Physics for Geology

Code: 101041
ECTS Credits: 10

2024/2025

Degree	Type	Year
2500254 Geology	FB	1

PROVISIONAL

Contact

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

If the student has not taken physics after compulsory secondary education, it is highly recommended to take the introductory physics course offered by the faculty. In any case, it is very convenient for the student to review their previous knowledge on general physics. It is also recommended that the student review concepts of derivatives and integrals, basic operations with vectors, and trigonometry.

Objectives and Contextualisation

This subject should serve to achieve and consolidate basic knowledge on general physics that is necessary to address other subjects in the Geology Degree.

Objectives of the subject:

1. To know physical magnitudes, their units, and how they are measured.

2. To know and be able to mathematically describe basic physical phenomena.

3. To be able to apply physics concepts and formulas to simple problems and solve them.

4. To be able to apply physics concepts to geological contexts.

Competences

- Learn and apply the knowledge acquired, and use it to solve problems.
- Synthesise and analyse information critically.
- Use concepts from physics when solving problems in geology.
- Work independently.

Learning Outcomes

1. Describe the basic physical phenomena.
2. Identify key points in problems and design strategies to solve them.
3. Interpret mathematical results and critically compare them with experimentation and observation.
4. Learn and apply the knowledge acquired, and use it to solve problems.
5. Relate the basic physical phenomena to geological processes and the dynamics of the Earth.
6. Solve both defined and open problems.
7. Synthesise and analyse information critically.
8. Use mathematics to describe the physical world, constructing suitable models.
9. Work independently.

Content

The content has been divided into 10 thematic units and 6 seminars. At the end of each thematic unit (except the first one), the fields of geology related to the presented contents are indicated, along with examples of application.

<u>1. Mathematical Fundamentals. Introduction to Physical Quantities and Their Expression.</u>

Mathematical Fundamentals: Trigonometric relationships, scalar product, vector product, derivatives, and integrals.

Introduction to Physical Quantities and Their Expression: Coordinate systems. Scalar quantities and vector quantities. Units. International System of Units. Unit conversion. Scientific notation. Orders of magnitude. Significant figures.

<u>2. Kinematics, Dynamics, and Gravitation of Point Systems.</u>

Kinematics: Displacement, average velocity, and instantaneous velocity. Uniform rectilinear motion. Acceleration. Uniformly accelerated rectilinear motion (motion with constant acceleration). Two-dimensional kinematics: Projectile motion. Three-dimensional kinematics. Circular motion.

Dynamics: Forces in nature. Linear momentum. Newton's laws (1st law of Newton: Law of inertia, 2nd law of Newton, and 3rd law of Newton: Action and reaction law). Frictional forces. Rotational dynamics. Torque. Angular momentum.

Gravitation: Planetary motion. Kepler's laws. Newton's law of gravitation. Earth's gravity.

Fields of geology where the learned concepts are applied: Geological engineering, internal geodynamics, geophysics, geodesy.

Examples of application: Rockfalls, slope stability, landslides.

<u>3. Work and Energy of Point Systems.</u>

Mechanical work done by a force. Kinetic energy. Potential energy. Conservative forces. Conservation of mechanical energy and applications. Non-conservative forces. Power.

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Fields of geology where the learned concepts are applied: Geological engineering, internal geodynamics, geophysics.

Examples of application: Rockfalls, mineral extraction, subsurface exploitation: natural reservoirs of water, gas, or oil.

4. Particle Systems and Rigid Solid: Kinematics, Dynamics, Work, and Energy. Mechanical Properties of Solids.

Particle systems: Center of mass. Motion of the center of mass of a system. Conservation of linear momentum. Kinetic energy of the particle system. Collisions in two dimensions.

Rigid solid: Kinematics and dynamics. Torque. Moment of inertia. Rolling motion. Kinetic energy of a rigid solid. Conservation of linear and angular momentum.

Mechanical properties of solids: Mechanical stress (tension) and mechanical deformation. Tensile stresses (Young's modulus). Shear stresses (shear modulus).

Fields of geology where the learned concepts are applied: Isostasy (compensation of Earth's relief), rheology.

Examples of application: Mountain formation, fractures, faults, brittle and ductile deformation, diapirism.

5. Statics and Dynamics of Fluids.

Fluid statics: Hydrostatics. Fluid. Density. Pressure. Hydrostatic pressure. Hydrostatic paradox. Pascal's principle. Buoyant force and Archimedes' principle.

Fluid dynamics: Hydrodynamics. Flow rate. Continuity equation. Bernoulli's equation. Venturi effect. Viscosity. Turbulence.

Fields of geology wherethe learned concepts are applied: External geodynamics (hydrogeology, glaciology, etc.), internal geodynamics.

