



GMAT4900 Principles of GPS Positioning

Semester 1, 2015

Never Stand Still

Faculty of Engineering

School of Civil and Environmental Engineering

COURSE DETAILS

Units of Credit	6	
Contact hours	4 hours per week (average)	
Class	Tuesday, 13:00 – 16:00	Mathews C
	Tuesday, 16:00 – 17:00	CE201, CE102
Course Coordinator & Lecturer	Chris Rizos (CR) email: c.rizos@unsw.edu.au office: 93854205 phone	
Lecturer & Demonstrator	Mazher Choudhury (MC) email: mohammad.choudhury@unsw.edu.au	

INFORMATION ABOUT THE COURSE

This course is a fourth year undergraduate elective 6UOC course in the B.E. programs. The lecture material and some of the demonstration and assessment tasks are identical to the graduate course GMAT9200 (offered by Surveying & Geospatial Engineering, School of Civil & Environmental Engineering) as part of Masters by coursework programs.

HANDBOOK DESCRIPTION

<http://www.handbook.unsw.edu.au/undergraduate/courses/2015/GMAT4900.html>

OBJECTIVES

To present the basic principles of satellite-based positioning, through lectures and computational sessions focusing on the U.S. developed Global Positioning System (GPS) as well as current and future generation *Global Navigation Satellite Systems (GNSS)*. GNSS is playing an ever increasing role in our modern, mobile societies. In the past systems such as GPS were used by professionals such as geodesists, surveyors and navigators. However increasingly consumer applications is driving the development of GPS/GNSS. This course will introduce students to this technology. The example of GPS will be used because all the GPS principles & applications are relevant to future GNSSs as well.

This course therefore provides an opportunity for the students to acquire the following attributes:

- The skills involved in scholarly enquiry
- An in-depth engagement with the relevant disciplinary knowledge in its inter-disciplinary context
- Capacity for analytical and critical thinking and for creative problem solving
- Ability to engage independent and reflective learning
- Information literacy
- Skills for effective communication

TEACHING STRATEGIES

A variety of teaching activities will be included to achieve the optimal teaching and learning outcomes. Major teaching activities in this course are:

- 1) Weekly lectures & Demonstrations
- 2) Laboratory/computation tasks

- 3) Field exercise(s)
- 4) Regular quizzes
- 5) Final examination

The lectures will provide the foundation to the course. The computational exercises, field exercise and quizzes/exam are intended to reinforce the basic principles.

The most important factors in learning are the students' commitment and learning methods. You are encouraged to attend all the lectures and other teaching activities. In addition, relevant resources on the web are of great help in understanding the basic concepts of GPS/GNSS positioning discussed in the lectures. An important component of this course will be based on analysing the implementation of the basic concepts as algorithms. An understanding of the mathematical basis of GPS single point positioning calculations is considered an important learning outcome of this course.

The basic tool will be the [MATLAB](#) software development environment. In addition, access will be provided to the [Constell](#) "GNSS Toolkit", a range of MATLAB functions relevant to GPS/GNSS processing, as well as several working MATLAB/Constell programs. (Other software may also be used.) The students are encouraged to gain a basic understanding of MATLAB, and to be able to "read", and even develop or modify, software using the GPS/GNSS M-files as a basis.

EXPECTED LEARNING OUTCOMES

By the end of this course the student should be able to:

- (a) Explain the principles of GPS point positioning using pseudorange measurements, including the mathematical algorithms.
- (b) Understand the GPS errors and how Differential GPS can be used to improve positioning accuracy.
- (c) Understand how a GPS receiver works, at a functional level, and can explain the raw and processed outputs based on NMEA and RINEX formats.
- (d) Describe the essential differences between different GNSSs such as GPS, GLONASS Galileo, and BeiDou, and other Regional Navigation Satellite Systems (RNSS).
- (e) Identify the different applications of GNSS.

