UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Scienze della Terra e del Mare
ACADEMIC YEAR	2023/2024
MASTER'S DEGREE (MSC)	GEORISKS AND GEORESOURCES
SUBJECT	APPLIED GEOPHYSICS
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50567-Discipline geofisiche
CODE	03598
SCIENTIFIC SECTOR(S)	GEO/11
HEAD PROFESSOR(S)	MARTORANA RAFFAELE Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	94
COURSE ACTIVITY (Hrs)	56
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**MARTORANA RAFFAELE** Wednesday 14:30 16:30 Via Archirafi 20, 3° piano

DOCENTE: Prof. RAFFAELE MARTORANA

PREREQUISITES	Knowledge and mastery of the main topics of Mathematics, General Physics, Geology and Geophysics.
LEARNING OUTCOMES	KNOWLEDGE AND UNDERSTANDING: - basic knowledge, of a theoretical, experimental and practical nature, fundamental in the geophysical disciplines; - sufficient familiarity with the scientific method of investigation; - ability to use mathematical and experimental tools for the analysis of geological processes from a physical point of view; ABILITY TO APPLY KNOWLEDGE AND UNDERSTANDING: - ability to use mathematical and experimental tools for the analysis of geological processes from a physical point of view; MAKING JUDGMENTS: Students will acquire adequate skills for the application of geophysical methods in various fields of Earth Sciences applied to the Territory; COMMUNICATION SKILLS: Students will acquire the ability to work in groups and to integrate promptly in the workplace. LEARNING SKILLS: The knowledge acquired and the learning ability developed will be useful for tackling higher level courses (Master's). The training acquired will also allow you to increase your knowledge with independent updates. The expected learning outcomes are developed throughout the training course through lectures and laboratory.
ASSESSMENT METHODS	The student's assessment includes an oral test in which questions on course topics are proposed, with particular attention to the integrated vision of the physical phenomena exploited by geophysical methods and inversion techniques. The ability to plan a geophysical survey will be evaluated, consisting in the choice of the method, the techniques of acquisition and data processing aimed at a specific geological problem. The student must demonstrate that he has acquired the knowledge of the fundamental geophysical survey methods and measurement techniques applied to the environment (geology, hydrogeology, geomorphology), cultural heritage and engineering. Particular attention will be given to seismic, electrical and GPR methods. The score of the exam is attributed by means of a vote expressed out of thirty. The active participation of the students in the lessons, exercises and work carried out individually in the form of exercises and reports assigned during the course may weigh for a maximum of 15/30 on the final evaluation. To pass the exam, thus obtaining a mark of at least 18/30, the student must demonstrate an elementary achievement of the objectives. The objectives achieved are considered elementary when the examinee demonstrates having acquired a basic knowledge of the topics described in the program, is able to make minimal connections between them, demonstrates having acquired a limited independence of judgment; her language is enough to communicate with the examiners. To achieve a score of 30/30 cum laude, the student must instead demonstrate that he has achieved the set objectives excellently. The objectives achieved are considered excellent when the examinee has acquired full knowledge of the topics of the program, demonstrates the ability to apply the acquired knowledge also in different / new / advanced contexts compared to those of the teaching, expresses himself with lexical competence also in the context of the specific reference language and is able to elaborate and express independent judgments based on the acquired knowledge.
EDUCATIONAL OBJECTIVES	The aim of the course is to provide solid basic knowledge of physics and mathematics applied to geophysical problems, both theoretical and experimental. The student must have acquired the following skills: 1) know how to make connections between the different geophysical methodologies, 2) recognize or establish relationships between different physical parameters of the subsoil, 3) classify geophysical methods based on the physical fields exploited, the physical parameters of the rocks investigated, the use of active or passive sources. 4) formulate hypotheses based on data obtained from geophysical surveys, 5) draw conclusions based on the results obtained and the hypotheses tested, 6) identify the most suitable geophysical methods to solve specific geological problems, applying the acquired knowledge to real situations.
TEACHING METHODS	Lectures, Acquisition of geophysical measurements in the field, compatibly with the resources of the course of study. Data processing laboratory, aimed at correct inversion and interpretation of geophysical surveys.
SUGGESTED BIBLIOGRAPHY	Mussett A.E., Khan M.A. (2003): Esplorazione del sottosuolo. Una introduzione alla geofisica applicata. Zanichelli, 421 pp.

