School of Civil and Environmental Engineering

Term 2, 2020

GMAT3700 GEODETIC POSITIONING AND APPLICATIONS

COURSE DETAILS

Units of Credit	6	
Contact hours	5 hours per week (average)	
Class	Monday, 15:00 - 17:00	Online via Moodle, BB Collaborate
	Tuesday, 2:00 - 4:00	Online
	Tuesday, 4:00 – 6:00	Online
Course Coordinator & Lecturer	Craig Roberts email: c.roberts@unsw.edu.au Office: CE412 office: 9385 4464	

INFORMATION ABOUT THE COURSE

This course is a 3rd year undergraduate 6UOC course in the B.E. programs. GMAT2700 and GMAT2550 are pre-requisite.

HANDBOOK DESCRIPTION

See link to virtual handbook -

https://www.handbook.unsw.edu.au/undergraduate/courses/2020/GMAT3700/

OBJECTIVES

Concepts of geodetic positioning using GPS/GNSS. Introduction to GNSS other than GPS, including GLONASS, BeiDou and Galileo, QZSS, IRNSS. Satellite orbit representation, analysis of GPS/GNSS carrier phase measurement errors, differential GNSS, integer ambiguity resolution, static baseline survey and control network design, adjustments of baseline measurements within control networks, height determination using GPS/GNSS, standards and specifications for GPS/GNSS geodetic control (SP1, S/G #9 & #12), Precise Point Positioning (PPP), online GPS data processing, continuous operating reference stations (CORS). Field exercise to complement lectures and class discussions for a greater understanding of precise GPS/GNSS positioning principles and the use of state-of-the-art user equipment. Discussion of modern geodesy: geometric techniques such as VLBI, SLR, DORIS & GNSS; gravity field mapping; geodetic services and applications; the IAG, the IGS and the Global Geodetic Observing Systems.

This course aims to introduce you to:

(a) Fundamentals of Modern Geodesy, its applications & technologies, as well as how it is organised

at a global, international level (IAG, IGS, GGOS)

(b) Review of Australian datums and contemporary international datums
(c) Precise GPS/GNSS positioning, including observation modelling & data processing
(d) Practical procedures for GPS/GNSS, including fieldwork and computations using Leica Infinity
(e) Precise GPS/GNSS positioning modes: Static, RTK, CORS, SBAS, PPP, NRTK, Multi-GNSS
(f) Datum modernisation issues for precise GPS/GNSS positioning, especially in Australia
(g) Standards and Practices for control surveying with GNSS and directions.

COURSE PROGRAM

Week No. (Strt Date)	**Lectures (2 hrs) Monday 3 – 5 pm**	**Lectures (2 hrs) Tuesday 2 – 4 pm**	**Workshop (2 hrs) Tuesday 4 – 6 pm**
1 (1 Jun)	Intro to the course/ admin (1) Revision of datums (2) GDA Tech manual revision + professional associations (3) CE G8	Modern geodetic technologies, the IAG & GGOS; Space geodetic applications (4,5) Presentation (due 30 Jul)	Wkshp 1: Mapping exercise* CE G8 GDA assignment** (due 16 June)
2 (8 Jun)	No Class – Public holiday	Principles of satellite orbital motion (6) Revision of GPS (7)	
3 (15 Jun)	Introduction to GPS signals & measurements (8)	Analysis of Least squares GPS measrmnt modelling (9) GPS Carrier Phase based positioning, DD (10)	Wkshp 2: Planning software and online services, precise orbits*
4 (22 Jun)	GPS Errors (11) CE G8	Introduction to GPS baseline processing (12) RINEX (& other) formats (14)	Wkshp 3: Download RINEX data and investigate*
5 (29 Jun)	Planning & executing surveys (13)	GNSS Heighting (16)	Wkshp 4: Using Infinity for baseline computations CE 201
6 (6 Jul)	From baselines to networks (15) CE G8 ***Class exercise Prac planning****	***Practical:*** *GNSS static baseline survey*	***Practical:*** *GNSS static baseline survey*
7 (13 Jul)	Multi-constellation GNSS (17) SBAS (18)	Datum modernisation, GDA2020 and ATRF (19)	Processing of GNSS baseline survey CE 201
8 (20 Jul)	Principles of GNSS RTK (20) & N-RTK positioning (21)	CORS networks (22,23)	Processing of GNSS baseline survey *CE 201 (Prac due 23/7)*
9 (27 Jul)	Precise Point Positioning (PPP) (24,25)	Datum transformations (26)	Wkshp 5: AUSPOS** Exercise *(Essay due 30 Jul)*
10 (3 Aug)	**Class presentations**	Standards & practices for control Surveys (27) S/G Directions # 9 & 12 (28)	**Class presentations**
11 (10 Aug)	Revision of material		

*- indicates 2 marks allocated (see assessment details below) **- 4 marks

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 - Online
2) Field exercise – In 2020 will use data from 2019 students and process.
3) Quizzes, hands-on workshops & discussions - Online
4) Class presentation
5) Final examination

The lectures will provide the foundation to the course. Students are encouraged to come to lectures live and interact and ask questions. The workshops, computational exercises, field exercise/ processing and quizzes/exam are intended to address the basic objectives of the course. The critical review and class presentation encourage the student to indulge in one specialist area of the course.

The most important factors in learning are the students' commitment and learning methods. **Participation is everything**. 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 the actual design of a static GPS field exercise, and the processing of the data collected in 2019.

