

ASEN 5190 GLOBAL POSITIONING SYSTEM TECHNOLOGY

Syllabus, Fall 2005

Lecture: Monday and Friday 1:00-1:50 PM ECAE 1B73 (Visions Lab)
Lab: Wednesday 11:00 – 1:00 PM ECAE 1B87 (GPS Lab)

Instructor

Steve Anderson
Office: ECNT 416 / Phone: 492-3944 / Email: stevea@ccar.colorado.edu
Office Hours: Monday and Friday 2-3pm

Internet Information

Class web site <http://www.colorado.edu/ASEN/asen5190>
Check for assignments and schedules.

Required Text

Global Positioning System – Signals, Measurements, and Performance, Pratap Misra and Per Enge, 2001

Note: You might find this book on Amazon or at the CU Book Store, but it is recommended that you buy this book directly from Navtech GPS Supply (www.navtechgps.com). Previously, they have had the best price.

Bound Laboratory Notebook – number and date pages

Overview

The Global Positioning System (GPS) is a worldwide, satellite-based navigation system used for aviation, remote sensing, shipping, vehicle tracking, surveying, time transfer, search and rescue operations, and personal communications via satellite. The GPS Technology Laboratory provides a hands-on introduction to this rapidly growing field, covering both applications and the technology that makes satellite navigation possible. It is by nature an interdisciplinary course, covering subject material in orbit prediction, satellite systems, signal processing, error modeling, computer programming, digital and microwave electronics.

Course Description and Format

The GPS Technology Laboratory provides an overview of the elements of satellite-based navigation, centered on five laboratory exercises and an independent research topic. The course is open to seniors and graduates students in Aerospace, Electrical, Mechanical, and Civil Engineering, Telecom, Physics, and Computer Science. Regular lectures are held on Monday at 1 PM. Friday lecture periods will be used for a variety of regular lectures, special guest lectures, question & answer sessions, and tutorials. Each student will be assigned to a two-hour lab section. The time and day for the lab sections will be scheduled during the first week of classes.

The GPS Technology course focuses on group work in the lab, in which you and your partners design, build, test, and analyze both hardware and software projects. Weekly lectures introduce the important concepts related to the current lab exercise and provide additional information enhancing the material covered in the labs. Lab groups meet once a week for regular lab instruction and the lab is accessible 24 hours a day for group work on your own. For each lab assignment, students are assigned to a new team. The team works together on the pre-lab exercises, lab exercises, and report write-up, and receives a common grade for their work.

Attendance to all lectures and scheduled laboratory hours is expected. Information on the labs will be presented during both lecture and lab periods. If it is necessary for you to miss a lab class please inform your lab partners promptly. If you miss a lecture, please contact the instructor or a classmate to find out what you missed.

Objectives of the Course

- Learn key concepts of satellite-based navigation. This is a growing field with many opportunities for employment and graduate research.
- Develop or enhance technical writing skills.
- Take an end-to-end view of a large, complex engineering system.
- Gain familiarity with common electronic lab equipment.
- Gain experience working as part of a team - division of responsibilities, teaching and learning from your peers.

Prerequisites

There are no explicit course prerequisites for this lab; however, we expect you to have the experience that goes along with being a graduate student in engineering or science. For example, you will need good problem solving skills, vector and matrix math, linear algebra, computer programming, and the ability to write a good lab report. Specifically, you do not need previous electronics experience, but you must have a positive attitude about learning how to use electronics lab equipment and dealing with the inevitable inconveniences of real hardware.

Labs

There are five lab assignments that explore various aspects of GPS technology. They are organized so that you start out by looking at the big picture - what is GPS and what can it do? Then you delve into the technology that makes it work. Students work on labs in assigned teams of two or three. Each lab handout includes a description of the lab, exercises or assignments, and an outline of the required report. Some variations in the lab are provided as well as optional activities that enable each group to look further into topics they find particularly interesting. You are also welcome to invent your own additions or modifications to the lab. You are advised to discuss these with the instructor ensure that your plan fits with the lab objectives and that the grading criteria are adjusted appropriately. Each team submits one report and shares a common grade.

