UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2023/2024
MASTER'S DEGREE (MSC)	AEROSPACE ENGINEERING
SUBJECT	ESTIMATION, FILTERING AND SYSTEM IDENTIFICATION
TYPE OF EDUCATIONAL ACTIVITY	D
AMBIT	20546-A scelta dello studente
CODE	21516
SCIENTIFIC SECTOR(S)	ING-INF/04
HEAD PROFESSOR(S)	SFERLAZZA ANTONINO Ricercatore a tempo determinato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	ESTIMATION, FILTERING AND SYSTEM IDENTIFICATION - Corso: INGEGNERIA DEI SISTEMI CIBER-FISICI PER L'INDUSTRIA
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**SFERLAZZA ANTONINO** Monday 15:00 17:00 Ufficio del Docente o su M. Teams (4r406w2) Thursday 11:00 13:00 Ufficio del Docente o su M. Teams (4r406w2)

DOCENTE: Prof. ANTONINO SFERLAZZA

PREREQUISITES	Calculus, Automatic Control, Signal Processing, Linear Algebra.
LEARNING OUTCOMES	Knowledge and ability to understand: stochastic processes and random variables, moments of first and second order, algorithms estimation, BLUE, MINIMUM VARIANCE, Gauss-Markov, estimate the maximum likelihood, method of Least Squares. Methods of identification, optimal filtering and estimation of systems modeled by stochastic processes. Knowledge and ability to apply the understanding: Given a stochastic system, design an optimal filtering for the estimation and/or prediction of the output variables. Given a dynamic system with a known model, but with unknown parameters, design an identification experiment that allows to estimate the unknown parameters of the model. Given an unknown system, design an identification experiment, by chosing appropriate input signals and measure of the output variables. Given a set of unknown data, determine the best parametric or non-parametric model that explains the data on the basis of the identification and estimation theory. Making judgments The student must be able to generalize the techniques and the acquired concepts and to establish relations with those introduced in the disciplines. Communication Ability The student will have to acquire the capacity to exhibit in a consist way and with a proper language all problems regarding the course content, knowing the connections with some topics covered in previous courses. Capacity to learn The course also aims to stimulate student interest in the systematic approach used in the treatment of the various topics covered by the course itself. The student will acquire that this method of study and be able to continue his/her engineering studies with greater autonomy.
ASSESSMENT METHODS	To evaluate the learning. the students will make a final oral test and an individual laboratory test to be discussed in the final oral exam. Each of these two tests is evaluated in 30/30 and the final mark is evaluated as the average mark of the tests. The minimum grade to pass each test is 16/30 but the final grade must be greater than 18/30 . MARK28 to 30 - 30 with distinction LEARNING OUTCOMES ACHIEVEMENTLearning outcomes have been achieved to a very good/excellent level. The student demonstrates most or all of the following characteristics. KNOWLEDGE AND UNDERSTANDINGFull/excellent knowledge, understanding and integration of principles, concepts, methods and techniques of the discipline APPLYING KNOWLEDGE AND UNDERSTANDINGExtensive/excellent evidence of relevant and perceptive application of theoretical and technical knowledge for tackling and solving problems, with very good/excellent level of autonomy, effectiveness and originality. MAKING JUDGMENTS, COMMUNICATION SKILLS, LEARNING SKILLSComprehensive/excellent evidence of logical, analytical and critical abilities for reaching appropriate judgments and decisions, even based on incomplete or complex information and data. Full/excellent ability to communicate knowledge, analyses and conclusions, with a very good/excellent level of clearness, fluency and correct use of language.Very good/excellent abilities of concepts reinterpretation and interdisciplinary connection, showing full evidence for autonomously undertaking further studies or professional activity. MARK24 to 27 LEARNING OUTCOMES ACHIEVEMENTLearning outcomes have been achieved to a good level. The student demonstrates most or all of the following characteristics KNOWLEDGE AND UNDERSTANDINGGood knowledge, understanding and integration of principles, concepts, methods and techniques of the discipline, with minor inaccuracies or errors APPLYING KNOWLEDGE AND UNDERSTANDINGGood evidence of application of theoretical and technical knowledge for tackling and solving problems, with fine/adequate level of autonomy and effectiveness. MAKING JUDGMENTS, COMMUNICATION SKILLS, LEARNING SKILLSGood/adequate evidence of logical, analytical and critical abilities for reaching appropriate judgments and decisions, based on available information and data. Good ability to communicate knowledge, analyses and

