COURSE OF STUDY: Triennial Degree in Earth System and Global Changes

ACADEMIC YEAR: 2025-2026

ACADEMIC SUBJECT: Solid Earth Geophysics

General information	
Year of the course	2nd
Academic calendar	2nd March 2026 – 15th June 2026
Credits (CFU/ETCS):	6
SSD	GEOS-04/A
Language	English
Mode of attendance	Frontal lessons with exercises in classroom

Professor/ Lecturer	
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Virtual room	https://teams.microsoft.com/dl/launcher/launcher.html?url=%2F_%23%2Fl%2Fchannel%2F19%3AGwp4AVdKZS7n6gs1ZBGmsUPQa0weJRVnbD22g2RC7ak1%40thread.tacv2%2FGeneral%3FgroupId%3D6f556b2a-853d-4d18-823a-25b8ff66058a%26tenantId%3Dc6328dc3-afdf-40ce-846d-326eead86d49&type=channel&deeplinkId=2a293a32-794b-487d-806c-ee9dc98e047b&directDl=true&msLaunch=true&enableMobilePage=true&suppressPrompt=true
Office Hours (and modalities: e.g., by appointment, on line, etc.)	Monday 11:00 – 13:00 or by appointment at agreed times.

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/Self-study hours
56	40	16	94
CFU/ETCS			
6	5	1	

Learning Objectives	Acquisition of fundamental knowledge on the physical properties of the Earth's interior.
Course prerequisites	Basic knowledge of Earth Sciences, Mathematics, Physics

Teaching strategie	Lectures supported by PowerPoint presentations, classroom exercises with problem solving and data interpretation with computer support. Students will be encouraged to actively discuss any difficulties encountered in completing the exercises, both among themselves and with the lecturer, in order to identify possible causes of errors.

Expected learning outcomes in terms of	
DD1 Knowledge and understanding on:	• Knowledge and understanding of the following topics: main physical characteristics of Earth (elastic properties, density, magnetization, heat flow); methods to determine earthquake parameters (focus location, focal mechanism, magnitude, intensity); gravity and geomagnetic field characteristics and measurement methods; meaning of gravimetric and magnetic anomalies; theories on the geomagnetic field origin and evolution; heat propagation in the Earth's interior, hypotheses on the origin of geothermal flow. Knowledge will be acquired through lessons on theoretical aspects.
DD2 Applying knowledge and understanding on:	• Aware application of acquired knowledge to: Seismogram reading, calculation of seismic wave velocities in the Earth interior, calculation of earthquake parameters, calculation of gravimetric and magnetic anomalies and result interpretation, location of paleomagnetic poles, geothermal gradient calculation. These skills will be acquired through classroom exercises.
DD3-5 Soft skills	• DD3: Making informed judgments and choices in: selecting the optimal method of geophysical data acquisition and analysing and interpreting the resulting data. These skills will be developed during classroom exercises. • DD4: Communicating knowledge and understanding by: developing the aptitude to expose the fundamental principles and concepts of study themes, as well as the ability to describe techniques and procedures for acquiring, processing and interpreting data with clarity and proper language usage, both within working groups comprising different areas of expertise and to the general public. These skills will be practised through dialogue with teachers and classmates during lessons and exercises. • DD5: Capacities to continue learning by: developing the ability to establish connections between different course topics and the content of other courses, and integrating the knowledge acquired from lessons with additional sources of information (library, web). To this end, students will be asked to recall essential concepts from previous courses in order to master the new concepts presented in the current course. They will also be asked to consult textbooks and websites.

Syllabus	
Content knowledge	The course provides 5 CFU from frontal lessons and 1 CFU from exercises that are also carried out with computer support. The subject of the course can be subdivided into four main parts dealing with Seismology, Gravimetry, Geomagnetism and Geothermics, respectively.

	PART I: SEISMOLOGY 1. Fundamentals of elasticity theory and elastic waves Strain. Stress. Stress-strain relations in static conditions. Generalized Hooke's law. Elastic waves. Types of seismic waves. Propagation of seismic wave: attenuation; reflection and refraction; critical refraction. 2. Elements of seismometry 3. Travel time equations and Earth structure Layered flat Earth model. Spherical Earth model varying with depth. Earth's internal structure. Seismic tomography data. 4. Earthquake source parameters Earthquake focus localisation: generalities; graphic method of epicentral localisation; numerical methods for hypocentral localisation. Focal mechanism: generalities on seismic sources; focal mechanism parameters; fault plane solution. Measurement of earthquake energy: generalities on seismic sources; magnitude; macroseismic intensity. 5. Geographical distribution of earthquakes and Plate Tectonics **PART II: GRAVIMETRY** 6. General characteristics of the gravity field Reference systems. Definition of the gravity field. Measurement instruments. Gravity potential. Gravity equipotential surfaces and the shape of the Earth. 7. Density distribution inside the Earth on a global scale Moments of inertia: calculations based on the rates of precession of artificial satellite orbits and equinoxes. Adams-Williamson equation. 8. Earth tides Field of tidal accelerations. Tidal friction. 9. Gravity field measurements at local scale Calculation of observed gravity. Bouguer anomalies: calculation and interpretation. Isostasy **PART III: GEOMAGNETISM** 10. Generalities on magnetic interactions Physics of magnetism: magnetic dipoles and magnetisation; magnetic induction field; magnetic potential of a dipole. Magnetic properties of materials: diamagnetism; paramagnetism; ferromagnetism. 11. Current characteristics of the Earth's magnetic field Measuring instruments: vector and scalar magnetometers. Components of the Earth's magnetic field: direction and strength of the Earth's magnetic field; Earth's magnetic field potential and dipolar field; non-dipolar

