CALIFORNIA STATE UNIVERSITY SACRAMENTO  
The Department of Mechanical Engineering

ME143 – VEHICLE DYNAMICS AND DESIGN

SYLLABUS

DESIGNATION: Mechanical Design and Mechatronic Systems

CATALOG DESCRIPTION:


COMPUTER USAGE

The course will provide an opportunity to hands on design using state of the art software. Students will solve Vehicle Dynamics using multibody systems in three dimensions. Using SOLIDWORKS, WORKING MODEL 2D, NASTRAN4D, ADAMS, MATLAB, SIMULINK, students will generate computer models of vehicles using solid models and dynamic models. The applications will range from two wheel vehicles to four wheel passenger vehicles to Aerospace Vehicles.

INSTRUCTOR: Prof. José J. Granda  
Riverside 5002, 916-278-5711  
Email: grandajj@ecs.csus.edu

OFFICE HOURS: 2:00-3:00 pm or by appointment

TIME: 10:30-11:45 a.m.

PLACE: Santa Clara 1218

WEB PAGE: Course documents will be posted on Web CT or on the instructor’s web site.

PREREQUISITE: ME 117
GRADED: Graded Student.
UNITS: 3.0. Lecture three hours.


REFERENCE:
- Vehicle Crash Mechanics Matthew Huang Dearborn, Michigan, USA ISBN: 0849301041
- "Race Car Vehicle Dynamics", Milliken/Milliken, SAE International, 1995
- “SOLIDWORKS” User’s manual
- “WORKING MODEL 2D” Users manual
- “CAMPG” User’s Manual
- “Nastran4D” User’s Manual
- “MATLAB/SIMULINK” User’s manuals

LEARNING PROCESS: You are the only one solely responsible for your learning success, not your Professor, not the Department and not the University. There will be new teaching methods and tools being developed as we go along. Lots of valuable information will be available on the Class Web Site. Please review these materials.

ASSIGNMENTS: Reading and homework assignments will be assigned every week. It is expected that the problems will be completed and turned in on time. No late homework will be accepted since after the due date, the solutions will be in the reserve section of the Main Library. There will be no makeup tests except in cases of confirmed illness.

CLASS WEB PAGE Some course documents will be posted on the internet or transferred to students.

CLASS NOTES: Students are responsible to take their own notes. The student should not rely only on class notes but rather your are expected to study independently the assigned reading assignments and homework following the schedule. Students are responsible for ALL material presented in class. This includes any announcements, changes or clarifications made in class as well as the due dates.
KNOWLEDGE, SKILLS TO BE GAINED FROM THIS COURSE

Analytical and computer skills that will allow students to:

1) Understand the behavior of vehicle systems and subsystems, tires, drive train, gear boxes
2) Use analysis and techniques learned in solid modeling and basic dynamics to develop computer models of linkages and complete working assemblies in two and three dimensions.

3) Understand vehicle dynamics for use in design and performance of ground vehicles.
4) Transform solid models into dynamic models of vehicles for analysis of kinematics, (velocities and accelerations), kinetics (forces and moments).
5) Perform simulations of rigid multi-body assemblies and calculation of loads, dynamic forces, energy and momentum in two and three dimensions.
6) Vehicle parts and assemblies under impulsive impact forces and collisions. Simulations using dynamic Finite Element Analysis under dynamic loads.
7) Study of vehicle stability and control. Simulations using dynamic Finite Element Analysis under dynamic loads.
8) Apply the concepts of vibrations to the design of vehicles.

COMPUTER USAGE: Computers are used for writing reports (WORD) and presentations (PowerPoint). Spreadsheets are used as appropriate in doing multiple trade studies. Computational tools such: SOLIDWORKS (Three Dimensional solid modeling), WORKING MODEL 2D (Mechanisms dynamic analysis), NASTRAN4D (Three dimensional multibody analysis and design), ADAMS (Vehicle design software), MATLAB (Simulation in time and frequency domain, state space models, transfer factions, SIMULINK (Block Diagrams, control).

KNOWLEDGE, SKILLS, AND ABILITIES STUDENTS SHOULD HAVE BEFORE ENTERING THIS COURSE: Communicate technical information accurately and concisely – both orally and in writing, use analysis, computer software, word processors, etc., to define and develop solutions to technical problems. The skills learned in E110, basic dynamics and in Eng 6 for Solid Modeling are required of every student taking this class. The student will be expected to study the assigned reading assignments and homework following the schedule. Students are responsible for ALL material presented in class. This includes any announcements, due dates, changes or clarifications made in class. The instructor and the materials available to you will be your guidance, but the real learning process takes place on your own going over examples in class and in communication with the instructor.
IMPACT ON SUBSEQUENT COURSES IN CURRICULUM: For those enrolled students, who have not yet participated in the capstone design course, provides a foundation for analysis and computer tools to be used in their senior projects of ME190, ME191. It will also facilitate the understanding of modeling, simulation of rigid and flexible multi-body systems.

