



THE UNIVERSITY OF  
NEW SOUTH WALES  
SYDNEY · 2052 · AUSTRALIA

**SCHOOL OF SURVEYING & SPATIAL INFORMATION SYSTEMS**

**GMAT4900 /GMAT9200**

## **Principles of GPS Positioning**

**Course Outline – Session 1, 2009**

Version: 11-Mar-2009

*This document, and other material, is available at the Course Website:*  
<http://www.gmat.unsw.edu.au/gmat4900>

(User name and password supplied in class)

## 1. Staff involved in the Course and their Contact Details

**1.1 Lecturer & Course Convenor** Prof. Chris Rizos (CR)  
Office: EE454 (Whenever present, you may just drop in)  
Email: c.rizos@unsw.edu.au  
Phone: 938 54205

**1.2 Assistant Lecturer** Dr. Binghao Li (BL)  
Office: EE413C  
Email: binghao.li@unsw.edu.au  
Phone: 938 54189

### 1.3 Staff Absences During Session

CR's absence in weeks 11 & 12 will be covered by BL's lectures and tutorials.

## 2. Educational Aspects of the Course

### 2.1 How this Course Relates to Others in the Program

This course is a fourth year undergraduate elective 6UOC course in the B.E. (SSIS) program. The lecture material and most of the computational tasks are identical to the graduate courses GMAT9200 (offered through the School of Surveying & SIS) as part of Masters by coursework programs.

### 2.2 Aims of the Course

To present the basic principles of satellite-based positioning, through lectures and computational sessions focussing on the U.S. developed Global Positioning System (GPS) as well as the emerging *Global Navigation Satellite Systems (GNSS)*.

GNSS will play an ever increasing role in modern, mobile societies. In the past systems such as GPS were used by professionals such as geodesists, surveyors and navigators. However increasingly consumer applications will drive the technological development of GPS/GNSS. This course will introduce students to this technology.

### 2.3 Learning Outcomes

By the end of this session you 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 COMPASS, 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.

### 2.4 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
- 2) Tutorials and computing tasks

- 3) Field exercise
- 4) Regular quizzes (and discussion/feedback)
- 5) Final examination

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

### 2.5 Suggested Learning Methods

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 (visit the course website for details) 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 and modifying computer software. 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, available on UNSW computers, including EE401A. 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. The students will be expected to gain a mastery of MATLAB, and to develop/modify software using the GPS/GNSS M-files as a basis.

### 2.6 UNSW Graduate Attributes

This course provides an environment that fosters in our students the following attributes:

The skills involved in scholarly enquiry	Significant
An in-depth engagement with relevant disciplinary knowledge in its interdisciplinary context	Significant
The capacity for analytical and critical thinking and for creative problem solving	Significant
The ability to engage in independent and reflective learning	Some
The skills to locate, evaluate and use relevant information (Information Literacy)	Some
The capacity for enterprise, initiative and creativity	NA
An appreciation of, and respect for, diversity	NA
A capacity to contribute to, and work within, the international community	NA
The skills required for collaborative and multidisciplinary work	Some
An appreciation of, and a responsiveness to, change	Some
A respect for ethical practice and social responsibility	Minimal

### 3. Proposed Course Schedule

(Any changes will be notified in the class and by email to the students.)

Week No. (Start Date)	Tuesday - Lecture 1-3pm OMB149	Tuesday - Tutorial 3-4pm EE418
1 (9/3)	Course outline, Introduction to GNSS, Introduction to reference systems, principles of range-based positioning, introduction to orbital motion	Cont.... from lecture
2 (16/3)	Datum definitions & transformations, coordinates, height systems, map projections	Introduction to Matlab & matrix operations <i>exercise 1 be familiar with Matlab</i> <i>Mini-quiz 1</i>

3 (23/3)	Introduction to GPS	Matlab and coordinate & time transformation <i>exercise 2 M file &amp; coordinate and time transformation</i> <i>Mini-quiz 2</i>
4 (30/3)	GPS signals & measurements, positioning modes	Satellite computations using ephemeris data & pseudorange modelling <i>Mini-quiz 3</i>
5 (6/4)	Principles of Least Squares estimation	Matlab routines <i>exercise 3 satellite computation using ephemeris/almanac data</i> <i>Mini-quiz 4</i>
	<i>Mid-session Break</i>	<i>Mid-session Break</i>
6 (20/4)	Mathematical aspects of range-based positioning & LS	Matrix operations & Least Squares <i>Mini-quiz 5</i>
7 (27/4)	Factors affecting GPS/GNSS accuracy, from measurements to position	Matrix operations & Least Squares <i>exercise 4 Matlab functions and LS exercise</i> <i>Mini-quiz 6</i>
8 (4/5)	Differential GPS/GNSS	RINEX format & Matlab routines <i>Mini-quiz 7</i>
9 (11/5)	Applications of GPS/GNSS	NMEA format & Matlab routines <i>Mini-quiz 8</i> <i>Assignment 1 submission</i>
10 (18/5)	Next generation GNSS, trends in technology & applications	Cont.... from lecture <i>Mini-quiz 9</i>
11 (26/5)	Introduction to GPS/GNSS carrier phase-based positioning	Cont.... from lecture <i>Mini-quiz 10</i>
12 (2/6)	Introduction to GPS receivers	Review of course <i>Assignment 2 submission</i>

#### 4. Assessment in the Course

Assessment for the course consists of:

- Mini-quizzes & tutorial topics: 35%
- Assignment 1 (Fieldwork): 20%
- Assignment 2 (Computing): 20%
- Final examination: 25% (during formal exam period)

##### 4.1 Mini-Quizzes & Tutorials

To reinforce the learning experience, 15min mini-quizzes will be given during the tutorial 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. Several of the tutorial exercises will also be assessed.

