THE UNIVERSITY OF NEW SOUTH WALES
SYDNEY · 2052 · AUSTRALIA

SCHOOL OF SURVEYING & SPATIAL INFORMATION SYSTEMS

GMAT9201

GPS Receivers and How They Work

Course Outline – Session 1, 2009

Version: 11/02/2009

This document, and other material, is available at the Course Website:
http://www.gmat.unsw.edu.au/agd/gmat9201/

(User name and password supplied in class)

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1. Staff involved in the Course and their Contact Details

1.1 Lecturer: A/Prof Andrew Dempster

Office: EE425 (Whenever present, you may just drop in)
Email: a.dempster@unsw.edu.au Phone: 9385 6890

Lecturing assistance will be provided by:

Mr Asghar Tabatabaei Balaei, room 413a, ext 54184
Dr Binghao Li, room 403, ext 54174
Mr Peter Mumford, room 413c, ext 54189

1.2 Laboratory Assistants:
Mr Asghar Tabatabaei Balaei

1.3 Staff absences during session:

A/Prof Dempster will be off campus from 5 - 9 May 2008. During that time he can be contacted by email at the above email address. Also, on campus assistance with this course can be obtained from Mr Tabatabaei Balaei, Dr Li or Mr Mumford during the period A/Prof Dempster is away.

2. Educational Aspects of the Course

2.1 How this course relates to others in the program

The courses are options in SSIS and EE programs:

8501 MEngSc Electrical Engineering
8503 MEngSc Telecommunications

The course applies techniques learned in other areas of telecommunications, and applies them to the special case of a satellite navigation receiver, which can be considered as passive telecoms device. All the functions of the receiver that enable it to provide a position are covered. Even if treated as a “black box”, GPS is a technology that is increasingly important in telecoms, providing not only position (used to provide location-based services), but timing information to cellular networks.

8651 MEngSc Surveying and Spatial Information Systems
8652 MEngSc Spatial Information Systems

Whereas most spatial information specialists require GPS simply to provide a position, this course enables the student to see how that position is extracted from the signals transmitted from the GPS satellites. Understanding how the signal and receiver combine to produce position measurements allows the student to better comprehend the source of many of the system’s fundamental shortcomings, such as multipath.

2.2 Aim of the Course

The aim of the course is to provide an end-to-end description of a GPS receiver, showing how the signal is received and processed, focussing particularly on the important functions of correlation, acquisition, and tracking. Ultimately, a GPS receiver must calculate a position, so all the design aspects are discussed in the context of how position is affected, and how positioning can be made more accurate by following different approaches.

2.3 Learning Outcomes

By the end of this session you should be able to

- design some of the digital hardware components required in a GPS receiver (specifically in

the correlator),
- identify the sources of error in a GPS-estimated position, and methods to reduce these errors,
- implement algorithms for acquiring and tracking a GPS signal,
- select appropriate subsystems (e.g. antenna, RF front end) for a GPS receiver design,
- make sound decisions about a GPS solution for integration within a larger system, based on your knowledge of how GPS components affect performance.

2.4 Teaching Strategies

The teaching of the course is in lectures that are stand-alone and cover one specific topic. The lectures are ordered such that there is a general introduction to GPS, then the definition of the signal to be processed, then the processing of that signal in the order in which the receiver performs the processing. Matlab tutorials give the student sufficient background to complete the Matlab-based assignments. The assignments themselves are aimed to give students experience of the material covered in the lectures, to allow “learning by doing”. Demonstrations of receivers and visualisation software bring other aspects of the theoretical discussions to life. Regular quizzes ensure the student is up to date with the lecture material.

2.5 Suggested Learning Methods

The core material for the course is the set of lecture notes. All that is required for the course is contained within them. The lectures have been derived from several sources, the most important of which is the Kaplan textbook. If the student was to buy one textbook, this one is recommended. As with almost any software-based learning experience, there is no substitute for writing and running code. The more familiar the student is with the Matlab exercises, the more likely that person is to understand and be able to use the theoretical ideas presented in lectures.

2.6 UNSW Graduate Attributes

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

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	Significant
the skills to locate, evaluate and use relevant information (Information Literacy)	Some
the capacity for enterprise, initiative and creativity	Minimal
an appreciation of and respect for, diversity	
a capacity to contribute to, and work within, the international community	
the skills required for collaborative and multidisciplinary work	
an appreciation of, and a responsiveness to, change	
a respect for ethical practice and social responsibility	