The student will gain an appreciation of the advantages and disadvantages of the GPS technology (as an exemplar of GNSS in general), as well as have identified application-specific requirements. The level of understanding will be considerably higher than the casual "man-in-the-street" user, but algorithmic details will be kept to a minimum. Only the mathematical basis of single point positioning (the simplest of the GPS/GNSS positioning modes) will be presented to the student.

ASSESSMENT

Assessment for the course consists of:

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|----------------------|-----|
| • Mini-quizzes: | 25% |
| • Assignment 1: | 20% |
| • Assignment 2: | 20% |
| • Final examination: | 35% |

Mini-Quizzes

To reinforce the learning experience, short mini-quizzes will be given during the workshop or lecture periods. Short questions will be asked on the material presented in the PREVIOUS lecture. Correct answers will be provided for student reference and self-learning.

Data Exercise Assignment 1

Students will undertake a project to process measurements in the single point positioning (SPP) and precise point positioning (PPP) modes using the RTKLIB software, compare the results, and submit a report.

Assignment 2

A report and/or presentation on a defined GPS/GNSS application topic.

COURSE PROGRAM

SEMESTER 1, 2015

Week	Date	Topic	Assessments Due
1	2/3	Topic 1: Course outline; Introduction to GPS/GNSS & its applications; Principles of range-based positioning (CR)	
2	9/3	Topic 2: Introduction to reference systems; Introduction to orbital motion; Datum definitions & coordinate; transformations; Height systems; Map projections (CR) <i>Introduction to Matlab & matrix operations (MC)</i>	
3	16/3	Topic 3: Introduction to GPS (CR) <i>Coordinate & time transformations (MC)</i>	Mini-quiz 1
4	23/3	<i>Satellite visibility & almanac format; Satellite computations using ephemeris data & other sources of GNSS ephemerides (MC)</i>	Mini-quiz 2
5	30/1	Topic 3 (continued): GPS positioning modes; GPS signal concepts; Introduction to GPS receivers & signal tracking (CR)	Mini-quiz 3
BREAK			
6	13/4	Topic 4: Principles of Least Squares estimation (CR) Topic 5: Mathematical models for GPS range-based positioning (CR) <i>NMEA & RINEX formats & Matlab routines (MC)</i> <i>Assignment 1 briefing</i>	Mini-quiz 4
7	20/4	Topic 6: Factors affecting GPS accuracy; pseudorange modelling & corrections (CR) Topic 7: GPS biases & errors; Differential GPS (CR) <i>Pseudorange modelling using Matlab routines (MC)</i>	Mini-quiz 5
8	27/4	Topic 8: Introduction to carrier phase-based precise GPS positioning (CR) <i>DOP calculations & interpretation (MC)</i> <i>Assignment 2 briefing</i>	Mini-quiz 6 Assignment 1 submissions
9	4/5	<i>Introduction to RTKLIB (MC)</i>	Mini-quiz 7
10	11/5	<i>Introduction to RTKLIB (MC)</i>	

11	18/5	Topic 9: Applications of GPS Topic 10: Challenges of GNSS (CR) <i>Assignment 2 presentations-1</i>	Assignment 2 presentations - 1
12	25/5	<i>Assignment 2 presentations-2</i>	Assignment 2 presentations - 2
13	1/6	Revision; Exam question samples (CR)	Mini-quiz 8

RELEVANT RESOURCES

The PPT slides are available for download as **PDF files** at the course Moodle site, however these are from last year's course. The updated versions of the lectures will be uploaded each week before or after the lecture period in which the topic is presented. *Electronic resources on the lecture topics are also available at the course Moodle website.*

There is no text book for this course. The following general reference books will assist the student:

Exploring GPS: A GPS User's Guide, S. McElroy, et al., GPSCO (Australia), 1997.

Guide to GPS Positioning, D. Wells, et al., Canadian GPS Associates, 1986.

Global Positioning System: Theory and Applications, J. Spilker & B. Parkinson (eds.), Vol. I & II, AIAA, 1996.

Global Positioning System, The Institute of Navigation, GPS monographs from ION.

ICD-GPS-200, Joint Program Office, ARINC Research, 1992.

