19	SPRING	RECESS	
03/24	Dynamics of Planar Systems; The principle of Virtual Work	Variational approach to deriving the equations of motion (EOM) for one planar body	6.1.1 thru 6.1.4 ADAMS[2] h9_mar24
03/26	Equations of Motion for a Planar Body	Equations of Motion for a body with centroidal reference frame Inertia properties for composite bodies Parallel axis theorem	
03/31	Virtual Work and Generalized Forces	Definition of Virtual Work Computing generalized forces for translational and rotational force elements	6.1.5, 6.2.1 h10_mar31
04/02	Guest Lecture Modeling and Simulation in Engineering Dynamics	Kevin Chang British Aerospace Engineering Systems	
04/07			
04/09	ADAMS Tutorial	Makarand Datar	
04/14			
04/16			
04/21	NO CLASS	TRAVEL to NSF	
04/23	EXAM 2[4]		
04/28	Guest Lecture Modeling and Simulation in Engineering Dynamics	Bill Prescott LMS Lab View	
04/30			
05/05			
05/07			

Final Exam[5]: Friday, May 15, 12:25 PM

[3] Review session will be held on Monday, 03/09/2009 at 7:15 PM. Room 3126ME.
[4] Review for Exam 2 will be held on Wednesday, April 22, at 7:15 PM. Room: 3126ME.
[5] Turn in and make 20 minute PowerPoint presentation of the Final Project