School of Civil and Environmental Engineering

UNSW Engineering

GMAT2700

Foundations of Geodesy & Geospatial Ref Frames

Term 2, 2023

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Jinling Wang	jinling.wang@unsw.edu.au	You may contact me via Teams or email any time.	CE413	+61293854 203

School Contact Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries e.g. admissions, fees, programs, credit transfer

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students).

Course Details

Units of Credit 6

Summary of the Course

Cartesian coordinate systems, applications of Cartesian coordinate transformations in surveying. Mathematical transformations between geodetic, Cartesian and topocentric coordinate systems, ellipsoid geometry, orthometric and ellipsoid height systems. Map projections and ellipsoidal geometry, principles of map projections, surveying and mapping projections, transverse Mercator projection, ellipsoidal computations. Corrections to field observations. Geodetic and astronomical reference systems; the relationship between natural and geodetic reference systems, deflection of the vertical; geoid models and reference ellipsoids, height systems, celestial coordinate systems. Geodetic coordinate systems and datums; definition of AGD, GDA, AHD; the impact of tectonic motion on datum and coordinates; and international systems such as ITRF. The use of GPS/GNSS to define reference frames, as well as providing a means for a surveyor or geospatial engineer to determine coordinates of points in the frame.

Course Aims

1. The course introduces the concept of geodesy, coordinate reference systems and frames at the most general level. The student is expected to understand the basic operations on Cartesian coordinates of rotation, translation and reflection.

2. The course introduces the student to geodetic reference frames and the variety of coordinate systems used, and the conversion formulas for changing coordinates from one system to another.

3. The course presents ellipsoidal geometry concepts, and how computations of position from measured quantities such as distance and azimuth are performed. The transformation between geodetic coordinates and map projection coordinates for the case of the Universal Transverse Mercator projection is dealt with.

4. The course describes the concept of the Earth's gravity field and geoid, how it is computed, and the role that it plays in geodesy and in the definition of the height system used by surveyors and engineers.

5. The undamental reference frames for Australian surveying and geodetic practice are described: AGD66/84, GDA94, AHD71, IRTFxx; and the transformations between them explained. The impact of tectonic motion, as well as local deformation, on coordinates in a reference frame is dealt with.

6. To gain experience in the use of RTK-GPS/GNSS for surveying and precise navigation applications.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Explain the definition of geodesy and its major tasks	PE1.1, PE1.2, PE1.6
2. Understand the basic concepts of the reference and coordinate	PE1.2, PE1.3, PE1.4

Learning Outcome	EA Stage 1 Competencies
systems	
3. Implement the practical procedures of the transformation between the coordinate systems	PE1.5, PE2.1, PE2.3
4. Describe the purposes and methods of map projections	PE2.2, PE2.3, PE3.3
5. Identify the geodetic reference frames (datums) and map projection systems used in practice	PE2.2, PE2.3, PE1.4
6. Understand the concept of satellite-based precise positioning technology	PE1.2, PE1.3, PE1.4
7. Use GPS/GNSS to define reference frames and determine the coordinates of points in a frame	PE2.4, PE3.3, PE3.4

This course is designed to address the learning outcomes corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers.

Teaching Strategies

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

1) Regular lectures

2) Tutorials and computing tasks

3) GPS/GNSS fieldwork

4) Regular quizzes, and discussions on the questions from the quizzes

5) Class discussions

The material in this course is fundamental to surveying and geospatial engineering as it relates to the definition of reference systems and reference frames, and how to change/transform between coorindate systems/frames as well map projection concept and common projection methods. Emphasis is placed on fundamentals of geodesy; geodetic positioning concepts and geodetic reference frames/datums; Earth's gravity field and geoid, and vertical reference frames/height datums with particular reference to datums and systems relevant to Australia. Teaching strategies are employed to ensure that the learning outcomes are satisfied.

Based on some studies by a higher education research expert John Biggs, most active students in the class do not just listen, see, collect notes and take notes, but most importantly, they will *"express understanding; raise issues, speculate, solve problems, discuss, answer questions and reflect"*.

Additional Course Information

Pre-requisites: GMAT1110

At UNSW, Normal workload expectations for each program are a minimum of 25 hours per semester per unit of credit, including class contact hours, preparation and time spent on all assessable work.

For each hour of contact it is expected that you will put in at least 1.5 hours of self-centred and self-directed study: for example, reading the course related materials provided through the course website and reflect on the conceptual framework discussed in the classes and workshops.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Quizzes	30%	Not Applicable	1, 2, 3, 4, 5, 6, 7
2. GPS/GNSS Practical Report	10%	24/07/2023 06:00 PM	1, 2, 3, 4, 5, 6, 7
3. Class Discussion Presentations	20%	Not Applicable	1, 2, 3, 4, 5, 6, 7
4. Final Exam	40%	Not Applicable	1, 2, 3, 4, 5, 6, 7

Assessment 1: Quizzes

Assessment length: Each Quiz will take about15 minutes
Submission notes: Quizzes will be scheduled in the classes on Wednesdays in Weeks 2-5 and 8-9

To reinforce the learning experience, a total of six quizzes will be given in closed book format during the classes in Weeks 2, 3, 4, 5, 8 and 9. Short answer questions will be asked on the materials presented in the previous lecturing period. Marks will be awarded for correct answers; partially correct answers will also be awarded with proportionally reduced marks. The detailed marking scheme will be provided to students after each quiz as part of feedback.

