Courses Provided in English by HMU

YEAR 2021-22

ELECTRONIC ENGINEERING - CHANIA					
COURSE TITLE	**INSTRUCTOR**	**STUDY LEVEL**	**PAGE #**	**SEMESTER**	**ECTS**
Structured Programming	N.Petrakis nik.s.petrakis@hmu.gr or new lecturer	Bachelor	4	W	5
Data Structures	N.Petrakis nik.s.petrakis@hmu.gr	Bachelor	5	S	5
Digital Image Processing	A. Konstantaras akonstantaras@hmu.gr	Bachelor	6	W/S	5
Power Electronics	I.Chatzakis jchatzakis@hmu.gr	Bachelor or Master	7	W/S	3
An Introduction to Laser Physics and Applications	K.Petridis cpetridis@hmu.gr	Bachelor	8	W/S	5
An Introduction to Nanoelectronics	K.Petridis cpetridis@hmu.gr	Bachelor	10	S	5
An Introduction to Optoelectronics & Optical Communications	K.Petridis cpetridis@hmu.gr	Bachelor	12	S	5
* **Algorithms and Complexity**	M. Zakynthinaki, marzak@hmu.gr	Bachelor or Master	13	W	5

***Differential Equations and Computational Algorithms**	M. Zakynthinaki, marzak@hmu.gr	Bachelor	14	S	5
Introduction to Plasma Engineering	I.Fitilis fitilis@hmu.gr	3rd Year and above	15	W/S	3
Display Technologies	I.Kaliakatsos giankal@hmu.gr	$\geq 4^{th}$ semester	16	W/S	4
Organic Electronics Devices	I.Kaliakatsos giankal@hmu.gr	$\geq 4^{th}$ semester	18	W/S	4
Antennas and Wireless Communications	I.Vardiambasis ivardia@hmu.gr	3rd Year and above	19	W	3
Satellite Communications and Systems	I.Vardiambasis ivardia@hmu.gr	3rd Year and above	23	W	3
Scattering, Propagation & Radiation of Electromagnetic Waves	I.Vardiambasis ivardia@hmu.gr	4th Year and above	26	W	3
Electromagnetic Compatibility	I.Vardiambasis ivardia@hmu.gr	3rd Year and above	30	S	3
Microwave Communications	I.Vardiambasis ivardia@hmu.gr	3rd Year and above	32	S	3
Microwave-Millimeter Wave Communications & Antennas	I.Vardiambasis ivardia@hmu.gr	4th Year and above	37	S	3

** These courses are provided from non-permanent personnel and may will not be offered (changes can be made the first week of the semester)*

Diploma Thesis (6 months)

Diploma Thesis Title	Positions	Study Level	Semester	Professor	Online
"Solving electromagnetic wave propagation, radiation and scattering problems using computational techniques"	3	Bachelor or Master	W/S	I.Vardiambasis ivardia@hmu.gr	
"Telecommunication systems design and development using FPGA technology"	2	Bachelor or Master	W/S	I.Vardiambasis ivardia@hmu.gr	

>>Other diploma thesis could be suggested upon request

Training/Practice (6 –months)

Description of Training/practice	Positions	Semester	Professor	Online
"Training in the Telecommunications and Electromagnetic Applications Laboratory (Mat lab programming, electromagnetic simulation software authoring, boundary value problems solving, electromagnetic field measurements, analysis, design and development of microwave devices and antennas)" (Needed :Adequate background in telecommunications and/or electromagnetics, Proficient use of Mat lab programming)	2	W/S	I.Vardiambasis ivardia@hmu.gr	

Course Title	**Structured Programming**
Instructor	Dr. Eng. Nikolaos Petrakis nik.s.petrakis@hmu.gr or new lecturer
Study level	Bachelor
ECTS	5
Prerequisite	None
Learning Outcomes	The course is an introduction to structured programming using the C programming language, where the student will start with the basic concepts of variable, data type, loop and will continue learning to structure his code correctly in functions. Upon successful completion of the course the student will be able to: ✓ find/discover solutions to problems of moderate difficulty, to describe the algorithmic solutions in pseudo-code and / or in a flowchart, and of course to be able to encode them. ✓ evaluate algorithmic solutions. ✓ design and implement software applications that provide access to text files. ✓ design and write code for programs that require the use of vectors or arrays composed of structure type elements. ✓ use sorting and/or searching techniques as appropriate.
Contents	• Introduction to Informatics and Computers. • Computer parts (hardware). Computer programs (software). • Numbering systems and conversions from one system to another. • The concept of the algorithm. Algorithm structures. Flowcharts. • Programming in C language. Data types. Variables. Constants. Strings. • Control statements. Operators (arithmetic, relational, logical, bitwise, etc). • Loop control statements. Functions and building blocks of the program. • One-dimensional / multidimensional arrays. Pointers. Recursion and recursive functions. • Structures and unions (defining/accessing). • Introduction to searching (Sequential Search, Binary Search) and sorting techniques (Sort by Selection, Bubble Sort). • Using real files (text streams). • Learn basic program design and implementation principles in the Dev-C ++ or CODE :: BLOCKS or MS Visual Studio environment.
Course type	Weekly Lectures 5hr/week *(if the number of students is greater than 4), else project based*
Assessment	Written exams, class contribution, delivery of small individual projects every two weeks
Bibliography	1. H.H.Tan, T.B. D'Orazio, C Programming for Engineering & Computer Science, McGraw-Hill, 2000. 2. H. M. Deitel, P. J. Deitel, C: How to program, (second edition), Prentice-Hall, 1999. 3. Brian Kernigham, Dennis Ritchie, The C Programming Language, (second edition), Prentice-Hall, 1988. 4. Herbert Schildt, C The Complete Reference, Osborn/McGraw-Hill, 1987. 5. A. Tenenbaum,Y. Langsam, M. Augenstein, Data Structures Using C, Prentice-Hall, 1990. 6. Herbert Schildt, C The Complete Reference, Osborn/McGraw-Hill, 1987.

Course Title	**Data Structures**
Instructor	Dr. Eng. Nikolaos Petrakis nik.s.petrakis@hmu.gr
Study level	Bachelor
ECTS	5
Prerequisite	Basic knowledge of Computer Programming using C.
Learning Outcomes	The course is an introduction to algorithms and data structures, using as a tool a programming language such as C / C ++, where the student will start with the basic concepts and terminology and will continue learning to design, implement and evaluate the solutions. Upon successful completion of the course the student will be able to: ✓ mention and describe the characteristics of the basic data structures. ✓ mention and describe the basic algorithms for searching and sorting data (internal and external). ✓ mention and describe binary trees traversal methods. ✓ mention basic algorithms in Graphs. ✓ analyze a complex problem and design the solution on an abstract level. ✓ analyze the quality of a solution in relation to the execution time of its individual procedures. ✓ Tcompose the solution of a problem based on the individual parts of the solution. ✓ check the correctness of a solution and to evaluate the various alternative solutions to a problem. ✓ Eevaluate both the quality of the design and the implementation of the solution of a problem. ✓ modify known algorithms so that they can be better utilized in solving a problem. ✓ evaluate the algorithmic solutions in relation to the execution time of the respective algorithm. ✓ design and write code for programs that require the use of data structures. ✓ use the most appropriate sorting or searching technique taking into account the expected distribution of data. ✓ find solutions to complex problems, to describe its algorithmic solutions in pseudo-code and / or in a flowchart, and of course to be able to encode them.
Contents	• Introduction to the basic concepts of data structures and algorithms. • Accessing sequential files. Define new type or variable as a data union. • Arrays, linearization of multidimensional arrays. • Stacks. Define the most important operations that can be performed in a stack, implemented using either static or dynamic data types. • Queues and fundamental operations that can be defined in a queue. Queue implementation with circular array (static) and queue implementation with nodes (dynamic). • Singly linked lists. Doubly linked lists and function definitions for basic operations. • Two-way interconnection technique using just a single link.

	• Trees. Binary tree traversal methods. Binary search trees. Balanced search trees. • Design and implementation of appropriate data structures for specific programming problems. • Evaluation of different data structures. • Straight sorting methods: sort by selection, shaker sort and bubble sort. • Quick sort technique. Sort variable-length sequences. • Sorting files using natural merge sort. Sequential search. Binary search. • Performance and analysis of algorithms. Time complexity. Algorithm performance comparison. • Graphs. • Learn software design and implementation principles in the Dev-C ++ or CODE :: BLOCKS or MS Visual Studio environment.
Course type	Weekly Lectures 5hr/week *(if the number of students is greater than 4), else project based*
Assessment	Written exams, class contribution, delivery of small individual projects every two weeks.
Bibliography	1. Leendert Ammeraal, Programs and data structures in C, John Wiley & Sons Ltd, 1987. 2. H.H.Tan, T.B. D'Orazio, C Programming for Engineering & Computer Science, McGraw-Hill, 2000. 3. H. M. Deitel, P. J. Deitel, C: How to program, (second edition), Prentice-Hall, 1999. 4. A. Tenenbaum,Y. Langsam, M. Augenstein, Data Structures Using C, Prentice-Hall, 1990. 5. A. Aho, J. Hopcroft, J. Ullman, The Design and Analysis of Computer Algorithms", Addison-Wesley Publishing Company, 1974.

Course Title	**Digital Image Processing**
Instructor	Dr. Antonios Konstataras akonstantaras@hmu.gr
Study level	Bachelor
ECTS	5
Prerequisite	None
Learning Outcomes	The basic concepts and algorithms applied to image processing systems and graphics cards are presented, while providing examples that allow students to become familiar with them, as well as technical computing tools in Matlab and CUDA. Students who have successfully completed the course will have a good understanding and knowledge of the main concepts, algorithms, and tools in the field of digital image processing and will have implemented applications in actual systems.
Contents	Image fundamentals, image enhancement in the spatial and frequency domains, restoration, color image processing, wavelets, image compression, morphology, segmentation, image description, and the fundamentals of object recognition.

Course type	Weekly meetings, project and lecture based
Assessment	
Bibliography	1. Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, Prentice Hall, 2008. 2. Rafael C. Gonzalez, Richard E. Woods and Steven Eddins, “Digital Image Processing Using Matlab”, McGraw Hill Education, 2010.

Course Title	**Power Electronics**
Instructor	Dr. John Chatzakis, jchatzakis@hmu.gr
Study level	Bachelor
ECTS	3
Prerequisite	Fundamental Analog Electronics
Learning Outcomes	Knowledge: After completing the course, the student will: ✓ have an in-depth understanding of the role of Power Electronics to electrical energy conversion as AC/DC, DC/DC or DC/AC and AC/AC conversion. ✓ understand operating principles and modulation strategies for basic Power Electronics Topologies and the properties of several PWM techniques and their applications to switch-mode power electronic systems. ✓ be able to identify the most important design parameters and to recognize the impact of operating parameters on the design and use of power electronic devices Skills: After conclusion of the course, the student will be able to: ✓ recognize, define, and analyze power electronic converters that perform AC/DC, DC/DC, DC/AC and AC/AC conversions ✓ design power electronic converters exhibiting high-performance operation ✓ analyse the operating principles and modulation for power electronic systems Competences: After completing the course, the candidate has increased: ✓ skills in cooperation - ability to communicate effectively about the Power Electronic Systems ✓ ability to contribute to innovation and innovation processes
Contents	• Definition of "Power Electronics", Semiconductors (Si, SiC, GaN) and Power Semiconductor Devices and Components, (Diode, Thyristor, GTO, MCT, TRIAC, Power BJT, Power MOSFETs, SJ MOSFET, IGBT, HEMT, TRIAC), Circuits with switches and diodes (with load RC, RL, RLC), semiconductor protection, damping • oscillations - snubbers, MOVs, fuses, current sensing protection - protection through the drive circuit. Rectifiers, multiphase rectifiers, controlled rectifiers with thyristor. • RL and LC low-pass filters, Fourier analysis, harmonics spectrum use, ripple coefficient (K), total harmonic distortion factor (THD), harmonic coefficients (HF 1,2), power factor (PF). DC / DC conversion, buck converter, CCM and DCM operation, Boost converter, positive to negative converter. Duty Cycle Definition and Control using Pulse Width Modulation (PWM). • Switching Power Supplies, power factor correction (PFC), pulse transformer, Forward Converter, semi-bridge, Full Bridge, Push-Pull, coupled coils,

	Flyback converter. Inverters: Half Bridge, Bridge, PWM Technique, MPWM Technique, Technique PDM, Modulation Factor (Mf), SPWM Technique, Normal Carrier Frequency (Fnc), HF-Link, Three Phase Inverters, Inverters and Motor Drive, Class D amplifiers. • Class E, Cycloconverters. • MCUs, DSPs and Power Electronics, Digital PWM Units. • MPPT, PFC, Batteries and Battery Management.
Course type	Weekly Lectures 2hr/week
Assessment	Written exams, class contribution, short project presentation.
Bibliography	1. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics: Converters, Applications, and Design", Whiley, 2002. 2. S. N. MANIAS, «POWER ELECTRONICS», SIMEON PUBLICATIONS, ATHENS 2012.

