DEVELOPMENT OF A SOLAR CAR FOR ASC

ECE DEPARTMENT FALL 2011

EE 309S 16480
EE 362S 16935
ASE 379L 13785
ME 379M 18860

Instructor: Professor Gary A. Hallock
ENS 513
471-4965
hallock@ece.utexas.edu
Office hours MW 2:00 – 3:00 PM or just drop by

Time and Place: 1) MW 5 – 6:30 PM ENS 109
2) Th 6:30 – 9:30 PM Location project dependent
ENS 416 Electrical Lab
ENS 252C ECE Lab
PRC Bldg 120 (solar car location)
YPS Facility (solar car location)

Approved Technical Elective (EE 362S):

- Power
- Electronics
- Robotics/Controls (362K prerequisite)
- Academic Enrichment
- Other areas, including outside ECE, with permission of your advisor

Textbook:

The Winning Solar Car – A Design Guide for Solar Race Car Teams
Douglas R. Carroll, SAE International, 2003, ISBN 0-7680-1131-0 (Optional)

Websites:

- http://www.utsvt.com/ (UT solar car main website)
- http://www.americansolarchallenge.org/ (ASC website)
- ftp://utsvt.ece.utexas.edu/ (document storage; requires password)

- http://utsvt.ece.utexas.edu/wiki/ (solar car team wiki)
- UTSVT Listserv (we will add everyone)

Course Grade:

- Project: 50 % (effort and accomplishment about equal)
- Oral presentation: 10 %
- Written report: 10 %
- Notebook: 15 %
- Attendance: 15 %
- Group project peer assessment welcome

This is a projects course, and your project determines most of your grade. You must keep an engineering notebook, where dated entries indicate your progress through the semester. You will give a short oral presentation at the end of the semester, and turn in a written report (5-10 pages) on your work. Your oral and written reports should emphasize what you *personally* accomplished during the semester.

This is a 3 credit hour course, and the general "rule of thumb" is 3 hours of outside work per course credit hour. Since this course will have no assigned homework and no exams, you should plan approximately 9 hours per week of work on your project and the solar car effort. This is to be documented in your engineering notebook, as described later.

The "effort" component of your project grade will be determined as follows:

> 2 hours a week average documented effort = "C"
> 4 hours a week average documented effort = "B"
> 8 hours a week average documented effort = "A"

Documented means described in your engineering notebook. The "accomplishment" part of your grade is successful completion of your project. A half-finished project is not good! Your project effort does not include our Monday and Wednesday class (that is the attendance part of your grade), but it DOES include your project work on Thursdays and of course all other times you work on your project. Do not lose your engineering notebook!!!!!

Our 3 hours of scheduled lab work on Thursday evening is obviously insufficient for your project. It is expected that groups will find additional times to meet during the week and/or weekends, as well as work individually on their project.

This course is unique in many ways. It is interdisciplinary, with students from ECE, ME, ASE, and possibly other engineering and non-engineering departments. You are encouraged to be involved with projects outside of your major. This is both interesting and good preparation for your engineering career. We also have a mix of students from freshman through seniors, with a wide range of abilities. What you get out of this course (and your grade) is primarily determined by the effort you put into it. In addition, freshman (for example) are not expected to undertake projects as sophisticated as seniors can undertake. We have a wide range of projects available.

This course is coupled with the solar car student organization (UTSVT). Experienced team members will be available to lead or provide guidance on projects. You should keep in mind that these team members are volunteers, unlike the TAs in more traditional courses. It is your responsibility to be putting effort into this course. If you are having trouble making progress on your project see Prof. Hallock. This puts a lot of responsibility on you.

OVERVIEW

The objective of this course is the development of unique, high tech solar cars for the American Solar Challenge (ASC) and the Formula Sun Grand Prix (FSGP). Our latest solar car is called the *Samsung Solorean*. We raced this car in 2010, in both the 2010 Formula Sun Grand Prix and the 2010 American Solar Challenge (as well as the 2009 FSGP). This semester, our objective is to continue to develop this car so that it is more competitive, as we may race it next summer in the 2012 ASC. In addition, this car is a platform for trying out new ideas and systems. We have lots to do, and it is an exciting time. Our objective is a competitive, reliable solar car capable of winning events.

In addition, we are developing a brand new solar car, for the 2013 Formula Sun Grand Prix and the 2014 American Solar Challenge. The name of this vehicle is TexSun. You are welcome to participate in this work as well, and if you become hooked on solar car raycing you can stay with the solar car team and help build and race this new car.