	Santarato et al. (2015): Lezioni di Geofisica Applicata.Edizioni libreriauniversitaria.it Dal Moro G. 2012. Onde di superficie in geofisica applicata. Acquisizione e analisi di dati secondo tecniche MASW e HVSR. Flaccovio Ed. Leucci G. (2015): Geofisica applicata all'archeologia e ai beni culturali. Flaccovio Ed. Loke M. H. (2001): Tutorial : 2-D and 3-D electrical imaging surveys. Dr. M.H.Loke. 129 pp. Daniels D. J. (1986): Surface-penetrating Radar. The Institution of Electrical Engineers, London, 300 pp. Software open source utilizzato in laboratorio con manuali.

SYLLABUS

Hrs	Frontal teaching
4	FORWARD AND INVERSE PROBLEMS IN GEOPHYSICS Geophysical modeling and dimension. Notes on the finite difference and finite element methods. Inverse problem: steps that regulate an inversion algorithm. Discretization of the investigated volume. Methods of 2D and 3D inversion with the Gauss-Newton least squares algorithm. Jacobian.
2	SEISMIC METHODS: INTRODUCTION Propagation of the elastic waves. Velocity of different wave phases. Relationship between wave velocities and elastic parameters of rocks. Seismograms and seismic sections. Paths of the seismic phases for layered models: direct waves, reflected waves and critically refracted waves.
3	PALMER METHOD (GRM) Data acquisition, picking, travel-time graphs. delay times. time-velocity and time-depth functions. Optimal shif
5	SEISMIC REFRACTION TOMOGRAPHY forward problem, beginning model, slowness, gridding, raytracing and inversion. Application cases.
2	IN-HOLE SEISMIC In-hole geophones. Down-hole seismic. Acquisition and data processing. Evaluation of vertical profiles of Vp, Vs and Poisson ratio. Cross-hole and Up-hole seismic. In-hole seismic tomography.
4	SURFACE WAVES METHODS Surface waves, Rayleigh and Love waves. Dispersion of surface waves. Multichannel Analysis of Surface Waves (MASW) technique: acquisition, f-k spectrum, velocity spectrum, dispersion curves and inversion. Refraction Microtremor (REMI) technique.
4	Environmental seismic noise. The soil transfer function. The HVSR method. The SESAME protocol. Micro-tremor data processing. Peak frequencies and amplification of horizontal seismic motion.
2	VERTICAL ELECTRICAL SOUNDING (VES). Choice of acquiring parameters, apparent resistivity curves, inversion of data and interpretation.
4	ELECTRICAL RESISTIVITY TOMOGRAPHY Resistivity-meters and accessories. Main electrode arrays and geometrical factors. Pseudosections and electrical resistivity tomography. Techniques of 2D and 3D data acquiring; the roll-along technique. Forward problem: finite difference and finite element methods. Inverse problem: Least squares methods, Gauss-Newton equation, Jacobian. Applications to hydrological, archaeological and engineering problems.
2	INDUCED POLARIZATION Electrode and membrane polarization. Time Domain I.P. measures. Chargeability. Frequency Domain IP measures. Induced Polarization Tomography (IPT).
3	ELECTROMAGNETIC METHODS Main properties of electromagnetic waves. The Ground Penetrating Radar (GPR). Instrumentation and principles of operation. Data acquisition, processing and interpretation. Transmitting and receiving antennas. Different antennas by frequencies. GPR tomography: time-slices and depth-slices. Application examples.
3	Time Domain electromagnetic methods (TDEM). Equation of induced electromagnetic potential.0 Voltage decay curve (early, intermediate and late stage). Apparent resistivity curve. TDEM data inversion techniques and interpretation. Instrumentation and application examples. Frequency Domain Electromagnetic Methods (FDEM, Slingram). Anomalies generated by a Slingram survey. Application examples. Instrumentation.
2	GEOPHYSICAL LOGS Seismic, electric, radioactive, electromagnetic logs, Instrumentation. Interpretation

Hrs	Workshops
4	Execution or simulation of a refraction seismic tomography. Data processing, inversion and interpretation of results.
4	Execution or simulation of MASW surveys. Data elaboration and interpretation.

Hrs	Workshops
4	Registration of environmental seismic noise. HVSR method interpretation.
4	Execution or simulation of electrical resistivity tomography and induced polarization tomography. Data processing, inversion and interpretation of results.