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| **Teaching** | Technologies for wireless systems |
| **Level and course of study** | Bachelor's degree in Electronic Engineering and Computer Science (L8) |
| **Academic discipline (SSD)** | IINF-02/A (ex ING-INF/02) |
| **Academic year** | 2025-2026 |
| **Course year** | 3 |
| **Total number of credits** | 6 |
| **Prerequisites** | Electromagnetic fields, guided propagation and microwave circuits |
| **Teacher** | Michela Longhi  Faculty: Engineering  Nickname: michela.longhi  Email: michela.longhi @unicusano.it  Office hours: Consult the calendar on the following page of our website by checking the Videoconference times <http://www.unicusano.it/calendario-lezioni-in-presenza/calendario-area-ingegneristica> |
| **Presentation** | The course is designed to provide the **methodologies and skills necessary to understand the technologies underlying modern wireless systems**. In particular, the course provides theoretical and practical information on the main wireless systems and on the enabling electronic and electromagnetic technologies. Knowledge and skills are provided on noise in telecommunications systems, antennas and radio propagation, as well as on the operation of the main microwave systems.  Particular emphasis is placed on the physical understanding of the phenomena that characterize the transmission and reception of information on radio carriers.  This course places us in the field of **electromagnetic field disciplines** and expands and deepens the knowledge acquired in the teachings of Electromagnetic Fields and Guided Propagation and Microwave Circuits. |
| **Disciplinary educational objectives** | **The course of Technologies for Wireless Systems aims to:**   1. Illustrate the main wireless communication systems and their specificities 2. Describe the enabling technologies for modern wireless systems 3. Describe noise and distortion issues in wireless systems 4. Illustrate the fundamentals of antenna theory and radio propagation 5. Illustrate the main microwave systems, their operation, and the related design criteria |
| **Prerequisites** | **Knowledge** of **the fundamentals of mathematical analysis** and **multivariable vector functions**.  **Knowledge** of the **fundamental properties of the electrostatic, magnetostatic and electromagnetic field**.  In this regard, it is advisable to review these notions, preparatory to learning and deepening the theory of propagation; to this end, it is possible to use the texts already consulted for the preparation for the basic exams of the mathematical (Analysis I and Analysis II) and physics (General Physics II and Electromagnetic Fields) areas previously taken |
| **Expected learning outcomes** | **Knowledge and understanding**  At the end of the course, the student will know the terminology, properties and characteristics of modern wireless systems. You will know the noise sources that affect the performance of a wireless system. He will also know the fundamentals of antennas and the physical quantities used for their characterization. Finally, the student will know the fundamentals of the free propagation of the electromagnetic field, the effects of the ground and the atmosphere and the problem of multiple paths.  **Application of knowledge**  At the end of the course, the student will have developed the ability to analyze and synthesize a wireless communication system and its propagation scenarios.  **Ability to draw conclusions**  At the end of the course, the student will have the ability to choose the components necessary to size a wireless system that meets certain design specifications. He will also have developed the ability to determine the effects of the environment on the propagation of the electromagnetic field and to take them into account in the design phase. Finally, the student will have developed a critical ability to interpret the results obtained during the performance of a numerical exercise and a simulation both in terms of physical coherence of the results obtained and in terms of engineering feasibility of the identified solution.  **Communication skills**  At the end of the course, the student will have developed a correct and understandable scientific language that will allow him to express in a clear and unambiguous way the technical knowledge acquired in the field of the theory of wireless systems, antennas and radio propagation.  **Learning skills**  At the end of the course, the student will have developed the ability to apply the acquired knowledge to the resolution of unfamiliar problems concerning the transmission and reception of information on a radio carrier. |
