UC DAVIS
Autonomous Race Car Student Design Project
EEC195A-B Course Outline, Fall 2009 – Winter 2010

Lecture (both quarters): Friday 9:00-9:50, Room 2147 Kemper Hall
Lab (fall only): Friday 10:00-12:50, Room 2147 Kemper Hall

Instructor:
Professor Spencer
2041 Kemper Hall
752-6885
spencer@ece.ucdavis.edu

Digital Help:
Mr. Halsted
2154 Kemper Hall
752-8959
halsted@ece.ucdavis.edu

Note: Please use email only when absolutely necessary. Do NOT use email in place of questions in class or office hours.

Prof. Spencer's office hours: In class or by arrangement

TAs: Travis Kleeburg, in lab: TBA, email: tkleeburg@gmail.com
Nicholas Hosein, in lab: TBA, email: nick195ta@gmail.com
Although either TA can help you with a problem, Travis is more knowledgeable about analog circuits and Nicholas is more knowledgeable about microcontrollers.

Required Texts: None (Your textbooks from E17, EEC100 & 110A will be useful references)

Texts on 2-hour reserve at library:
(these are also available in the cabinet in the lab – do NOT remove or leave out!):

The Art of Electronics, 2nd ed., P. Horowitz and W. Hill, 1989, Cambridge University Press (A great all-around reference on both digital and analog circuits with lots of practical information and examples)
Introduction to Electronic Circuit Design, R. Spencer and M. Ghausi, 2003, Prentice Hall (A book used in EEC110A-B, but it also covers op amp circuits in Chapter 5)

Pre- & Co-requisites:

You should have already completed EEC110A. EEC157A is strongly recommended as a co-requisite to EEC195A. In addition, if you plan to implement your car with digital circuits, EEC172 is strongly recommended in the fall.

Course Website:

The course website contains the detailed schedule for this class, the homework and laboratory assignments and handouts, solutions to homework problems (after they have been handed in) and other information necessary for the course. Some of the information requires a username and password to access; the username is eec195 and the password is runfast. The course website can be reached from MyUCDavis or directly at the following URL: **www.ece.ucdavis.edu/~spencer/195/**

General Information:

In signing up for this course **you are agreeing to take both quarters**. This class uses deferred grading, which means that you will receive an "In Process" grade for the fall quarter. At the end of the winter quarter we will submit your grade and it will be applied to both quarters. An IP grade reverts to an "F" just like an incomplete does if you don't finish the course. After the drop deadline for the **fall** quarter, you will need the approval of the dean to drop this course (i.e., you don't get a new drop deadline every quarter, there is only one deadline for the entire 2-quarter class).

Because you frequently work odd hours on this project, we will occasionally use email to provide you with important and timely information. As a result, **you are required to check your email daily while taking this course** (so be sure we have your correct email address).

You will be assigned to work in teams and your work will be graded partly on the performance of the team as a whole, and partly on your individual contributions. There is a web page for this project, which is different from the course website, that has all of the competition rules and the results of the races from the past few years (including videos, course maps and speeds). **www.ece.ucdavis.edu/natcar/** You are required to be familiar with the rules posted on this website.

Organization:

In the fall quarter we will have some lectures, homework assignments, and laboratory assignments aimed specifically at getting you up to speed to design and build a car. In fact, you will build a basic functioning car in the labs during the quarter. In the winter quarter, there will be bi-weekly progress checks and the final reports and race at the end of the quarter. In the spring quarter, you may compete against teams from other schools in the Natcar competition. If you tell me that you are going to compete in that race, I can give you an "incomplete" grade and will allow you to improve your grade based on the performance you achieve then.

There are tools available in the cabinet in the laboratory, but **we strongly recommend** that you have your own tools. A pair of needle-nose pliers, a small pair of diagonal cutters, a wire stripper, a soldering iron, and a digital multimeter will help a lot. If you also have some screwdrivers, nut drivers or wrenches and an X-acto knife, that should handle most of your needs. We will provide each team with a car. Each team will be provided a key to the room (the keys will each require a $5 deposit and must be returned at the end of the year in order to get your deposit back). The keys are available from Destiny Fassett in the department office.

The cabinets in our lab may be used for storing your car and tools and also contain a number of useful parts, books, and tools. KEEP THE CABINETS LOCKED when you are not in the room. They all have combination locks on them and we may change the combinations once in a while. The new combination will be sent to you via email.