Course Title	**An Introduction to Laser Physics and Applications**
Instructor	Dr. Kostas Petridis cpetridis@hmu.gr
Study level	Bachelor
ECTS	5
Prerequisite	None
Objectives	**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation – LASERS introduced to the scientific community in 1958 (as a theoretical concept) and in 1960's as an operational device. Since then more than 33 Nobel Prizes in Physics have been awarded for works directly related to LASER Technology (with the last one in 2018). Today there is no activity that does not involve Laser light The **objectives** of the course (offered for undergraduate and postgraduate students) are the following: • Develop an understanding of the special properties of laser light; monochromaticity, directionality, spatial & temporal coherence • To offer the understanding of the building blocks of a laser device • Develop the understanding of the operational principles of a laser device: (a) Threshold Level; (b)Small Gain Coefficient; (c) Gain Saturation; (d) Steady State Condition Operation; (e) Spectral Broadening; (f) Laser Beam Propagation through vacuum and through optical elements; and (g) Pulsed Operation • The Introduction of various Laser Systems • The Introduction of various Laser Applications
Intended Learning Outcomes	The Learning Outcomes of the module 'An Introduction to Laser Physics and Applications' are the following: • to be able to explain how does a laser device operate • to be able to design a laser system

	• to be able to calculate various parameters related to a laser configuration: laser beam size, laser intensity, tunning range
Indicative Syllabus	An indicative syllabus of the course follows: 1. An Introduction of Lasers & Applications 2. The Light Matter Interaction Processes, the Einstein Rate Equations and the requested Population Inversion 3. The Electron Harmonic Oscillator Model 4. The Small Gain Coefficient & Related Losses 5. The Pumping Schemes 6. The Role of the Optical Oscillator 7. The Broadening Mechanisms: Homogeneous and Inhomogeneous Broadening 8. Longitudinal & Transverse Laser Modes 9. The Gain Saturation (Spatial Hole Burning and the Lamb Deep) 10. Tunable Laser Systems 11. Gaussian Beams and the ABCD Matrix Method 12. Generation of Laser Pulses: The Q-Switching Method 13. Generation of Laser Pulses: The Mode Locking Technique 14. Modern Laser Systems I 15. Modern Laser Systems II 16. Laser Applications in Medicine 17. Laser Applications in Nanoelectronics 18. Laser Applications in Energy Generation: Laser Fusion 19. Laser Applications in Engineering: Laser 3D Printing and Laser Biomimetics 20. Laser Applications in Optical Communications
Teaching/Learning Methodology	**Lectures (online, face to face):** Every week three hours **Seminars:** One seminar per two weeks where an external/invited speakers interacts with our students in Laser Applications
Assessment Methods in Alignment with Intended Learning Outcomes	Final Test (70% of the overall grade) Presentations during the course (30% of the overall grade)
Students' Working Load	Lectures: 36 hrs Homework/Study Time 108 hrs Seminars: 12 hrs In total 156 hours → 5ECTS
Reading List and References	• Lecture's Notes • Principles of Lasers by O. Svelto • Fundamentals of LASERS by Silfast

Course Title	**An Introduction to Nanoelectronics**
Instructor	Dr. Kostas Petridis cpetridis@hmu.gr
Study level	Bachelor
ECTS	5
Prerequisite	None
Objectives	The modern smartphone is enabled by a billion-plus nano-transistors, each having an active region that is barely a few hundred atoms long. Interestingly the same amazing technology has also led to a deeper understanding of the nature of current flow on an atomic scale and my aim is to make these lessons from nanoelectronics accessible to anyone in any branch of science or engineering. The course also will present the nanoelectronics from the materials point of view with a special focus in Graphene & 2D Materials based devices. Various production and characterization processes will be presented such as Atomic Frequency Microscopy (AFM), Transverse Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), X-Ray Diffraction, UV-VIS Absorption Spectroscopy I will assume very little background beyond linear algebra and differential equations, although we will be discussing advanced concepts in non-equilibrium statistical mechanics that should be of interest even to specialists. The **objectives** of the course (offered for undergraduate and postgraduate students) are the following: • Develop an understanding of the Quantum Physics Concepts • Facilitate the impact of Quantum Mechanics into the nano-devices and more particular nano-electronics • To develop an appreciation for the conceptual foundations underlying the operation of nanoelectronic devices. • The realization of the impact of nanoelectronics to the development of the field of electronics and the market in general • The awareness of the role of new materials in the field of nanoelectronics such as layered materials e.g. Graphene and 2D materials
Intended Learning Outcomes	The Learning Outcomes of the module 'An Introduction to Laser Physics and Applications' are the following: • to be able to understand the concept of the Quantum Mechanics in the field of nano-devices • to be able to understand the various fabrication, and characterization techniques using in nanoelectronics • to be able to understand and use the operational mechanisms of nano-electronic devices: field effect transistors, light emitting diodes & lasers, quantum dot devices, organic & perovskite solar cells

	• to be able to understand the special properties of graphene and 2D (Transitional Metal Chalcogenides – TMDs) material based devices
Indicative Syllabus	An indicative syllabus of the course follows: 21. Particles and Waves 22. Wave Mechanics 23. Materials for Nanoelectronics: Semiconductors, Organic Semiconductors, Graphene and TMDs 24. Growth and Fabrication Processes 25. Electron Transport Mechanisms 26. Electrons in low dimensional structures: Graphene, TMDs and Quantum Dots 27. Examples of Nanostructured Devices a. Field- Effect Transistors b. Solar Cells c. Emitting Devices: LEDs and Lasers
Teaching/Learning Methodology	**Lectures (online, face to face):** Every week three hours **Seminars:** One seminar per two weeks where an external/invited speakers interacts with our students in Nanotechnology Applications
Assessment Methods in Alignment with Intended Learning Outcomes	Final Test (70% of the overall grade) Presentations during the course (30% of the overall grade)
Students' Working Load	Lectures: 36 hrs Homework/Study Time 108 hrs Seminars: 12 hrs In total 156 hours → 5ECTS
Reading List and References	• Lecture's Notes • An Introduction to Graphene and 2D Materials – the CRETE Project (crete2020.hmu.gr) • Introduction to Nanoelectronics by V. Mitin, Cambridge University Press

Course Title	**An Introduction to Optoelectronics & Optical Communications**
Instructor	Dr. Kostas Petridis cpetridis@hmu.gr
Study level	Bachelor
ECTS	5
Prerequisite	None
Objectives	

	Optical communications are the dominant means of information transmission in the world. Even though the physical limitations of electrical cable prevent speeds in excess of 10 Gigabits per second, the physical limitations of fiber optics have not yet been reached. Everyday life applications such as broadband internet, cable HD TV, telemedicine, YouTube, online gaming and cloud based services like e-banking, Facebook and Twitter, owe their existence to the vast bandwidth capacity of the currently deployed global optical communication system. Optical communications to address limitations of radio frequency (RF) communications, including: bandwidth, spectrum and overall size of frequency packages and power used. **Optical spectrum** uses light as a means of transmitting information via lasers. **Optical communications** benefits include being faster, more secure, lighter and more flexible. The **objectives** of the course (offered for undergraduate and postgraduate students) are the following: • Realise the different technologies involved within the Optical Communication Technologies • Understand the operational principles of the various optoelectronic systems are involved in an optical communications network • To be aware of the new concepts of optical communications in the fields of optical networking and 5G Communications
Intended Learning Outcomes	The Learning Outcomes of the module 'An Introduction to Optoelectronics and Optical Communications' are the following: • to be able to understand the concepts of laser operation • to be able to understand the concepts of laser pulsed operation • to be able to understand the various laser pulses modulation schemes • to be able to explain the operation of an optical fiber • to be able to calculate the dispersion of a laser pulse within an optical fiber • to be able to calculate the various losses within a waveguide • to be able to design an optical network system
Indicative Syllabus	An indicative syllabus of the course follows: 28. An Introduction to Lasers 29. The Lorentz Principle 30. The Einstein Rate Equations 31. Broadening Mechanisms 32. The Resonator Principle 33. Gaussian Optics 34. The Semiconductor Laser Systems 35. Generation of Laser Pulses 36. Characterization of Laser Pulses 37. Frequency and Amplitude Modulation of Laser Pulses 38. The Fiber Optic Concept

	39. The Wave Propagation in vacuum and in waveguides 40. The EDFA concept 41. Optoelectronic Devices for Optical Communications 42. The Dispersion issue within optical fibers – solutions 43. Wavelength Dispersion Multiplexing 44. Optical Technologies for networking 45. Optical Technologies for Access Network 46. Optical Technologies for 5G Networking 47. Optical Technologies for Data Center Networking
Teaching/Learning Methodology	**Lectures (online, face to face):** Every week three hours **Seminars:** One seminar per two weeks where an external/invited speakers interacts with our students in Optical Communications
Assessment Methods in Alignment with Intended Learning Outcomes	Final Test (70% of the overall grade) Presentations during the course (30% of the overall grade)
Students' Working Load	Lectures: 36 hrs Homework/Study Time 108 hrs Seminars: 12 hrs In total 156 hours → 5ECTS
Reading List and References	• Lecture's Notes • Suggested Bibliography

Course Title	**Algorithms and Complexity**
Instructor	Dr. Maria Zakynthinaki marzak@hmu.gr
Study level	Bachelor or Master
ECTS	5
Prerequisite	Basic knowledge of the mathematical method of reduction. Knowledge of programming.
Learning Outcomes	The course provides an introduction to differential equations, specially designed for electronic engineers. Topics also include numerical techniques for the solution of initial value problems.
Contents	• What is an algorithm? The concept of complexity. • Iterative and recursive algorithms • Greedy algorithms • Divide and Conquer • Sorting • Searching • Random number generation • Linear programming

	• Dynamic programming • NP completeness. Reductions
Course type	Weekly Lectures 4hr/week (3 theory, 1 programming)
Assessment	Written exams, weekly assessments, final project in Python.
Bibliography	1. The Algorithm Design Manual, S.S. Skiena, 2nd ed., Springer-Verlag,2008 2. Introduction to the Design and Analysis of Algorithms (3rd Edition) 3rd Edition, 3. Anany Levitin, 2012 4. Introduction to Algorithms, T. H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein, S.S. Skiena, 3rd ed., The MIT Press, 2009

Course Title	**Differential Equations and Computational Algorithms**
Instructor	Dr. Maria Zakynthinaki marzak@hmu.gr
Study level	Bachelor
ECTS	5
Prerequisite	Basic knowledge of differentiation and integration techniques.
Learning Outcomes	The course provides an introduction to differential equations, specially designed for electronic engineers. Topics also include numerical techniques for the solution of initial value problems.
Contents	• First order ODEs, method of variable separation • Gradient, divergence and curl. Laplacian • First order nonhomogeneous ODEs. Method of undetermined coefficients • Applications of first order ODEs to practical problems in mechanical and electrical engineering • ODEs of order >1, method of variable separation • Second order linear homogeneous ODEs with constant coefficients • Second order nonhomogeneous ODEs with constant coefficients. Method of undetermined coefficients • Applications of second order ODEs with constant coefficients to practical problems • N-th order linear homogeneous and nonhomogeneous ODEs with constant coefficients • Second order linear homogeneous ODEs with constant coefficients - The Laplace transform method • Numerical solution of first order initial value problems. Euler, and RK methods
Course type	Weekly Lectures 4hr/week (3 theory, 1 tutorial)
Assessment	Written exams, weekly assessments.
Bibliography	1. C.H. Edwards, Jr., David E. Penney, *Elementary Dfifferential Equations with Applications (Third Edition)*, Prentice-Hall, Englewood Cliffs, NJ, 1996. 2. Chapra, S. C., & Canale, R. P. (2006). *Numerical methods for engineers*. Boston: McGraw-Hill Higher Education.

Course Title	**Introduction to Plasma Engineering**
Instructor	Dr. Ioannis Fitilis fitilis@hmu.gr
Study level	Bachelor 3rd year or Master
ECTS	3
Prerequisite	Basic knowledge of electromagnetism and optics (Lorentz force, e/m waves formalism, Maxwell equations, dielectric\magnetic constant, refractive index, refraction, etc.)
Learning Outcomes	The course introduces the students to the fundamental of plasma and the applications of plasma technology. After completing the course, the student will be able to: ✓ understand the plasma phase of the matter, the unique properties it has and the different types of plasmas. ✓ calculate/evaluate basic plasma parameters ✓ mention the different formulations of plasma description and where could be applied ✓ recognize the different type of waves that could develop/propagate in plasmas and their properties ✓ have knowledge of the different technologies of plasma sources and their properties ✓ describe various plasma applications and choose the proper plasma sources ✓ use proper diagnostics for plasma sources characterization ✓ mention and describe the various type of dense plasma generators and their applications.
Contents	• Introduction to plasma: definitions, properties, Debye shielding, temperatures-densities, types of plasmas, plasma frequency. • Plasma descriptions: particle motion, kinetic description, two-fluid description, magneto-hydrodynamic (MHD) description, ideal-MHD, plasma conductivity. • Waves in plasma: waves in non-magnetized plasma, phase velocity, refractive index, critical density. Waves in magnetized plasma, cutoff-resonance, MHD waves. • Plasma sources: electric discharge tubes, plasma torch, corona discharge, Dielectric Barrier discharge, RF discharge, Microwave discharge. Electron beam plasmas. Laser plasmas. • Plasma applications: Material processing, nanolithography, plasma antennas, plasma monitor, plasma thrusters, spectroscopy, sterilization, • Plasma diagnostics: diagnostics of magnetic field, current, particle flow, refractive index, spectroscopy. Diagnostics with X-rays, ion beam. • Dense plasma & applications: pulsed power plasma devices. Z-pinch, plasma instabilities, X-pinch & other pinch configurations, Dense Plasma Focus, Tokamak, Stellarator. high photon energy sources, particle acceleration, fusion energy.
Course type	Weekly Lectures 2hr/week
Assessment	Written exams 60%, class contribution 20%, short project presentation 20%.