Examples of application: Glacier movement, lava flow, aquifers, landslides, soil liquefaction, turbidity currents, permeability in natural water, gas, or oil reservoirs, rivers, lakes.

6. Thermodynamics: Temperature and Heat.

Temperature: Celsius and Fahrenheit temperature scales. Absolute temperature scale. Thermometers. Thermal expansion. Ideal gas law. Kinetic theory of gases (molecular interpretation of temperature).

Heat: Heat capacity and specific heat. Phase change and latent heat. Heat transfer. Sign convention.

Principles of thermodynamics: First law. Internal energy of ideal gases. Thermodynamic work. Pressure-volume diagram for an ideal gas: isobaric compression, isothermal compression, and adiabatic compression. Sign convention. Second law of thermodynamics.

Fields of geology where the learned concepts are applied: Petrology, internal geodynamics.

Examples of application: Rock cooling, magma chambers, convective movements in the mantle, geothermal energy.

7. Oscillations and Waves.

Oscillations: Simple harmonic motion (period and frequency): mass attached to a spring. Relationship between simple harmonic motion and circular motion. Energy of simple harmonic motion. Simple pendulum. Damped oscillations. Forced oscillations and resonance phenomenon.

Waves: Wave motion and propagation. Types of waves. Huygens' principle. Harmonic waves. Energy, power, and intensity of harmonic waves. Superposition and interference of harmonic waves. Standing waves.

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Properties of waves: transmission, reflection, refraction, absorption, dispersion, and diffraction (Young's double-slit experiment). Doppler effect. Sound and sound intensity. Nature of light. Seismic waves. Seismic prospecting.

Fields of geology where the learned concepts are applied: Seismology, seismic prospecting, crystallography, geophysics, internal geodynamics.

Examples of application: Structural characterization and phase identification through X-ray diffraction, computed tomography in the study of fossils embedded in the matrix.

8. Electric Field and Electric Current.

Electric field: Electric charge. Conductors and insulators. Coulomb's law. Electric field. Electric field lines. Action of the electric field on charges. Electric dipole. Electric flux. Gauss's law. Potential difference. Lightning and thunder. Capacitance. Capacitors. Electric energy storage.

Electric current: Movement of charges. Current density. Resistance and Ohm's law. Dissipated power: Joule effect. Batteries. Circuits. Association of resistors in series and parallel. Equivalent resistances. Kirchhoff's rules.

Fields of geology where the learned concepts are applied: Geophysical prospecting.

Examples of application: Morphological and structural analysis of the Earth's crust and mantle through resistivity/conductivity measurements.

9. Magnetic Field.

Magnetic field: Force exerted by a magnetic field on a moving charge. Magnetic field created by moving point charges. Magnetic field created by electric currents. Magnetic field created by a current loop. Magnetic field due to a current in a solenoid. Magnetic dipole moment. Magnetic flux and electromagnetic induction.

Magnetism in matter: Origin of magnetism. Magnetic moment and magnetization. Diamagnetism. Paramagnetism. Ferromagnetism. Ferrimagnetism. Antiferromagnetism. Measurement of magnetic properties through vibrating sample magnetometry. Earth's magnetism.

Fields of geology where the learned concepts are applied: Paleomagnetism, geophysical prospecting (geomagnetism).

Examples of application: Morphological and structural analysis of the Earth's crust and mantle through local variations in the magnetic field, prospecting of metallic minerals, magnetic resonance for the study of fossils embedded in the matrix.

10. Structure of Matter and Radioactivity.

Structure of matter: Atoms (elements of the periodic table). Early atomic models. Evolution of atomic models to the present day. Origin of elements. Isotopes. Electromagnetic spectrum and radiation-matter interaction. X-ray diffraction. Nuclear structure.

Radioactivity: Nuclear stability. Radioactive decay. Activity. Half-life. Concentration. Decay chains. Evolution of activity. Geochronology and geological dating.

Fields of geology where the learned concepts are applied: Geochemistry, geochronology.

Examples of application: Geological dating, structural characterization through X-ray diffraction, X-rays for computed tomography, morphological characterization through X-ray fluorescence, use of stable and radioactive isotopes to identify processes: groundwater flows, sedimentation, erosion, etc.

At the end of the theory classes of a given thematic unit, examples of application to geology of the studied contents will be discussed. The list of problems will contain representative problems from each chapter, and a significant portion of these will be contextualized within thefield of geology. Additionally, 6 practical seminars will be conducted to directly apply the physics concepts learned to geological contexts.

PROVISIONAL

Seminar 1: Application of Kinematics

Study of the fall/release of a rock block.

Seminar 2: Application of Dynamics

Study of the stability of a rock slope.

Seminar 3: Application of Gravimetry

Local gravity study to obtain information on the distribution of masses in depth. Geodesy. Isostasy.

