UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Course guide
230470 - ONEMAG - Electromagnetic Waves

Last modified: 25/05/2023

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

PRIOR SKILLS

Foundations on Electriciy and Magnetism, both in free space and in dielectric and magnetic media. Waves, vectorial analysis and ordinary differencial equations

REQUIREMENTS

The course of Electromagnetism.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Knowledge of electromagnetism laws. Ability to solve engineering problems: magnetism, electricity and electrical technology, electromagnetic waves and wave optics.
2. Knowledge of the mechanisms of propagation and transmission of electromagnetic waves. Ability to analyze and use transmitter and receiver devices.

Generical:
1. ABILITY TO IDENTIFY, FORMULATE, AND SOLVE PHYSICAL ENGINEERING PROBLEMS. Planning and solving physical engineering problems with initiative, making decisions and with creativity. Developing methods of analysis and problem solving in a systematic and creative way.

Transversal:
2. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.

TEACHING METHODOLOGY

It is developed mainly through lectures, sometimes with prepared presentations, and also through visualization of computer simulations.
Analysis and simulation work is proposed so that students can verify and visualize the phenomena described in lectures. All the contents can be found at the Atenea page.

LEARNING OBJECTIVES OF THE SUBJECT

The main goal is provide students with a clear insight, visual and also mathematic, about the phenomena associated with wave propagation, in free space and through transmission line of any type.

STUDY LOAD

Type	Hours	Percentage
Self study	85,0	56.67
Hours large group	65,0	43.33

Total learning time: 150 h

CONTENTS

1. Electromagnetic waves in free space

Description:
1.1 Wave equation. Wave functions.
1.2 Plane waves and spherical waves.
1.3 Plane waves in steady sinusoidal state. Uniform and non uniform plane waves. Wave impedance.
1.4 Power and power density associated at the wave.
1.5 Polarization. Types of polarization. Elements for the control of polarization: polarizer and retarder plates.
1.6 Plane waves in lossy media.

Full-or-part-time: 30h
Theory classes: 7h
Practical classes: 5h
Guided activities: 2h
Self study : 16h

2. Incidence of waves in separation surfaces

Description:
2.1 Incidence in dielectrics and in conductors. Coefficients of reflection and transmission. Fresnel formulas. Brewster's angle.
2.2 Total reflection.
2.3 Standing waves. Totally and partially standing waves. Standing wave ratio. Anti-reflection coatings.
2.4 Reflection in multilayer coatings. Generalized reflection coefficient. Generalized wave impedance.

Full-or-part-time: 30h
Theory classes: 7h
Practical classes: 5h
Self study : 18h

3. Transmission lines

Description:
3.1 Introduction: problems in circuit theory associated to high frequencies. Necessity of a new formulation. Types of transmission lines
3.2 TEMz waves in a transmission line of two conductors. Telegraphist?s equation
3.3 Model of distributed parameters. Circuit parameters per unit length.
3.4 Wave propagation in a transmission line. Propagation velocity and characteristic impedance.
3.5 Terminated transmission line without losses. Reflection coefficient, standing wave ratio and input impedance. Smith chart.
3.6 Generator and load mismatching. Power transmission and conjugated impedance matching.
3.7 Losses in transmission lines.

Full-or-part-time: 26h
Theory classes: 7h
Practical classes: 4h
Guided activities: 1h
Self study : 14h

4. Waveguides and optical fibers

Description:
4.1 Waveguides with conducting walls
Modes of propagation in a guide. TE and TM modes. Wavelength in the guide. Cut-off frequency of a mode.
4.2 Rectangular conducting waveguides
Propagation modes. Dispersion curves. Transmitted power
4.3 Resonators
4.4 Plane dielectric waveguides
Guided and radiation modes
4.5 Optical fibers. Fiber structure. Fiber types. Propagation modes. Dispersion curves.

Full-or-part-time: 32h
Theory classes: 9h
Practical classes: 5h
Self study : 18h

5. Foundations of radiation

Description:
5.1 Antenna parameters and transmission equation.
5.2 Radiated and induced fields.
5.3 Far field approximation. Significance of the radiation vector.
5.4 Elemental antennas: electric and magnetic dipoles
5.5 Images theory
5.6 Antenna arrays

Full-or-part-time: 32h
Theory classes: 9h
Practical classes: 5h
Self study : 18h

GRADING SYSTEM

The final mark is given by three figures: the final exam (EF) , the middle term exam (EP) and the evaluation of specific works realized during the course (TE).

The final mark is given by: Max {0.90*EF+0.10*TE , 0.55*EF + 0.35*EP + 0.10*TE }

In the case of having to go to the extraordinary exam, the note of this will also be averaged with the note of the works, which are not re-evaluated. That is, the final calification would be in this case
{0.90 x ExExtra + 0.10 x TE }

EXAMINATION RULES.

There is an 'official' formula sheet for the subject, drawn up by course teachers, which can be used during exams. Annotations can NOT be added to that form.

BIBLIOGRAPHY

Basic:

- Dios, F. [et al.]. Campos electromagnéticos [on line]. Barcelona: Edicions UPC, 1998 [Consultation: 07/06/2021]. Available on: http://hdl.handle.net/2099.3/36160. ISBN 8483012499.
- Cheng, D.K. Fundamentos de electromagnetismo para ingeniería. Wilmington, Delaware: Addisson-Wesley Iberoamericana, 1997. ISBN 9684443277.
- Pozar, D.M. Microwave engineering [on line]. 4th ed. Hoboken: Wiley, 2012 [Consultation: 09/04/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=2064708. ISBN 9780470631553.
- Kao, M.S.; Chang, C.F. Understanding electromagnetic waves [on line]. Cham, Switzerland: Springer International Publishing AG, 2020 [Consultation: 09/06/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=6263940. ISBN 9783030457082.

Complementary:

- Reitz, J.R.; Milford, F.J.; Christy; R.W. Fundamentos de la teoría electromagnética. 4a ed. Wilmington: Addisson-Wesley Iberoamericana, 1996. ISBN 020162592X.
- Hecht, J. Understanding fiber optics. 5th ed. Upper Saddle River: Prentice Hall, 2006. ISBN 0131174290.
- Cardama, Á. [et al.]. Antenas [on line]. 2a ed. Barcelona: Edicions UPC, 2002 [Consultation: 07/06/2021]. Available on: http://hdl.handle.net/2099.3/36797. ISBN 8483016257.