European School of Antennas

Short course

Coordinators: **Stefano Maci (UNISI)** and **Zvonimir Sipus (UNIZAG)**

UNISI

S. Maci

UNIZAG

Z. Sipus

Title of the course

Advanced Mathematics for Antenna Analysis

Place	Hotel Uvala, Dubrovnik, Croatia	Date: **May 09 – May 14, 2016**

Summary

The objective of this course is to explain the mathematical methods used in computational antenna analysis and to provide students with mathematical background necessary for advanced antenna engineering and electromagnetic software development. This course can also serve as a mathematical introduction to other ESoA courses. The course will cover different approaches to solving wave equations, various wave representations, and mathematical theorems used to simplify the original electromagnetic problem. In this sense, the aim of this course is to help students gain a deeper understanding of which field representation is suited for a given complex electromagnetic problem.

Involved institutions

Structure of the course

Lectures	Self study & Assignments	Computer exercise	Total	Credits	Assessment typology
40h	10h	-	50h	3 ECTS	Attendance: 2 cr Assignments: 1 cr

Teachers

Name	Organization	Title
S. Maci	UNISI	Prof.
Z. Sipus	UNIZAG	Prof.
A. Freni	UNIFI	Prof.
A. Skrivervik	EPFL	Prof.
G. Vecchi	POLITO	Prof.

Availability of dedicated structures

College rooms		Dedicated Labs		Classrooms		Computer rooms		Canteen	
yes	not	yes	not	yes	not	yes	not	yes	not
■			■	■			■	■	

Grants

Four grants were provided; one by IDS, Italy, one by CST, Germany, and two by University of Zagreb, Croatia.

Monday: FUNDAMENTAL THEOREMS FRAMED IN THE ANTENNA ANALYSIS		
Z. Sipus (UNIZAG)	9.30-10.00	• The European School of Antennas • Introduction to the course
A. Freni (UNIFI)	10.00-13.00	**Fundamental theorems (1)** • Uniqueness • Energy
	Lunch and swimming break	
	15.30 19.30	**Fundamental theorems (2)** • Equivalence and induction theorems • Integral equation and Computational Electromagnetics (CEM) • HF approximations for scattering and diffraction • Examples and exercises

Tuesday: FUNDAMENTAL THEOREMS AND SCALAR AND VECTOR WAVE EQUATION IN ABSENCE OF SOURCES		
A. Freni (UNIFI)	9.00-13.00	**Fundamental theorems (3)** • Reciprocity Theorem • Implication of reciprocity in IE-MoM and application in CEM
	Lunch and swimming break	
	15.30 17.30	**Fundamental theorems** • Examples and exercises
Z. Sipus (UNIZAG)	17.30 19.30	**Scalar wave equation** • Introduction to waves • Definition of scalar wave equations; basic properties • Solving scalar wave equation using separation of variables

Wednesday: SCALAR AND VECTOR WAVE EQUATION IN ABSENCE OF SOURCES AND COMPLEX ANALYSIS		
Z. Sipus (UNIZAG)	9.00 13.00	**Scalar wave equation** • Solving scalar wave equation using separation of variables • Eigenvectors, eigenmodes and completeness relations • Examples and exercises **Vector wave equation** • Helmholtz' and Deby' potentials • Open and closed domains • Green's identities • Examples and exercises
	Lunch and swimming break	
	15.30 17.30	**Examples, open discussion and exercises** • Scalar and vector wave equation
S. Maci (UNISI)	17.30 19.30	**Complex analysis fundamentals** • Complex transformations • Transformation of complex variables

Thursday: GREEN's FUNCTION		
S. Maci (UNISI)	9.00 13.00	**Green's functions** • Generalities • Scalar and Dyadic GF Scalar GF representation • 1D, 2D and 3D GF for the wave eqs.- GF in cylindrical spectral coordinates open-domain • ρ-Tx line and z-Tx line GF in closed –domains • Waveguides and cavities
		Lunch and swimming break
	15.30 19.30	**Examples and Exercises:** • Parallel plate waveguide • Horizontal dipole in stratified media, • Dipoles close to cylindrical multistrates • Dipoles close to a wedge

Friday: ASYMPTOTIC EVALUATION OF INTEGRALS		
S. Maci (UNISI)	9.00 13.00	**Basics of asymptotic evaluation of integrals:** • Typical integral representation • Saddle points and SDP • Examples and exercises
		Lunch and swimming break
	15.30 19.30	**Non Uniform and Uniform asymptotics:** • Saddle-point – pole interaction (wedge problem) • Saddle-point – complex pole (evanescent wave diffraction, slab Green's function) • End-point – saddle-point (PO-diffraction, Shadow boundary diffraction)

Saturday: PERIODIC STRUCTURES		
G. Vecchi (POLITO)	9.00 13.00	**Periodic structures:** • Floquet Theorem • Green's functions for periodic structures in space domain • Green's functions for periodic structures in spectral domain • Convergence problems
		Lunch and swimming break
A. Skrivervik (EPFL))	15.30 18.30	**Periodic structures – advanced topics:** • Finite period structures and quasi periodic structures • Acceleration of calculation of Green's functions (summation by parts, Shanks' transform, Ewald's transform,....) • Dispersion of Green's functions for periodic structures (dispersion diagrams, bandgaps, EBG structures, metamaterials)
	18.30 19.30	**Final assessment tests**