Global Navigation, A GPS User's Guide, N. Ackroyd & R. Lorimer, Lloyd's of London Press Ltd., 2nd ed., 1994.

Understanding the NAVSTAR, GPS, GIS, and IVHS, T. Logsdon, Van Nostrand Reinhold, New York, 1995.

Understanding GPS: Principles & Applications, E. Kaplan & C.J. Hegarty (eds.), Artech House, 2nd ed., 2006.

GPS Positioning Guide, Geodetic Survey Division, EMR Canada, 1993.

GPS Manual, Principles & Applications, S. Dye & F. Baylin, Baylin Pubs., 1997.

Introduction to GPS, A. El-Rabbany, Artech House, Mobile Comms series, 2002.

GNSS Global Navigation Satellite Systems: GPS, GLONASS, Galileo, and More, B. Hofmann-Wellenhof, H.

Lichtenegger & E. Wasle, Springer Verlag, Wien New York, ISBN 978-3-211-73012-6, 516pp, 2008.

Applied Satellite Navigation: Using GPS, GALILEO, and Augmentation Systems, R. Prasad & M. Ruggieri, Artech House Mobile Communications Series, ISBN 1-58053-814-2, 290pp, 2005.

Global Positioning System: Signals, Measurements and Performance, P. Misra and P. Enge, Ganga-Jamuna Press, 2001.

DATES TO NOTE

Refer to MyUNSW for Important Dates available at:

<https://my.unsw.edu.au/student/resources/KeyDates.html>

PLAGIARISM

Beware! An assignment that includes plagiarised material will receive a 0% Fail, and students who plagiarise may fail the course. Students who plagiarise are also liable to disciplinary action, including exclusion from enrolment.

Plagiarism is the use of another person's work or ideas as if they were your own. When it is necessary or desirable to use other people's material you should adequately acknowledge whose words or ideas they are and where you found them (giving the complete reference details, including page number(s)). The Learning Centre provides further information on what constitutes Plagiarism at:

ACADEMIC ADVICE

Refer to Academic Advice on the School website:

<http://www.engineering.unsw.edu.au/civil-engineering/resources/academic-advice>

Expected Workload

At UNSW, the normal workload expectations of a student are 25-30 hours per session for each Unit Of Credit (UOC), including class contact hours, preparation and time spent on all assessable work. Hence 150-180 hours in total.

Academic Rules

Students should read the University Calendar

(<http://www.handbook.unsw.edu.au/general/2015/SSAPO/GeneralRules.html>) for University Rules and special considerations.

Students are reminded that the University regards academic misconduct as a very serious matter. Unauthorised material must not be taken into a test or examination. Students are reminded that the University regards academic misconduct as a very serious matter (see <https://my.unsw.edu.au/student/atoz/Plagiarism.html>). Any work submitted for assessment must be entirely the student's own work. The penalty for any suspected academic misconduct ranges from zero mark for the assignment or exam involved, through failure of the course, to expulsion from the University. If absent from an examination, class test or practical, students must submit written documentation to the University.

Assignments are compulsory parts of the course and must be handed in by the due date. A mark of zero will be given for any submission which violates this rule. OR the marks for late submissions will be reduced as follows: -10% (of the maximum mark) for each 24 hour period late.

If a student is unable to submit on time due to illness or other legitimate reason, then a brief written explanation must be sent by email to the lecturer for consideration as soon as is feasible. In some cases the lecturer may grant an extension to the submission date provided he has been contacted before the due date. Further assessment may be granted in this course at the lecturer's discretion.

If students attend less than 80% of classes without due cause they may be asked to "show cause".

Grievances

In the first instance all grievances should be discussed with the lecturer involved. If the problem cannot be resolved then the Associate Head of the School of Civil & Environmental Engineering (A/Prof Mario Attard) will be involved.

Other Matters

Feedback on the course will be gathered by the lecturer in order to improve the course in future years. This feedback will be garnered both informally, as well as by means such as the Course and Teaching Evaluation and Improvement (CATEI) Process. For example, in response to feedback in 2014 the assignment 2 has been changed.