| **Course structure** | The course is developed through **pre-recorded audio-video lessons** lasting half an hour each that compose, together with slides, handouts and exercises, the study materials available on the platform.  Self-assessment tests **are then proposed**, asynchronously, which accompany the pre-recorded lessons and allow students to ascertain both the understanding and the degree of knowledge acquired of the contents of each of the lessons. Web-conference lessons scheduled on the calendar are also available during the teaching periods and **video-receptions** with the teacher to clarify any doubts.  The Course of Technologies for Wireless Systems includes **6 credits (CFU).** The *total study load* for this teaching module is between *150 and 160 hours* divided as follows:   1. **about 130** hours for viewing and studying the videotaped material 2. **about 20 hours** for the use and study of the exercises 3. **about 5 hours of interactive teaching** for the execution of the self-assessment tests.   It is advisable to spread the study of the subject evenly over a period of 6-8 weeks, dedicating between 20 and 25 hours of study per week. |
| **Course programme** | **Module 1 – Electromagnetic Field Reminders**  (Week 1 – 20-hour commitment)  Maxwell's equations. Electromagnetic waves. Continuity equation. Constitutive relationships. Kramers-Kronig reports. Boundary conditions.  **Module 2 – Fundamentals of Antennas**  (Weeks 2-3 – 25-hour commitment)  Electrodynamic potentials. Green function: Green function for free space. Radiation from an arbitrary distribution of current. Radiation from elementary antennas. Electrical and radiative characteristics of antennas. Effective area and noise temperature of an antenna. Separation between field regions. Friis' formula. Notes on the main types of antennas.  **Module 3 – Receiving antennas and noise**  (Week 4 – 20-hour commitment)  Power received from an antenna in polarization matching condition. Power received from an antenna in a polarization mismatch condition. Antenna noise.  **Module 4 – Propagation in free space**  (Week 5 – 20-hour commitment)  Field in a distant area. Friis' formula. Radar equation.  **Module 5 – Introduction to Microwave Systems**  (Week 6 – 25-hour commitment)  Noise temperature and background noise. Wireless communication systems. Architecture of a radio receiver. Digital modulation and bit error rate. Radar systems. Radiometric systems. Microwave propagation. Microwave heating.  **Module 6 – Electromagnetic Simulation Software (CST)**  (Week 6 – 20-hour commitment)  Introduction to electromagnetic simulation. Generic electromagnetic simulation process. Main electromagnetic simulation software. Use of CST Microwave Studio software. |
| **Study materials** | TEACHING MATERIALS BY THE TEACHER  The teaching material on the platform is divided into 6 modules. They cover the entire program and each of them contains handouts, exercises, slides, video lessons in which the teacher comments on the slides. This material contains all the tools necessary to deal with the study of the subject.  **Recommended texts:**   * David M. Pozar, "Microwave and RF Design of Wireless Systems," John Wiley & Sons, Inc. * Kai Chang, "RF and Microwave Wireless Systems," John Wiley & Sons, Inc. * Aldo Paraboni and Michele D'Amico, "Radiopropagazione", McGraw-Hill Education Italy. |
| **Assessment methods** | The exam usually consists of a **written test** aimed at ascertaining the ability to analyze and rework the concepts acquired.  The written test includes **2 numerical exercises and 2 theory questions** to be carried out in **90 minutes**. Each of the questions has a maximum score of 7.5 points.  The exercises in the exams will concern the modules for which there are exercises in the platform (uploaded as a single file within the corresponding module).  The student who has to take the exam on the entire 6 CFU program will be able to choose, indicating his choice during the exam, to take the exam through TWO PARTIAL EXAMS (see facsimile task uploaded on the platform).   * The partial exam 1 (3 CFU) will cover the following modules: Module 1, Module 2, Module 3. Partial exam 1 will be evaluated up to a maximum of 15 points. * The partial exam 2 (3 CFU) will cover the following modules: Module 4, Module 5, Module 6. Partial exam 2 will be evaluated up to a maximum of 15 points. |
| **Criteria for the assignment of the final paper** | The assignment **of the final paper** will take place on the basis of an interview with the teacher in which the student will express his or her specific **interests** in relation to some topic he or she intends to deepen; there are no preclusions to the request for assignment of the thesis and there is no particular average to be able to request it. |