ABET CRITERIA 2000 OUTCOMES ACHIEVED: This course contributes to the following EC2000 Criterion 3 outcomes and those specific to the EAC accredited program.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. An ability to apply knowledge of mathematics, science, and engineering</td>
<td>√ g. An ability to communicate effectively</td>
</tr>
<tr>
<td>b. An ability to design and conduct experiments, as well as to analyze and interpret data</td>
<td>√ h. The broad education necessary to understand the impact of engineering solutions in a global/societal context</td>
</tr>
<tr>
<td>c. An ability to design a system, component or process to meet desired needs</td>
<td>√ i. A recognition of the need for and an ability to engage in life-long learning</td>
</tr>
<tr>
<td>d. An ability to function on multi-disciplinary teams</td>
<td>√ j. A knowledge of contemporary issues</td>
</tr>
<tr>
<td>e. An ability to identify, formulate, and solve engineering problems</td>
<td>√ k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
</tr>
<tr>
<td>f. An understanding of professional and ethical responsibility</td>
<td>√ l. Begin list of any other outcomes unique to the program.</td>
</tr>
</tbody>
</table>

ABET PROGRAM CRITERIA OUTCOMES ACHIEVED: Program criteria outcomes are unique to each degree program and are to be compiled from the program criteria given for each degree program and listed in bullet format below.

a. Demonstrate a knowledge of the science, mathematics, and engineering principles that are fundamental to thermal and mechanical systems design and manufacturing;

b. Identify, analyze, and solve technical problems in the areas of machine design, including solid mechanics and control systems; fluid mechanics, thermodynamics, and heat transfer, materials properties and selection; and manufacturing, using the principles of multivariate calculus and differential equations, including the appropriate use of computer technology;

d. Apply creativity in design of systems, components, or processes to meet desired needs.

e. Function effectively as part of a team

f. Communicate effectively through speaking, writing and graphics, including appropriate use computer technology.

g. Show understanding of professional, ethical, and social responsibilities and the need for a commitment to life-long learning and participation in professional societies.

CLASS FORMAT: This course follows a lecture format. Assignments will be both
individual and group. Groups will be approximately 4 people, and pre-assigned by the instructor. Students are responsible for reading the assigned material prior to the scheduled class. Class participation is required and part of the course grading. Students are encouraged to actively participate and to ask questions freely. Students will be expected to present their work periodically.

**COURSE GRADING:**

- Quizzes/Exams .................... 40%
- Homework Assignments ..... 10%
- Computer assignments .......... 30%
- Term Vehicle Design Project.. 10%
- Final Exam  ......................... 10%

\[ \frac{40\% + 10\% + 30\% + 10\%}{100\%} \]

Exams and assignments will be graded balancing the procedure used and the correctness of your answer on an equal basis. Presentation and organization of your assignments will also be considered in grading. There will be Quizzes approximately one to two weeks apart, including the last week of class. Quizzes and final exam will be closed book exams. If there is a discrepancy in grading, you have two weeks from the date you received it to bring up for discussion. After that period grades are final. Projects are due on the last day of class. Work turned in after the deadlines will not be computed in your final grade. If there is a discrepancy in grading, you have two weeks from the date you received it to have it reviewed. Do not expect a change simply because it is reviewed but rather on the merit of your work. After that period, all grades are final. Homework, computer assignments will have deadlines and Final Projects are due on the last day of class. Work turned in after that will not be computed in your final grade. An incomplete will not be assigned unless an agreement with student has been outlined for course completion prior to the date grades are due. The student should not rely only on class notes but rather your are expected to study independently the assigned reading assignments and homework following the schedule. Students are responsible for ALL material presented in class. This includes any announcements, changes or clarifications made in class as well as the due dates.

**HOMEWORK, COMPUTER ASSIGNMENTS POLICY:**

Assignments are issued each week and students work is due in one week unless otherwise noted in the accompanying class schedule. Assignments are due at the start of class on the due date. Late assignments may be accepted, but at a loss of 20% of the grade per 24 hours late. Homework assignments will be returned to students post grading. There will be reading homework and computer assignments. Students are responsible for ALL material presented in class. This includes any announcements, changes, clarifications on assignments, or due dates. It is expected that the assignments will be completed and turned in before or on the specified deadlines. There will be no makeup tests except in cases of confirmed and documented illness or emergency.

As the semester goes on and you realize "things" are not going well for you in this class or you become frustrated with the computer, be aware of the policy on drops and incomplete. To drop
the class you must meet deadlines and an incomplete is rarely granted and cannot be used to "bail out" of the class.

EXAMINATIONS:
There will be quizzes and exams. These will be announced to cover specific topics of the course. The final exam will be administered in accordance with the University scheduled time. Make-up exams require the permission of the instructor prior to the day of the exam.

ATTENDANCE:
Regular attendance is expected. Note that a portion of your grade is based on class participation and self-initiative. Professional contribution is a goal of this course.

SCHEDULE / CRITICAL DATES:

- Last Day of Official Adds/Drops
- Holidays
- Last Drop Day for Possible Refund
- Mid-Term Exam
- Spring Break
- Last Drop Day (with Approval)
- Final Reports Due
- Final Exam

Other important dates are available from the University Academic Calendar web site.