Bibliography	1. Introduction to Plasma Technology: Science, Engineering and Applications Dr. John Ernest Harry, 2010, Wiley-VCH ISBN Print:9783527327638 Online:9783527632169 2. Plasma Physics and Engineering, A. Fridman, L. A. Kennedy, 2011, CRC Press ISBN 9781439812280 3. Plasma Engineering: Applications from Aerospace to Bio and Nanotechnology, 1st edition (or 2nd edition), M. Keidar , I. Beilis, 2013 (2018), Academic Press ISBN: 978-0123859778 (978-0128137024) 4. Principles of Plasma Physics for Engineers and Scientists, U. S. Inan, M. Gołkowski, 2011, Cambridge University Press ISBN 13:9780521193726

Course Title	**Display Technologies**
Instructor	Dr. Ioannis.Kaliakatsos giankal@hmu.gr
Study level	≥4 semester
ECTS	4
Prerequisite	Electronic Devices and Circuits
Objectives	The class examines the fundamentals of 2D and 3D display technologies (e.g. human visual system, color and depth perception, color theory and metrology, and state-of-the-art display technologies), display performance evaluation and calibration, and display research frontiers. The class is suited for both graduate and undergraduate students. You are encouraged to talk to the Instructor to find out if this is the right course for you.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: ✓ Understand Anatomy of Eye, Light Detection and Sensitivity, Spatial Vision and Pattern Perception, Binocular Vision and Depth Perception. ✓ Understand Photolithography for Thin Film LCD, Wet Etching, Dry Etching; Flexible Displays. ✓ Understand Thin Film Electroluminescent Displays, AC Powder Electroluminescent Displays; Organic Electroluminescent Displays: OLEDs, Active Matrix for OLED Displays ✓ Be aware of Colorant Transposition Displays, MEMs Based Displays, 3-D Displays, 3-D Cinema Technology, Autostereoscopic 3-D Technology ✓ Understand Liquid Crystals on Silicon Reflective Micro-display, Trans missive Liquid Crystal Micro-display, MEMs Micro-display, DLP Projection Technology.
Indicative Syllabus	1.Introduction (2 hours) ○ How applications have been driving display developments? ○ Evolution of display technology 2. Human visual system (8 hours) ○ Eye anatomy and eye optics ○ Visual performance of the eye

	○ Models of visual performance and photometry 3. Color vision and colorimetry (12 hours) ○ Color vision basics ○ Color matching experiments and color matching functions ○ Color systems and spaces ○ Colorimetry 4. 2D display technology and operation (16 hours) ○ Display system interfaces and performance parameters ○ CRT displays ○ Flat panel displays: AMLCD, LCOS, Plasma, OLED, ○ Projection systems ○ New display technologies: high dynamic range display, enriched color display 5.Display metrology: display performance measurement and calibration (6 hours) ○ General principles of display evaluation ○ Evaluation of 2D displays ○ Color management and calibration 6. Binocular vision and 3D display technology (6 hours) ○ Binocular vision and perception basics ○ 3D display principles and techniques ○ head-mounted displays ○ Spatially immersive displays
Teaching/Learning Methodology	**Lecture:** the fundamentals of physics, chemistry, design, manufacturing processes and various applications of displays will be described using ppt presentations, demonstrating videos, Internet. The students are free to request help. The students are encouraged to solve problems and to use their own knowledge to verify their solutions before seeking assistance. **Tutorial:** a set of problems and group discussion topics will be arranged in the tutorial classes. Students are encouraged to solve problems before having solutions.
Assessment Methods	Continuous assessment: 40% Written Report 20% Oral Presentation 40% Continuous assessment consists of assignments, laboratory reports and mid-term test. The continuous assessment will assess the students' understanding of basic concepts and principles in materials science.
Students' Working Load - ECTS	Lectures 50 hours Written Report 8 hours Oral Presentation 2 hours Homework 60 hours In total 120 hours → **4ECTS**
Reading List and References	1. Organic Electronics: Materials, Manufacturing, and Applications: Hagen Klauk 2. Organic Electronics II: More Materials and Applications: Wiley, Hagen Klauk 3. Color vision and colorimetry: theory and applications (by Daniel Malacara)

	4. Electronic image display (by Jon C. Leachtenauer)

Course Title	**Organic Electronics Devices**
Instructor	Dr. Ioannis.Kaliakatsos giankal@hmu.gr
Study level	≥4 semester
ECTS	4
Prerequisite	None
Objectives	The aim of this subject is to provide a course treating the emerging field of Organic Electronics from basics. Organic Semiconductors are an important introductory part of this course. The theory and practice of fabricating discrete and integrated molecular electronic devices and their applications in diverse fields is covered. Means of achieving various electronics functionalities such us memory, logic, etc. by the molecules are treating. Lessons from biological molecular behavior for organic electronics is also examined. An introduction to nano-photonics and nano-FET is also included
Intended Learning Outcomes	Upon completion of the subject, students will be able to: ✓ Understand the physics behind organic semiconductors ✓ Calculate transport properties in the mesoscopic systems. ✓ Identify the molecules that can be used for different functions in organic electronics ✓ Chose a proper method (or different methods) for fabricating particular component ✓ Exploit the behavior of biomolecules for organic electronics ✓ Gain an introductory knowledge on nano-photonics and nanodevices
Indicative Syllabus	• Introduction to Organic Electronic • Electronic transport in crystalline organic materials and conductive polymers • Conducting Polymers, small molecules organic semiconductors, • Polymer organic semiconductor, • Electrical and optical properties of organic semiconductors. • Basic Organic LED structure, thin film layers: Hole injection, hole transport, emissive, electron transport and electron injection layers used in organic LEDs. • Fabrication and characterization techniques. • Recent advances in organic LEDs • Applications of OLEDs • History of Organic TFTs • Device design of OTFT, device preparation and characterization • Applications of OTFTs • Optically-pumped organic semiconductor lasers • Electrically-driven organic lasers • Recent advances in solid-state organic lasers • NanoFETs • Fabrication of different types of sensors using organic semiconductors,

	• Study of different sensors using conjugated polymers.
Teaching/Learning Methodology	**Lecture:** the fundamentals of organic semiconductors physics and various applications in organic electronics devices will be described using ppt presentations, demonstrating videos, Internet. The students are free to request help. The students are encouraged to solve problems and to use their own knowledge to verify their solutions before seeking assistance. **Tutorial:** a set of problems and group discussion topics will be arranged in the tutorial classes. Students are encouraged to solve problems before having solutions.
Assessment Methods	Continuous assessment: 40% Written Report 20% Oral Presentation 40% Continuous assessment consists of assignments, laboratory reports and mid-term test. The continuous assessment will assess the students' understanding of basic concepts and principles in materials science.
Students' Working Load - ECTS	Lectures 50 hours Written Report 8 hours Oral Presentation 2 hours Homework 60 hours In total 120 hours → **4ECTS**
Reading List and References	1. Handbook of Organic electronics and Photonics: Hari Singh Nalwa 2. Organic Electronics: Materials, Manufacturing, and Applications: Hagen Klauk 3. Organic Electronics II: More Materials and Applications: Wiley, Hagen Klauk

Course Title	**Antennas & Wireless Communications**
Instructor	Asc. Professor **Ioannis Vardiambasis**, Director of the Laboratory of Telecommunications & Electromagnetic Applications, Directors of the Division of Telecommunications & Networks, Director of the MSc in "Telecommunication & Automation Systems" at the Department of Electronic Engineering of the Hellenic Mediterranean University, ivardia@hmu.gr
Study level	3rd Year and above
ECTS	3-ECTS* * Based on the 5-year undergraduate curriculum of the Electronic Engineering Department of HMU (Course 502), but modified according to the actual workload of the Erasmus students.
Prerequisite	Basic knowledge of engineering electromagnetics (electromagnetic fields and waves, Maxwell equations, boundary conditions, boundary value problems, etc.)
Learning Outcomes	The explosive growth and continuous development of the wireless and personal telecommunication systems creates a growing demand for telecommunication engineers with (a) very good background on the theory of antennas and electromagnetic

	wave propagation, and (b) special knowledge and experience in modern wireless systems. This course prepares students for a career in the rapidly evolving telecommunications industry, because the antenna is the interface between any telecommunication system and the transmission means in wireless communications. This course aims to get students acquainted with the principles of antenna theory and electromagnetic wave propagation, in order to use them during analysis and design of wireless telecommunication links. Upon successful completion of the course, students will have acquired knowledge, skills, appropriate tools for dealing with practical applications related to antennas and propagation models, as well as experience in designing and optimizing real antennas. More specifically students will be able to: + understand electromagnetic theory and its applications to antennas and transmission of electromagnetic signals carrying information, + understand the theory of antennas and electromagnetic wave propagation in a uniform way, in order to use them in the analysis and design of wireless telecommunications, + describe the basic mechanisms of radio wave propagation and understand the interaction of electromagnetic waves with the environment, + be aware of the wave propagation phenomena caused in the real environment and the measurement methods used in practice, + calculate and measure the basic antenna parameters and characteristics (eg radiated power, radiation intensity, directivity, gain, radiation resistance), + compare antenna characteristics (advantages/disadvantages), deciding which is the most suitable antenna for each practical application, + perform antenna and electromagnetic radiation measurements, + familiarize with various practical antenna devices, + calculate the radiation diagram of an antenna, when its current distribution is known, + evaluate propagation models and select the appropriate model for calculating losses in a telecommunications link, + prepare radio coverage studies, + be informed about the latest developments in the field of wireless and personal communication systems, + analyze and design wireless telecommunication systems according to the respective needs, + be ready to supervise and maintain wireless telecommunications systems. The course is at the core of the Electronic Engineer curriculum. **Note:** The project-based version of the course will help the Erasmus students to get many of the above mentioned learning outcomes.
Contents	The project-based version of the course will cover many of the following subjects: Review on telecommunications and electromagnetic theory. Electric, magnetic, electromagnetic field. Electrical signals. Telecommunication systems. Wireless telecommunications. Frequency spectrum (HF, VHF, UHF, microwaves). Maxwell Equations. Wave equations. Boundary conditions. Scalar and vector potentials. Fields of sinusoidal time change. Electromagnetic radiation and power. Poynting vector. Planar electromagnetic waves [polarization, wave propagation in conductive and non-conductive media, phase and group velocities, reciprocity]. Reflection and refraction

	of planar waves [Snell's law, Fresnel equations, reflection and transmission coefficients, normal and oblique incidence on perfect dielectric and lossy media, standing waves, incidence on dielectric plates, scattering]. Transmission lines [complex and characteristic line resistance, wave reflection, transmitted power, adjustment, standing wave, Smith diagram]. Microwave waveguides [parallel plated, rectangular, circular, coaxial, microstrip, dielectric]. Optical waveguides. TE, TM and TEM propagation modes. Power and losses. Rectangular and cylindrical cavities. Electromagnetic waves in free space. Introduction to antenna theory. Antenna and transmission line matching. Radiation mechanisms. Antenna characteristics, radiation diagrams, gain, bandwidth, quality factor. Theory of simple linear antennas. Analysis of antennas with assumed current distributions. Hertz dipole. Applications of electrically small antennas. Linear dipole antennas. Field and radiation pattern, directivity, gain, radiation resistance, active antenna height. Dipole λ/2. Traveling wave antennas. Loop antennas. Antennas above perfect ground. Mirroring and image theory. General analysis of the radiation field of any antenna. Applications. Antenna arrays. Rhombic antenna. Principles of antenna design. Applications. Linear arrays. Uniform linear arrays with small and large number of elements. Polynomial theory of linear arrays. Applications. Superdirective antennas. Phase detection. Methods of radiation pattern synthesis. Dolph-Chebyshev linear arrays. Composition of linear arrays with Fourier sums. Applications and examples of antenna analysis and synthesis. Antenna applications and measurements. Aperture antennas. Radiation from flat surfaces. Radiation from rectangular surfaces. Horn antennas. Parabolic reflector antennas. Horn-reflector antennas. Lens antennas. Passive reflectors. Input antenna resistance. Equivalent sources. Magnetic charges and currents. Voltage and current sources. Reciprocity theorem. Self-impedance of conductive antennas. Voltage induced on open-ended antenna by an incident field. Induced electromotive force method. Transmission and reception equivalent circuits. Dipole near field. Bandwidth. Receiving antennas. Antenna polarization. Noise in telecommunication systems and antenna noise temperature. Dipole self-impedance. Antenna as terminal impedance. Asymmetric excitation of dipoles. Matching conditions and maximum transmitted power. Matching using stubs. Folded dipole. Mutual complex resistance between dipoles. Antenna array excitation impedance. Impedance of dipoles above perfect ground. Antenna feeding with appropriate currents. Yagi-Uda antennas. The antenna as a receiver. Equality of mutual complex resistances. Equality of transmission and reception radiation patterns. Equality of transmission and reception self-impedances. Equality of transmission and reception antenna active heights. Active antenna surface. Received to transmitted power ratio. Transmission of waves in free space. Friis equation. Losses and maximum transmission distance. Radar equation. Propagation of electromagnetic waves in the earth environment. Ground reflection of obliquely incident plane waves with vertical

