UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2021/2022
BACHELOR'S DEGREE (BSC)	ELECTRONICS ENGINEERING
SUBJECT	BIOMEDICAL DATA AND SIGNAL PROCESSING
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50286-Ingegneria biomedica
CODE	21979
SCIENTIFIC SECTOR(S)	ING-INF/06
HEAD PROFESSOR(S)	PERNICE RICCARDO — Ricercatore a tempo determinato — Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	BIOMEDICAL DATA AND SIGNAL PROCESSING - Corso: INGEGNERIA BIOMEDICA BIOMEDICAL DATA AND SIGNAL PROCESSING - Corso: BIOMEDICAL ENGINEERING
YEAR	3
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**PERNICE RICCARDO** Wednesday 08:00 10:00 Stanza 3001, terzo piano Ed. 9, oppure su Microsoft Teams, in entrambi i casi previa prenotazione tramite Portale Studenti Thursday 15:00 16:00 Stanza 3001, terzo piano Ed. 9, oppure su Microsoft Teams, in entrambi i casi previa prenotazione tramite Portale Studenti

DOCENTE: Prof. RICCARDO PERNICE

PREREQUISITES	Notions of Mathematics and Physics II. Basic knowledge of differential and integral calculus. Good knowledge of vector calculus and phasors.
LEARNING OUTCOMES	Knowledge and comprehension capacity: The student will acquire in-depth knowledge of deterministic signal representation and of the corresponding frequency analysis, of the impulse response, of the transfer function of discrete time linear systems, of the design of numerical filters, of the statistical and spectral analysis of random processes. Moreover, the student will acquire basic knowledge of statistical data analysis, in particular regarding descriptive inferential statistics, statistical hypothesis testing and decision theory. The topics of the course will be focused on biomedical data and signal representation. The course will include a substantial amount of laboratory activities employing the MATLAB environment for numerical computing, which will allow the student to fully understand data and signal analysis techniques, to evaluate their peculiarities through numerical exercises, and to exploit their potentialities to extract physiological, biological and clinical information starting from biomedical data and signals. Ability to apply the acquired knowledge: The student will be able to apply the acquired knowledge for the analysis and synthesis of simple continuous- or discrete-time signal processing systems, and will be able to represent a biomedical signal in both time and frequency domains, extracting descriptive indexes of physiological and medical interest. The student will be also able to design numerical filters to perform signal conditioning, to improve the signal-to-noise ratio or to emphasize the oscillations of interest in a biomedical signal. Finally, the student will be able to apply the basic statistical tools to characterize biomedical data and physiological signals, and also to execute the main statistical significance tests to assess physiological alterations and to aid clinical decision. The laboratory activities will stimulate the student's skills to apply the acquired knowledge in the biomedical field, and will favor self-comprehension about the analytical tools studied in the theoretical part of the course. Ability to evaluate scenarios: The student will be able to identify the operational limits of the data information processing techniques studied during the course, and thus to assess their soundness. The student will be also able to estimate, both quantitatively and qualitatively, the performance of processing algorithms and of biomedical software, in order to devise the most suitable strategies and solutions in the application field taken into account. This objective will be verified by the written test. Communication skills: The student will be able to: communicate and express in group projects problems related to the topics covered during the course. The student will be able to sustain conversation on topics related to bioinformatics, he will be able to underline problems related to software operating limits and to offer solutions. Finally, the student will be able to sustain conversation on topics related to biomedical data and signal processing and to computer and IT tools employed in such field. This objective will be verified by the oral examination. Learning ability: The student will have learned the techniques to employ to process biomedical signals acquired by sensors, and will be able to provide a suitable representation of such signals in time and frequency domains, as well as to extract parameters of clinical and physiological interest. The student will also be able to represent and interpret, from a statistical point of view, biomedical signals of different typologies in the most common applications. This will allow the student to continue the engineering studies in the field of Biomedical Engineering with a greater autonomy and discernment. This objective will be verified by the written and the oral test.
ASSESSMENT METHODS	Written final exam, Oral examination The learning evaluation will be carried out by means of a final written examination, and an oral examination. The minimum score needed to pass both the written and the oral test will be 18 out of 30. The final written test will be composed of open questions and exercises on topics covered during the course by the teacher. For each question and exercise, the level of knowledge of the topics will be evaluated (90% of the final grade) and also the level in the capacity of expressing correctly in the technical language of the subject (10% of the final grade). The final oral examination consists in the request to the student to discuss some topics covered during the course by the teacher. For each topic, the student will