SPECIAL NOTES:

Students with Disabilities: The California State University provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students or the College of Engineering Director of Students with Disabilities.

Class Web Sites and Student Privacy: Web-based, password-protected class sites are associated with all academic courses taught at The University. Syllabi, handouts, assignments and other resources are types of information that may be available within these sites. Site activities could include exchanging e-mail, engaging in class discussions and chats, and exchanging files. In addition, electronic class rosters will be a component of the sites. Students who do not want their names included in these electronic class rosters must restrict their directory information in the Office of the Registrar.

EVALUATION:
The Measurement and Evaluation Center forms for the College of Engineering will be used during the last week of class to evaluate the course and the instructor.
UNIVERSITY AND CLASSROOM POLICIES

- You are the only one responsible for your success in learning, not the Professor, not the Department, not the University.
- CSUS is a high level educational institution and fosters a professional environment. However discipline problems or attempts to disrupt any aspect of the course, or influence other students to do the same will not be allowed.
- Assignments are to be individual unless assigned as a group. The honor code is to prevail in all assignments. Copying assignments or exams will at the very least, result in zeroes assigned to ALL involved.
- It is the Mechanical Engineering Department's policy to remove from the major students who copy an exam or to expel them from the university. Copying or deleting unauthorized disk files will have the same effect. Logging onto somebody else's account is not permitted.
- Students are expected to answer questions on any of the work they hand in and proof they have done the work themselves.
- Students are encouraged to make constructive suggestions to the instructor about any aspect of the course. Please feel welcome to come and see the Professor.
- Students are encouraged also to suggest projects, particular engineering problems or research topics of interest to the whole class.
- The Professor will assist students and conduct the in class as follows:
  - Encourage free pursuit of learning by students.
  - Students will be guided by the Professor, but the learning process is the responsibility of the students themselves.
  - Students are evaluated solely on an academic basis.
  - Provide timely and relevant feedback to students
  - Report incidents of student plagiarism and cheating to the Campus Judicial Officer.
  - Follow campus procedures in dealing with disruptive student behavior.
  - Resolve complaints. If students are unhappy with any aspect of the course, they must meet with the professor and attempt to resolve the issue between them. If they are not able to resolve the issue, students can address their concerns with the department chair. No complain will be processed or documents received by the Department or administrative offices in the College without the knowledge of the Professor and after an attempt has been made to resolve the issue. Otherwise, such actions constitute backstabbing of Professors, which are unethical at a University level and may carry disciplinary actions.
  - Implement accommodation for students authorized by Services to Students with Disabilities (SSWD) and/or discuss concerns only with SSWD.
  - Accommodate reasonable student absences for religious observances.

INSTRUCTOR RESERVES THE RIGHT TO REVISE SCHEDULE AS NECESSARY
<table>
<thead>
<tr>
<th>WEEK</th>
<th>TOPICS</th>
<th>PRACTICE TOPICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Introduction, fundamental principles. vehicle tires performance, cornering characteristics Mechanics of Vehicle Terrain interaction.</td>
<td>Introduction to Working Model 2D Tire models</td>
</tr>
<tr>
<td>2.</td>
<td>Introduction to Vehicle Design using SOLIDWORKS</td>
<td>Auto Body</td>
</tr>
<tr>
<td>3.</td>
<td>Vehicle Kinematics. Fundamental principles of velocity, acceleration. Two dimensional mechanisms Forward Vehicle Dynamics</td>
<td>Two dimensional mechanisms and vehicle analysis Working Model 2D</td>
</tr>
<tr>
<td>6.</td>
<td>Suspension Design.</td>
<td>MATLAB, SIMULINK, suspensions Simulations</td>
</tr>
<tr>
<td>7.</td>
<td>Vehicle vibrations principles. Seat Belt Design Mathematical Models</td>
<td>Seat Belt, Bumper Design computer models</td>
</tr>
<tr>
<td>8.</td>
<td>Drive train dynamics, vehicle performance</td>
<td>MATLAB/SIMULINK</td>
</tr>
<tr>
<td>10.</td>
<td>Vehicle Collisions. Fundamental laws of motion, energy and momentum Forces and Moments 2D and 3D</td>
<td>Computer models for the calculations of impact forces. Two and Three Dimensional computer models of real situations.</td>
</tr>
<tr>
<td>11.</td>
<td>The Dynamics of vehicle rollovers. NHTSA Computer Simulation Tests</td>
<td>Two and Three dimensional computer models of real situations</td>
</tr>
<tr>
<td>12.</td>
<td>Finite Element Modeling (FEA) and failure analysis</td>
<td>Stress, deformation calculations. NASTRAN4D</td>
</tr>
<tr>
<td>13.</td>
<td>Handling Characteristics of Road Vehicles</td>
<td>Individual Groups Vehicle</td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Introduction to the ADAMS Vehicle Design Software</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Groups and Individual Vehicle Design Project</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Introduction to Aerospace Vehicles. Space Shuttle, Space Station</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Final Exams</td>
<td></td>
</tr>
</tbody>
</table>