	or parallel polarization. Brewster angles. Ground wave. Space wave. Surface wave. Antennas elevated above ground level. Approximate relationship for propagation at very high frequencies. Near ground surface wave tilt and polarization. Spherical earth. Effects of the earth's curvature. Line-of-sight condition. Barrier effects in wave propagation. Diffraction links. Tropospheric refractive index. Tropospheric propagation, refraction, waveguiding, scattering. Radio horizon. Multiple routes. Intervals. Differential reception systems. Atmosphere attenuation. Critical frequency and ionosphere changes. Ionospheric propagation, refraction, reflection, scattering. Applications. Calculation of radio links. Over sharp obstacle links. Line-of-sight links. Above perfect ground links. Technical characteristics and practical applications of wireless links.
Course type	Project-based (exclusively)
Assessment	Final project evaluation. Blended learning using synchronous and asynchronous methods.
Bibliography	• C. Parini, S. Gregson, J. McCormick, D.J. van Rensburg, and T. Eibert, *Theory and Practice of Modern Antenna Range Measurements*, SciTech Publishing, 2021 (2nd Edition), ISBN-10: 1839531282. • ARRL, *The ARRL Antenna Book for Radio Communications*, American Radio Relay League, 2019 (24th edition), ISBN-10: 1625951116. • J. Volakis, *Antenna Engineering Handbook*, Mc Graw Hill, 2018 (5th edition), ISBN-10: 1259644693. • J.D. Kraus, R.J. Marhefka, and A.S. Khan, *Antennas and Wave Propagation*, Mc-Graw Hill India, 2017 (5th edition), ISBN-10: 9352606183. • R.J. Mailloux, *Phased Array Antenna Handbook*, Artech House, 2017 (3rd Edition), ISBN-10: 1630810290. • C.A. Balanis, *Antenna Theory: Analysis and Design*, Wiley, 2016 (4th edition), ISBN-10: 1118642066. • W.L. Stutzman and G.A. Thiele, *Antenna Theory and Design*, Wiley, 2012 (3rd edition), ISBN-10: 0470576642. • S.K. Das and A. Das, *Antenna and Wave Propagation*, Tata Mc-Graw Hill Education, 2012, ISBN-10: 1259097587. • J. Carr and G. Hippisley, *Practical Antenna Handbook*, Mc Graw Hill, 2011 (5th edition), ISBN-10: 9780071639583. • R.E. Collin, *Antennas and Radiowave Propagation*, Mc-Graw Hill, 1985, ISBN-10: 0070118086. ***Related to Wireless Communications*** • R.L. Haupt, *Wireless Communication Systems: An Introduction*, Wiley-IEEE Press, 2019, ISBN-10: 1119419174. • R.W. Heath and A. Lozano, *Foundations of MIMO Communication*, Cambridge University Press, 2018, ISBN-10: 0521762286. • C. Beard and W. Stallings, *Wireless Communication Networks and Systems*, Pearson, 2015, ISBN-10: 9780133594171. • D. Tse and P. Viswanath, *Fundamentals of Wireless Communication*, Cambridge University Press, 2005, ISBN-10: 0521845270.

	• A. Goldsmith, *Wireless Communications*, Cambridge University Press, 2005, ISBN-10: 0521837162. • W. Stallings, *Wireless Communications and Networks*, Pearson, 2004 (2nd Edition), ISBN-10: 9788132231561. • T. Rappaport, *Wireless Communications: Principles and Practice*, Prentice Hall, 2002 (2nd Edition), ISBN-10: 0130422320.

Course Title	**Satellite Communications and Systems**
Instructor	Asc. Professor **Ioannis Vardiambasis**, Director of the Laboratory of Telecommunications & Electromagnetic Applications, Directors of the Division of Telecommunications & Networks, Director of the MSc in "Telecommunication & Automation Systems" at the Department of Electronic Engineering of the Hellenic Mediterranean University, ivardia@hmu.gr
Study level	3rd Year and above
ECTS	3-ECTS* * Based on the 5-year undergraduate curriculum of the Electronic Engineering Department of HMU (Course 712), but modified according to the actual workload of the Erasmus students
Prerequisite	Basic knowledge of telecommunication systems.
Learning Outcomes	Satellites have the unique ability to provide coverage in large geographic areas and to connect remote and inaccessible telecommunication nodes. Thus satellite networks are now an integral part of most telecommunications systems. In recent decades the technology of satellite systems is advancing constantly and the use of all kind of satellites for long distance communications is developing rapidly. Today, electronic engineers face the absolute necessity to have in depth knowledge of the satellite technology, communications and links, because satellite communications play an ever-increasing role in modern telecommunication systems. This course properly prepares students for a career in the rapidly evolving telecommunications industry. The aim of this course is to familiarize tomorrow's electronics/telecommunications engineers with the analysis of satellite communication systems and the design of satellite links. The course covers the total of the required theoretical and practical background. Upon successful completion of the course, students will have acquired the necessary knowledge and skills to: + understand the structure of any satellite communications system, + understand the basic principles and concepts governing satellite communications, + understand the operation of satellite systems and the principles of modern telecommunications networks, + understand the design issues and options concerning satellite links, + have experience in the design and optimization of real telecommunication systems, which can be used for the analysis and design of new microwave and satellite radio links, + design and analyze satellite communication systems, + be familiar with various practical antenna devices, + have initial training in satellite link design,

	+ be familiar with radio propagation models and modern techniques for digital modulation and voice-data information encoding, + be informed about the latest developments in the field of wireless and personal communication systems, + be familiar with the modern satellite technology, communications systems, assembly and subsystems, + supervise and maintain satellite communication systems, + understand the factors that degrade the quality of satellite wireless links and the methods to overcome this degradation, + evaluate the quality of services provided by satellite communications systems, + be familiar with the multiple access satellite networking techniques and the modern standards for satellite communications and mobile telephony systems. The course is at the core of the Electronic Engineer curriculum. **Note:** The project-based version of the course will help the Erasmus students to get many of the above mentioned learning outcomes.
Contents	The project-based version of the course will cover many of the following subjects: Configuration of a satellite communication system. Radio frequencies of satellite services. Motion, position and orbit of satellites. Satellite networks. Geosynchronous, geostatic, GEO, LEO satellites. Satellite segments. Basic features related to satellite link design [radio regulations, transmission/broadcasting types, line of sight, link power budget, refractive index, Fresnel zones, troposcatter links]. Electromagnetic wave propagation and the satellite radio channel. Radiation characteristics and types of satellite dishes. Parabolic antenna and targeting control. Noise measures. Signal noise in satellite systems. Space environment. Absorption, diffusion, refraction and depolarization of electromagnetic wave signals in the satellite channel. Effects of rainfall, noise and propagation medium on the satellite link power balance. Frequency reuse techniques. Channel configuration, modulation and coding. Analog techniques PM, FM. Digital communication techniques. Digital signal modulation. Custom filter analysis. Error possibility in digital communications. FSK, PSK, QPSK, DPSK, DQPSK, MSK modulations/encodings (with emphasis on demodulation, spectrum and error probability). Spectrum modulation techniques. Telecommunication satellite and ground station platform, configuration and subsystems (monitoring, control, position stabilization, orbit determination, propulsion, telemetry, communication, thermal control, power supply/generation). Satellite types. Earth stations. Receiver input. RF-filters and satellite signal frequency converters. Power amplifiers and low noise satellite signal amplifiers. Amplification non-linearity. Effects of noise, filtering, frequency conversion and amplification on satellite system design. Analysis of error possibility in satellite systems. Methods of coding, detection and error correction in satellite systems. Rectangular, semi-rectangular, linear (Hamming, Golay, BCH, Reed-Solomon), circular and convolutional codes. Error checking, parity check, syndromes. Error correction. Spectrum control. Satellite channel capacity. Coding gain. Channel discrete model. Coding error possibility. State diagrams. Coding trees. Trellis chart. Coding systems evaluation.

	Communication payload. Channel and modulation type performance. Bit error rate in digital data transmission systems. Noise factor. Noise models (white, pink, Gaussian). Factors affecting satellite link reliability and availability. Space differential reception. Effects of rainfall, depolarization and neighboring satellite interference on satellite system performance. Study of satellite communication systems. Satellite link design based on ITU's specifications and recommendations. Applications. Multiplexing techniques FDM, FDM/MA, TDM, TDM/MA, CDMA, Carrier Sense Multiple Access, CSMA/ Collision Avoidance, CSMA/Collision Detection (signal to noise ratios, multipath, jamming). Frequency Division Multiple Access System FDMA (with emphasis on nonlinear phenomena effects). Time Division Multiple Access System TDMA (with emphasis on synchronization, carrier retrieval, identity word detection and frame synchronization). Code division multiple access systems DS-CDMA and FH-CDMA (with emphasis on interpolation analysis). Satellite system protocols ALOHA, S-ALOHA, R-ALOHA. Services: telecommunication audio systems, telephony, analog TV, digital TV, direct to home broadcasts, SMATV, satellite news gathering, VSAT, meteorology, global atmospheric research program, geostationary meteorological satellites, sea navigation, Global Positioning System, differential GPS, mobile communications, Iridium, computer networks, fast internet, video on demand, multimedia services, video conferencing, telemedicine, geography, topography, GIS. Satellite installation and launch vehicles. Reliability of satellite communication systems.
Course type	Project-based (exclusively)
Assessment	Final project evaluation. Blended learning using synchronous and asynchronous methods.
Bibliography	• G. Maral, M. Bousquet, and Z. Sun, *Satellite Communications Systems: Systems, Techniques and Technologies*, Wiley, 2020 (6th Edition), ISBN-10: 1119382084. • T. Pratt and J.E. Allnut, *Satellite Communications*, Wiley, 2019 (3rd Edition), ISBN-10: 1119482178. • L.J. Ippolito, *Satellite Communications Systems Engineering: Atmospheric Effects, Satellite Link Design and System Performance*, Wiley, 2017 (2nd Edition), ISBN-10: 1119259371. • M.O. Kolawole, *Satellite Communications Engineering*, CRC Press, 2016 (2nd Edition), ISBN-10: 1138075353. • D. Minoli, *Innovations in Satellite Communications and Satellite Technology: The Industry Implications of DVB-S2X, High Throughput Satellites, Ultra HD, M2M, and IP*, Wiley, 2015, ISBN-10: 1118984056. • M. Richharia, *Mobile Satellite Communications: Principles and Trends*, Wiley, 2014 (2nd Edition), ISBN-10: 1119998867. • R. Cochetti, *Mobile Satellite Communications Handbook*, Wiley, 2014 (2nd Edition), ISBN-10: 1118357027. • K.N. Raja Rao, *Satellite Communication: Concepts and Applications*, PHI Learning, 2013 (2nd Edition), ISBN-10: 8120347250.

	• R.M. Gagliardi, *Satellite Communications*, Springer, 2012 (2nd Edition), ISBN-10: 9401097623. • T.M. Braun, *Satellite Communications Payload and System*, Wiley-IEEE Press, 2012, ISBN-10: 0470540842. • F. Gustrau, *RF and Microwave Engineering: Fundamentals of Wireless Communications*, Wiley, 2012, ISBN-10: 1119951712. • P. Fortescue, G. Swinerd, and J. Stark, *Spacecraft Systems Engineering*, Wiley, 2011 (4th Edition), ISBN-10: 047075012X. • D.R. Cheruku, *Satellite Communication*, IK International Publishing, 2009, ISBN-10: 9380026412. • D. Roddy, *Satellite Communications*, McGraw-Hill, 2006 (4th Edition), ISBN-10: 0071462988. • A. Fares, *Satellite Communications Engineering*, BookSurge Publishing, 2006, ISBN-10: 1419639056.

