Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

Expected Implementation in Academic Year (New format)	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Asst Prof Feng Lujia
Course Author Email	lfeng@ntu.edu.sg
Course Title	Space Geodesy
Course Code	ES3006
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	ES1003, ES2001
Co-requisites	N/A
Pre-requisite to	N/A
Mutually exclusive to	N/A
Replacement course to	N/A
Remarks (if any)	

Course Aims

This course is designed to introduce you to the field of geodesy, with a particular emphasis on the Global Navigation Satellite System (GNSS), one of the most important geodetic methods. The course begins with an introduction to the fundamental concepts and principles of geodesy, followed by a broad overview of various geodetic methods and data. You will learn how these methods are used to study geohazards and climate change, along with their strengths and limitations. The course then delves into the diverse applications of GNSS in Earth and environmental sciences, including GNSS deformation for tectonics and volcanology, GNSS meteorology for weather and climate studies, GNSS ionospheric seismology for earthquake and tsunami early warnings, GNSS interferometric reflectometry (GNSS-IR) for measuring sea-level rise and soil moisture, and GNSS Transmissometry (GNSS-T) for studying ecosystems.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Explain the fundamental concepts and principles of geodesy
ILO 2	Describe how different geodetic methods work, including their strengths and limitations
ILO 3	Identify appropriate geodetic methods for specific scientific questions
ILO 4	Evaluate and interpret various types of geodetic data
ILO 5	Create computer programs for analyzing geodetic data
ILO 6	Communicate the results of geodetic data analysis both verbally and in writing

Course Content

Geodesy is the scientific study of the Earth's shape, size, and gravity field, and how these properties change over time. With the advent of space-based techniques, the availability of geodetic data has dramatically increased, offering global coverage, high temporal resolution, and the ability to take measurements in even the most challenging environments. This wealth of geodetic data has broad applications across various Earth and environmental science disciplines such as tectonics, earthquake physics, volcanology, hydrology, oceanography, glaciology, ecology, and atmospheric sciences (including weather and climate sciences).

In the theory section, this course aims to introduce fundamental concepts and principles of geodesy and provide a broad overview of various geodetic methods and data, how these methods are used to study geohazards and climate change, along with their strengths and limitations.

In the application section, this course focuses on the diverse uses of GNSS in Earth and environmental sciences. This includes GNSS deformation for studying tectonics and volcanology, GNSS meteorology for weather and climate studies, GNSS ionospheric seismology for earthquake and tsunami early warnings, GNSS interferometric reflectometry (GNSS-IR) for measuring sea-level rise and soil moisture, and GNSS transmissometry (GNSS-T) for studying ecosystems.

The learning approach combines lectures on theoretical concepts, practical tutorial activities to reinforce learning, interactive discussions to explore ideas and applications, and hands-on experiences to apply geodetic methods in real-world scenarios. While the course offers a broad introduction to geodetic data and tools, it does not provide in-depth instruction on each topic. Instead, you will have the opportunity to explore a topic of your choice in greater depth through the class project, allowing you to apply and reinforce the knowledge and skills gained throughout the course.

By the end of this course, you will have the knowledge, skills, and confidence to apply geodetic methods in your future research and career. You will be equipped to use geodesy to address challenges in Earth and environmental sciences.

Reading and References (if applicable)

Geodesy by Wolfgang Torge, Jürgen Müller, and Roland Pail, 5th edition, De Gruyter, 2023

Planned Schedule

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
1	Introduction to the course and basics of geodesy	1, 2	In-person	Lecture and tutorial	Geodesy Chapter 1
2	Overview of various geodetic methods	1, 2, 3	In-person	Lecture and tutorial	Geodesy Chapter 5
3	Reference frames and datums	1, 2, 3, 4	In-person	Lecture and tutorial	Geodesy Chapter 2
4	Fundamentals of deformation	1, 2, 3, 4	In-person	Lecture and tutorial	N/A
5	GNSS basic theory	1, 2, 3, 4	In-person	Lecture and tutorial	N/A
6	Tectonic and volcano geodesy	1, 2, 3, 4	In-person	Lecture and tutorial	N/A
7	GNSS campaign on campus	1, 2, 3, 4	In-person	Lecture and tutorial	N/A
8	GNSS meteorology and GNSS ionospheric seismology	1, 2, 3, 4	In-person	Lecture and tutorial	N/A
9	GNSS interferometric reflectometry (GNSS-IR) and GNSS Transmissometry (GNSS-T)	1, 2, 3, 4	In-person	Lecture and tutorial	N/A
10	Visit geodetic infrastructures in Singapore	1, 2, 3, 4	In-person	Local field trip	N/A
11	Class Project	1, 2, 3, 4, 5, 6	In-person	Ptacticum	N/A
12	Class Project	1, 2, 3, 4, 5, 6	In-person	Practicum	N/A

