

# **Program of the course *Electromagnetism***

**Degree:** Electrical Engineering

**Academic year 2019-2020, 1<sup>st</sup> semester**

**Teaching staff:** Professor Mikhail Benilov (theoretical classes, direction of the course),  
Professor Pedro Almeida (theoretical-practical classes)

1. Electric Charge and Electric Field
  - 1.1 Electric charge
  - 1.2 Coulomb's law
  - 1.3 Electric field
2. Electrostatics
  - 2.1 Work in electric field
  - 2.2 Potential of electric field
  - 2.3 Energy of distributions of charges
  - 2.4 Notion of flow of a vector field
  - 2.5 Gauss's law
  - 2.6 Fields created by simple distributions of charges
  - 2.7 Differential form of Gauss's law
  - 2.8 Electric field in an ideal conductor
  - 2.9 Capacitance and capacitors
3. Polarization of Matter
  - 3.1 Polarization
  - 3.2 Electric displacement
  - 3.3 Energy density of electric field in matter
4. Direct Electric Current
  - 4.1 Movement of charges and electric current
  - 4.2 Ohm's law
  - 4.3 Microscopic vision of transport of current in matter

- 4.4 Energy dissipated in a resistance and Joule effect
- 4.5 Electromotive force
- 4.6 Analysis of circuits and Kirchhoff's laws
- 5. Magnetic Field
  - 5.1 Magnetic field and its effect on moving charges. The Lorentz force
  - 5.2 Effect of magnetic field on electric current. The Laplace force
- 6. Magnetostatics
  - 6.1 Production of magnetic field by current. The Biot-Savart law
  - 6.2 Interaction between two parallel wires
  - 6.3 Ampere's law
  - 6.4 Magnetic flux
- 7. Variable Magnetic Fields and Electromagnetic Induction
  - 7.1 Electromagnetic induction and Faraday's law
  - 7.2 Lenz's law and Foucault currents
  - 7.3 Mutual induction and self-induction
  - 7.4 Energy in inductive circuits
- 8. Magnetization of Matter
  - 8.1 Diamagnetism, paramagnetism and ferromagnetism
  - 8.2 Magnetization and magnetic field strength
  - 8.3 Energy density of magnetic fields in matter
- 9. Maxwell's Equations
  - 9.1 Displacement current
  - 9.2 Maxwell's equations
  - 9.3 Electromagnetic waves
- 10. Alternating Current Circuits
  - 10.1 Elements of alternating current circuits
  - 10.2 Impedance
  - 10.3 Examples of calculation of alternating current circuits
  - 10.4 Power in AC circuits

## 11. Poynting Theorem and Electromagnetic Momentum

### 11.1 Poynting theorem

### 11.2 Electromagnetic momentum

## 12. Vector Potential

### 12.1 Definition and properties of vector potential

### 12.2 Vector potential of simple fields

### 12.3 Scalar potential in the non-stationary case

### 12.4 Maxwell's equations in terms of potentials

## 13. Sinusoidal electromagnetic waves

### 13.1 Sinusoidal plane wave

### 13.2 Harmonic plane waves in non-conducting media

### 13.3 Plane waves in conducting media

## Literature

D. Halliday, R. Resnick, and K. S. Krane, *Physics*, vol. 2 extended, 4<sup>th</sup> ed., Wiley, New York, 1992. (This book is permanently available for reading in the library of UMA.) Other editions of this book can also be used.

R. A. Serway and J. W. Jewett, *Physics for Scientists and Engineers*, 9<sup>th</sup> ed., Brooks/Cengage Learning, 2014. The relevant part of the book is *Part IV: Electricity and Magnetism*. (This book is permanently available for reading in the library of UMA.) Other editions of this book can also be used.

P. A. Tipler and G. Mosca, *Physics for scientists and engineers*, 5<sup>th</sup> edition, W. H. Freeman and Company, New York, 2004. The relevant part of the book is *Part IV: Electricity and Magnetism*. (This book is permanently available for reading in the library of UMA.) Other editions of this book can also be used.

R. K. Wangsness, *Electromagnetic Fields*, 2<sup>nd</sup> ed., Wiley, New York, 1986. (This book is permanently available for reading in the library of UMA.)

## Evaluation

During the semester, the students do three tests. No auxiliary material is allowed; graphic and programmable calculators are not allowed as well. The tests have a duration of 1.5 hours each and will refer to the following material, respectively: Chapters 1-4, Chapters 5-9, Chapters 10-13. The tests will contribute to the final classification with the following weights, respectively: 40%, 25%, 35%. The students can repeat any of the three tests during the re-sitting period in January or February.