Course Title	**Scattering, Propagation & Radiation of Electromagnetic Waves**
Instructor	Asc. Professor **Ioannis Vardiambasis**, Director of the Laboratory of Telecommunications & Electromagnetic Applications, Directors of the Division of Telecommunications & Networks, Director of the MSc in “Telecommunication & Automation Systems” at the Department of Electronic Engineering of the Hellenic Mediterranean University, ivardia@hmu.gr
Study level	4th Year and above
ECTS	3-ECTS* * Based on the 5-year postgraduate curriculum of the Telecommunications & Automations Systems MSc of the Electronic Engineering Department of HMU (Course TeleAutoS-11), but modified according to the actual workload of the Erasmus students
Prerequisite	Basic knowledge of engineering electromagnetics (electromagnetic fields and waves, Maxwell equations, boundary conditions, boundary value problems, etc.)
Learning Outcomes	Aim of this course is the qualitative understanding and mathematical formalism of the concepts concerning the electromagnetic fields and the propagation, radiation and scattering of electromagnetic waves through their correlation with intelligible applications and phenomena, in order to create the necessary background, knowledge and experiences at the level of the advanced engineering electromagnetics and computing. Additional purpose is to develop the skills and abilities, which are necessary for the scientific and technical subject of the electronic and telecommunication engineer. Upon completion of the course the postgraduate students are expected to be able to: + understand the correlation between several types of sources and the corresponding fields’ characteristics, + understand the concepts of vector field, electric field, Ampere’s law, magnetic field, Faraday's law, Gauss’ laws, induction, wave, interconnected existence of electric and magnetic field in case of time change, physical origin of electromagnetic waves, Maxwell's integral and differential equations for continuous and time-varying fields, propagation, radiation and scattering of electromagnetic waves and fields in space and

	time, + understand the electrical properties of materials (conductive/dielectric, isotropic/anisotropic, homogeneous/inhomogeneous, dispersive/nondispersive, linear/nonlinear, time-constant/time-varying, simple/metamaterials), + calculate differential (divergence, rotation) and integral quantities (flow, circulation) of fields in the main coordinate systems (Cartesian, cylindrical, spherical), as well as the electric and magnetic field, the corresponding potentials and the amounts of energy in given physical problems, + elaborate on electromagnetic theory and Maxwell’s equations, + analyze and evaluate the technological applications concerning the broader field of electronic and telecommunication engineering, recognizing the presence and impact of electromagnetic field phenomena, + formulate given time-varying electromagnetic problems into mathematical expressions of boundary value problems, through differential equations with appropriate initial and/or boundary conditions, + handle simple and rather complex boundary value problems of electromagnetic field calculation using Maxwell equations, boundary conditions, auxiliary potentials and appropriate methods and techniques, + systematically deal with electromagnetic boundary value problems using analytical and computational methods, + understand the various phenomena of electromagnetic wave propagation, radiation and scattering, along with the corresponding quantities/concepts that characterize, distinguish and categorize them, + apply the taught methods and techniques for the analysis of electromagnetic problems, the composition of proper solutions and the evaluation of appropriate alternatives. The course is at the core of the Electronic/Telecommunications Engineer postgraduate curriculum. **Note:** The project-based version of the course will help the Erasmus students to get many of the above mentioned learning outcomes.
Contents	The project-based version of the course will cover many of the following subjects: Time-varying and time-harmonic electromagnetic fields (Maxwell’s equations, constitutive parameters and relations, circuit-field relations, boundary conditions, power and energy, time-harmonic electromagnetic fields). Electrical properties of matter (dielectrics, polarization and permittivity; magnetics, magnetization and permeability; current, conductors and conductivity; semiconductors; superconductors; metamaterials; linear, homogeneous, isotropic and nondispersive media; AC variations in materials). Wave equation and its solutions (time-varying electromagnetic fields; time-harmonic electromagnetic fields; solutions to the wave equation in the rectangular, cylindrical and spherical coordinate systems). Wave propagation and polarization (Transverse Electromagnetic Modes; uniform plane waves in unbounded lossless and lossy media at principal axis and oblique angle; polarization). Reflection and transmission (Normal and oblique incidence in lossless media; lossy media; reflection and transmission of single slab, multiple layers and multiple

	interfaces; polarization characteristics on reflection; metamaterials). Auxiliary vector potentials; construction of solutions; radiation and scattering equations (vector potentials; construction of solutions; solution of the inhomogeneous vector potential wave equation; far-field radiation; radiation and scattering equations). Electromagnetic theorems and principles (duality theorem; uniqueness theorem; image theory; reciprocity theorem; reaction theorem; volume equivalence theorem; surface equivalence theorem (Huygens's principle); induction theorem; physical equivalent and physical optics equivalent; induction and physical equivalent approximations). Rectangular cross-section waveguides and cavities (rectangular waveguide; rectangular resonant cavities; hybrid LSE and LSM modes; partially filled waveguide; transverse resonance method; dielectric waveguide; artificial impedance surfaces; stripline; microstrip line; ridged waveguide). Circular cross-section waveguides and cavities (circular waveguide; circular cavity; radial waveguides; dielectric waveguides and resonators). Spherical transmission lines and cavities (construction of solutions; biconical transmission line; spherical cavity). Scattering (infinite line-source cylindrical wave radiation; plane wave scattering by planar surfaces; cylindrical wave transformations and theorems; scattering by circular cylinders; scattering by a conducting wedge; spherical wave orthogonalities, transformations, and theorems; scattering by a sphere). Integral equations and Method of Moments (integral equation method; electric and magnetic field integral equations; finite diameter wires; two-dimensional radiation and scattering; Pocklington's wire radiation and scattering; Numerical Electromagnetics Code). Geometrical theory of diffraction (geometrical optics; straight edge diffraction at normal and oblique incidence; curved edge diffraction at oblique incidence; equivalent currents in diffraction; slope diffraction; multiple diffractions). Diffraction by wedge with impedance surfaces (impedance surface boundary conditions and reflection coefficients; Maliuzhinets impedance wedge solution; geometrical optics; surface wave terms; diffracted fields; surface wave transition field; computations). Green's Functions (Green's functions in engineering; Sturm–Liouville problems; two-dimensional Green's function in rectangular coordinates; Green's identities and methods; Green's functions of the scalar Helmholtz equation; dyadic Green's functions).
Course type	Project-based (exclusively)
Assessment	Final project evaluation. Blended learning using synchronous and asynchronous methods.
Bibliography	• A.S. Khan and S.K. Mukerji, *Electromagnetic Fields: Theory and Applications*, CRC Press, 2020. • N. Ida, *Engineering Electromagnetics*, Springer, 2020 (4th Edition), ISBN-10: 3030155560. • S. Balaji, *Electromagnetics Made Easy*, Springer, 2020, ISBN-10: 9811526575.

	• M.-S. Kao and C.-F. Chang, *Understanding Electromagnetic Waves*, Springer, 2020, ISBN-10: 3030457079. • M. Sadiku, *Elements of Electromagnetics*, Oxford University Press, 2018 (7th Edition), ISBN-10: 0190698616. • M. Nahvi and J. Edminister, *Schaum's Outline of Electromagnetics*, McGraw-Hill, 2018 (5th Edition), ISBN-10: 126012097X. • A. Ishimaru, *Electromagnetic Wave Propagation, Radiation, and Scattering: From Fundamentals to Applications*, Wiley-IEEE Press, 2017 (2nd Edition), ISBN-10: 1118098811. • A.V. Osipov and S.A. Tretyakov, *Modern Electromagnetic Scattering Theory with Applications*, Wiley, 2017, ISBN-10: 0470512385. • D.H. Werner and Z.H. Jiang, *Electromagnetics of Body Area Networks: Antennas, Propagation, and RF Systems*, Wiley-IEEE Press, 2016, ISBN-10: 1119029465. • E.F. Kuester and D.C. Chang, *Electromagnetic Boundary Problems*, CRC Press, 2015, ISBN-10: 1498730264. • U. Inan, A. Inan, and R. Said, *Engineering Electromagnetics and Waves*, Pearson, 2014 (2nd Edition), ISBN-10: 0132662744. • F. Ulaby and U. Ravaioli, *Fundamentals of Applied Electromagnetics*, Pearson, 2014 (7th Edition), ISBN-10: 0133356817. • C.A. Balanis, *Advanced Engineering Electromagnetics*, Wiley, 2012 (2nd Edition), ISBN-10: 0470589485. • J.G. van Bladel, *Electromagnetic Fields*, Wiley-IEEE Press, 2007 (2nd Edition), ISBN-10: 0471263885. • S.M. Wentworth, *Applied Electromagnetics: Early Transmission Lines Approach*, Wiley, 2007, ISBN-10: 0470042575. • R.K. Wangsness, *Electromagnetic Fileds*, Wiley, 2007 (2nd Edition), ISBN-10: 0471811866. • S.M. Wentworth, *Fundamentals of Electromagnetics with Engineering Applications*, Wiley, 2006, ISBN-10: 9780470105757. • R.E. Collin, *Field Theory of Guided Waves*, Wiley-IEEE Press, 1990 (2nd Edition), ISBN-10: 0879422378. • D. Cheng, *Field and Wave Electromagnetics*, Addison-Wesley, 1989 (2nd Edition), ISBN-10: 0201128195. **<u>Related scientific journals</u>** • IEEE Transactions on Microwave Theory and Techniques (IF=3.176) • IEEE Microwave and Wireless Components Letters (IF=2.169) • IET Microwaves, Antennas and Propagation (IF=1.739) • Microwave and Optical Technology Letters, Wiley (IF=0.948) • IEEE Transactions on Antennas and Propagation (IF=4.13) • IEEE Antennas and Wireless Propagation Letters (IF=3.448) • IEEE Antennas and Propagation Magazine (IF=3.007) • International Journal of Antennas and Propagation (IF=1.378) • MDPI Electronics

Course Title	**Electromagnetic Compatibility**
Instructor	Asc. Professor **Ioannis Vardiambasis**, Director of the Laboratory of Telecommunications & Electromagnetic Applications, Directors of the Division of Telecommunications & Networks, Director of the MSc in “Telecommunication & Automation Systems” at the Department of Electronic Engineering of the Hellenic Mediterranean University, ivardia@hmu.gr
Study level	3rd Year and above
ECTS	3-ECTS* * Based on the 5-year undergraduate curriculum of the Electronic Engineering Department of HMU (Course 887), but modified according to the actual workload of the Erasmus students.
Prerequisite	Basic knowledge of electromagnetics.
Learning Outcomes	The course covers the theoretical and practical background required for: electromagnetic theory and its applications, electromagnetic compatibility (EMC) principles, electromagnetic interference (EMI) and methods for suppressing EMI effects, EMC measurements, analysis and design of electromagnetically compatible devices and systems. Upon successful completion of the course the students will be able to: + have in-depth knowledge of electromagnetic theory principles, + be able to present uniformly the theory of propagation, scattering and radiation of electromagnetic waves, so that the electromagnetic behavior of practical telecommunication systems can be understood, + explain and present in a comprehensive way the theory of electromagnetic compatibility, + be extremely familiar with possible electromagnetic effects-interference in devices and systems, + be informed about the regulations and the electromagnetic compatibility standards currently applicable, + measure electromagnetic interference in various cases, + certify the electromagnetic compatibility of simple devices, + design circuits and devices free from electromagnetic interference. The course is at the core of the Electronic Engineer curriculum. **Note:** The project-based version of the course will help the Erasmus students to get many of the above mentioned learning outcomes.
Contents	The project-based version of the course will cover many of the following subjects: Electromagnetic Compatibility (EMC) overview. Definitions. Examples of EMC problems. Noise sources (natural and man-made sources). General methods for solving interference problems and complying with EMC requirements. EMC regulations and tests. Basic concepts of electromagnetism and their use in EMC (ferromagnetic materials). Maxwell's equations from the EMC point of view (Maxwell, Poisson and Laplace equations). Near and far field approaches and energy flow. The near field, the far field and the energy flow around small wire and small loop antennas. Fields of high and small impedance. Reaction fields.