Lab Notebook:

Each student (not on a team basis) is required to keep a neat engineering notebook in which you do all your calculations, write down your ideas, keep track of things you find in books and articles, draw your schematics, record your test results and so on. We expect that you will have your notebook with you with all relevant information available when you ask for help. In fact,

when you ask for help in debugging a circuit, you will be asked to show us the schematic for the circuit (including package pin numbers) and to show us what you have already done to check it out. If you cannot show us these things, we may not help you until you get them done! You may use any notebook you want as long as it is bound (i.e., you can't remove or insert pages). If the pages aren't numbered, you should number them. It is a good idea to use the first couple of pages for an index and to date and sign every page as you fill it up.

Grading:

Your grade will be based on the following items: 10% on homework and assigned laboratory projects, 20% on the written examination, 10% on meeting the deadlines, 15% on your written report, and 45% on the quality of your design and construction and the performance of your vehicle. The grades for quality of design and construction and performance will be weighted based on your contribution to the team effort as reported by the team in the final report.

Competitions:

In addition to the in-class competition at the end of the winter quarter, we may hold a demonstration on Picnic Day, April 17, 2010, if there is interest. Finally, there will be a final competition with other universities, which is tentatively set for Friday, May 21, 2010. You are not required to compete in the final race, but if you let Prof. Spencer know in the winter quarter and your performance improves, we will use that improved performance in determining your grade. In addition, cash awards will be given for the top three places in the final competition (if funding permits).

EEC195 Class Schedule – Fall 2009
The lecture and lab are back to back from 9 AM to 1 PM. Some days the lectures will spill over into part of the lab period. On days without lectures, the lab period will start at 9 AM.

Date		**Day**	**Topic**	**Online Lectures (note 1)**
Sept.	25	F	**Lecture**: Introduction to design project and opamp circuits **Laboratory**: Safety, basic measurements, and a lecture on practical design and construction information. Practical lab tips.	1 & 11
Oct.	2	F	**Lecture**: Power conditioning, PWM & DC motors **Laboratory**: Lab 1: Build and test a DC-to-DC converter.	2 & 3
	9	F	**Lecture**: DC motor control, track sensing, control loops **Laboratory**: Lab 2: Build and test a motor drive circuit.	4 & 5
	16	F	**Lecture**: PID controllers, modeling the car **Laboratory**: Lab 3: Build and test a motor drive circuit with feedback.	6
	23	F	**Lecture**: Reliability & manufacturability **Laboratory**: Lab 3: Continued.	
	30	F	**Laboratory**: Lab 4: Build magnetic and optical track sensing circuits.	

Nov.	6	F	**Laboratory**: Lab 5: Build and test a track sensing circuit.	
	13	F	**Laboratory**: Lab 6: Build and test a proportional steering control loop.	
	20	F	**Laboratory**: Lab 6 continued.	10
	27	**F**	**Thanksgiving Holiday**	
Dec.	4	F	**Laboratory**: Final demonstration for quarter.	
	10	**Th**	**3:30-5:30 PM Final written examination**	

Notes:

1 I have updated the lectures somewhat, but the ones available on-line are mostly the same and are available to help you review material whenever you need to. You can jump to given locations in the lectures, so you don't need to watch an entire lecture to review one part. Also, lectures 7 & 8 will not be given in class; they are provided as a service to students using the Adapt9S12E128 microcontrollers and are only available online.

Recorded Lectures:

1 43 minutes: Covers basic op amp operation, negative feedback & virtual short circuit, gain circuits, frequency-dependent circuits (LPFs and HPFs used as differentiators and integrators), offsets, slew rate and full-power bandwidth.

2 36 minutes: Covers power conditioning, DC-to-DC conversion, switching regulators and linear regulators.

3 50 minutes: Covers pulse-width modulation (PWM), a comparator with hysteresis, relaxation oscillators, the 555 timer, review of basic electromagnetics, magnetic sensing, DC motor operation & modeling.

4 42 minutes: Covers DC motor speed control and track sensing.

5 48 minutes: Covers negative feedback as a control loop, stability (including loop gain and phase, Nyquist plots and gain and phase margins), step responses, root-locus plots.

6 53 minutes: Covers proportional, integral and derivative (PID) controllers, a kinematic model of the car, simulated response, and compensation of the steering control loop.

7 40 minutes: Covers microprocessor-based considerations, Adapt9S12E128 processor board overview, digital I/O on the Adapt9S12E128, A-to-D conversion on the Adapt9S12E128.

8 40 minutes: Covers configuring the clocks on the Adapt9S12E128 and an overview of interrupts on the Adapt9S12E128.

9 Not used.

10 71 minutes: Covers reliability and manufacturability; causes of system failure and design for reliability (DFR) procedures.

11 41 minutes: Covers practical design and construction information, testing, debugging, safety, cost, task scheduling and report writing.