ME 106/227 – Vehicle Dynamics and Control
Spring Quarter 2001
TTh 9:30-10:50am
Terman 556

Instructor:

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Course Text:

Gillespie, Thomas. Fundamentals of Vehicle Dynamics, SAE, 1992.
Available through SAE (www.sae.org) or at various online booksellers.

Course Website:

http://www-cdr.stanford.edu/dynamic/me106_227

Other References:

Bosch Automotive Handbook, 4th Edition.
Great reference for all sorts of automotive systems, components and engineering principles. More qualitative than quantitative.

Milliken and Milliken, Race Car Vehicle Dynamics.
Good coverage of race car principles and a good deal of information about transient handling. This is an excellent book, but takes a bit of time to navigate because there is simply so much material included.

Dixon, Tires, Suspension and Handling.
Less comprehensive with regards to covering all aspects of vehicle dynamics, but an excellent resource for suspension design and transient handling response.

Adams, Chassis Engineering.
Often found in bookstores next to titles like *How to Paint Flames*, this is an excellent practical resource from someone who obviously understands the underlying physics.

All of these are available through SAE (www.sae.org) and other online booksellers.

The automotive section of How Stuff Works at www.howstuffworks.com
Tom and Ray Magliozzi online at www.cars.com
The Garage section at www.nascar.com.

Prerequisites:

You should have a basic understanding of dynamic systems comparable to ME161 or E104, but no experience with control theory (E105, E205,…) is assumed. This background is assumed to include familiarity with Laplace Transforms, the basic characteristic responses in mass-spring-damper systems (overdamped, underdamped and critically damped) and frequency response (gain and phase of a linear system at any frequency, Bode plots,…). If any of these sound unfamiliar, there will be two extra sessions held to review Laplace transforms and frequency responses. The two extra sessions will be held on Monday evenings prior to the material being used in class:

Laplace Transform review:	Monday, April 23	7:00pm	530-127
Frequency Response review:	Monday, May 14	7:00pm	530-127

Many of the assignments will require the use of MATLAB. Familiarity with this software (or willingness to pick it up and learn) is a prerequisite for the class. To avoid overly tedious programming, some subroutines in the form of MATLAB code will be provided to you.

Course Objectives:

During this quarter, you should:

(1) Develop an understanding of the fundamental dynamic considerations that influence the design of ground vehicles and vehicle control systems.
(2) Use the example of the automobile to investigate modeling dynamic systems at various levels of abstraction.
(3) Explore the tradeoffs between completeness and simplicity when choosing an appropriate level of modeling abstraction.

Course Policies:

(1) Lectures are an integral part of the class. There is no textbook available that captures the full range of class topics, so some information may only be available in lecture. Attendance and participation during the lectures are expected.
(2) Reading assignments should be completed (skimming is fine) prior to the class period for which they are assigned.
(3) Late assignments will be docked 10% for one day late, 30% for two days late and 50% for three or more. No credit will be given for homework turned in after the solutions have been made available.
(4) No last minute extensions will be granted.

Assignments and Grading:

There will be four contributors to the final grade given in the course: problem sets, a midterm exam, a final group project and class participation. The breakdown of grading is as follows:

Problem Sets:	50%
Midterm:	25%
Final Project:	20%
Class Participation:	5%

<u>Reading Assignments</u>:

Reading assignments from the textbook are intended to provide an introduction to vehicle dynamics and quasi-static analysis techniques. In addition, there will be a few technical papers

assigned over the course of the quarter. These papers demonstrate some of the more detailed analytical techniques employed in vehicle research and development and some of the control algorithms implemented in production systems. Papers assigned as reading will be placed on reserve in the Engineering library. Material in the reading assignments is fair game for problem sets or the midterm.

Problem Sets:

The problem sets are designed to integrate and expand upon the analytical techniques presented in lecture. Most problem sets will require the use of software analysis tools in order to obtain a solution. ***You are strongly encouraged to begin (or at least assess) the problem sets soon after they are handed out***. Many of the concepts in the class are best understood when you can work with a physical or mathematical model. Several of the problem sets require you to develop such models. If you develop the model early, the rest of the problem set should be quite easy; waiting until the last minute, however, can be a recipe for disaster. You are encouraged to collaborate with others in the class to develop and debug analysis necessary for the problems – the answers to any open-ended problems should be your own work, however. The tentative problem set topics are:

Problem Set 0: A closer look at simple handling models
Problem Set 1: Steady handling and race car set-up
Problem Set 2: Vehicle parameter estimation and suspension design
Problem Set 3: Transient handling and design for performance
Problem Set 4: Nonlinear effects and simulation
Problem Set 5: Anti-lock braking
Problem Set 6: Ride quality and frequency response

Problem Sets 1, 4 and 5 will require significant work with MATLAB. Problem Set 2 will require forming a group and crawling under a car to identify suspension components and build a parameter set.

Midterm Exam:

The midterm will cover material from the first five weeks of the class including tire modeling, steady-state handling, transient handling, suspension design and stability control.

Final Project:

In lieu of a final exam, the course requires a final analysis project that builds upon the concepts covered in lecture, the text and previous assignments. The final project will work slightly differently for students enrolled in ME106 and students enrolled in ME227. For both courses, the final project will be a team project. Students in ME106 will be given an open-ended final assignment covering the design and analysis aspects of the course. Students in ME227 are expected to either define their own project or choose from a list of suggested projects. Relative to the ME106 project, more emphasis is put on defining a topic and appropriate methodology for the ME227 projects. In both courses, teams are expected to prepare a final report and a poster summarizing their results. Further information on the projects will be provided as the quarter progresses.

ME 106D/227D:

For the first time this year, we will offer an optional lab with in-vehicle experiments. The lab is intended to give additional hands-on experience with the course concepts and introduce the types of tests and sensors commonly used to evaluate the dynamic performance of vehicles. Although the instrumentation and data acquisition used in this lab has been developed and tested

previously, we make no claim that things will work smoothly in the first year. As a result, labs may have to be rescheduled if we experience equipment difficulties.

Labs will be held on Saturday mornings and early afternoons to ensure ample parking lot space for maneuvers and will be performed in teams of three. There will be a mandatory pre-lab session from 2:00-3:00pm on Fridays immediately preceding Saturdays when labs are held. Enrollment in the lab section is limited to 18 students. Students must attend and write up all four labs to get credit for the lab portion of the class.