

## Course guide

### 300520 - OE-S - Electromagnetic Waves

**Last modified:** 27/01/2026

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

**Degree:** BACHELOR'S DEGREE IN SATELLITE ENGINEERING (Syllabus 2024). (Compulsory subject).

**Academic year:** 2025    **ECTS Credits:** 5.0    **Languages:** Catalan, Spanish

#### LECTURER

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**Coordinating lecturer:** Definit a la infoweb de l'assignatura.

**Others:** Definit a la infoweb de l'assignatura.

#### PRIOR SKILLS

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Real and complex numbers  
Coordinate systems and changes of variable  
Vector spaces. Linear applications  
Differential equations and linear systems with constant coefficients. Properties and solutions  
Scalar and vector fields  
Waves: Transversal and longitudinal waves Wave equation  
Reflexion, refraction and diffraction. Doppler effect  
Superposition and stationary waves. Interference. Dispersion. Group velocity  
Coulomb force, electrical charge and electrostatic field  
Electric potential  
Electrostatic energy. Capacity  
Electric current  
Magnetic field. Sources of magnetic field  
Maxwell Equations.  
Fourier series. Fourier transform. Frequency response  
Circuit analysis in DC and AC  
Basic concepts. Kirchhoff laws, Joule's law

#### TEACHING METHODOLOGY

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Four hours per week (in two-hour blocks) of lectures, with visual aids (slides) and exercises completed on the board.  
In even-numbered sessions, a short quiz on the week's material will be administered on the ATENEA platform. The scores on these quizzes are essential to the continuous assessment grade.  
Students will have access to the course slides on the ATENEA platform.

#### LEARNING OBJECTIVES OF THE SUBJECT

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To understand, analyze, and design basic electromagnetic communication systems in both the RF and optical bands. Both wired systems (transmission lines and fiber optics) and wireless systems (radio and laser communication systems) will be covered. Given that the terminals involved in wireless communication are mobile, special attention will be paid to concepts such as point-ahead and Doppler shift. Particular attention will also be given to optical band transmitters/receivers.

The emphasis is on the transmission of carrier signals (in both bands), as aspects related to information transmission are covered in the "Fundamentals of Communications" course.

## STUDY LOAD

Type	Hours	Percentage
Hours large group	55,0	44.00
Self study	70,0	56.00

**Total learning time:** 125 h

## CONTENTS

### Transmission Lines

#### Description:

Transmission Lines:

Concept of interfering waves in a transmission line.

Circuit model of transmission lines.

Examples of transmission lines: coaxial cable, microstrip line. Software: Txline.

Impedances, reflection coefficient, and standing wave ratio.

Wave power in the line and power delivered to the load.

Microwave circuits: S-parameters.

Smith chart: impedance matching with lumped elements and stubs. Software: Smith.

**Full-or-part-time:** 30h

Theory classes: 12h

Self study : 18h

### Fiber optics

#### Description:

Main characteristics of optical fibers and advantages/disadvantages

Characteristic parameters (attenuation coefficient, dispersion coefficient, bandwidth)

Dimensioning of an optical fiber system

**Full-or-part-time:** 15h

Theory classes: 6h

Self study : 9h

### Optical transmission and reception devices (intra- and inter-satellite)

#### Description:

Analysis of requirements and complete transmission and reception schemes

Optical transmitters (1064 and 1550 nm): laser diodes, fiber amplifiers

Optical receivers (PIN, APD)

**Full-or-part-time:** 17h 30m

Theory classes: 6h

Self study : 11h 30m

### RF communication

**Description:**

Electromagnetic waves in free space  
Electric and magnetic fields radiated by a current element.  
Polarization: linear and circular.  
Transmitted power flux density.  
Radiation pattern of different antenna types.  
Basic transmission equation: directivity, effective receiving area; antenna gain concept.  
Description of basic propagation loss.  
Transmitting and receiving antennas.  
Losses in system elements.  
Propagation losses: clouds, gases, terrain effects.  
Complete transmission equation.

**Full-or-part-time:** 26h

Theory classes: 10h

Self study : 16h

### Wireless laser communications

**Description:**

Directivity in optical transmission systems.  
Satellite-to-satellite communication  
Satellite-to-ground communication:  
Cloud attenuation  
Gas attenuation  
Refractive turbulence:  
Downlink:  
Received power fluctuation  
Apparent angle of arrival (AOA) fluctuation  
Uplink:  
Wavefront power fluctuation  
Beam wandering  
Beam spreading

**Full-or-part-time:** 26h

Theory classes: 10h

Self study : 16h

### Additional considerations regarding wireless communication

**Description:**

Point-ahead angle.

Doppler effect in the propagation of electromagnetic waves.

**Full-or-part-time:** 10h 30m

Theory classes: 4h

Self study : 6h 30m

## GRADING SYSTEM

The evaluation criteria defined in the infoweb of the subjects will be applied.



## EXAMINATION RULES.

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Short tests:

At the end of each even-numbered session, a brief quiz on the session's content will be conducted. To expedite feedback to students, answers will be submitted via the ATENEA platform. Laptops, tablets, mobile phones, and calculators may be used. The estimated duration of each quiz is 15 minutes.

MQ and FQ Exams:

Written exam. Books, notes, computers, tablets, and mobile phones are not permitted. Duration: 120 minutes

## BIBLIOGRAPHY

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### Basic:

- Javier Bará Temes. Ondas electromagnéticas en comunicaciones [on line]. Barcelona: Edicions UPC, 1999 [Consultation: 12/01/2026]. Available on: <https://hdl.handle.net/2099.3/36205>. ISBN 9788498802405 .
- Javier Bará Temes. Circuits de microones amb línies de transmissió [on line]. Barcelona: Edicions UPC, 1993 [Consultation: 12/01/2026]. Available on: <https://hdl.handle.net/2099.3/36162>. ISBN 9788498800456.
- J. Senior. Optical Fiber Communications, principle and practice [on line]. 3. Essex: Pearson, 2009 [Consultation: 12/01/2026]. Available on: <https://shijuinpallotti.wordpress.com/wp-content/uploads/2019/07/optical-fiber-communications-principles-and-pr.pdf>. ISBN 978-0-13-032681-2.

### Complementary:

- Cardama Aznar, Ángel ; Jofre Roca, Lluís ; Rius Casals, Juan Manuel ; Romeu Robert, Jordi ; Blanch Boris, Sebastián ; Ferrando Bataller, Miguel. Antenas [on line]. Barcelona: Edicions UPC, 2002 [Consultation: 12/01/2026]. Available on: <https://hdl.handle.net/2099.3/36797>. ISBN 9788483019900.

## RESOURCES

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### Other resources:

Slides, available at ATENEA.