

230626 - NMEE - Numerical Methods for Electromagnetic Engineering

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
 Teaching unit: 739 - TSC - Department of Signal Theory and Communications
 Academic year: 2019
 Degree: MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019).
 (Teaching unit Optional)
 MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit
 Optional)
 ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: JUAN-MANUEL RIUS CASALS
 Others: ALEXANDER HELDRING - EDUARDO UBEDA FARRE - JOSE MARIA GONZALEZ ARBESU

Prior skills

Algebra, differential and integral calculus and vector analysis. Electromagnetic fields and waves. Antennas.

Requirements

None.

Teaching methodology

Teaching is based on lectures by teachers. Slides and computer simulation software may be used by the teachers to clarify concepts. Students may be asked to solve problems and to write simple programs in MATLAB language.

Learning objectives of the subject

Background in advanced electromagnetics, from an engineering point of view. Understanding of electromagnetic radiation and diffraction, and ability to compute radiated and diffracted fields. Understanding of modern numerical methods for computer simulation. Ability to write simple computer programs for numerical simulation.

Study load

Total learning time: 125h	Hours large group:	39h	31.20%
	Self study:	86h	68.80%

230626 - NMEE - Numerical Methods for Electromagnetic Engineering

Content

1- Fundamentals	Learning time: 6h Theory classes: 6h
<p>Description:</p> <ul style="list-style-type: none"> Vector calculus (review) Maxwell's equations and boundary conditions (review) Electrical properties of material media Conservation of energy Time harmonic fields (review) Wave equation and its solutions (review) Potentials, construction of solutions Induced and radiated fields 	
2- Electromagnetic theorems and principles	Learning time: 6h Theory classes: 6h
<p>Description:</p> <ul style="list-style-type: none"> Fundamental theorems and concepts Electric and Magnetic Field Integral equations (EFIE and MFIE) 	

230626 - NMEE - Numerical Methods for Electromagnetic Engineering

<p>3- Numerical methods in Electromagnetics</p>	<p>Learning time: 18h Theory classes: 18h</p>
<p>Description:</p> <ul style="list-style-type: none"> Overview of numerical methods for solution of the wave equation Integral equation methods (overview) The Method of Moments (or weighted residuals method) Nyström method Linear system solution, iterative solvers and preconditioning Acceleration techniques (Fast Solvers) Finite differences methods and sparse matrices Finite element methods (FEM) (overview) Finite differences in time domain (FDTD) (overview) <p>Related activities:</p> <p>Practical project 1: Method of moments in electrostatics: Design a 3D “quadrupole ion trap” using method of moments discretization of electrostatics integral equation and Adaptive Cross Approximation fast solver.</p> <p>Practical project 2: Method of moments for wire antennas: Model a straight wire antenna with the thin-wire approximation. Discretize the integral equation with method of moments. Computation of resonant frequencies for a monopole antenna. In order to validate the software developed in this project, students will do network analyzer measurements in the laboratory.</p> <p>Practical project 3: Method of moments in electrodynamics: Implement the Electric Filed Integral Equation (EFIE) in 2D for scatterers with cylindrical symmetry.</p> <p>Practical project 4: Optimization. Develop cost functions and penalty criteria to optimize a Yagi-Uda antenna design to agree with antenna parameters specification. Compare the performance of local optimization methods with global ones (like Genetic Algorithms, Particle Swarm Optimization or Ant Colony Optimization).</p>	
<p>4- Radar Cross Section, scattering and high-frequency techniques</p>	<p>Learning time: 6h Theory classes: 6h</p>
<p>Description:</p> <ul style="list-style-type: none"> Radar Cross Section Analytic solutions for canonical geometries Diffraction of 2D TM and TE waves High frequency diffraction phenomena High frequency methods (from "Antenas", Cardama et al.) 	

230626 - NMEE - Numerical Methods for Electromagnetic Engineering

5- Efficient programming tips	Learning time: 3h Theory classes: 3h
<p>Description:</p> <ul style="list-style-type: none"> Code profiling Strategies for speed Parallelization Tunning the code Efficient programming in MATLAB Efficient use of memory Examples 	

Qualification system

Students will solve a problem (or a few short exercises) at the end of each chapter (20%). Practical projects will also contribute to final course mark (40%). There will be a final examination (40%).
 Final Mark = $0.4 \cdot (\text{Final exam}) + 0.4 \cdot (\text{Practical projects}) + 0.2 \cdot (\text{Problems})$

Bibliography

Basic:

Balanis, C.A. Advanced Engineering Electromagnetics. 2nd. John Wiley & Sons, 2012. ISBN 9780470589489.

Griffiths, D.J. Introduction to electrodynamics. 4th. Wesley, 2012. ISBN 9780321856562.

Cardama, Á. [et al.]. Antenas [on line]. 2a ed. Barcelona: Edicions UPC, 2002 [Consultation: 09/02/2015]. Available on: <<http://hdl.handle.net/2099.3/36797>>. ISBN 8483016257.