#### 4.2 Field Exercise Assignment 1

During a convenient period following week 5, students will undertake a “geocaching” field exercise and submit a report in week 9.

#### 4.3 MATLAB-based Assignment 2

An important component of this course will be based on using MATLAB (or a computing language of the student’s choice) to program one of the following tasks: GPS orbit generation, measurement simulation, Least Squares based estimation of GPS single point positioning (SPP) using pseudorange measurements, and others. The basic M-files will be provided, and the student will be expected to investigate some aspect of SPP data processing.

**All assignments and assessment items should be submitted with a signed Assessment Cover Sheet:**

<p>I declare that this assessment item is my own work, except where acknowledged, and has not been submitted for academic credit elsewhere, and acknowledge that the assessor of this item may, for the purpose of assessing this item:</p> <p>Reproduce this assessment item and provide a copy to another member of the University; and/or,</p> <p>Communicate a copy of this assessment item to a plagiarism checking service (which may then retain a copy of the assessment item on its database for the purpose of future plagiarism checking).</p> <p>I certify that I have read and understood the University Rules in respect of Student Academic Misconduct.</p> <p>Signed: .....date: <input type="text"/><input type="text"/> <input type="text"/><input type="text"/> <input type="text"/><input type="text"/></p>
---

### 5. Course Resources

#### 5.1 Lecture Material (check the course website)

<http://www.gmat.unsw.edu.au/gmat4900/>

The PPT slides are available for download as PDF files at the course website, however these are from last year’s course. The updated versions of the lectures will be uploaded each week after the lecture period in which the topic is presented.

*Electronic resources on the lecture topics are also available at the course website.*

#### 5.2 Reference Books

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.

### 5.3 Course Study Kit

A Study Kit containing useful journal and conference articles is available for purchase from the UNSW Bookshop, or electronically (as downloadable PDF files) from the Library MyCourse (search under the course code).

## 6. Administrative Matters

### 6.1 Expected Work Load

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

To assist students with the organisation of their studies, sample workloads of the various components of this 6UOC course are listed below. It is strongly advised that students plan their work during the session.

Lectures (12 x 2hr)	24hr
Tutorials (12 x 1hr)	12hr
Self-study of lecture material (12 x 3hr)	36hr
Self-study of reference material (12 x 2hr)	24hr
Assignment work (approximately 4hr x 12wk)	48hr
Total	152hr

### 6.2 Rules

Students should read the University Calendar (or go to <http://www.handbook.unsw.edu.au/general/2009/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/academiclife/assessment/AcademicMisconductStudentMisconduct.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, via the Student Centre in the Chancellery.

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:** -20% (of the maximum mark) for up to 24 hours after the scheduled submission time, then -10% (of the maximum mark) for each additional 24 hour

period late. (The lecturer has the discretion to vary this penalty up or down, depending upon circumstances.)

If a student is unable to submit on time due to illness or other legitimate reason, then a brief written explanation must be given to the lecturer (or sent as an email) 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 their possible classes they may be refused final assessment.

### 6.3 Academic Honesty & Plagiarism

#### What is Plagiarism?

Plagiarism is the presentation of the thoughts or work of another as one's own.\* Examples include:

- direct duplication of the thoughts or work of another, including by copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person's assignment without appropriate acknowledgement;
- paraphrasing another person's work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- piecing together sections of the work of others into a new whole;
- presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and
- claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.†

For the purposes of this policy, submitting an assessment item that has already been submitted for academic credit elsewhere may be considered plagiarism.

Knowingly permitting your work to be copied by another student may also be considered to be plagiarism (<https://my.unsw.edu.au/student/atoz/Plagiarism.html>).

Note that an assessment item produced in oral, not written, form, or involving live presentation, may similarly contain plagiarised material.

The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does *not* amount to plagiarism.

The Learning Centre website is main repository for resources for staff and students on plagiarism and academic honesty. These resources can be located via:

<http://www.lc.unsw.edu.au/onlib/plag.html>

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

Individual assistance is available on request from The Learning Centre.

Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

\* Based on that proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle

† Adapted with kind permission from the University of Melbourne.

#### **6.4 Grievances**

In the first instance all grievances should be discussed with the lecturer involved. If the problem cannot be resolved, students should contact the School's Grievance Officer (the Head of School) in writing.

#### **6.5 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.