	component of the core field and crustal field; IGRF and magnetic anomalies. 12. Long-term variations of the Earth's magnetic field Paleomagnetism: Virtual Geomagnetic Pole localisation; Geocentric Axial Dipole hypothesis and pole migration curves. Polarity reversals of the Earth's magnetic field. 13. Origin of the Earth's magnetic field **PART IV: GEOTHERMICS** 14. Generalities on heat propagation Conduction. Convection. 15. Heat flow and thermal state of the Earth's interior Geothermal flux. Origin of the geothermal flow. Temperatures in the Earth 's interior. **EXERCISES**: Velocity model calculation by means of the Herglotz-Wiechert inversion equation. Digital seismogram reading. Use of numerical methods for earthquake location. Calculation of focal mechanism. Gravity data processing. Localisation of paleomagnetic poles. Calculation of sea-floor spreading rate from a shipborne magnetic profile. Calculation of the effect of Sun's heat flow on geothermal gradient measurements.
Texts and readings	LOWRIE W.: Fundamentals of Geophysics. Cambridge University Press. Seconda Edizione, 2007. FOWLER C.M.R.: The solid Earth. Cambridge University Press. Seconda Edizione, 2005
Notes, additional materials	Textbook consultation is to be integrated with lesson notes and suggested websites' browsing.
Repository	Lecture notes, copy of PowerPoint presentation slides, copies of material for exercises (data tables, maps, digital seismograms, software, Wulff net for stereographic projection)

Assessment	
Assessment methods	The final assessment of the students will be based mainly on the results of an oral exam, during which the students must prove to know the fundamental concepts of the 4 main fields covered by the course (Seismology, Gravimetry, Geomagnetism and Geothermics) and to be able to correctly describe the methods of data acquisition, processing and interpretation. The students will be evaluated also taking into account the assiduity of the lesson attendance, the active participation to exercises and the effectiveness in facing the problems proposed. The accuracy of communication both in the discussion of the lesson topics and in the exercise activity, will also be an element of judgement.

Assessment criteria	• Knowledge and understanding The student must demonstrate his comprehension of the main concepts of Seismology, Gravimetry, Geomagnetism and Geothermics. The level of knowledge achieved and the mastery of the fundamental concepts will be verified through the discussion of the study topics during an oral exam. • Applying knowledge and understanding The student must be able to use the basic knowledge acquired to deal with problems on Seismology, Gravimetry, Geomagnetism and Geothermics, demonstrating to be able to follow the correct procedures in the acquisition, processing and interpretation of data. The skills acquired will be verified through practical tests performed during the exercises, also assessing the ability of interaction with the course colleagues. • Autonomy of judgment The student must be able to solve a geophysical problem relative to course topics, making the most suitable methodological choices for solving the problem. The achievement of this objective will be verified on the basis of the results of tests conducted during the exercises and through the proposition, during the oral examination, of problems, for which the student must prove to be able to identify the best procedures to deal with them. • Communication skills The student must be able to describe clearly and with language propriety all the topics covered during the course, without giving cause for ambiguity or misunderstandings. She/he must also be able to dialogue and relate to other students. The verification of these skills will be assessed on the basis of the language propriety shown explaining the subjects of the oral exam and discussing the cases proposed during the exercises. • Capacities to continue learning The student must be able to independently acquire further knowledge starting from the basis of the contents illustrated during the lessons, and making connections with the subjects of other courses. The level reached in this capacity will be verified through the discussion of the exam topics.

Final exam and grading criteria	During the exam, evidence of a lack of understanding of fundamental concepts may result in the exam being interrupted and the student being referred to a later session. Successfully completing the exercise tests is one of the elements that contributes to the student's overall assessment and final grade. If, by the end of the course, students have not demonstrated that they have acquired the necessary skills, this deficiency may result in them failing the exam and needing to retake it at a later date. The ability to propose appropriate methods for specific problems is a fundamental requirement for achieving a high final grade. Insufficient mastery of language skills will result in a lower final mark and exclude the possibility of obtaining the highest mark. Demonstrating an ability to broaden one's knowledge through independent learning may result in the award of honours.
Further information	