The format of the course includes lectures, group discussion, student presentations, and laboratory work. As part of this work, each student will develop an overall understanding of the theory, design, operation, and construction of a solar electric vehicle. Although we will focus on a solar car, much of what we discuss is relevant to electric/hybrid vehicles (battery systems, for example) and terrestrial solar power (solar arrays and power trackers, for example). These should be an important part of your future. In addition, each student will develop in-depth knowledge in a particular focused area. The solar car is an interdisciplinary project, involving electrical, mechanical, and aerospace engineering, as well as business, strategy, and other skills.

A number of topics will be covered in the course lectures. We will begin with an introduction to the *Samsung Solorean*. We will discuss solar car raycing and the American Solar Challenge and Formula Sun Grand Prix. We will discuss raycing history, and UT raycing. Next we will discuss the overall modeling of a solar car. This will include topics such as aerodynamics, rolling resistance and losses, and the main electrical system (array, battery, and motor). We will then look at several systems in detail. We will investigate car aerodynamics, including body shape effects, Reynolds number, drag calculations, and air flow. We will look at chassis design, covering topics such as the suspension, drive train, and steering.

We will study solar array design, covering solar cell fundamentals, efficiency, temperature effects, coatings, and shading. We will discuss several types of electric motors, and their suitability for electric vehicles. We will look at battery technologies, including lead-acid, nickel-cadmium, nickel-metal-hydride, lithium-ion, lithium-polymer, and lithium iron phosphate. This will include battery modeling, charge-discharge characteristics, and basic chemistry.

CLASS FORMAT

Our class on Mondays will be a lecture. I will discuss topics relevant to a solar vehicle, as previously described. Please come to this class to hear my lecture. Do not do homework, surf the web, e-mail, etc. Otherwise you will not receive attendance credit in your grade. I will try to keep this material interesting.

Our class on Wednesday will be a group meeting with the UT Solar Vehicles Team student organization (UTSVT). During this meeting we will discuss ongoing work on *Solorean* and *TexSun,* upcoming group events, scheduling, and other issues such as fund raising. This will also be a time of interaction between our class and other members of the UTSVT. There may be time on Wednesday for project groups to get together. Project groups should be prepared to give informal progress reports, and should in particular discuss major decisions or modifications to the solar car they have planned.

Our first Thursday class (6:30 – 9:30 PM) will meet at the solar car, located at the Pickle Research Center. This is UT's research campus, located in North Austin. We will NOT meet this Thursday (8/25). We will begin meeting Thursdays starting Sept. 1st. There is free parking at PRC, with no UT permit required, after normal business hours. It is also accessible using the PRC shuttle and Capitol Metro bus service (Route 3 bus), both of which are free to UT students and staff. Your first assignment is to familiarize yourself with the PRC location, and determine the bus schedule you will use if you do not have a car. After Sept. 1st, groups will meet at the location appropriate for their project (PRC, ENS 252C, ENS 416, or some other location).

Our first class at PRC will be an introduction to the solar car and shop. After our initial meeting, it is up to you to be organized for your project work. You need to be familiar with the parts and equipment we have, and make sure we have or you bring what you need. You will have to be organized, and think about what you will be doing on Thursday earlier in the week. You should not be coming up to Prof. Hallock, and asking "what can I do?".

PROJECTS

Each student will undertake at least one project. Some projects are more complex than others. Some projects involve upper division skills (ex. microcomputer skills or LabVIEW programming) and are more suitable to 362/379 students. Other projects are less complex and suitable for students without these skills. Most projects will be undertaken by several students as a team. We have large projects that will take the entire semester and smaller projects that can be done in a few weeks. Remember that your grade (as well as what you will get out of this course) is primarily based on your level of effort – not the number of projects that you get involved with. If you get involved with too many projects and spend all your time in meetings you may not actually accomplish very much.

A diverse number of projects are available, which span electrical, mechanical, aerospace, and non-technical areas. If you are taking this course for a technical area elective you should keep that in mind when you select a project(s). If you are taking a heavy technical course load you may enjoy working in a less technical area, such as our outreach program. The semester goes by fast and we must get organized quickly to allow adequate time for projects:

8/24 (today): Review Course Descriptor
8/29 (Mon): Overview solar car and begin discussing projects (list of projects distributed)
8/31 (Wed): Meet with UTSVT and discuss projects; hand out project preference sheets
9/1 (Thurs): **Turn in project preference sheet** (while we are at PRC)
9/5 (Mon): Labor Day Holiday – no class
9/7 (Wed): Projects assigned
9/8 (Thurs): Groups get organized in ENS 252C and begin projects
9/21 (Wed): Each group turns in a project schedule

Projects should emphasize reliability, minimum weight, and high performance.

