



# UNIVERSITÀ DEGLI STUDI DI PALERMO

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| DEPARTMENT                   | Ingegneria                                                       |
| ACADEMIC YEAR                | 2023/2024                                                        |
| MASTER'S DEGREE (MSC)        | ELECTRONICS AND TELECOMMUNICATIONS ENGINEERING (FULLY ONLINE)    |
| SUBJECT                      | RADAR THEORY AND TECHNIQUES                                      |
| TYPE OF EDUCATIONAL ACTIVITY | D                                                                |
| AMBIT                        | 20582-A scelta dello studente                                    |
| CODE                         | 22084                                                            |
| SCIENTIFIC SECTOR(S)         | ING-INF/01                                                       |
| HEAD PROFESSOR(S)            | LIVRERI PATRIZIA      Professore Associato      Univ. di PALERMO |
| OTHER PROFESSOR(S)           |                                                                  |
| CREDITS                      | 9                                                                |
| INDIVIDUAL STUDY (Hrs)       | 162                                                              |
| COURSE ACTIVITY (Hrs)        | 63                                                               |
| PROPAEDEUTICAL SUBJECTS      |                                                                  |
| MUTUALIZATION                |                                                                  |
| YEAR                         | 2                                                                |
| TERM (SEMESTER)              | 1° semester                                                      |
| ATTENDANCE                   | Not mandatory                                                    |
| EVALUATION                   | Out of 30                                                        |
| TEACHER OFFICE HOURS         | LIVRERI PATRIZIA<br>Tuesday    12:00    13:00    DEIM            |

**DOCENTE:** Prof.ssa PATRIZIA LIVRERI

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| <b>PREREQUISITES</b>          | Antennas and Wireless Systems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>LEARNING OUTCOMES</b>      | <p>Knowledge and fundamental skills related to radar systems, remote sensing, inverse scattering, and microwave imaging as well as notions on antenna arrays for radar systems.</p> <p>Knowledge and understanding: Acquisition of basic principles of radar detection and signal processing.</p> <p>Applying knowledge and understanding: Ability to quantitatively solve radar detection problems in different scenarios. Solution of inverse and optimization problems.</p> <p>Making judgements: Ability to identify and compare the most appropriate methods for studying real problems.</p> <p>Communication skills: Ability to present orally. Ability to write a lab report using technical language.</p> <p>Learning skills: Learning assessment may also be carried out on-line depending on specific circumstances required</p>                                                                                                                                                                                                                                                                                    |
| <b>ASSESSMENT METHODS</b>     | <p>Oral discussion of a final work.</p> <p><b>GRADES</b></p> <p>30-30 and laude: Excellent. Full knowledge and understanding of concepts and methods of the discipline, excellent analytical skills even in solving original problems; excellent communication and learning skills.</p> <p>27-29: Very good. Very good knowledge and understanding of concepts and methods of the discipline; very good communication skills; very good capability of concepts and methods applications.</p> <p>24-26: Good. Good knowledge of main concepts and methods of the discipline; discrete communication skills; limited autonomy for applying concepts and methods for solving original problems.</p> <p>21-23: Satisfying. Partial knowledge of main concepts and methods of the discipline; satisfying communication skills; scarce judgment autonomy.</p> <p>18-20: Acceptable: Minimal knowledge of concepts and methods of the discipline; minimal communication skills; very poor or null judgement autonomy.</p> <p>Non acceptable: Insufficient knowledge and understanding of concepts and methods of the discipline.</p> |
| <b>EDUCATIONAL OBJECTIVES</b> | The course Principles of Radar will cover the following topics: 1) Basics of radar functioning and radar nomenclature 2) Radar components 3) Radar equation 4) Radar detection theory 5) Coherent and incoherent radar 6) Clutter and detection in clutter 7) Radar target tracking 8) Moving target detector                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>TEACHING METHODS</b>       | Recorded lessons                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>SUGGESTED BIBLIOGRAPHY</b> | <p>1) Radar Principles, Peyton Z. Peebles, John Wiley &amp; Sons Inc, United States (1998). ISBN 10: 0471252050 ISBN 13: 9780471252054</p> <p>2) Radar Principles, Nadav Levanov, Wiley, ISBN-10 : 0471858811, ISBN-13 : 978-0471858812</p> <p>4) Synthetic Aperture Radar Processing, G. Franceschetti and R. Lanari, CRC Press, ISBN 9781439876275</p> <p>5) M. A. Richards et al., "Principles of modern radar", Scitech Publishing, 2010, ISBN-10. 1891121529 ; ISBN-13. 978-1891121524</p> <p>6) Notes from the lecturers</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

## SYLLABUS

| Hrs | Frontal teaching                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
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| 63  | <p>Radar Processing and Systems (4 CFU – 28 h)</p> <p>Elements of Wave Propagation. The Radar Equation. Radar Cross Section. Radar Resolution. Doppler Frequency. Monopulse Radar. Radar Signals and Networks. Range Measurements and Tracking in Radar. Radar Measurements-Limiting Accuracy. Radar Equation with Jamming. Effects of the Earth's Surface on the Radar Equation. Atmospheric Attenuation. The Matched Filter techniques and the Ambiguity function. Analog and Discrete Coded Waveforms. Filtering techniques. Radar Antennas, Arrays and Systems.</p> <p>Synthetic Aperture Radar (2 CFU - 14 h)</p> <p>Electromagnetic scattering models for remote sensing: natural surfaces and urban areas. Physical optics (PO) and geometrical optics (GO). Scan mode and spot mode (signal analysis and data processing). Strip Mode Transfer Function and Data Processing. Synthetic Aperture Radar Interferometry.</p> <p>Microwave Imaging Techniques (1 CFU – 7h)</p> <p>Ill-posedness and non-linearity. Regularization and linearized scattering models: Born, Rytov and Kirchhoff approximation. Minimum energy solution and Singular Value Decomposition (SVD). Optimization problems and Gradient based methods.</p> <p>Topics lectures in collaboration with companies, universities and research centers (1 CFU – 7 h)</p> <p>Automotive Radar / Direction Finding (Angle of Arrival)</p> <p>Ground Penetrating Radar / Through-the-Wall Imaging</p> <p>Microwave Medical Imaging / Nuclear Magnetic Resonance</p> <p>Radar / Mw-Mm Waves Diagnostics of Plasma</p> <p>Laboratory (1 CFU – 7 h)</p> <p>RADAR and SAR data processing with Matlab</p> <p>Acquisition and processing of radar signals by means of a compact mm-waves radar prototype</p> <p>RCS measurement of canonical target in anechoic chamber</p> |