Seminar 4: Application of Solid Mechanics and Waves: Earthquakes. Hydrodynamics of viscous fluids.

Influence of the mechanical properties of the solid medium on the propagation of seismic waves. Earthquakes. Material fractures.

Movement of viscous fluids. Glacial movement. Lava flow. Underground and surface water flow.

Seminar 5: Application of Heat Conduction

Propagation Heat propagation in rocks.

Seminar 6: Application of Electricity, Magnetism, and Electromagnetic Induction Law

Study of depth magnetic anomaly and its application to subsurface geophysical prospecting.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Class of problems	28	1.12	2, 3, 6, 7, 8
Seminars	8	0.32	5, 6
Theory classes	56	2.24	1, 3, 5, 8
Type: Supervised			
Delivery of resolved problems	23	0.92	2, 3, 5, 6, 7, 9
Type: Autonomous			
Individual student work	125	5	1, 3, 4, 5, 9

There will be three types of learning activities:

1) Directed learning activities

a) Theory classes: Approximately two hours per week will be dedicated to theory classes, where the content will be presented on the blackboard (supported by PPT presentations) and students' questions will be addressed. PPT presentations will be available on the virtual campus at least two weeks in advance. Small experiments, either real or virtual, will also be conducted to deepen in the understanding of the concepts. Some of these hours will be taught by a professor from the Department of Geology in seminar format, presenting applications of physics to geology.

b) Problem-solving classes: Students will spend approximately one hour per week solving problems. The lists of problems will be available on the virtual campus at least two weeks in advance. In class, participation of students in the resolution of the problems will be encouraged.

Attendance at these classes is mandatory. However, repeating students have the option to only take the final exam. Any other circumstances preventing normal class attendance should be communicated to the coordinator as soon as possible.

2) Supervised learning activities: Time will be allocated in both theory and problem-solving classes for students to solve questions and problems under the supervision of the teaching staff. Outside of class hours, and upon prior request from students, time will be allocated for individual or group tutorials.

3) Autonomous learning activities: Students should be aware of the need for individual study of the proposed material. The PPTs presentations of theory and the lists of problems will be available on the virtual campus weeks in advance.

Note: 15 minutes of a class, within the established schedule, will be reserved for students to complete surveys evaluating teaching staff performance and course evaluation.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Individual written tests	0,7	6	0.24	1, 3, 5, 6, 8
Reports of resolved problems and supervised activities	0,3	4	0.16	2, 4, 6, 7, 9

The learning activities will be evaluated continuously. There will be two types of assessment activities: A) individual written tests, and B) monitoring of the student's portfolio.

A) Four individual written tests (also called partial exams) will represent 70% of the final grade. These written tests will include both theoretical aspects and the resolution of exercises and problems done during the evaluation period. Attendance to the tests is mandatory.

B) Monitoring of the student's portfolio. The remaining 30% of the grade will include reports of activities carried out in seminars (20%) and the results of continuous assessment tests that will be conducted throughout the year (10%). All these tasks are mandatory.

To pass the course, it is mandatory to have grades for all assessable activities. The combined result of parts A) and B) will be the final course grade.

In case a student has attended all assessment activities but has not passed the course, they may take the final exam (a test of the entire course), which will replace the grade from part A). The grade from part B) will remain. Students who have already passed the course may take this final exam to improve their grade.

PROVISIONAL

IMPORTANT: Students who have failed with a final grade below 3 cannot take the final exam and will have the course failed.

In the case of a second or subsequent enrollment, it is necessary for the student to follow the continuous assessment under the same conditions as first-time enrollees.

A student who has participated in any assessment activity of the course cannot be recorded as "absent."

In this course, there is no option for single assessment.

In this subject, there is no single assessment option.

Bibliography

1) Volum 1: Paul A. Tipler & Gene Mosca. "Física para la ciencia y la tecnología. Volumen 1: Mecánica, oscilaciones y ondas, termodinámica." Editorial Reverté, sisena edició, 2012.

2) Volum 2: Paul A. Tipler & Gene Mosca. "Física para la ciencia y la tecnología. Volumen 2: Electricidad y magnetismo, luz y óptica." Editorial Reverté, sisena edició, 2012.

3) "Fundamentals of Physics", David Halliday, Robert Resnick & Jearl Walker. Wiley, 10^{th} edition, 2013.

4) "Physics for Geologists", Richard E. Chapman, Routledge, 10^{th} edition, 2002.

5) "Física", Juan Enciso Pizarro, Schaum/McGraw-Hill Interamericana de España S.L., 2a edició, 2005.

Software

No specific program is required.

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	1	Catalan	annual	morning-mixed
(SEM) Seminars	1	Catalan	annual	morning-mixed
(SEM) Seminars	2	Catalan	annual	morning-mixed
(TE) Theory	1	Catalan	annual	morning-mixed

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