Bachelor in Physics
(Academic Year **2021-22**)

Physics of the Earth		**Code**	800512	**Year**	3rd	**Sem.**	2nd
Module	Applied Physics	**Topic**	Mandatory Applied Physics		**Character**	Optional	

	Total	**Theory**	**Exercises**	**Lab**
ECTS Credits	6	4.2	1.8	
Semester hours	43	30	8.5	4.5

Learning Objectives (according to the Degree's Verification Document)

- Apply the principles of Physics to the study of the Earth.
- Know the fundamental physical processes of the Earth and apply mathematical methods for their understanding and analysis.
- Know the basic techniques to study the physical properties, structure and dynamics of the Earth.
- Know the methods for resources exploration and evaluating and mitigating natural risks.
- Recognize the influence of the physical properties of the Earth in all physical observations and experiments (LHC, satellites, etc.)

Brief description of contents

Structure of the Earth; radioactivity, Earth's age and heat flow; gravity field; Earth magnetic field: internal field and external field; gravimetric and magnetic anomalies; Physics of earthquakes, seismic waves.

Prerequisites

Knowledge of Physics and Mathematics at the level of 2nd Grade in Physics

Coordinator	María Luisa Osete López		**Dept.**	FTA
	Office	115	**e-mail**	mlosete@ucm.es

Theory/Exercises – Schedule and Teaching Staff

Group	Lecture Room	Day	Time	Professor	Period/ Dates	Hours	Dept.
B	10	Tu Th	17:00-18:30 16:30-18:00	Fátima Martín Hernández	24/1-11/3	19,5	FTA
				Juan José Ledo	14/3-10/5	19	FTA

Laboratory – Schedule and Teaching Staff

Group	Lecture Room	Day	Time	Professor	Hours	Dept.
B	M2	1/3; 19/4; 3/5	17:00-18:30	Fátima Martín Hernández	4.5	FTA
	M2	1/3; 19/4; 3/5	17:00-18:30	Juan José Ledo	4.5	FTA

Office hours				
Group	**Professor**	**Schedule**	**E-mail**	**Location**
B	Fátima Martín Hernández	Friday 10:00-13:00	fatima@ucm.es	Room 103, 4th floor, east side
	Juan José Ledo	M y X: 13.00h-16.00h	jledo@ucm.es	Room 101, 4th floor, east side

Syllabus

1. INTRODUCTION. Physics of the Earth. Concepts and developments of Geophysics. Characteristics of Geophysics. Disciplines and fields of study. Coordinate systems

2. GRAVITY AND FIGURE OF THE EARTH. Size and shape of the Earth. Rotation of the Earth. Laplace's equation. Figure of the Earth. The Geoid and the Ellipsoid Normal gravity.

3. MEASURES AND ANOMALIES OF GRAVITY. Free-air anomaly. Bouguer anomaly. Isostasy. Interpretation of local and regional anomalies.

4. GEOMAGNETISM. Sources of the Earth's Magnetic Field. Components of the Earth's Magnetic Field. Harmonic analysis: separation of internal and external source of the Geomagnetic field.

5. INTERNAL MAGNETIC FIELD OF THE EARTH. Dipole field. Geomagnetic poles and Geomagnetic coordinates. Non-dipole field. International Geomagnetic Field of Reference. Temporal variation of the Internal Field.

6. PALEOMAGNETISM. Rock Magnetic Properties. Remanent magnetization. Geomagnetic Virtual Poles. Paleomagnetic Poles. Apparent Polar Wonder Path. Paleomagnetism and continental drift. Geomagnetic field reversals. Marine magnetic anomalies.

7. EXTERNAL MAGNETIC FIELD OF THE EARTH. Origin of the External Field. Source. Structure of the Magnetosphere. Ionosphere. Variations external field: diurnal variation, magnetic storms. Polar auroras.

8. GENERATION AND PROPAGATION OF SEISMIC WAVES. Mechanics of an elastic medium: elastic parameters of the Earth. Seismic waves: body waves and surface waves. Reflection and refraction of body waves. Trajectories and travel time.

