ENGO 625 – Advanced GNSS Theory

Fall 2020 – L01

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Acknowledgements

- **The following individuals have contributed to the preparation of these lecture notes:**
  - *Dr. Gerard Lachapelle (primary author of the notes)*
  - *Dr. Elizabeth Cannon*
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Course Objectives

- To provide a thorough knowledge and understanding of the following ***advanced*** GNSS theory: concepts, signal structure and propagation, WGS84 and its link to other systems, fundamental receiver design, receiver performance, code and carrier observables, error sources, signal masking, single point and differential positioning methods with emphasis on kinematic carrier phase positioning, advanced ambiguity resolution techniques, augmentation, integration, attitude determination.
- To provide an in-depth knowledge of specialized GNSS-related topics selected during the course
- To conduct effective ***reviews*** of related technical literature
- To develop the ability to ***prepare, analyse, discuss, and critique*** GNSS research presentations, including your own
- To develop the ability to plan and carry out an advanced GNSS-related research project, to collect and process the data, and to analyze the results and derive conclusions

Background Required

- An *a priori* knowledge of RF propagation, signal processing techniques and estimation theory is required to succeed this course. Students are expected to have the knowledge equivalent to that of ENGO 465, taught to 3^{rd} year students in the Geomatics Engineering undergraduate program. This implies the skills to acquire raw GPS observations and to develop programs to analyse this data
- Independence, self-motivation, scientific curiosity and boundless energy
- In addition, involvement in on-going research closely related to GNSS - This is required for research seminars. If a person is not actively involved in GNSS-related R&D, the learning experience in this course will be relatively limited

Expected Skills at End of Course

- To be able to discuss related signal acquisition and tracking, standard and high sensitivity GNSS, especially code and carrier phase error sources and processing methods with experts in the field

- To be able to read, evaluate and assess the impact of GNSS research papers available in the literature

- To be able to design and conduct experiments to evaluate user equipment, signal tracking algorithms, and navigation and positioning method performance

COURSE STRUCTURE

- **Lectures by the instructor: MWF 13:00 to 13:50**

- **Labs/Practical computational exercises (25%)**
  - During the term, two or three labs will be given to the students taking the course for credit. These will count for 25% of the total final mark. Selected students may be asked to discuss their labs during class

- **Project/Paper (25%)**
  - Potential topics are presented relating to GNSS R&D. Typically testing and evaluation of advanced existing or emerging algorithms and methods are appropriate. Papers usually includes use of data and development of software or theory. Presentations in early December.

- **Quizzes,** Three, open book, 10% each for a total of 30%

- **Attendance** + active participation in debates and questions, 20%

RESEARCH SEMINAR FORMAT

- Write a paper on a topic of your choosing. It does not necessarily need to be novel
  - One page proposals will be required
    - Consult with your supervisor regarding the topic
    - Submit to instructor by due date

- Prepare a 20 minute presentation, similar to a conference presentation, to introduce your paper's topic
- The paper should be structured as a traditional paper and include an abstract, introduction, theory, results, conclusions and references.
- A thorough literature review is required

LECTURE COMPONENTS

1. Fundamentals of GNSS
2. Satellites, Signal Structure, etc.
3. Receivers (not so much this year as ENGO 638 hopefully will offered this summer)
4. Observables and Differencing Concepts
5. Errors
6. Mathematical Models for GNSS Positioning
7. Ambiguity Resolution
8. Differential GNSS Augmentations
9. Advanced Aspects
10. Attitude Determination

LECTURE NOTES

- **Lecture Notes**
  - **Soft copies of each chapter will be posted on D2L**
  - **Not to be reproduced**
  - **It should be noted that the course notes represent only a small part of the course content. The rest of the course is learned by attending class, taking notes, participating in discussion, reading papers, doing the labs and the research seminar project.**

- **Recommended Text Books**
  - Understanding GPS–Principles and Applications (Kaplan & Hegarty)
  - Global Positioning System Signals, Measurements and Performance (Misra & Enge)
  - Global Positioning System: Theory and Applications (Parkinson & Spilker)

SCHEDULE

- MWF 13:00 to 13:50 unless otherwise indicated

Chapter Sequence

In order for students to acquire the knowledge to complete the labs in a timely manner, the chapters will be presented in the following sequence: 1, 4, 6, 2, 3, 5, 7, 8, 9, 10