LAB 1- GPS-Based Personal Navigation

As an introduction to GPS technology, students learn how to work with a handheld GPS device. We take modern GPS receivers out into the field to locate sites in and around Boulder. GPS data are logged and processed to review data analysis techniques and to investigate the navigation performance of GPS. The use of mapping software and PCMatlab for data analysis and plotting is introduced.

LAB 2 – GPS Measurements and Errors

Although GPS is an extremely accurate system for navigation, there are still sources of error. In Lab 2 we explore these errors and various modeling techniques for compensating for the errors using actual GPS data. Several variations of the lab are available to permit students to select the type of error - ionospheric delay, orbit mismodeling, and multipath, that they would most like to investigate.

LAB 3 – GPS Spread Spectrum Codes

Pseudo random noise (PRN) codes are the key to GPS and other modern communications systems based on a technique known as "spread spectrum". PRN codes can be readily generated using very simple digital logic chips or a short computer program. In Lab 3 we design and construct GPS C/A code generators in both hardware and software implementations.

LAB 4 - GPS Signal Modulation

In Lab 4 we create a spread spectrum signal using the circuits constructed in the previous lab to modulate a radio frequency signal. We investigate both time and frequency domain signal representations using equipment in the laboratory, and compare the characteristics of the signals you generate to those transmitted by the GPS satellites.

LAB 5 - GPS Receiver Acquisition and Tracking Loops (ASEN 5190)

In this lab we study the operation and performance of the code and carrier tracking loops in a GPS receiver. Using an open architecture GPS receiver card and elements of a software receiver implementation we can compare the measurement noise using frequency and phase lock loops, varying the loop bandwidth, and the coherent integration time.

Independent Research

In addition to the labs, each student will investigate some aspect or application of GPS individually and prepare a presentation and report on their chosen subject. The presentations will be given during the last 2 weeks of the semester. The instructor and class members will critique and grade the presentations on the basis of technical content, clarity, and style.

Community Service

Students are to perform some type of community service activity that involves applying the knowledge learned during your college experience. Recommended activities include presentations on an engineering or science topic to an elementary, junior or senior high school class or club, senior citizen or community group, participation in programs such as peer tutoring or high school student recruitment to pursue majors in engineering. The University of Colorado has many programs such as the Space Grant College and Peer Advocates that will aid in the completion of this requirement.

Textbook and Other Resources

Required Text - *Global Positioning System – Signals, Measurements, and Performance*, Pratap Misra and Per Enge, 2001.

Other GPS Literature -

Understanding GPS - Principles and Applications, Elliott D. Kaplan, Ed., Artech House, 1996.

Global Positioning System: Theory and Applications, Volume I&II, Ed. by B.W. Parkinson, J.J. Spilker, P. Axelrad, and P. Enge, AIAA, 1996.

GPS World Magazine, Edited by Glen Gibbons

Navigation, Journal of the Institute of Navigation

GPS Satellite Surveying, A. Leick

GPS Theory and Practice, B. Hofmann-Wellenhof, H. Lichtenegger, and J. Collins

Guide to GPS Positioning, D. Wells, et al.

World Wide Web -

There is a lot of information on GPS and GPS applications available on the World Wide Web. Useful links will be posted on the class web site.

Grading

Most of your grade (75%) is based on the lab reports. All labs are weighted equally and all the students in a group receive the same grade on the lab. (Partners are switched for each lab assignment.) The report grades have both

technical and style components. The individual presentations are also worth 15% of your final grade and include both content and style factors.

An additional 5% of your final grade is based on your participation in the lab groups. Each lab report must include a one page appendix describing the work done by each partner in the group. Each team member must initial this page to show concurrence with the description. If you are an active contributor to all lab exercises you receive the full class participation credit. Finally, 5% of your final grade is given for community service participation. There are no exams or quizzes.

| | |
|----------------------|-----|
| Five Labs | 75% |
| Independent Research | 15% |
| Class Participation | 5% |
| Community Service | 5% |

Important Dates

Lab reports are due on Friday at 5 PM. You may have an automatic extension until the lecture class period on Monday at 1 PM. DO NOT wait until Monday morning to finish up your report. Natural disasters such as printer failures, disk crashes, and data eating viruses are prone to strike just prior to an assignment deadline. If there is a legitimate reason that the assignment cannot be turned in on time please contact the instructor as soon as possible. Not having enough time to finish, sudden printer or computer failures after Friday, are not legitimate excuses.