	first have to contextualize the subject within the course, describe its meaning and importance, for example by means of formal definitions and scope of applications, and define the study methods and eventually the validity limits. Finally, the student will have to discuss the topic by a correct use of language and a fluent analytical treatment. The aim of the final examination will be to evaluate whether the student has a good knowledge and comprehension of the most common statistical analysis techniques of data samples, of numerical signal processing and their employment in biomedical field. At the end of the oral examination, the examination committee will inform the student whether he/she has passed the exam. If the examination has been passed, the committee gives the final result to the student based on the following evaluation criteria: a) level of knowledge of the topics discussed during the oral examination, and the capacity of autonomously interconnecting such topics to other covered during the course (90% of the final grade); b) obtained level in the capacity of expressing correctly in the technical language of the subject (10% of the final grade).
EDUCATIONAL OBJECTIVES	The course aims to provide future engineers with the knowledge and the key enabling technologies to enter the Biomedical Engineer profession, with regard to numerical processing of data acquired from biomedical equipment and measurement systems. This course delivers knowledge with regard to: representation of time series obtained sampling continuous signals, and their spectral analysis; design and implementation of numerical filters for discrete time signal processing; statistical description of signals using the concept of stochastic process and its corresponding frequency-domain description using spectral analysis based on classic techniques based on Fourier transform and novel methods based on parametric models; data representation through statistical estimators, and utilization of the most common approaches for statistical hypothesis testing. The main objective of the course is to allow the student to exploit the acquired knowledge by developing and using algorithms within the MATLAB environment. At the end of the course, the student will be able to describe a signal in the time and frequency domains employing both deterministic and statistical approaches, to design a numerical filter and employ it for signal processing, and to extract parameters of interest from the different signal representations. Thanks to the acquired software skills, the student will be able to deal with the most common biomedical signals and to extract physiological information of medical interest from such signals.
TEACHING METHODS	Frontal lectures and tutorials; Laboratory tutorials
SUGGESTED BIBLIOGRAPHY	- Luigi Landini: Fondamenti di analisi di segnali biomedici. Pisa University Press, 2013 - Suresh R. Devasahayam: Signals and systems in biomedical engineering – Signal processing and physiological systems modeling. Springer, 2nd edition, 2013 - Rangaraj M. Rangayyan: Biomedical signal analysis – a case-study approach. IEEE Press Series on Biomedical Engineering – John Wiley & Sons, 2002

SYLLABUS

Hrs	Frontal teaching
3	Introduction to biomedical signals: definition, classification and examples.
2	Continuous and discrete time signals: features and representation. Energy and power of a signal.
6	Spectral signal analysis: Fourier series, discrete and continuous Fourier transform (FT, DFT, DTFT, FFT). Analog-to-digital conversion and sampling theorem.
4	Numerical processing of biomedical signals: convolution, z transform, transfer function
5	Digital filters: definitions, specifications, design methods. FIR and IIR filters.
6	Statistical analysis of biomedical data: probability, random variables, statistical independence; characteristics of a diagnostic test, contingency tables and ROC curves.
5	Statistical estimation: mean, variance, correlation, confidence intervals. Statistical tests and hypothesis testing
2	Time series analysis. Heart Rate Variability: introduction and measurements in time and frequency domain.

Hrs	Practice
3	Introduction to MATLAB. Graphical User Interface and workspace. Arrays and matrices. Operations with arrays. Files and scripts..
2	Exercises on FFT and convolution.
2	Visualization of zeros and poles of a transfer function.
4	Design of filters and application to biomedical signals (electrocardiogram, photoplethysmogram).
2	Exercises on probability calculation and characteristics of a diagnostic test.
4	Statistical analysis of biomedical data: statistical estimation and tests – application to physiological and clinical data.

Hrs	Workshops
4	Experimental acquisition of biomedical signals in laboratory and their processing using MATLAB