UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Fisica e Chimica - Emilio Segrè
ACADEMIC YEAR	2023/2024
MASTER'S DEGREE (MSC)	PHYSICS
SUBJECT	LAB OF PHYSICAL CHARACTERIZATION AND BIOSIGNAL PROCESSING
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	20901-Attività formative affini o integrative
CODE	22659
SCIENTIFIC SECTOR(S)	FIS/07
HEAD PROFESSOR(S)	PERSANO ADORNO DOMINIQUE — Professore Associato — Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	82
COURSE ACTIVITY (Hrs)	68
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**PERSANO ADORNO DOMINIQUE** Monday 12:00 14:00 Stanza 112 (primo piano) Dipartimento di Fisica e Chimica Viale delle Scienze, Ed. 18

DOCENTE: Prof.ssa DOMINIQUE PERSANO ADORNO

PREREQUISITES	Knowledge of the fundamental concepts of Physics, Geometry and Calculus. Basic knowledge of vector and matrix calculus, probability and statistics, data processing and visualization. Basic knowledge of high-level programming.
LEARNING OUTCOMES	Knowledge and understanding At the end of the course, the student will have mastered the techniques of representation and statistical analysis of signals of any type, particularly biomedical signals with a physiological derivation. The student will have learned how to build a statistical physical model for the description of random processes and how to extract quantitative indices that characterize the the complexity of a signal and the coupling between different signals. A large part of laboratory exercises will allow the student to understand the techniques of data and signal processing and fully apply them to biomedical signal databases. Ability to apply knowledge and understanding The student will have acquired the ability to apply the knowledge acquired during the course to identify the oscillatory content of the main biomedical signals and to model the dynamics of internal regulation of a physiological system and the interactions between distinct physiological systems. At the end of the course, the student will also be able to extract, starting from series temporal, quantitative indices useful, in the medical context, for the construction of a classifier of pathologies. Making judgments The student will be able to establish whether a "dynamic" approach or, otherwise, an "energetic" approach should be used in a given problem. At the end of the course the student will be able to identify the most appropriate analysis technique for the signal under examination (FFT, Wavelets, EMD, etc.). Furthermore, the student will be able to identify the most useful characteristics for the construction of a classifier, optimizing the analysis technique. Communication skills The student will acquire the ability to communicate and express problems concerning the subject of the course. He will be able to hold conversations on topics related to physical modeling, statistical representation of data and processing of signals, highlighting limitations, identifying criticalities and offering alternative solutions. Learning skills The student will have acquired and refined the skills to consult scientific books and journals. This will allow him to better understand the topics covered during the course. In particular, the set of knowledge gained during the course will equip the student with the essential tools for the physical-statistical analysis of signals in contexts also different from the purely biomedical one. This will allow the student to continue their studies with greater intellectual independence and increased ability to make assessments and make decisions.
ASSESSMENT METHODS	Oral examination. The evaluation is expressed in thirtieths. The oral test consists of an interview, in order to check student skills and disciplinary knowledge provided by the course. The candidate must answer at least three / four oral questions/problems on all parties covered by the program. Oral examinations aim to assess whether the student holds mastery and understanding of the topics, has acquired interpretative competence and independence of judgment in real cases. The sufficiency will be reached if the student knows and understands the topics, at least in general terms, and holds minimal skills of problem solving. Below this threshold, the examination will result insufficient. Evaluation methods: Excellent: 30-30 cum laude: the student shows a good knowledge of the topics, excellent properties of language, good analytical skills, and his/her ability to apply knowledge to solve the proposed problems. Very good: 26-29: the student owns good mastery of the subjects, language skills, and is able to apply knowledge to solve the proposed problems. Good: 24-25: the student shows good knowledge of the main topics, good language skills, but limited ability to independently apply knowledge to solve the proposed problems. Satisfactory: 21-23: the student possess basic mastery of the main topics of the course and owns satisfactory language skills. The student is not able to independently apply knowledge to solve the proposed problems.

	Sufficient: 18-20: the student owns basic knowledge of the main topics and minimum language skills, but very little ability to independently apply the knowledge gained. Insufficient: the student does not have an acceptable knowledge of the topics of the course.
EDUCATIONAL OBJECTIVES	The aim of the course is to provide students of the Master's Degree in Physics, particularly interested in Applied Physics, with the knowledge relating to the multiple techniques of multivariate statistical analysis and numerical processing of signals, with particular reference to signals biomedical and physiological time series. The course, starting from basic knowledge of probability and statistics acquired by students in the Bachelor's Degree in Physics, offers an overview of signal processing techniques both in the domain of time and frequency. The comparison between the physical aspect of the problem and the statistical description obtained will allow the student to have a complete understanding of the phenomenon considered.
TEACHING METHODS	Lectures, classroom exercises, laboratory experiments.
SUGGESTED BIBLIOGRAPHY	G. Gelli, F. Verde - Segnali e sistemi. Fondamenti di analisi ed elaborazione dei segnali analogici e digitali, editore Liguori (1 gennaio 2014) Dispense, slides e materiale didattico fornito dal docente. Testi consigliati per consultazione e approfondimento: - Fondamenti di segnali per ingegneria biomedica, McGraw-Hill Education, 2017 - Semmlow J. - Biosignal and Biomedical Image Processing (2004, CRC Press) - H. Pishro-Nik, "Introduction to probability, statistics, and random processes", available at https://www.probabilitycourse.com, Kappa Research LLC, 2014.

SYLLABUS

Hrs	Frontal teaching
8	Elements of signal theory, concept of filter, Fourier analysis. Descriptive statistics (exploratory data analysis, indices, histograms), probability, inferential statistics (confidence interval; optimal sample size; hypothesis testing; parametric and non-parametric tests).
8	Random processes: definition and properties. Statistical models. Introduction to random phenomena as a general tool for describing biomedical signals. Characterization of biosignals in the time domain. Periodicity, stationarity, ergodicity. Signal to noise ratio. Acquisition, sampling, conversion. Correlation and cross-correlation function. Entropy of Shannon.
8	Description of physiological systems and time series related to the most common biosignals in the medical field. Concept of spatial resolution, contrast, noise, artifacts; averaging procedure. Biosignal processing techniques: predictive models, spectral analysis, multivariate analysis.

Hrs	Practice
12	Time series processing: Fourier transform, DFT, FFT. Energy spectrum, power spectrum. Wavelets. Empirical mode decomposition (EMD), Principal Component Analysis (PCA). Extraction of features, classificatory, neural networks. Practical implementation of the studied analysis and modeling methods and their application to biomedical signal databases (e.g. ECG, EMG, EEG, ERG, polysomnography signals, spirometry signals, etc.).

Hrs	Workshops
16	Introduction to the Functional Near-Infrared Spectroscopy (fNIRS) technique for the study of the response of the cerebral cortex (neuro signals). Choice of the experimental paradigm. Carrying out the measurements. Time series filtering, modeling and processing using the Homer2 interface and the MATLAB Signal Processing Toolbox. Feature extraction.
16	Creation of a "smart mask", with sensors for controlling the main physiological parameters: temperature, heart rate, respiration rate, blood oxygenation, etc. for their real-time monitoring. Operation of a PPG sensor. Carrying out the measurements. Time series filtering, modeling and processing using the MATLAB Signal Processing Toolbox.