Assessment 2: GPS/GNSS Practical Report

Assessment length: GPS/GNSS practical reports may have 30-35 pages
Submission notes: Based on the field work and data collected by the group, individual reports are submitted for assessments.
Due date: 24/07/2023 06:00 PM

Each student will be a member of a group of 4-6 students to carry out the GPS/GNSS positioning filed work. Succesful GPS/GNSS practical activities require considerable interaction between the students. Further information about the practical will be distributed during the lectures. Building upon the collective efforts of collecting data, each student will carry out indepdent data analysis and submit an individual report. All the practical reports are assessed in terms of: 1) Presentation (20%); 2) Field Notes and Computations (40%); 3) In-depth discussions on relevant issues (40%). The detailed marking scheme will be provided together with the practical instruction in Week 5.

Assessment 3: Class Discussion Presentations

Assessment length: 5 minutes for each presentation
Submission notes: Presentation PPT slides are submitted for feedback 2-3 days before the scheduled presentation

Students should regularly attend the lectures and participate actively in worksop class discussions. The students are invited to give four short presentations to the classes in Weeks 4, 5, 8 and 10. These short presentations will offer the opportunities for students, a) to demonstrate and enhance their understanding of the concepts covered in the lectures; b) to establish links between the concepts and real world applications of these concepts, c) to articulate relevant problems and issues in learning, d) to develop technical presentation skills. The detailed marking scheme will be provided together with the class presentation instructions in the week before each presentation.

Assessment 4: Final Exam

Assessment length: 2 hours

Final Exam will be of 2 hours duration. and will be held in the formal examination period, in closed book format, but the complicated formulae to be used in the exam will be provided in the examination paper. The final exam will cover all the contents covered in the course teaching activities. Past sample exam questions and answers will be provided to the class as part of revision in Week 10. The formal exam scripts will not be returned. The final mark for the course will be officially available to you via myUNSW. You may find the key dates for the UNSW exams at: https://student.unsw.edu.au/exam-dates

Additional details

1. The course coordinator reserves the right to adjust the final marks by scaling if agreed to by the Head of School.
2. Supplementary Examinations will be held by the School, should you be required to sit one. You are required to be available during the dates for the Supplementary Examinations. Please check with the School about the scheduled dates.

Attendance Requirements

Like other UG courses in the School, workshops for this course are compulsory (students are required to attend minimum 80%). If any student has difficulties to meet this attendance requirement, contact the course coordinator for alternative arrangements to cover the classes missed.

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 29 May - 2 June	Lecture	Course Outline. Fundamentals of Positioning; Introduction to Geodesy. Geodesy and Earth Motion
	Workshop	Introduction to Sun Tracking; Use of Matlab for geodetic computations; Discussions on Surveying vs Geodesy; The Surveyor 4.0
Week 2: 5 June - 9 June	Lecture	Concepts of Reference Systems and Reference Frames; Coordinate Transformation. Time systems; Positioning, Navigation and Timing (PNT); Quiz 1 on Wednesday
	Workshop	Case Studies: Reference Frames; Coordinate transformations. Review of Sun Tracking progress. Preparation on Class Discussion A
Week 3: 12 June - 16 June	Lecture	Reference Systems/Frames in Geodesy and Astronomy; Terrestrial Positioning and Horizontal Geodetic Datums; Practical review of datums; Quiz 2 on Wednesday
	Workshop	No class (Public holiday)
Week 4: 19 June - 23 June	Lecture	Earth's Gravity Field; Geoid and Gravity Models; Case study on gravity measurements from smartphones; Heights and vertical datums. Quiz 3 on Wednesday
	Workshop	Case Studies: Positioning, Navigation and Timing (PNT); GDA technical manual and Height datums; Review on Sun Tracking results. **Class Discussion A**
Week 5: 26 June - 30 June	Lecture	GPS SPP revision, error sources and RTK GPS/GNSS Surveying; Practical use of RTK GPS/GNSS. Quiz 4 on Wednesday
	Workshop	Case study: GPS/GNSS measurements and

