

2005-06 WINTER Quarter
AA272D Advanced Navigation Systems
Instructors: Enge, Spilker and Akos
M-W: 11:00-12:15
Building 60-61G

Course Description

AA272D is an advanced course focusing on inertial navigation, satellite navigation and their combined use. Specifically, it builds towards an understanding how satellite navigation can be used in challenging radio environments that may include radio frequency interference (RFI) or signal obstructions. To this end, it describes both internal and external sources of signal assistance. Internal sources include the processing gain of the GPS signal itself or the use of controlled radiation pattern antennas (CRPAs). External sources of assistance include inertial navigation, television signals and information broadcast over cellular networks.

Prerequisite: AA272C/EE392A – Global Positioning System (GPS)

Course Reader (available at the bookstore on Thursday 6 April or Friday 7 April):

1. Chapters 8-13 of the Global Positioning System (GPS): Signals, Measurements and Performance, P. Misra and P. Enge, 2nd edition, 1st printing, Ganga-Jamuna, 2006

References:

1. Global Positioning System: Theory and Applications, edited by B. Parkinson, J. Spilker, P. Axelrad, and P. Enge, AIAA, <http://www.aiaa.org>, 1996
2. Understanding GPS: Principles and Applications, edited by Elliot Kaplan, Artech House, Artech House, 1996
3. Avionics Navigation Systems, edited by Kayton and Fried, Wiley Interscience, 1997
4. The Global Positioning System and Inertial Navigation, Farrell and Barth, McGraw-Hill, 1999
5. The Navstar Global Positioning System, Logsdon, Van Nostrand Reinhold, 1992
6. Fundamentals of Global Positioning System Receivers: A Software Approach, James Bao-Yen Tsui, Wiley Interscience, 2000
7. Global Positioning Systems, Inertial Navigation and Integration, Grewal, Weill and Andrews, Wiley Interscience, 2001

GPS for Geodists

8. GPS: Theory and Practice, Hofmann-Wellenhof, Lichtenegger and Collins, Springer, fourth edition, 1997
9. GPS Satellite Surveying, Leick, Wiley Interscience, 1990
10. GPS for Geodesy, Teunissen and Kleusberg, Springer, second edition, 1998
11. Linear Algebra, Geodesy and GPS, Strang and Borre, Wellesley Cambridge Press, 1997
12. Guide to GPS Positioning, edited by David Wells, Canadian GPS Associates, second printing, 1987

GPS Policy

13. The Global Positioning System: Assessing National Policies, Pace et al, RAND, 1995

14. The Global Positioning System: A Shared National Asset, National Research Council, National Academy Press, 1995

Evaluation:

- 10% True/false quiz on Chapter 8 from the course reader and the early lectures.
- 30% based on final receiver laboratory project. This project calls for you to work in teams of 2-3 and will require you to acquire and track GPS signals buried in noise. These noisy signals will be provided in data files that we will provide.
- 20% Homework.
- 30% Mid Term (in class exam in mid February)
- 10% True/false quiz late in the term to cover the late lectures.
- no final exam

Contact Information:

- Professor Per Enge: Durand 023, per.enge@stanford.edu, 723-2853, email for appointments
- Mr. Juyong Do: Durand 060, jdo@stanford.edu, 723-6754, Office hours: M 4:30-5:30 in Durand 157, email for appointments outside office hours
- Course information will be distributed using the web site for this class which is at <http://www.stanford.edu/class/aa272d/>. We may move this information to <http://coursework.stanford.edu>.

Tentative! Syllabus

April 5, 10 & 12: Inertial Navigation.

Dead reckoning, accelerometers, gyroscopes, GPS/INS integration, one dimensional error analysis.

Reading Assignment – Chapter 8 and Section 13.5.

Homework 1: – problems 8-1, 4, 5, 10 and 11.

April 17 & 19: Link Budgets.

Satellite signal link budget and noise floor. Link budget for terrestrial signals.

Reading - Chapter 10 and Section 13.2.

April 24 & 26: GPS Signals and Codes by Professor Spilker

Fundamentals of the code, tracking, and multiple access problem. Desirable correlation properties.

Gabor bandwidth and relation to tracking accuracy. Processing gain against radio frequency interference. Different families of codes including: maximal length codes, Gold codes, concatenated Gold codes, short and long set Kasami codes, nonlinear feed-forward codes and the Bent code subset.

Reading – Chapter 9

May 1 & 3: GPS Signal Tracking by Professor Spilker

Optimal signal tracking, with and without multipath. Vector signal correlation of the composite received signals from all signals and all satellites in view.

Reading – Chapter 12

May 8, 10 & 15: Signal Conditioning and Acquisition by Professor Akos

Low noise amplification and noise figure. Down conversion and analog to digital sampling. Searching over code phase and Doppler frequency. These lectures will launch the final project.

Reading – Chapter 11

May 17: Tentative for Exam

May 22 & 24: Controlled Radiation Pattern Antennas (CRPAs)

General concept of beam steering and null steering. Detailed description of a ring-nuller for aircraft. Introduction to Space Time Adaptive Processing and Space Frequency Adaptive Processing (STAP and SFAP).

Reading – Section 13.3

May 29: Memorial Day

May 31, June 1, 5 & 7: Assisted GPS, Tracking Television Signals and Adaptive Analog to Digital Converters

Using GPS navigation information from a radio-quiet site to aid a receiver in a challenging environment. Tracking signals from a television transmitter to augment the GPS suite of range measurements. Adapting the slicing levels of an analog to digital converter to attenuate narrowband radio frequency interference.

Reading – Sections 13.4 and 13.6

Finals Week: Final Project Due (Date TBD)