	Electromagnetic waves in various media (refractive index, characteristic impedance of dielectrics). Near field impedance. The importance of the impedance concept. The impedance in front of a boundary surface (λ/2 dielectric windows, λ/4 and λ/2 layers). Plane waves in arbitrary media (propagation constant, penetration depth). Wave propagation in good conductors. Internal resistance of conductors. Diffusion. Maxwell's equations in integral form. Faraday and Ampere laws. Electric fields in conductors. Illustrative examples in EMC. Interference in small loops. Interpretation of measurements at various distances. Capacitive and inductive coupling. Transient switching phenomena (transformer feeding, transformer's power supply interruption, early time transitions). Input resistance of materials with losses. TEM wave incidence on boundary surfaces. TEM wave propagation. A first approximation of the transmission factor. Re-reflection effects. Shielding efficiency. Decibels and Nepers. Multi-layer media reflection coefficient. Absorber design and affecting factors. Absorber performance at various frequencies. Real absorber examples. Transmission lines and waveguides. Impedance and phase shift of ideal lines. Characteristic impedance of lines with losses. Voltage and current reflection coefficients. Short-circuited transmission line input impedance. Coupling between transmission lines. Inductively coupled directional couplers. Short-length line coupling. Transmission line coupling and the corresponding mathematical framework. Coupling of shielding currents with signal wires. Waveguides and resonators. Cutoff frequency and attenuation constant. Effectiveness of apertures'/openings' shielding. Resonator tuning. Shielding theory and practical applications. Static or almost static field protection. Magnetostatic protection. Superconductive materials shielding. Electrostatic shielding. Equivalent shielding circuit models. Electric field shielding. Almost static magnetic field shielding. Plane wave or transmission line shielding models. Extensions of plane wave theory to non-ideal situations. Shielding theories relationship with practical applications. Apertures, windows and thin conductive films. Alternative ways to describe shielding quality. Cables and connectors. Conclusions and comments about earthing/grounding. Spectral analysis and antenna theory in EMC. Basic principles. Harmonic distortion. Intermodulation distortion or mixing. Spectral analysis. Fourier series. Fourier series of pulse trains. Fourier transforms. Fast Fourier transforms. Spectrum analyzers. Finite rise time effect. Coil voltage noise. Fourier spectrum approach. Interference bandwidth. Antennas and radiation. Differential-mode and common-mode radiation. Antenna general characteristics (field, radiation and power patterns, directivity, gain, radiation resistance, effective area). Slot antennas and apertures. Radiation field estimation and measurement. Loop radiation (loops with $Z<Z_o$ or $Z>Z_o$ impedance). Radiated field estimation (basic calculation, intensity calculation spreadsheet). Common-mode cable radiation. Computer codes for radiation estimation. Broadband antennas. Electromagnetic field generation for EMC tests. Crawford cell. GTEM cell. Reverberation chambers.

	Coupling calculation examples. Earthing, security and signal grounding. Cable grounding and pigtails. Single and multiple shielding housings' grounding. Passive components (conductors, resistors, capacitors and coils). Filters. Isolation and supression. Isolation techniques (balanced or compensated circuits, transformers, common-mode suppression coils, optical isolators and optical fibers. Suppression techniques. Design of electromagnetically compatible circuits. EMC system design.
Course type	Project-based (exclusively)
Assessment	Final project evaluation. Blended learning using synchronous and asynchronous methods.
Bibliography	• LearnEMC LLC, T. Hubing, and N. Hubing, *Study Guide for the iNARTE Electromagnetic Compatibility (EMC/EMI) Certification Exam – 2020*, 2020. • C. Kathalay, *A Practical Approach to Electromagnetic Compatibility: With an Introduction to CE Marking*, 2020, ISBN-13: 979-8665728742. • H. Zhang, Y. Zhang, C. Huangm Y. Yuan, and L. Cheng, *Spacecraft Electromagnetic Compatibility Technologies*, Springer, 2020, ISBN-10: 9811547815. • M. Van Helvoort and M. Melenhorst, *EMC for Installers: Electromagnetic Compatibility of Systems and Installations*, CRC Press, 2018, ISBN-10: 1498702481. • A. Ishimaru, *Electromagnetic Wave Propagation, Radiation, and Scattering: From Fundamentals to Applications*, Wiley-IEEE Press, 2017 (2nd Edition), ISBN-10: 1118098811. • T. Williams, *EMC for Product Designers*, Newnes, 2016 (5th Edition), ISBN-10: 0081010168. • D.A. Weston, *Electromagnetic Compatibility: Methods, Analysis, Circuits, and Measurement*, CRC Press, 2016 (3rd Edition), ISBN-10: 148229950X. • P.G. André and K. Wyatt, *EMI Troubleshooting Cookbook for Product Designers*, Scitech Publishing, 2014, ISBN-10: 1613530196. • H.W. Ott, *Electromagnetic Compatibility Engineering*, Wiley, 2009, ISBN-10: 0470189304. • C.R. Paul, *Introduction to Electromagnetic Compatibility*, Wiley-Interscience, 2006 (2nd Edition), ISBN-10: 0471755001. • V. Prasad Kodali, *Engineering Electromagnetic Compatibility: Principles, Measurements, Technologies, and Computer Models*, Wiley-IEEE Press, 2001 (2nd Edition), ISBN-10: 0780347439. • P. Chatterton and M. Houlden, "*EMC: Electromagnetic Theory to Practical Design*", Wiley, 1992, ISBN-10: 047192878X.

Course Title	**Microwave Communications**

Instructor	Asc. Professor **Ioannis Vardiambasis**, Director of the Laboratory of Telecommunications & Electromagnetic Applications, Directors of the Division of Telecommunications & Networks, Director of the MSc in "Telecommunication & Automation Systems" at the Department of Electronic Engineering of the Hellenic Mediterranean University, ivardia@hmu.gr
Study level	3rd Year and above
ECTS	3-ECTS* * Based on the 5-year undergraduate curriculum of the Electronic Engineering Department of HMU (Course 811), but modified according to the actual workload of the Erasmus students.
Prerequisite	Basic knowledge of engineering electromagnetics (electromagnetic fields and waves, Maxwell equations, boundary conditions, boundary value problems, etc.)
Learning Outcomes	Microwaves are widely used in radar (shipping, meteorology, air traffic control), terrestrial and satellite telecommunication links, medicine (tomography, hyperthermia), astrophysics (star observation), physics (spectroscopy, acceleration), industry, in everyday life (microwave ovens, antennas, vehicle speed measurement). On the other hand, the future of wireless communications (5G, MIMO) is based on millimeter waves. Therefore, familiarity of the electronic/telecommunication engineers with microwave theory, millimeter waves and their applications is necessary. This course properly prepares students for a career in the rapidly evolving telecommunications industry. The aim of this course is to familiarize electronic/telecommunication engineers with the technology of microwave and millimeter waves and their applications, in order to fully understand the operation of wired and wireless telecommunication systems. Upon completion of this course students will have acquired the necessary knowledge and skills, the appropriate tools for dealing with practical applications related to waveguides and antennas, as well as the experience to design and optimize real telecommunication systems, in order to: + select the most appropriate propagation mean and spectrum part for each telecommunication system, + analyze any transmission line and propagation mean, + evaluate the performance of telecommunication systems based on the propagation means it is using, + analyze and design wired and wireless telecommunication systems according to the needs, + be able to supervise and maintain wired and wireless telecommunication systems, and + design telecommunication systems using different transmission lines. Upon successful completion of the course, the students will: + understand the theory of microwaves and electromagnetic wave propagation in a unified manner, in order to use them for the analysis and design of wireless telecommunications links, + familiarize with the various phenomena at microwave and millimeter-wave frequencies, + understand the behavior of any waveguide and of the microwave energy transmission over distance (point-to-point transmission and reception),

	+ understand the operation of various elements, circuits and devices at microwave and millimeter frequencies, + familiarize with active and passive microwave components of modern telecommunication systems, + gain experience in measuring the basic characteristics and parameters of microwave devices, + familiarize with various waveguiding and propagation layouts of practical interest, in order to compare their characteristics (advantages/disadvantages), deciding which is the most appropriate for each practical application, + be informed about the latest developments in the field of wired and wireless telecommunications, + gain experience in the design of components (transmission lines, waveguides, power generators, amplifiers), circuits and systems, + gain experience in the analysis of microwave networks, + gain experience in designing and optimizing real telecommunication systems, which can be used in the analysis and design of new microwave, millimeter and optical systems. The course is at the core of the Electronic Engineer curriculum. **Note:** The project-based version of the course will help the Erasmus students to get many of the above mentioned learning outcomes.
Contents	The project-based version of the course will cover many of the following subjects: Review of electromagnetic theory (description of electromagnetic phenomena, Maxwell equations, boundary conditions, electromagnetic field power and energy, planar electromagnetic waves, propagation and attenuation of electromagnetic waves, polarization). Wired and wireless communications. Transmission line theory. Transverse and sinusoidal time-varying waves in transmission lines. Characteristic impedance and complex resistance in transmission lines. Smith chart. Standing waves in transmission lines without losses. Propagation constant and speed in transmission lines. Load matching in transmission lines using $\lambda/4$ transformers, one or two short-circuited stubs, or non-uniform transmission lines. Non-periodic phenomena in transmission lines. Coupled transmission line analysis. Wired transmission line types (two-wire or coaxial lines). Phase and amplitude distortion. Balanced and unbalanced lines. Phone network. Phase instability, cross-talk, impact noise, structured cabling. Waveguiding. Guided waves and waveguide modes. Parallel-plate waveguide. Description of waves. Separation of variables method. TE, TM, TEM modes. Radial description of wave propagation. Propagation and waveguide losses. Waveguides of rectangular cross section. Wave equation solution. Cutoff conditions. Boundary conditions. Field components in Cartesian coordinates. TM and TE modes. Excitation, characteristic resistance and attenuation of rectangular waveguide modes. Rectangular waveguide resonator. Waveguides of circular cross section. Wave equation solution. Cutoff conditions. Boundary conditions. Field components in cylindrical coordinates. TM and TE modes. Excitation, characteristic resistance and attenuation of circular waveguide modes. Polarization. Circular waveguide resonator. Coaxial waveguide. TEM, TM and TE modes.

	Microstrip and stripline. Radial and field description of a dielectric layer waveguide. Dielectric layer and dielectric strip. Graded-index strips. Uniform and non-uniform circular optical fiber. Special types of waveguides. Propagation in lines of parallel conductors. Mode excitation. Dielectric and magnetic materials. Electron motion in ferrites. Magnetization equation. Magnetic susceptibility tensor. Wave propagation in ferrites. Faraday rotation. Ferritic microwave elements. Gyrotron. Isolator. Circulator. YIG filter. Mixing materials with different ε, μ. Waveguiding in rectangular waveguides containing strips of material (ε, μ). Non-linear waveguides and waveguides with discontinuities [propagation in a circular section of a rectangular waveguide, propagation in a rectangular waveguide with helical twist, cylindrical small poles with inductive or capacitive behavior in rectangular waveguides, probes]. Waveguide technical characteristics [metal waveguides, optical fibers, flanges, additional elements of waveguide structures, excitation, resonators, filters]. Analysis of microwave circuits [S-parameters, power, efficiency]. Description of signals in microwave circuits. Microwave multiport networks. Scattering matrices. Bidirectional and symmetrical multiport networks. Magic T coupler. Multiport networks without losses. Directional couplers. Power dividers. Other couplers. Methods of microwave network analysis. Microwave resonant circuits. Microwave filters. Integrated microwave circuits [striplines, microstrips, slotlines, coplanar lines, hybrid MICs]. Passive microwave components [design of lumped resistors-capacitors-inductors, circuits with lumped loads]. Waveguide matching [waveguide resistance, measurement of line resistance at any point, load resistance computation]. Electron beam interaction with electromagnetic waves. High-power microwave sources [vacuum tubes, operating limits, klystron, magnetron, traveling-wave tube (TWT), gyrotron]. Low-power microwave sources. Semiconductor and solid-state devices [bipolar transistors, microwave transistors, field-effect transistors (FETs), semiconductor oscillators, oscillator modes with electron transfer effects]. Microwave mixing diodes. Tunnel diodes. Gunn diodes. IMPATT diodes. Masers. Microwave communications [microwave circuits, terminal equipment, filters, terminal transceivers and repeaters]. Microwave applications [diagnostic and therapeutic medicine, industrial measurements, speed measurements, ovens and thermal devices]. Biological effects of microwaves [radiation limits, biological phenomena, dielectric properties of the human body, electromagnetic environment]. Millimeter wave communications and applications.
Course type	Project-based (exclusively)
Assessment	Final project evaluation. Blended learning using synchronous and asynchronous methods.
Bibliography	• A.S. Khan and S.K. Mukerji, *Electromagnetic Fields: Theory and Applications*, CRC Press, 2020.