ASSESSMENT

Assessment for the course consists of:

- Workshops and mini-quizzes: 22% (2 +2 +2 +2 +4 +2 +2 +2 +4)
  - (Wkp 1, 2, 3, prac planning, 5, Quiz 1, 2, 3 and GDA tech manual exercise)
- Class presentation submission: 20%
- Group Field exercise report: 25%
- Final examination: 33%

Workshops and Mini-Quizzes

There will be 5 workshops during this course. Workshop 1, 2, 3 and the prac planning exercise in week 6 will require attendance and participation to score a maximum of 2 marks each. Workshop 4 will be to ensure all students have access to the Leica Infinity sw and can process. Workshop 5 will entail computation and submission of results and be worth 4 marks. To reinforce the learning experience, three short mini-quizzes based on material presented in previous lectures will be given during the lecture/ workshop period worth 2 marks each and a GDA assignment in week 1 will be worth 4 marks.

Critical Review & Class Presentation

Students choose a topic, critically review this topic and prepare a concise presentation to be delivered live or pre-recorded. Instructions for assessment are given and in short comprise a) presentation; b) clarity; and c) in-depth discussion and full referencing. **Due Thursday 30 July 5pm**. The 5 min presentation in class will also be required in Week 10. Attendance from all students will be compulsory for all presentations (online).

GPS Practical & Computations Report

A GPS static prac will be designed by the student cohort. Two blocks of students comprising 4 groups each will design the field logistics. Due to restrictions from Covid-19, data from 2019 will be used without the students observing data in 2020. Each student will be a member of a group of 3 students. Groups will be finalised during the first weeks of the course. **Group** practical reports will be assessed with respect to: a) presentation; b) field notes & computations; and c) in-depth discussions on GPS baseline processing, network adjustment and any other relevant issues. Further information about the practicals will be distributed during the lectures and will be made available on the class web site. **Due Friday 24 July**.

Final Examination

The final examination will cover all topics related to precise positioning and modern geodesy. It will be an open book examination. The paper will be emailed to students at an allotted time and students write their answers into a word doc and return the paper via email.

Note: "Supplementary Examinations for Term 2 2020 will be held on Monday 7th – Friday 11th September (inclusive) should you be required to sit one. You are required to be available during these dates. Please do not to make any personal or travel arrangements during this period."

RELEVANT RESOURCES

The PPT slides are available for download as PDF files at the course Moodle site. 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:

GPS for Land Surveyors, *Van Sickle, J. (4th Edition) 2015*

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.

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

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.

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

GPS Satellite Surveying, A. Leick, 3rd Edition, J. Wiley & Sons, 2004.

Computer software relevant to this course and available in the School's computer lab CE201, includes Matlab, Leica Infinity and numerous online URLs.

PENALTIES

Late submissions will be penalised at the rate of 10% per day after the due time and date have expired.

DATES TO NOTE

Refer to MyUNSW for Important Dates available at:

https://student.unsw.edu.au/dates

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:

https://student.unsw.edu.au/plagiarism

ACADEMIC ADVICE

For information about:

- Notes on assessments and plagiarism;
- Special Considerations: student.unsw.edu.au/special-consideration;
- General and Program-specific questions: The Nucleus: Student Hub
- Year Managers and Grievance Officer of Teaching and Learning Committee, and
- CEVSOC/SURVSOC/CEPCA

Refer to Academic Advice on the School website available at:

https://www.engineering.unsw.edu.au/civil-engineering/student-resources/policies-procedures-and-forms/academic-advice

EXPECTED LEARNING OUTCOMES

This course is designed to address the learning outcomes below and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

After successfully completing this course, you should be able to:

Learning Outcome		**EA Stage 1 Competencies**
1.	*Explain the principles of GPS/GNSS precise positioning using carrier phase measurements, including the mathematical algorithms.*	*PE1.1, PE1.2, PE1.4, PE2.1*
2.	*Understand the GPS/GNSS errors and how Differential GPS/GNSS and Precise Point Positioning can be used to improve positioning accuracy.*	*PE1.1, PE1.2, PE1.4, PE2.1*
3.	*Understand the different ways in which GPS/GNSS field work can be conducted, for different applications, and the planning and testing procedures necessary.*	*PE1.5, PE2.2, PE2.3, PE2.4, PE3.2, PE3.3, PE3.6*
4.	*Understand the role precise GPS/GNSS positioning plays in support of geospatial data acquisition, point coordination, and Modern Geodesy and understand the relevant regulations that apply to these procedures.*	*PE1.3, PE1.5, PE2.2, PE3.1*

For each hour of contact it is expected that you will put in at least 1.5 hours of private study

Appendix A: Engineers Australia (EA) Competencies

Stage 1 Competencies for Professional Engineers

	Program Intended Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
	PE1.3 In-depth understanding of specialist bodies of knowledge
	PE1.4 Discernment of knowledge development and research directions
	PE1.5 Knowledge of engineering design practice
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving
	PE2.2 Fluent application of engineering techniques, tools and resources
	PE2.3 Application of systematic engineering synthesis and design processes
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability
	PE3.2 Effective oral and written communication (professional and lay domains)
	PE3.3 Creative, innovative and pro-active demeanour
	PE3.4 Professional use and management of information
	PE3.5 Orderly management of self, and professional conduct
	PE3.6 Effective team membership and team leadership