ME 227 – Vehicle Dynamics and Control
Spring Quarter 2021
TTh 10:30-11:50am PDT
Everywhere in the world

Instructor:

Chris Gerdes
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Special Guest Instructor:

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Check Piazza announcements for timing and logistics of office hours. These will likely change over the course of the quarter as we figure out what works the best.

Course Requirements:

In developing this course, we are assuming students have the following:

- A computer with a web browser, the ability to view pdf files and a reasonably sized monitor (videos look fine on a 13" laptop screen but don't translate to a phone)
- Internet access with sufficient speed to participate in Zoom calls
- A means of entering assignments into Gradescope

There is no required text – notes will be posted online.
MATLAB questions can be answered using the links to MATLAB Grader.

Course Websites:

Access through http://canvas.stanford.edu/

References:

Krumm, Driving on the Edge: The Art and Science of Race Driving
A fantastic book on driving and racing lines backed up by results from data acquisition and Krumm's own racing experience.

Bosch Automotive Handbook
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. Takes time to navigate because there is so much material.

Smith, Tune to Win, Prepare to Win, Race to Win, Engineer to Win

These classic books are more practical than mathematical but give a lot of solid engineering insight into race car setup with a readable, humorous style.

Required Inspirational Quotes:

"All models are wrong. Some of them are useful." - George Box

"Everything should be made as simple as possible and not simpler." - Albert Einstein

"Nothing great was ever achieved without enthusiasm." - Ralph Waldo Emerson

Prerequisites:

You should have a basic understanding of dynamic systems and control comparable to material covered in ME161 and E105 at Stanford. This background is assumed to include familiarity with Laplace Transforms, the basic characteristic responses of mass-spring-damper systems (overdamped, underdamped and critically damped), frequency response (gain and phase of a linear system at any frequency, Bode plots) and basic understanding of poles and zeros. Familiarity with automotive design is not assumed and you need not know anything about cars to take the class and enjoy it. We do not assume any responsibility if this course results in an urge to binge old episodes of "Top Gear" while sheltering in place.

All of the assignments will require the use of MATLAB. Familiarity with this software is a prerequisite for the class. In particular, you should know how to write basic MATLAB functions and scripts. To help guide you in structuring code, we will be using MATLAB Grader which provides you with a template to follow for each assignment. MATLAB simulation is a big part of this class so be aware of this going in.

Course Objectives:

During this quarter, you should:

(1) Develop an understanding of the fundamental dynamic considerations that influence the design of ground vehicles, vehicle control systems and automated vehicles.
(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.
(4) Develop algorithms to enable a car to track a desired path at varying speeds and implement those algorithms on a detailed simulation (and, for active participants, an actual test vehicle).

Course Policies:

(1) Lectures will be streamed using Zoom at our regularly scheduled class time (10:30-11:50 PDT) and, barring any technical challenges, will start promptly at 10:30.
(2) 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 in lectures is expected unless you:

- Are taking another class that conflicts with the class time and requires attendance
- Lack connectivity to join during class time
- Are in a time zone that makes attending overly difficult

If one of these situations (or something similar) applies to you, contact the teaching team for an exemption to lecture participation. You will be expected to watch the posted lecture videos.

(3) Lecture attendance with video camera on is strongly encouraged. Turning video on and off periodically during class is perfectly fine. Rolling out of bed and putting on a hat to join class is entirely socially acceptable (Chris reserves the right to do the same).
(4) Everyone will join the lecture sessions on mute. If you want to ask a question (and we hope you do), please ask in the chat. The TAs will moderate the chat and Chris will pause periodically to clear questions.
(5) Recordings of lectures will be put up on the Canvas site following the lecture.
(6) Links to the lecture Zoom calls will be through the Canvas site.
(7) Announcements will be posted on the Piazza site (available through Canvas).
(8) Assignments are due by 5pm PDT on Thursdays. Late assignments are reduced by a penalty of 8% per day.
(9) We can grant an extension on an assignment if you request it at least a week in advance. If you have a serious health issue, please contact the teaching team to make arrangements.

Resources Available:

If at any point in the quarter, you feel behind or overwhelmed, we encourage you to talk to the teaching team about strategies for the class. If you feel you need more help then we can provide, Stanford also has the following resources available:

- Counseling and Psychological Services offers crisis counseling. Walk-in appointments are available, and clinicians are always on call at (650) 723-3785.
- The Graduate Life Office is available during office hours at (650) 736-7078, or 24/7 at (650) 723-8222, pager ID number 25085.
- The Bridge Peer Counseling Center offers counseling by trained students 24/7 at (650) 723-3392.

Assignments and Grading:

The final grade will be based on problem sets and a project:

Problem Sets:	65%
Vehicle Control Project:	35%

Problem Sets:

The problem sets are designed to integrate and expand upon the analytical techniques presented in lecture. All problem sets will consist of a combination of analytical work using MATLAB Grader and a written portion submitted through Gradescope. Many of the concepts in the class are best understood when you can work with a physical or mathematical model. For all assignments, you are encouraged to collaborate with others in the class to develop and debug analysis necessary for the problems – your code and the answers to any open-ended problems should be your own work.

If you have a question about the homework, it may be most convenient to post it on the Piazza site. Be sure to include a hypothesis. In other words, don't just ask "What do you mean?" or "What should I do on problem 2?" but instead write something along the lines of "I think I should do X" or "I am interpreting this to mean Y, am I correct?" Questions are meant to be challenging and this makes it clear that you have spent time trying to sort out the issues. At the other extreme, please don't bang your head against the wall – if you aren't getting anywhere on an assignment, just ask for some help! We will monitor Piazza both to answer questions and to ensure that posts are not short-circuiting the learning process. Purely logistical questions like "Where do I find the Zoom link?" do not require a hypothesis.

Vehicle Control Project:

The first few weeks of the class will work up to the point where you are able to develop code for controlling steering and acceleration of an automated vehicle in order to track a desired path and velocity profile. The basic work for this project begins with the first few assignments and continues into code development and a design review on May 6 or 7. Following the design reviews, we will open up a more detailed simulation for you to test and refine your controllers. While the assignments are performed individually, the code development, simulation and write-up will be performed in groups. You may choose a group or asked to be assigned to one. The grade will be based on the initial design review and a final report on the controller development. While this project will offer plenty of opportunities to bring your ideas and control expertise to bear on the problem, knowledge beyond the prerequisites and course material is not necessary to do well. ***You must fully participate in this project to receive credit for the class.***

Niki chilling while waiting to test your vehicle control code

Taking the class S/NC:

S/NC grading is allowed this year. If you do want to aim only for the 'S' (the one on the transcript, not the one on the side of the car), be sure you complete the project and gain at least 70% of the total assigned points.