9. INTERNAL STRUCTURE AND DYNAMICS OF THE EARTH. Earth's radial seismic waves velocity. Reference Earth Models. Physical and compositional stratification of the Earth. Density, gravity, and pressure within the Earth. Seismic tomography. Dynamic of plate tectonics.

10. EARTHQUAKES. Location and time of origin. Global seismicity plate tectonics. Size of an earthquake: intensity, magnitude, energy. Gutenberg-Richter Law.

11. AGE AND THERMAL STATE OF THE EARTH. Radiometric age determination. Temperature distribution inside the Earth. Heat sources. Heat flow. Heat transport.

Experiences (3 sessions taught by the two teachers of each group):

1. Gravimetry. Application of gravimetric corrections: treatment and representation of data.

2. Paleomagnetism. Operation of a paleomagnetism laboratory. Analysis archaeomagnetic data. Use of archaeomagnetism as a dating technique.

3. Geochronology. Radiometric dating. From isotopic ratios determine the age of a material.

Bibliography

Fundamental
• W. Lowrie and A. Fichtner (2020, 3ª edición). Fundamentals of Geophysics. Cambridge Univ.
• W. Lowrie (2011). A Student's Guide to Geophysical Equations. Cambridge Univ.
• C.M. Fowler (2005). The Solid Earth: An Introduction to Global Geophysics. Cambridge University Press.
• N. H. Sleep y K. Fujita (1997). Principles of Geophysics. Blackwell Science.
• E. Buforn, C. Pro y A. Udías. 2012, Solved problems in Geophysics. Cambridge University Press.
• Udías and J. Mezcua (1997). Fundamentos de Geofísica. Textos. Alianza Universidad
Complementary
• E. Buforn, C. Pro, A. Udías. (2010). Problemas resueltos de Geofísica. Pearson Education S. A

Online Resources

Campus virtual

'Lecture notes' from MIT Open Course:

Essentials of geophysics: http://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-201-essentials-of-geophysics-fall-2004/

PDF's of class notes will be upload.

Methodology

On-campus teaching 100% (Scenario 0)

The following training activities will be developed:

1. Theory lessons where the main concepts of matter will be explained, including real examples and applications.

2. Problems solving classes that will be combined with the theoretical lessons that complement each other appropriately.

3. Practices: three practices will be carried out.

As part of the continuous assessment, students must submit solved exercises individually.

Semi-online teaching (Scenario 1)

MODEL A

Students will be divided into subgroups whose size meets the maximum capacity allowed in the classroom, taking into account the established sanitary restrictions. Classes will be taught in the usual regime, but only one of the subgroups of students will attend in person. The rest of the students will follow the class remotely, rotating each subgroup in person on a weekly basis. To follow up remote classes, the Teams, Google Meet or similar tool will be used. The practical sessions will be face-to-face for all students.

Online teaching (Scenario 2)

Online classes of problems, questions, review of fundamental concepts and practices will be done with the tools available on the virtual campus. The theoretical and master classes will be available on the virtual campus through Videos, power-points with audio, etc.

Evaluation Criteria		
Exams	**Weight:**	70%
The exam will consist of a series of theoretical and practical questions (of a similar level to those solved in class). The grade obtained will be Nexam.		
Other Activities	**Weight:**	30%
During the course, the student will deliver individually the problems, activities, and reports of practices, as well as questions that the professor indicates to him on the dates that he determines, provided that on that date you have attended at least 70% of the classes (if the activity is face-to-face). Only those students who have attended at least 70% of the classes (if the teaching is face-to-face) would obtain a mark (NOtherAct) on these tasks.		
Final Mark		
The final grade will be the best of the options: CFinal = 0.7Nexam + 0.3NOtherAct, CFinal = Nexam Where NOtherAct is the qualification corresponding to Other Activities and Nexam the one obtained in the Final exam. The qualification of the extraordinary call of June-July will be obtained following exactly the same evaluation procedure.		