Course: MAE 593I Global Positioning System

Semester: Fall 2014

Course Format: 3 hr Lecture

Prerequisites: Math 251, MAE 460, and MAE 411, or consent

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Office Hours: TBD

Course Objectives: The objectives of this course are to present the different segments of Global Positioning System and introduce its applications, error sources, and advanced methods for mitigating these errors sources. Additionally, estimation procedures, which are the backbone of GPS processing, will be introduced and utilized throughout the course.

Required Text:

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

Several course handouts will also be provided to supplement the text.

Expected Learning Outcomes:

Upon successful completion of this course:

1. Students will be able to describe the fundamentals of GPS operations:
    - Coordinates, time systems, satellite orbital motions;
2. Students will be able to interpret GPS measurements and describe their error sources:
    - Pseudo Range, Carrier Phase, Common data formats
    - Propagation medium: Ionosphere, Troposphere, Multipath
3. Students will be able to process GPS data by employing estimation procedures:
    - Least squares, Stochastic and mathematical models, Kalman Filters
4. Students will learn to process GPS data for Position, Velocity and Time
    - Estimation filters for stand-alone GPS of varying complexity
5. Students will learn how to formulate more advanced GPS algorithms, including:
    - Differential GPS techniques
    - GPS/INS sensor fusion
    - GPS Precise Point Positioning (PPP)
6. Students will be able to describe various Earth science applications of GPS

Course Introduction: GPS is a ubiquitous source of navigation and timing information that has entrenched itself in modern society, much like the Internet. Its applications include aviation, space, agriculture, transportation, distributed timing, surveying & mapping, environmental monitoring, and many others (see: (http://www.gps.gov/applications/). This course begins with introductory material, quickly moves into developing algorithms necessary to process GPS, and ends with more advanced topics involving methods used to mitigate GPS error sources for improved accuracy. If you would like to gain a working knowledge of GPS, be exposed to its many applications, and use GPS as a tool in your research and professional lives, this is a good course for you.

Grading:
Homework: 30%
2 Mid-Term Exams: 30%
Research Paper: 20%
Final Exam: 20%

Homework: Homework is a significant portion of the course. Most (if not all) of the homework assignments will involve developing MATLAB® code. Working with other students is appropriate, but copying code from others is not appropriate and will result in a grade of "F" in the course (please refer to the Academic Integrity section of this syllabus).

Research Paper: As graduate students, learning to determine the state-of-the-art is an invaluable skill. The GPS has many applications and active research areas. Students will be required to select an area to review in the fields of GPS and to write a research paper on the subject summarizing the major developments leading to the state-of-the-art. The instructor must approve the paper topics, and a mid-semester review will be conducted with suggested revisions from the instructor.

Course Outline:

	Reading
Week 1	
Course Overview: A preview of what will be covered over the semester and how it all ties together.	1.1-1.4
Fundamentals of GPS Operation: GPS system architecture: user, ground, space segments. Description of GPS satellite constellation, signal structure, receivers.	2.2-2.4
Week 2	
GPS Coordinate Frames, Time Reference and Orbits: Global Coordinate Systems, Time Scales, GPS Orbits and Satellite Position Determination	4.1-4.4
Week 3 and Week 4	
GPS Observables and Error Sources: Code and Carrier Phase, Signal Propagation Errors, Single Vs. Dual Frequency, Measurement Errors	5.1-5.7
Week 5	
Probability and Least Squares Estimation	Handouts
Week 6	
Estimating Position Velocity and Time: Linear Model, Least Squares, Dilution of Precision	6.1-6.2
Week 7 and Week 8	
The Kalman Filter: Optimal Recursive Estimator (Extended, Unscented for nonlinear systems)	Handouts
	EXAM 1
Week 9 and Week 10	**Week 9**
Stand-Alone GPS Kalman Filters: for Position, Velocity and Time Estimation: Pseudo-Range only estimators, Carrier Smoothing, Code and Carrier Phase estimators	Handouts
Week 11	
Differential GPS for Error Mitigation: Eliminating Nuisance Parameters by data differencing, Carrier Phase Integer Ambiguity Resolution	2.5, 5.8, 7.3-7.5
Week 12	
GPS Precise Point Positioning: NASA JPL's GIPSY-OASIS, International GNSS Service, NASA GDGPS	7.6 & Handouts
	EXAM 2
Week 13 and Week 14	**Week 14**
Combining GPS and INS: Loosely-Coupled (3,6,9,15-state filter) and Tightly-Coupled Position, Velocity and Attitude Estimation	Handouts
Week 15	
GPS For Earth Science Applications: Atmospheric, Tectonics, etc.	13.5

Academic Integrity Statement:

Instances of academic dishonesty will be handled by the issuance of a grade of "F". This includes evidence of cheating on exams, homework assignments, etc. and is applied to both the individual using the work of another and the individual who allows his/her work to be used by another. Please refer to the West Virginia University Student Handbook for information relating to academic dishonesty

Social Justice Statement:

"West Virginia University is committed to social justice. I concur with that commitment and expect to maintain a positive learning environment based upon open communication, mutual respect, and non-discrimination. Our University does not discriminate on the basis of race, sex, age, disability, veterans status, religion, sexual orientation, color or national origin. Any suggestions as to how to further such a positive and open environment in this class will be appreciated and given serious consideration. If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with the Office of Disability Services (293-6700). "