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
13	Class Project Presentation	1, 2, 3, 4, 5, 6	In-person	Class Project Presentation	N/A

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Active	You will engage in active learning throughout the course.
Computer based class project	This will enable you to process, analyze, and interpret data using computer programming to address scientific questions, fostering creative problem-solving skills.
Oral Presentation	You will present your research and findings to the whole class. This supports peer-learning as well as developing research and presentation skills.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Others(Continuous assessment - 1)	1, 2, 3, 4, 5	1, 2, 3, 4, 5, 6	40		Individual	Holistic	Extended Abstract
2	Continuous Assessment (CA): Others(Continuous assessment - 2)	1, 2, 3, 4, 5	1, 2, 3, 4, 5, 6	20		Team	Holistic	Extended Abstract
3	Continuous Assessment (CA): Project(Class Project)	1, 2, 3, 4, 5	1, 2, 3, 4, 5, 6	40		Individual	Holistic	Extended Abstract

Description of Assessment Components (if applicable)

Continuous assessment – 1 (CA1): Throughout the course, short in-class quizzes, after-class assignments and paper discussions will be administered to evaluate your understanding of the material. Quizzes will be graded based on the correctness of multiple-choice questions. Paper discussions will be assessed based on participation and comprehension. Assignments, which will involve data analysis and/or processing, will be evaluated for completeness, conceptual understanding, and technical accuracy.

Continuous assessment – 2 (CA2): You will conduct a GNSS campaign on the NTU campus and join a local field trip to visit geodetic infrastructures in Singapore. You will work in teams to complete assignments related to these class activities.

Class project: You will analyze a geodetic data set of your choosing to answer a scientific question in one of the following five topics: GNSS deformation, GNSS meteorology, GNSS ionospheric seismology, GNSS interferometric reflectometry (GNSS-IR), or GNSS Transmissometry (GNSS-T). You may use any programming language of your choice for the project. You will deliver a short oral presentation (5-10 minutes) on your project and submit a written report (5 pages, double-spaced, including figures) along with your corresponding computer code. The class project report will be graded on completeness, neatness, and quality. The computer code will be evaluated for technical correctness and proper commenting. The presentation will be assessed on how clearly you explain your project in plain English, highlighting key points. Specifically, your presentation should demonstrate your ability to communicate complex scientific concepts effectively, engage your audience, and provide a clear and concise overview of your findings and methodologies.

Formative Feedback

Throughout this course, the TAs and I will be available to answer any questions you may have about your learning. We will provide feedback on common mistakes made in quizzes and assignments, helping you learn from them. Additionally, you will receive guidance on your class project to ensure you are on the right track.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Curiosity	Advanced
Digital Fluency	Advanced
Problem Solving	Advanced
Transdisciplinarity	Advanced
Information Literacy	Advanced

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

You are expected to complete all assigned readings, activities, assignments, attend all classes punctually and complete all scheduled assignments by due dates. You are expected to take responsibility to follow up with assignments and course related announcements. You are expected to participate in all project critiques, class discussions and activities.

Policy (Absenteeism)

In-class activities make up a significant portion of your course grade. Absence from class without a valid reason will affect your participation grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for in-class activities.

Policy (Others, if applicable)

ASE Diversity and Inclusion policy
Integrating a diverse set of experiences is important for a more comprehensive understanding of science. It is our goal to create an inclusive and collaborative learning environment that supports a diversity of thoughts, perspectives, and experiences, and that honours your identities (including ethnicity race, gender, socioeconomic status class, sexual orientation, religion or, ability., etc.).
To help accomplish this:

- If you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to come and talk with one of the instructors or an ASE faculty member. We want to be a resource for you.
- Your classmates and instructors (like many people) are still in the process of learning about diverse perspectives and identities. If something was said in class (by anyone) that made you feel uncomfortable, please talk to the instructors or an ASE faculty member about it.
- As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: (e.g., using preferred pronouns and names; being respectful of others opinions and actively, making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions., etc.).

We expect all members of the class to adhere to the NTU Anti-harassment policy (https://ts.ntu.edu.sg/sites/policyportal/new/Documents/msrf%20included%20NIE%20staff/Anti-Harassment%20Policy.pdf), if you witness something that goes against this or have any other concerns, please speak to your instructors or an ASE faculty member.

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