	conclusions, with a good level of clearness, fluency and correct use of language. Good/adequate abilities of concepts reinterpretation and interdisciplinary connection, showing evidence for autonomously undertaking further studies or professional activity. MARK18 to 23 LEARNING OUTCOMES ACHIEVEMENTLearning outcomes have been achieved to an acceptable/basic level. The student demonstrates most or all of the following characteristics KNOWLEDGE AND UNDERSTANDINGAcceptable/basic knowledge and understanding of principles, concepts, methods and techniques of the discipline, even if with some inaccuracies, errors or omissions APPLYING KNOWLEDGE AND UNDERSTANDINGEvidence of adequate/basic application of theoretical and technical knowledge for tackling and solving problems, even if with limited level of autonomy and effectiveness. MAKING JUDGMENTS, COMMUNICATION SKILLS, LEARNING SKILLSEvidence of some logical, analytical and critical abilities for coherent judgments and decisions attempts.Basic ability to communicate knowledge, analyses and conclusions, with an acceptable level of clearness, fluency and use of language. Sufficient abilities, although with some limitations, of concepts reinterpretation and connection in disciplinary contexts, showing some evidence for autonomously undertaking further studies or professional activity.
EDUCATIONAL OBJECTIVES	To learn optimal filtering techniques for stochastic systems. to learn how to determine a mathematical model from the experimental data measured on the system.
TEACHING METHODS	The teaching consists in lectures, exercises in the classroom, exercises using Matlab-Simulink. The method is aimed at letting the students be able to immediately and independently test and try the arguments.
SUGGESTED BIBLIOGRAPHY	•L. Ljung, System Identification - Theory For the User,1999, Pearson College Div. ISBN: 0136566952. •Appunti del corso del Prof. Garulli, DII, Siena (http://control.dii.unisi.it/iead/Dispense_v2.1.pdf). •G. Pillonetto, T. Chen, A. Chiuso, G. De Nicolao, L. Ljung Regularized System Identification - Learning Dynamic Models from Data, 2022, Springer. ISBN 978-3-030-95859-6. (open access book). •S. Bittanti, Identificazione dei modelli e sistemi adattativi, 2003/5, Pitagora. ISBN: 8837112009. •S. Bittanti: Teoria della predizione e del filtraggio, 2002/6, Pitagora. ISBN: 8837110928. •T. Sodestrom, P. Stoica, System Identification, 1989, Pentice Hall. ISBN: 0138812365.

SYLLABUS

Hrs	Frontal teaching
6	Introduction to the course. Review of random variables and probability theory
6	Stochastic processes: definitions and properties, examples of stochastic processes
3	Frequency analysis
3	Linear models of stochastic processes
3	Introduction to estimation theory
4	Parametric estimation, least squares estimator and Gauss-Markov estimator
2	Maximum likelihood estimate
4	Bayesian estimate and minimum mean square error estimate
4	Optimal filtering, Wiener FIR filter, Wiener FIR predictor
4	Spectral factorization and Wiener IIR predictor
6	Kalman filter and extended Kalman filter
8	Model identification: black box approach
4	Parametric identification
3	Recursive estimation of linear regression models

Hrs	Practice
21	Exercises and examples on the topics covered. Exercises with Matlab. Matlab Identification toolbox. Matlab Optimtool