	• J.P. Dunsmore, *Handbook of Microwave Component Measurements: With Advanced VNA Techniques*, Wiley, 2020 (2nd Edition), ISBN-10: 1119477131. • K. Kuang and R. Sturdivant, *RF and Microwave Microelectronics Packaging II*, Springer, 2017, ISBN-10: 3319516965. • I. Robertson, N. Somjit, and M. Chongcheawchamnan, *Microwave and Millimetre-Wave Design for Wireless Communications*, Wiley, 2016, ISBN-10: 1118917219. • S. Mumtaz, J. Rodriguez, and L. Dai, *mmWave Massive MIMO: A Paradigm for 5G*, Academic Press, 2016, ISBN-10: 0128044187. • K.-W. Yeom, *Microwave Circuit Design: A Practical Approach Using ADS*, Pearson, 2015. • A.A. Behagi, *RF and Microwave Circuit Design: A Design Approach Using ADS*, Techno Search, 2015, ISBN-10: 0996446613. • T.S. Rappaport, R.W. Heath, R.C. Daniels, and J.N. Murdock, *Millimeter Wave Wireless Communications*, Pearson, 2014, ISBN-10: 0132172283. • A.I. Kozlov, L.P. Ligthart, and A.I. Logvin, *Mathematical and Physical Modelling of Microwave Scattering and Polarimetric Remote Sensing: Monitoring the Earth's Environment Using Polarimetric Radar: Formulation and Potential Applications*, Springer, 2014, ISBN-10: 9401739110. • R. Sturdivant, *Microwave and Millimeter-Wave Electronic Packaging*, Artech House, 2014, ISBN-10: 1608076970. • R. Garg, I. Bahl, and M. Bozzi, *Microstrip Lines and Slotlines*, Artech House, 2013 (3rd Edition), ISBN-10: 1608075354. • B. Razavi, *RF Microelectronics*, Pearson Education Ltd, 2013 (2nd Edition), ISBN: 1292024720. • C.A. Balanis, *Advanced Engineering Electromagnetics*, Wiley, 2012 (2nd Edition), ISBN-10: 0470589485. • U.L. Rohde and M. Rudolph, *RF and Microwave Circuit Design for Wireless Communications*, Wiley, 2012 (2nd Edition), ISBN: 1118431405. • A. Georgiadis, H. Rogier, L. Roselli and P. Arcioni, *Microwave and Millimeter Wave Circuits and Systems: Emerging Design, Technologies and Applications*, Wiley, 2012, ISBN-10: 1119944945. • D.M. Pozar, *Microwave Engineering*, Wiley, 2011 (4th Edition), ISBN-10: 0470631554. • K.-C. Huang and Z. Wang, *Millimeter Wave Communication Systems*, Wiley-IEEE, 2011, ISBN-10: 0470404620. • M. Golio, *RF and Microwave Handbook*, CRC Press, 2008 (2nd Edition), ISBN-10: 0849372178. • J.G. van Bladel, *Electromagnetic Fields*, Wiley-IEEE Press, 2007 (2nd Edition), ISBN-10: 0471263885. • T.S. Laverghetta, *Microwaves and Wireless Simplified*, Artech House, 2006 (2nd Edition), ISBN-10: 1580539432. • D.K. Misra, *Radio-Frequency and Microwave Communication Circuits: Analysis and Design*, Wiley-Interscience, 2004 (2nd Edition), ISBN-10: 9780471478737. • W.F. Egan, *Practical RF System Design*, Wiley- IEEE, 2003, ISBN-10: 0471200239.

	• R.E. Collin, *Foundations for Microwave Engineering*, Wiley-IEEE Press, 2001 (2nd Edition), ISBN-10: 0780360311. • K. Chang, *RF and Microwave Wireless Systems*, Wiley-Interscience, 2000, ISBN-10: 0471351997. • T.S. Laverghetta, *Microwave Materials and Fabrication Techniques*, Artech House, 2000 (3rd Edition), ISBN: 1580530648. • B.Z. Katsenelenbaum, L. Mercader del Rio, M. Pereyaslavets, M. Sorolla Ayza, and M. Thumm, *Theory of Nonuniform Waveguides – The Cross-Section Method*, IEE, 1998, ISBN: 085296918X. • R.G. Winch, *Telecommunication Transmission Systems*, McGraw Hill, 1998 (2nd Edition), ISBN-10: 007070970X. • P. Vizmuller, *RF Design Guide: Systems, Circuits, and Equations*, Artech House, 1995, ISBN: 0890067546. • G. Roussy and J.A. Pearce, *Foundations and Industrial Applications of Microwaves and Radio Frequency Fields – Physical and Chemical Processes*, Wiley, 1995, ISBN-10: 0471938491. • ARRL, *The ARRL UHF/Microwave Projects Manual – Vol. 1*, ARRL, 1994, ISBN: 0872594491. • S. Ramo, J.R. Whinnery, and T.V. Duzer, *Fields and Waves in Communication Electronics*, Wiley, 1994 (3rd Edition), ISBN-10: 0471585513. • G.H. Bryant, *Principles of Microwave Measurements*, IET, 1993 (Revised Edition), ISBN: 0863412963. • B.L. Smith and M.-H. Carpentier, *The Microwave Engineering Handbook – Vol. 1: Microwave Components*, Van Nostrand Reinhold, 1993, ISBN-10: 0442315880. • B.L. Smith and M.-H. Carpentier, *The Microwave Engineering Handbook – Vol. 2: Microwave Circuits, Antennas - and Propagation*, Van Nostrand Reinhold, 1993 (2009th Edition), ISBN 10: 1441901140. • B. Smith and M.H. Carpentier, *The Microwave Engineering Handbook – Vol. 3: Microwave Systems and Applications*, Springer, 1992 (1993rd Edition), ISBN-10: 041245680X. • D.A. Olver, *Microwave and Optical Transmission*, Wiley, 1992, ISBN-10: 047193478X. • S.F. Mahmoud, *Electromagnetic Waveguides: Theory and Applications*, IET, 1991, ISBN-10: 0863412327. • R.E. Collin, *Field Theory of Guided Waves*, Wiley-IEEE Press, 1990 (2nd Edition), ISBN-10: 0879422378. • A.E. Fantom, *Radio Frequency and Microwave Power Measurement*, IET, 1990, ISBN-10: 0863411207. • T. Itoh, *Numerical Techniques for Microwave and Millimeter-Wave Passive Structures*, Wiley-Interscience, 1989, ISBN-10: 9780471625636. N. Marcuvitz, *Waveguide Handbook*, IET, 1986, ISBN-10: 0863410588.

Course Title	**Microwave-Millimeter Wave Communications & Antennas**

Instructor	Asc. Professor **Ioannis Vardiambasis**, Director of the Laboratory of Telecommunications & Electromagnetic Applications, Directors of the Division of Telecommunications & Networks, Director of the MSc in "Telecommunication & Automation Systems" at the Department of Electronic Engineering of the Hellenic Mediterranean University, ivardia@hmu.gr
Study level	4th Year and above
ECTS	3-ECTS* * Based on the postgraduate curriculum of the Telecommunications & Automations Systems MSc of the Electronic Engineering Department of HMU (Course TeleAutoS-12), but modified according to the actual workload of the Erasmus students..
Prerequisite	Basic knowledge of engineering electromagnetics (electromagnetic fields and waves, Maxwell equations, boundary conditions, boundary value problems, etc.)
Learning Outcomes	Microwaves are widely used in radar (shipping, meteorology, air traffic control), terrestrial and satellite telecommunication links, medicine (tomography, hyperthermia), astrophysics (star observation), physics (spectroscopy, acceleration), industry, in everyday life (microwave ovens, antennas, vehicle speed measurement). On the other hand, the future of wireless communications (5G, MIMO) is based on millimeter waves. Therefore, familiarity of the electronic/telecommunication engineers with microwave theory, millimeter waves and their applications is necessary. The explosive growth and continuous development of the wireless and personal telecommunication systems creates a growing demand for telecommunication engineers with (a) very good background on the theory of antennas and electromagnetic wave propagation, and (b) special knowledge and experience in modern wireless systems. This course properly prepares postgraduate students for a career in the rapidly evolving telecommunications industry. This course aims (a) to familiarize electronic/telecommunication engineers with the technology of microwave and millimeter waves and their applications, in order to fully understand the operation of wired and wireless telecommunication systems, and (b) to get postgraduate students acquainted with the principles of antenna theory and electromagnetic wave propagation, in order to use them during analysis and design of wireless telecommunication links. Upon successful completion of this course postgraduate students will have acquired the necessary knowledge and skills, along with the appropriate tools for dealing with practical applications related to waveguides, antennas, and propagation models, as well as the experience to design and optimize real microwave/millimeter-wave devices, antennas, and telecommunication systems. More specifically students will be able to: + select the most appropriate propagation mean and spectrum part for each telecommunication system, + analyze any transmission line and propagation mean, + evaluate the performance of telecommunication systems based on the propagation means it is using, + analyze and design wired and wireless telecommunication systems according to the needs, + be able to supervise and maintain wired and wireless telecommunication systems, + design telecommunication systems using different transmission lines,

	+ understand the theory of microwaves and electromagnetic wave propagation in a unified manner, in order to use them for the analysis and design of wireless telecommunications links, + familiarize with the various phenomena at microwave and millimeter-wave frequencies, + understand the behavior of any waveguide and of the microwave energy transmission over distance (point-to-point transmission and reception), + understand the operation of various elements, circuits and devices at microwave and millimeter frequencies, + familiarize with active and passive microwave components of modern telecommunication systems, + measure the basic characteristics and parameters of microwave devices, + familiarize with various waveguiding and propagation layouts of practical interest, in order to compare their characteristics (advantages/disadvantages), deciding which is the most appropriate for each practical application, + be informed about the latest developments in the field of wired and wireless telecommunications, + design of components (transmission lines, waveguides, power generators, amplifiers), circuits and systems, + analyze microwave networks, + design and optimize real telecommunication systems, which can be used in the analysis and design of new microwave, millimeter and optical systems, + understand electromagnetic theory and its applications to antennas and transmission of electromagnetic signals carrying information, + understand the theory of antennas and electromagnetic wave propagation in a uniform way, in order to use them in the analysis and design of wireless telecommunications, + describe the basic mechanisms of radio wave propagation and understand the interaction of electromagnetic waves with the environment, + be aware of the wave propagation phenomena caused in the real environment and the measurement methods used in practice, + calculate and measure the basic antenna parameters and characteristics (eg radiated power, radiation intensity, directivity, gain, radiation resistance), + compare antenna characteristics (advantages/disadvantages), deciding which is the most suitable antenna for each practical application, + perform antenna and electromagnetic radiation measurements, + familiarize with various practical antenna devices, + calculate the radiation diagram of an antenna, when its current distribution is known, + evaluate propagation models and select the appropriate model for calculating losses in a telecommunications link, + prepare radio coverage studies, + be informed about the latest developments in the field of wireless and personal communication systems, + analyze and design wireless telecommunication systems according to the respective needs, + be ready to supervise and maintain wireless telecommunications systems.

	The course is at the core of the Electronic/Telecommunications Engineer postgraduate curriculum. **Note:** The project-based version of the course will help the Erasmus students to get many of the above mentioned learning outcomes.
Contents	The project-based version of the course will cover many of the following subjects: Review of electromagnetic theory. Electric, magnetic, electromagnetic fields. Description of electromagnetic phenomena. Maxwell's equations. Wave equations. Boundary conditions. Electromagnetic field power and energy. Poynting vector. Scalar and vector potentials. Fields of sinusoidal time change. Planar electromagnetic waves [polarization, wave propagation in conductive and non-conductive media, phase and group velocities, reciprocity]. Reflection and refraction of planar waves [Snell's law, Fresnel equations, reflection and transmission coefficients, normal and oblique incidence on perfect dielectric and lossy media, standing waves, incidence on dielectric plates, scattering]. Propagation and attenuation of electromagnetic waves. Polarization. Electromagnetic waves in free space. Transmission line theory. Transverse and sinusoidal time-varying waves in transmission lines. Characteristic impedance and complex resistance in transmission lines. Smith chart. Standing waves in transmission lines without losses. Propagation constant and speed in transmission lines. Load matching in transmission lines using λ/4 transformers, one or two short-circuited stubs, or non-uniform transmission lines. Non-periodic phenomena in transmission lines. Coupled transmission line analysis. Wired transmission line types (two-wire or coaxial lines). Phase and amplitude distortion. Balanced and unbalanced lines. Phone network. Phase instability, cross-talk, impact noise, structured cabling. Waveguiding. Guided waves and waveguide modes. Parallel-plate waveguide. Description of waves. Separation of variables method. TE, TM, TEM modes. Radial description of wave propagation. Propagation and waveguide losses. Waveguides of rectangular cross section. Wave equation solution. Cutoff conditions. Boundary conditions. Field components in Cartesian coordinates. TM and TE modes. Excitation, characteristic resistance and attenuation of rectangular waveguide modes. Rectangular waveguide resonator. Waveguides of circular cross section. Wave equation solution. Cutoff conditions. Boundary conditions. Field components in cylindrical coordinates. TM and TE modes. Excitation, characteristic resistance and attenuation of circular waveguide modes. Polarization. Circular waveguide resonator. Coaxial waveguide. TEM, TM and TE modes. Microstrip and stripline. Radial and field description of a dielectric layer waveguide. Dielectric layer and dielectric strip. Graded-index strips. Uniform and non-uniform circular optical fiber. Special types of waveguides. Propagation in lines of parallel conductors. Mode excitation. Dielectric and magnetic materials. Electron motion in ferrites. Magnetization equation. Magnetic susceptibility tensor. Wave propagation in ferrites. Faraday rotation. Ferritic microwave elements. Gyrotron. Isolator. Circulator. YIG filter. Mixing materials with different ε, μ. Waveguiding in rectangular waveguides containing strips of material (ε, μ).