ENGINEERING NOTEBOOK

Each student must keep an engineering notebook. This is the primary way you document your progress through the course. This must be a bound notebook (no loose pages) such as used in senior lab and considered "legal" in industry for patent issues and so forth. The pages in your notebook must be numbered (you may number them yourself if necessary). Your engineering notebook is to be separate from your class notes. Make sure it is neat and legible.

Your engineering notebook is to be kept in real time; i.e., make entries on a daily basis whenever you work on your project. An entry must be dated and indicate the amount of time spent. The entry should summarize what was done on that day. Sketches, summaries of meetings, calculations, ideas, etc. are all appropriate for your notebook. Record decisions you or your group make and any other important information.

At the beginning of your notebook list each week of the semester, and then the number of hours you devoted to the project after that week is over. Begin with the week of 8/29 and end with the week of 11/28 (14 weeks). This will allow you to keep track of your effort in the course. Your notebook will be turned in to me during our last class. I will be happy to return your notebook to you after grading.

What can you do the week of 8/29? Suggestions:

1. Look over solar car websites.
2. Read the ASC 2012 regulations (go to ASC website, click on Tech Center, click on Regulations (pdf)).
3. If you do not have a car, figure out the Capital Metro bus route you will use to get to Pickle and YPS. Using UT online maps, figure out where building 120 is at Pickle. Review the online PRC shuttle service operating hours.
4. Think about the type of project you would like to do this semester.

FACILITIES

Pickle Research Center Building 120

Solar Car Storage

Work Area – mechanical fabrication and body

2 Mills, Drill Press, Band Saw, Hand Tools, etc.

Weekdays: Building open; take PRC shuttle from Dean Keeton (PRC has no non-permit Parking during regular hours)

Off-hours: Sign-in access (you must be on their list); Non-permit parking ok or take Capital Metro; Building 120 locked (a key for a project group can be arranged)

If you desire non-business hours PRC access (other than Thursday evening) you must fill out a form

YPS Facility (2311 West Rundberg Lane, Suite 175, Austin, 78758)

- Solar Car Storage
- Work Area – electrical and mechanical assembly
- Parts storage and hand tools
- Lots of space – about 3000 square feet
- Not air conditioned – wear light clothing in hot weather
- YPS is located close to Pickle, on the other side of Burnet Road (east side).
- YPS is one of our sponsors, and the location is a business.
- Access is limited to business hours or with Prof. Hallock

ENS 416

- Back of lab: new motor and cRIO, other electrical work
- Front of lab: solar cell testing and lamination
- Experienced solar car members have office space
- Mostly electrical, but have small prototyping machine tools
- Lab is locked; access through Dr. Hallock, grad students, UTSVT members with keys

ENS 252C

- ECE lab scheduled for solar car work Thursday evenings 6:30 – 9:30 pm (closes at 10)
- 10 instrumented stations with 20 seats
- Also available throughout the week

ME Machine Shop (ETC first floor)

- Extensive machine shop
- Access permitted for any student doing solar car work (a privilege not available to other non-ME students)
- Must take safety class for access (see Don Artieschoufsky, ETC 1.214). This is a 3 hour Class is typically given on a Friday afternoon – signup required

All areas must be kept clean! Put tools away and clean up when you finish.

PURCHASING

It is likely that you will need to purchase components for your project. Most of our purchasing is done using our University Procard. There is a precise set of rules that must be followed, which we will discuss. We don't have a mechanism to reimburse personal expenses used to purchase parts for the solar car (student organization bank account has gone away).

Evaluation: The course will be evaluated using the standard UT course/instructor evaluation forms. Your comments are very important.

Disabilities: The University of Texas at Austin provides, upon request, appropriate academic adjustments for qualified students with disabilities. For more information, contact the Division of Diversity and Community Engagement, Services for Students with Disabilities, 471-6259, http://www.utexas.edu/diversity/ddce/ssd/.

Drop Policy: The last day to drop this course without permission from the Dean is the 12th class day.

Class Web Sites and Student Privacy: Web-based, password-protected class sites are associated with all academic courses taught at the University. Electronic class rosters are a component of these 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, Main Building, Room 1.