		geometric strength analysis; Preparation for GNSS RTK Practical. **Class Discussion B**
Week 6: 3 July - 7 July	Fieldwork	Field Trip Week - No class
Week 7: 10 July - 14 July	Lecture	Classes to be rescheduled for GPS/GNSS practicals and Sun tracking activities.
	Workshop	GPS/GNSS practical (to be rescheduled)
Week 8: 17 July - 21 July	Lecture	Spherical and Ellipsoidal Computations; Reduction of observations; Map Projections: Concepts, classifications; Map projection theory; Geodetic computations on ellipsoid; Quiz 5 on Wednesday
	Workshop	**Class Discussion C.** Review of GNSS practical results.
Week 9: 24 July - 28 July	Lecture	Transverse Mercator Projection; Lambert Conformal Conic Projection; Grid computations: Zone to zone. Quiz 6 on Wednesday
	Workshop	Case Study: GDA/MGA coordinate transformations. Preparation on class discussion D
	Assessment	GPS/GNSS Practical Report: Based on the field work and data collected by the group, individual reports are submitted for assessments.
Week 10: 31 July - 4 August	Lecture	Image coordinates and transformation; 3D Point Cloud; Course Revisions. Locus Charter: ethical and responsible practice when using location data
	Workshop	**Class Discussion D:** Presentations on geodesy and geospatial reference frames; Future trends in positioning and mapping, Surveying

Resources

Prescribed Resources

Lecture Materials

The course materials will be available through "Moodle": http://moodle.telt.unsw.edu.au/

The Power Point lecture slides are available for download as PDF files at the course website.

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

The class notes, latest journal articles and references related the course topics will be referred to and/or distributed during the lectures.

Text and Reference Books

Rizos C. (1997) *Principles and Practice of GPS Surveying*, Monograph No. 17, School of Surveying and Spatial Information Systems, UNSW. Online at course website

Bossler, J., Jenson, J., Mcmaster, R., & Rizos, C. (eds.) (2002). *Manual of Geospatial Science and Technology*. Taylor & Francis Inc., ISBN 0-7484-0924-6, 623pp.

Mather, R.S. (1978) *The Theory and Geodetic Use of Some Common Projections*, Monograph 1, School of Surveying & Spatial Information Systems, UNSW. Online at course website

Stolz, A. (2001) *An Introduction to Geodesy*, Monograph 16, School of Surveying & Spatial Information Systems, UNSW. Online at course website

Locus Charter: Principles to support ethical and responsible practice when using location data https://ethicalgeo.org/locus-charter/

Recommended Resources

Computational Aids

Pocket calculators are required during lecturing hours, for exercises and practicals in this course. They have to be hand-held, internally powered and silent. They must be brought to all lectures and practicals.

Computer software relevant to this course and available in the School's computer lab CE611/201, includes: Matlab or MicroSoft Excel, which will be used for exercises and GPS/GNSS practical reports, see the practical instructions for details.

Course Evaluation and Development

Students are encouraged to engage into all the teaching activities, and the feedback from students on any aspects of the course is always welcome. There will be regular chats with individual or groups of students, to deal with any potential difficulties in learning. As a small class, we have all the advantages to collect feedback and address any concerns in a timely manner.

This course has been a core subject for the UNSW surveying program over past few decades. The contents and teaching resources have been developed over the years. Some concerns on the complex mathematical aspects of the courses had mentioned by the past students, but this has been addressed with the activities focusing on the concepts behind the formulaes and additonal comoutational tools such as Matlab to gain more more insights into the complex equations.

Laboratory Workshop Information

6 GNSS RTK receivers from the Survey Store will be used for GPS/GNSS practical field work

Submission of Assessment Tasks

Please refer to the Moodle page of the course for further guidance on assessment submission.

UNSW has a standard late submission penalty of:

- 5% per day, for all assessments where a penalty applies, capped at five days (120 hours), after which a student cannot submit an assessment, and no permitted variation.

Academic Honesty and 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 Information

Final Examinations:

Final Exams in T2 2023 will be held on campus between Friday 11th and Thursday 24th August (inclusive), and Supplementary Exams between Monday 4th and Friday 8th September (inclusive). You are required to be available on these dates. Please do not to make any personal or travel arrangements during this period.

For students enrolled in the distance offering of a postgraduate course, and who reside further than 100km from UNSW Kensington campus, will be contacted regarding sitting an external exam. The school's External Exam Policy can be found on the Intranet.

ACADEMIC ADVICE

- Key Staff to Contact for Academic Advice (log in with your zID and password): https://intranet.civeng.unsw.edu.au/key-staff-to-contact-during-your-studies-at-unsw
- Key UNSW Dates - eg. Census Date, exam dates, last day to drop a course without academic/financial liability etc.
- CVEN Student Intranet (log in with your zID and password): https://intranet.civeng.unsw.edu.au/student-intranet
- Student Life at CVEN, including Student Societies: https://www.unsw.edu.au/engineering/civil-and-environmental-engineering/student-life
- Special Consideration: https://student.unsw.edu.au/special-consideration
- General and Program-Specific Questions: The Nucleus: Student Hub
- Book an Academic Advising session: https://unswengacademicadvising.as.me/schedule.php

Disclaimer

This course outline sets out description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle should be consulted for the up to date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline (as updated in Moodle), the description in the Course Outline/Moodle applies.

Image Credit

Mike Gal.

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	✓
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	✓
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in 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	