Program	59EC – Communications Electronic Engineering B. Eng. 59SC – Telecommunications Systems Engineering B. Eng. 59SO – Sound and Image Engineering B.Eng. 59TL – Telematics Engineering B. Eng.

Course number and name	
Number	595000019, 595000318, 595000118, 595000218
Name	Wave Propagation
Semester	S7 [(September-January)] & S8 [(February-June)]

Credits and contact hours	
ECTS Credits	4,5
Contact hours	45

Coordinator's name	Merodio Cámara, Pablo [pablo.merodio@upm.es]

Specific course information

Description of course content

Phenomena of generation and propagation of both electromagnetic and acoustic waves are studied.
The syllabus consists of 9 topics; the first one (Vector Operators) is a review of essential mathematical knowledges for a right progress of the course.

List of topics to be covered

1. Vector operators
   - 1.1. Gradient of a scalar field
   - 1.2. Divergence and rotational of a vector field
   - 1.3. Helmholtz's theorem
2. Plane acoustic waves
   - 2.1. Complex notation
   - 2.2. Linear acoustics
   - 2.3. Wave equation. Harmonic solution
   - 2.4. Energy density. Acoustic intensity
3. Spherical acoustic waves
   - 3.1. Spherical wave equation
   - 3.2. Harmonic solution. Acoustic variables of a spherical wave
   - 3.3. Intensity of a spherical wave
4. Stationary acoustic waves
   - 4.1. Reflection and transmission of a plane wave
   - 4.2. Standing acoustic waves
   - 4.3. Impedance of a standing wave
5. Maxwell equations. Wave equation. Energy
   - 5.1. Maxwell's equations in differential form

5.2. Electrical and magnetic potentials
5.3. Wave equation for fields and potentials
5.4. Electromagnetic field energy. Poynting's theorem
5.5. Application: Radiation from an oscillating dipole

6. Propagation of electromagnetic waves in a dielectric medium
   6.1. Solution for plane waves
   6.2. Impedance and refractive index of the medium
   6.3. Energy propagation
   6.4. Polarization
7. Propagation of electromagnetic waves in conductive media
   7.1. Free charge density in the conductor. Transversal character
   7.2. Solution for plane waves. Complex magnitudes
   7.3. Energy balance
8. Reflection and refraction
   8.1. Reflection and refraction at the dielectric-dielectric boundary
   8.2. Fresnel equations
   8.3. Reflection and refraction coefficients
   8.4. Reflection and refraction at the dielectric-conductor boundary
9. Guided waves
   9.1. Standing waves produced by reflection at the dielectric-conductor boundary. TE and TM waves
   9.2. Waveguide formed by two parallel conductive planes
   9.3. Energy balance
   9.4. Rectangular waveguide

Prerequisites or co-requisites

- Electromagnetism and Waves
- Calculus I & II
- Linear Algebra

Course category in the program

_ X _ R (required)	**__ E (elective)** *(elective courses may not be offered every year)*

Specific goals for the course

Specific outcomes of instruction

- RA94 – To analyze plane and spherical acoustic waves within limited and unlimited environments.
- RA89 – To analyze the main characteristics of the electromagnetic waves and fields.
- RA95 – To understand the basic properties of the device materials.
- RA85 – To analyze the phenomena associated to the oscillations.
- RA88 - To analyze the main characteristics of the magnetostatic field.
- RA87 - To analyze the phenomena associated to the electric field.
- RA90 – To understand and analyze the meaning and consequences of the Maxwell’s equations.
- RA92 – To analyze the effect of the boundary conditions and the guided

electromagnetic wave propagation.

- RA93 – To analyze the phenomena associated to the radiation.
- RA86 – To analyze the main characteristics of the wave propagation.
- RA91 – To analyze the electromagnetic wave propagation in dielectrics and conductors.

Further reading and supplementary materials
– Elementos de electromagnetismo. Matthew N. O. Sadiku. Edición 3ª. Ed. Oxford University Press. – Fundamentos de la teoría electromagnética. Reitz, Milford y Christy. Ed. Pearson Educación. – Campos y ondas electromagnéticos. P. Lorrain y D.R.Corson. Ed. Selecciones Científicas. – Fundamentos de Acústica. L.E. Kinsler, A.R. Frey, A.B. Coppens y J.V. Sanders. Ed. Limusa. – Moodle.