3. Proposed Course Schedule

Wk No.	Wednesday 3-4 pm Lecture a Quad G047	Wednesday 4-5 pm Lecture b Quad G047	Wednesday 5-6 pm Tutorial Quad G047	Wednesday Optional Computer Lab Period EE401A
1 11/3	Introduction to Radionavigation	Introduction to GPS	**Matlab Tutorial 1 Introduction**	Matlab tutorial exercises (student edition)
2 18/3	GPS Signal Specification	*GPS Rx Demo 1*	**Matlab Tutorial 2 Graphics**	Matlab tutorial exercises (website 1)
3 25/3	Navigation Message	Positioning Principles	**Matlab Tutorial 3/4 Programming**	Matlab tutorial exercise (website 2)
4 1/4	Positioning Errors	**Quiz 1** *Skyplot Demo*	Datums	Matlab tutorial exercise (website 3)
5 8/4	Differential GPS	Augmentation Systems	**Assignment Tutorial: Preparation**	Assignment work
	Easter	break		
6 22/4	Antennas	**Quiz 2**	RF Front End	Assignment work **Assignment 1 due**
7 29/4	Correlators: Acquisition	Software Acquisition	**Assignment Tutorial: Feedback/Preparation**	Assignment work
8 6/5	Namuru	**Quiz 3**	***A-GPS Demo***	Assignment work
9 13/5	Real GPS Data	Tracking Loops	Code Locked Loops	Assignment work **Assignment 2 due**
10 20/5	Special Correlators	Carrier Locked Loops	**Quiz 4** **Assignment Tutorial: Feedback/Preparation**	Assignment work
11 27/5	Assignment 3 Presentations	Assignment 3 Presentations	Assignment 3 Presentations	Assignment work
12 3/6	Baseband Chips, Making a Measurement	*GPS Rx Demo 2*	Future of GNSS	Assignment work **Assignment 3 due**

4. Assessment in the Course

Assessment for the course includes:

• Assignment 1	15%	Due week 6
• Assignment 2	20%	Due week 9
• Assignment 3	25%	Due week 12
• In-class quizzes	10%	Several weeks during session
• Final Quiz	30%	In formal exam period

***Laboratories**:*

Assignments 1 and 2 will be Matlab-based and will require writing of Matlab code. Assignment 3 will be a unique topic to research and will involve a presentation. The report for each assignment is required to have relevant theoretical background material, from lectures or textbooks, as well as reporting the actions taken and results produced.

5. Course Resources

5.1 Lecture Material (check the course website):

The Powerpoint lecture slides and other important resources are available for download as PDF files at the course website:

http://www.gmat.unsw.edu.au/agd/gmat9201/

The lecture material will be **supplemented** by:

5.2 Text and Reference Books

- Elliott D Kaplan and Christopher Hegarty, "Understanding GPS: Principles and Applications", Artech House,2nd ed., 2006
- James Bao-Yen Tsui, "Fundamentals of Global Positioning System Receivers: A Software Approach", 2nd ed., Wiley, 2005
- Borre, K., Akos, D.M., Bertelsen, N., Rinder, P., Jensen, S.H. , "A Software-Defined GPS and Galileo Receiver: A Single-Frequency Approach", 2007, ISBN: 978-0-8176-4390-4, Birkhäuser
- B W Parkinson and J J Spilker Jr., "Global Positioning System: Theory and Applications", vols I & II, American Inst Aeronautics & Astronautics, 1996
- Pratap Misra and Per Enge, "Global Positioning System: Signals, Measurements, and Performance", Ganga-Jamuna Press, 2001

5.3 Computational Aids

Pocket calculators may be useful during lecturing hours, for tutorials and laboratories in this course. They must be hand-held, internally powered and silent.

Computer software relevant to this course and available in the School's computer lab EE401, includes:

Matlab and several toolboxes

6. Administrative Matters

6.1 Expected work load

At UNSW, the normal workload expectations of a student are 25-30 hours per session for each unit of credit, including class contact hours, preparation and time spent on all assessable work.

To assist students with the organisation of their studies, the expected workloads of the various components of the course are listed below. It is strongly suggested that students use the listed hours to plan their work during session.

Lectures (11 x 2hr)	22hr
Tutorials (12x1hr)	12hr
Assignment, Field exercises & demos	12hr
Revision of Lectures, preparation of practical/tutorial reports, background reading (approximately 4hr x 14wk)	54hr
Total	100hr

6.2 Rules

Students should read the University Calendar or Student Guide for details of 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. 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 subject, 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.

All assignments or practical reports are compulsory parts of the course and must be handed in by the due date. **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. (For example, a student submitting a report/assignment 4 days late has his/her mark reduced by 4 if the maximum mark of the submission is 10.). Any late submission must be made before solutions are issued to the class.

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 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 further assessment is granted then performance in tutorials may be considered as well as an oral exam including use of a computer.

If students attend less than 80% of their possible classes they may be refused final assessment.

6.3 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 work, or knowingly permitting it to be copied. This includes 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.†

Submitting an assessment item that has already been submitted for academic credit elsewhere may also be considered plagiarism.

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

Students are reminded of their Rights and Responsibilities in respect of plagiarism, as set out in the University Undergraduate and Postgraduate Handbooks, and are encouraged to seek advice from academic staff whenever necessary to ensure they avoid plagiarism in all its forms.

The Learning Centre website is the central University online resource for staff and student information on plagiarism and academic honesty. It can be located at:

www.lc.unsw.edu.au/plagiarism

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 in writing.

6.5 Rules for practical / field classes

Students are required to read the supplied instructions well before the exercise is commenced.