	Non-linear waveguides and waveguides with discontinuities [propagation in a circular section of a rectangular waveguide, propagation in a rectangular waveguide with helical twist, cylindrical small poles with inductive or capacitive behavior in rectangular waveguides, probes]. Waveguide technical characteristics [metal waveguides, optical fibers, flanges, additional elements of waveguide structures, excitation, resonators, filters]. Analysis of microwave circuits [S-parameters, power, efficiency]. Description of signals in microwave circuits. Microwave multiport networks. Scattering matrices. Bidirectional and symmetrical multiport networks. Magic T coupler. Multiport networks without losses. Directional couplers. Power dividers. Other couplers. Methods of microwave network analysis. Microwave resonant circuits. Microwave filters. Integrated microwave circuits [striplines, microstrips, slotlines, coplanar lines, hybrid MICs]. Passive microwave components [design of lumped resistors-capacitors-inductors, circuits with lumped loads]. Waveguide matching [waveguide resistance, measurement of line resistance at any point, load resistance computation]. Electron beam interaction with electromagnetic waves. High-power microwave sources [vacuum tubes, operating limits, klystron, magnetron, traveling-wave tube (TWT), gyrotron]. Low-power microwave sources. Semiconductor and solid-state devices [bipolar transistors, microwave transistors, field-effect transistors (FETs), semiconductor oscillators, oscillator modes with electron transfer effects]. Microwave mixing diodes. Tunnel diodes. Gunn diodes. IMPATT diodes. Masers. Microwave communications [microwave circuits, terminal equipment, filters, terminal transceivers and repeaters]. Microwave applications [diagnostic and therapeutic medicine, industrial measurements, speed measurements, ovens and thermal devices]. Biological effects of microwaves [radiation limits, biological phenomena, dielectric properties of the human body, electromagnetic environment]. Millimeter wave communications and applications. Review on telecommunications. Electrical signals. Telecommunication systems. Wired and wireless communications. Frequency spectrum (HF, VHF, UHF, microwaves). Introduction to antenna theory. Antenna and transmission line matching. Radiation mechanisms. Antenna characteristics, radiation diagrams, gain, bandwidth, quality factor. Theory of simple linear antennas. Analysis of antennas with assumed current distributions. Hertz dipole. Applications of electrically small antennas. Linear dipole antennas. Field and radiation pattern, directivity, gain, radiation resistance, active antenna height. Dipole $\lambda/2$. Traveling wave antennas. Loop antennas. Antennas above perfect ground. Mirroring and image theory. General analysis of the radiation field of any antenna. Applications. Antenna arrays. Rhombic antenna. Principles of antenna design. Applications. Linear arrays. Uniform linear arrays with small and large number of elements. Polynomial theory of linear arrays. Applications.

	Superdirective antennas. Phase detection. Methods of radiation pattern synthesis. Dolph-Chebyshev linear arrays. Composition of linear arrays with Fourier sums. Applications and examples of antenna analysis and synthesis. Antenna applications and measurements. Aperture antennas. Radiation from flat surfaces. Radiation from rectangular surfaces. Horn antennas. Parabolic reflector antennas. Horn-reflector antennas. Lens antennas. Passive reflectors. Input antenna resistance. Equivalent sources. Magnetic charges and currents. Voltage and current sources. Reciprocity theorem. Self-impedance of conductive antennas. Voltage induced on open-ended antenna by an incident field. Induced electromotive force method. Transmission and reception equivalent circuits. Dipole near field. Bandwidth. Receiving antennas. Antenna polarization. Noise in telecommunication systems and antenna noise temperature. Dipole self-impedance. Antenna as terminal impedance. Asymmetric excitation of dipoles. Matching conditions and maximum transmitted power. Matching using stubs. Folded dipole. Mutual complex resistance between dipoles. Antenna array excitation impedance. Impedance of dipoles above perfect ground. Antenna feeding with appropriate currents. Yagi-Uda antennas. The antenna as a receiver. Equality of mutual complex resistances. Equality of transmission and reception radiation patterns. Equality of transmission and reception self-impedances. Equality of transmission and reception antenna active heights. Active antenna surface. Received to transmitted power ratio. Transmission of waves in free space. Friis equation. Losses and maximum transmission distance. Radar equation. Propagation of electromagnetic waves in the earth environment. Ground reflection of obliquely incident plane waves with vertical or parallel polarization. Brewster angles. Ground wave. Space wave. Surface wave. Antennas elevated above ground level. Approximate relationship for propagation at very high frequencies. Near ground surface wave tilt and polarization. Spherical earth. Effects of the earth's curvature. Line-of-sight condition. Barrier effects in wave propagation. Diffraction links. Tropospheric refractive index. Tropospheric propagation, refraction, waveguiding, scattering. Radio horizon. Multiple routes. Intervals. Differential reception systems. Atmosphere attenuation. Critical frequency and ionosphere changes. Ionospheric propagation, refraction, reflection, scattering. Applications. Calculation of radio links. Over sharp obstacle links. Line-of-sight links. Above perfect ground links. Technical characteristics and practical applications of wireless links.
Course type	Project-based (exclusively)
Assessment	Final project evaluation. Blended learning using synchronous and asynchronous methods.
Bibliography	***Related to Microwave and Millimeter-Wave Communications, Technology and Applications*** • A.S. Khan and S.K. Mukerji, *Electromagnetic Fields: Theory and Applications*, CRC Press, 2020.

	• J.P. Dunsmore, *Handbook of Microwave Component Measurements: With Advanced VNA Techniques*, Wiley, 2020 (2nd Edition), ISBN-10: 1119477131. • K. Kuang and R. Sturdivant, *RF and Microwave Microelectronics Packaging II*, Springer, 2017, ISBN-10: 3319516965. • I. Robertson, N. Somjit, and M. Chongcheawchamnan, *Microwave and Millimetre-Wave Design for Wireless Communications*, Wiley, 2016, ISBN-10: 1118917219. • S. Mumtaz, J. Rodriguez, and L. Dai, *mmWave Massive MIMO: A Paradigm for 5G*, Academic Press, 2016, ISBN-10: 0128044187. • K.-W. Yeom, *Microwave Circuit Design: A Practical Approach Using ADS*, Pearson, 2015. • A.A. Behagi, *RF and Microwave Circuit Design: A Design Approach Using ADS*, Techno Search, 2015, ISBN-10: 0996446613. • T.S. Rappaport, R.W. Heath, R.C. Daniels, and J.N. Murdock, *Millimeter Wave Wireless Communications*, Pearson, 2014, ISBN-10: 0132172283. • A.I. Kozlov, L.P. Ligthart, and A.I. Logvin, *Mathematical and Physical Modelling of Microwave Scattering and Polarimetric Remote Sensing: Monitoring the Earth's Environment Using Polarimetric Radar: Formulation and Potential Applications*, Springer, 2014, ISBN-10: 9401739110. • R. Sturdivant, *Microwave and Millimeter-Wave Electronic Packaging*, Artech House, 2014, ISBN-10: 1608076970. • R. Garg, I. Bahl, and M. Bozzi, *Microstrip Lines and Slotlines*, Artech House, 2013 (3rd Edition), ISBN-10: 1608075354. • B. Razavi, *RF Microelectronics*, Pearson Education Ltd, 2013 (2nd Edition), ISBN: 1292024720. • C.A. Balanis, *Advanced Engineering Electromagnetics*, Wiley, 2012 (2nd Edition), ISBN-10: 0470589485. • U.L. Rohde and M. Rudolph, *RF and Microwave Circuit Design for Wireless Communications*, Wiley, 2012 (2nd Edition), ISBN: 1118431405. • A. Georgiadis, H. Rogier, L. Roselli and P. Arcioni, *Microwave and Millimeter Wave Circuits and Systems: Emerging Design, Technologies and Applications*, Wiley, 2012, ISBN-10: 1119944945. • D.M. Pozar, *Microwave Engineering*, Wiley, 2011 (4th Edition), ISBN-10: 0470631554. • K.-C. Huang and Z. Wang, *Millimeter Wave Communication Systems*, Wiley-IEEE, 2011, ISBN-10: 0470404620. • M. Golio, *RF and Microwave Handbook*, CRC Press, 2008 (2nd Edition), ISBN-10: 0849372178. • J.G. van Bladel, *Electromagnetic Fields*, Wiley-IEEE Press, 2007 (2nd Edition), ISBN-10: 0471263885. • T.S. Laverghetta, *Microwaves and Wireless Simplified*, Artech House, 2006 (2nd Edition), ISBN-10: 1580539432. • D.K. Misra, *Radio-Frequency and Microwave Communication Circuits: Analysis and Design*, Wiley-Interscience, 2004 (2nd Edition), ISBN-10: 9780471478737. • W.F. Egan, *Practical RF System Design*, Wiley- IEEE, 2003, ISBN-10: 0471200239.

	- R.E. Collin, *Foundations for Microwave Engineering*, Wiley-IEEE Press, 2001 (2nd Edition), ISBN-10: 0780360311. K. Chang, *RF and Microwave Wireless Systems*, Wiley-Interscience, 2000, ISBN-10: 0471351997. - T.S. Laverghetta, *Microwave Materials and Fabrication Techniques*, Artech House, 2000 (3rd Edition), ISBN: 1580530648. - B.Z. Katsenelenbaum, L. Mercader del Rio, M. Pereyaslavets, M. Sorolla Ayza, and M. Thumm, *Theory of Nonuniform Waveguides – The Cross-Section Method*, IEE, 1998, ISBN: 085296918X. - R.G. Winch, *Telecommunication Transmission Systems*, McGraw Hill, 1998 (2nd Edition), ISBN-10: 007070970X. P. Vizmuller, *RF Design Guide: Systems, Circuits, and Equations*, Artech House, 1995, ISBN: 0890067546. G. Roussy and J.A. Pearce, *Foundations and Industrial Applications of Microwaves and Radio Frequency Fields – Physical and Chemical Processes*, Wiley, 1995, ISBN-10: 0471938491. - ARRL, *The ARRL UHF/Microwave Projects Manual – Vol. 1*, ARRL, 1994, ISBN: 0872594491. S. Ramo, J.R. Whinnery, and T.V. Duzer, *Fields and Waves in Communication Electronics*, Wiley, 1994 (3rd Edition), ISBN-10: 0471585513. - G.H. Bryant, *Principles of Microwave Measurements*, IET, 1993 (Revised Edition), ISBN: 0863412963. - B.L. Smith and M.-H. Carpentier, *The Microwave Engineering Handbook – Vol. 1: Microwave Components*, Van Nostrand Reinhold, 1993, ISBN-10: 0442315880. - B.L. Smith and M.-H. Carpentier, *The Microwave Engineering Handbook – Vol. 2: Microwave Circuits, Antennas and Propagation*, Van Nostrand Reinhold, 1993 (2009th Edition), ISBN-10: 1441901140. B. Smith and M.H. Carpentier, *The Microwave Engineering Handbook – Vol. 3: Microwave Systems and Applications*, Springer, 1992 (1993rd Edition), ISBN-10: 041245680X. - D.A. Olver, *Microwave and Optical Transmission*, Wiley, 1992, ISBN-10: 047193478X. - S.F. Mahmoud, *Electromagnetic Waveguides: Theory and Applications*, IET, 1991, ISBN-10: 0863412327. - R.E. Collin, *Field Theory of Guided Waves*, Wiley-IEEE Press, 1990 (2nd Edition), ISBN-10: 0879422378. - A.E. Fantom, *Radio Frequency and Microwave Power Measurement*, IET, 1990, ISBN-10: 0863411207. T. Itoh, *Numerical Techniques for Microwave and Millimeter-Wave Passive Structures*, Wiley-Interscience, 1989, ISBN-10: 9780471625636. N. Marcuvitz, *Waveguide Handbook*, IET, 1986, ISBN-10: 0863410588. ***<u>Related to Antennas</u>*** C. Parini, S. Gregson, J. McCormick, D.J. van Rensburg, and T. Eibert, *Theory and Practice of Modern Antenna Range Measurements*, SciTech Publishing, 2021 (2nd Edition), ISBN-10: 1839531282.

	• ARRL, *The ARRL Antenna Book for Radio Communications*, American Radio Relay League, 2019 (24th edition), ISBN-10: 1625951116. • J. Volakis, *Antenna Engineering Handbook*, Mc Graw Hill, 2018 (5th edition), ISBN-10: 1259644693. • J.D. Kraus, R.J. Marhefka, and A.S. Khan, *Antennas and Wave Propagation*, Mc-Graw Hill India, 2017 (5th edition), ISBN-10: 9352606183. • R.J. Mailloux, *Phased Array Antenna Handbook*, Artech House, 2017 (3rd Edition), ISBN-10: 1630810290. • C.A. Balanis, *Antenna Theory: Analysis and Design*, Wiley, 2016 (4th edition), ISBN-10: 1118642066. • W.L. Stutzman and G.A. Thiele, *Antenna Theory and Design*, Wiley, 2012 (3rd edition), ISBN-10: 0470576642. • S.K. Das and A. Das, *Antenna and Wave Propagation*, Tata Mc-Graw Hill Education, 2012, ISBN-10: 1259097587. • J. Carr and G. Hippisley, *Practical Antenna Handbook*, Mc Graw Hill, 2011 (5th edition), ISBN-10: 9780071639583. • R.E. Collin, *Antennas and Radiowave Propagation*, Mc-Graw Hill, 1985, ISBN-10: 0070118086.