University Policies

(1) Disability Task Force Statement

If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs may be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and www.Colorado.EDU/disabilityservices

Disability Services' letters for students with disabilities indicate legally mandated reasonable accommodations. The syllabus statements and answers to Frequently Asked Questions can be found at www.colorado.edu/disabilityservices

(2) Religious Observations

Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, I ask that you take the time to review the calendar for the coming semester and inform me within the first two weeks of the semester of any anticipated conflicts. Last minute requests - especially those occurring days before a scheduled due date - will likely be rejected.

See full details at http://www.colorado.edu/policies/fac_relig.html

(3) Class Room Behavior

Students and faculty each have responsibility for maintaining an appropriate learning environment. Students who fail to adhere to such behavioral standards may be subject to discipline. Faculty have the professional responsibility to treat all students with understanding, dignity and respect, to guide classroom discussion and to set reasonable limits on the manner in which they and their

students express opinions. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See policies at

<http://www.colorado.edu/policies/classbehavior.html> and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

(4) **Honor Code**

All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at

<http://www.colorado.edu/policies/honor.html> and at <http://www.colorado.edu/academics/honorcode/>

(5) **Discrimination and Sexual Harassment**

The University of Colorado at Boulder policy on Discrimination and Harassment (<http://www.colorado.edu/policies/discrimination.html>, the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships applies to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of discrimination or harassment based upon race, color, national origin, sex, age, disability, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the ODH and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at <http://www.colorado.edu/odh>

| | Week of | Lectures (Monday/Friday) & Reading Assignments | Lab Sections (Wednesday) |
|----|----------------|--|---|
| 1 | 8/22 | Course overview, scheduling (Monday) Introduction to GPS (Friday) Ch 1-2.2 | Lab Equipment and Procedures Lab Report Guidelines |
| 2 | 8/29 | Fundamentals of GPS Ch 2.3-2.4 GPS Orbits and Navigation Message (Friday) Ch 3.3 | Lab 1 Personal Navigation |
| 3 | 9/5 | <i>No Lecture on Monday - Labor Day</i> Lab 1 Q&A (Friday) | Lab 1 |
| 4 | 9/12 | GPS Measurements (Monday) Ch 4-4.2 GPS Errors (Friday) Ch 4.3-4.4 | Lab 2 Measurements & Errors |
| 5 | 9/19 | Differential GPS (Monday) Ch 2.5 & 4.8 <i>No Lecture on Friday</i> | Lab 2 |
| 6 | 9/26 | GPS Basic Codes (Friday) Ch 7.4-7.5 Lab 2 & 3 Discussion (Friday) | Lab 3 Spread Spectrum Codes |
| 7 | 10/3 | GPS Signals (Monday) Ch 7 Fourier Analysis Review (Friday) | Lab 3 |
| 8 | 10/10 | Frequency domain (Monday) Ch 7.2-7.3, 9.1.1 <i>No lecture on Friday 10/14 – Fall Break</i> | Lab 4 Signal Modulation |
| 9 | 10/17 | GPS Link Analysis (Monday) Ch 8.1-8.4 GPS Receivers (Friday) - Ch. 9 | Lab 4 |
| 10 | 10/24 | Antennas (Monday) Acquisition and Tracking (Friday) Ch. 9.2-9.6 | Lab 5 Receiver Acquisition & Tracking Loops & Antennas |
| 11 | 10/31 | Code Tracking Loop Models (Monday) Ch. 9.5 Carrier Tracking Loops (Friday) Ch 9.6 | Lab 5 |
| 12 | 11/7 | GPS Modernization (Monday) <i>Handout</i> Lab 5 Discussion (Friday) | Lab 5 |
| 13 | 11/14 | GPS Positioning – Comparisons of stand-alone, DGPS, Kinematic (Monday) Carrier phase techniques (Friday) | Projects |
| 14 | 11/21 | Project Discussion (Monday) <i>Thanksgiving Break</i> | Office Hours on Monday & Wednesday Lab Time |
| 15 | 11/28 | Presentations (Monday & Friday) | Presentations |
| 16 | 12/5 | Course Summary (Monday) Last Day of Class – Thursday Dec 8 | Presentations |