UCLouvain

lphys1221

2024

Electromagnetism 1

10.00 credits	52.5 h + 52.5 h	Q1

Teacher(s)	de Wasseige Gwenhaël ;Lemaitre Vincent ;
Language :	French
Place of the course	Louvain-la-Neuve
Prerequisites	It is recommended that students master the basics of classical mechanics as developed in the LPHYS1111 and LPHYS1113 courses. Having passed LMAT1121 is an asset.
Main themes	The concepts of electric charges (charge density) and of electric fields, Coulomb's law, the electric potential. Introduction to a number of mathematical tools (gradient, divergence). The concepts of conductors and electrical capacity, electric currents (current density), and Ohm's law (with its physical modeling). The fields produced by moving charges, the transformation of the electric field and Ampère's law. Definition of the magnetic field through the Lorentz force, the concepts of the curl of a vector field and of the magnetic vector potential, and the Biot-Savart law. Faraday's law, the concepts of electromotive force, of self-inductance, of the displacement current, and the expression of Maxwell's equations in the form of differential equations. Notions of electrical circuits with alternating currents, RL, LC, RC and RLC circuits. Electromagnetic waves and light propagation. Concepts of wave packets, phase and group velocities for electromagnetic waves. Waves in two and three dimensions, polarization. Wave guides and transmission lines. Interference and diffraction, and the justification of the geometrical optics description. Electric and magnetic fields in matter : polarization phenomena, the concepts of microscopic and macroscopic fields, the D field, diamagnetism and paramagnetism, magnetization, the H field, ferromagnetic materials.
Learning outcomes	**At the end of this learning unit, the student is able to :** 1 **a. Contribution of the teaching unit to the learning outcomes of the programme** **AA1 :** 1.1, 1.3, 1.4, 1.5 **AA2 :** 2.1, 2.2, 2.4 **AA3 :** 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 **AA4 :**4.3 **AA6 :**6.3, 6.4 **b. Specific learning outcomes of the teaching unit** At the end of this teaching unit, the student will be able to : 1. express in mathematical form the laws of electromagnetism based on experimental observations ; 2. distinguish the complementarity and the relations linking the ensembles charge-current, E- and B-fields, V- and A-potentials ; 3. appreciate the relative character of some fundamental concepts such as the E and B fields ; 4. appreciate the relevance of a reductionist approach towards a fundamental understanding of the electromagnetic phenomena ; 5. solve concrete electromagnetic problems by putting into action the laws, methods and theorems having been discussed in the teaching unit ; 6. provide a mathematical description of oscillatory and wave phenomena in classical physics ; 7. distinguish the basic concepts related to electromagnetic waves and the relations these concepts possess ; 8. identify and account for the important interference and diffraction phenomena ; 9. handle experimental instrumentation, perform measurements and provide a physical analysis of their results.

Evaluation methods	The evaluation is done by: - a written exam on the first part of the course, - supplemented with an oral exam, if the mark of the written exam is sufficient. The written exam includes several problems (similar to those solved during the tutorial sessions) and questions which aim to evaluate whether the concepts and developments presented in the theoretical course have been assimilated (comprehension questions, demonstrations, etc.). It may also include MCQs. The oral exam covers the second part of the course as well as the laboratories. Success is conditional on: - upon obtaining a total of points for both exams (written and oral) greater than 10/20 - obtaining a mark higher than 8/20 in the oral exam The terms mentioned above are valid regardless of the session.
Teaching methods	The teaching activities include : (1) the theoretical course, (2) tutorial sessions, (3) experimental work in the laboratory, (4) monitoring. It is essential to bring a simple scientific calculator to the tutorial sessions and to the practical work in the laboratory. All of the material is exposed to the theoretical course via slides and notes on the board. The fundamental concepts are illustrated by everyday applications, short films or animations and experiments. The directed exercises play an essential role for the understanding of the theoretical course and make it possible to apply the theoretical notions seen to concrete problems. It is deemed crucial to emphasize the physical concepts through their mathematical formulation based on experimental facts such as the laws of Coulomb, Ampère and Faraday. Likewise the concepts of the invariance and the conservation of a series of physical quantities and observables are emphasized. The unification of these physical laws through the concept of the electric charge and of the electromagnetic interaction which results from these, is thoroughly highlighted. Consequently, and in contradistinction to general physics courses as usually taught in scientific curriculae, an important emphasis is given to the relativity of the E and B fields through Lorentz transformations (the latter having already been discussed in the teaching unit LPHYS1111, and being reconsidered in the present one). Maxwell's laws are thereby represented through differential equations rather than integral equations. A more inductive approach is followed within the laboratory practicals which remain modest in number to allow for a better integration of the experimental method (and to avoid reducing these solely to acquiring experience in instrumentation) in direct relation with the theoretical and abstract concepts being developed in the lectures in class. Participation in the experimental work sessions in the laboratory is obligatory. A test will also be offered before each lab session and this test may have an impact on the success of the course (see the section on the evaluation method). A laboratory report can be written and submitted at the end of the session. This will then be corrected by the assistant for educational purposes but the evaluation will have no influence on the final grade of the exam.
Content	The teaching unit is structured in sections organised along the different general themes being addressed : 1. Electrostatics : concepts of electric charges (charge density) and fields, Coulomb's law ; 2. Electric potential : introduction to a number of mathematical tools and methods (gradient, divergence) ; 3. Fields around conductors : the concepts of conductors and electrical capacity ; 4. Electrical currents : the concept of current density, Ohm's law (physical model) ; 5. The field of moving charges, transformation of the electric field, Ampère's law ; 6. The magnetic field : definition, based on the Lorentz force, the concepts of curl, of vector potential, the Biot-Savart law ; 7. Electromagnetic induction and Maxwell's equation. Faraday's law, the concept of electromotive force, self-inductance, displacement current. Maxwell's equations. 8. Notions of electrical circuits with alternating currents, RLC circuits. 9. Electric fields in matter : polarisation, microscopic and macroscopic fields, the D field ; 10. Magnetic fields in matter : physical origin of diamagnetism and paramagnetism, magnetisation, the H field, ferromagnetic materials. --------- 11. Electromagnetic waves ; 12. Reflection ; 13. Modulation, electromagnetic impulses and wave packets ; 14. Electromagnetic waves in two and three dimensions ; 15. Light polarisation ; 16. Interference and diffraction ; 17. Elements of geometrical optics.
Inline resources	The slides (with links to the films or animations projected during the theoretical course), the list of exercises to solve, the materials for practical work in the laboratory and other useful documents are made available to students on the MoodleUCLouvain website of the Classes. The reference book (in French) being out of print, a copy of the chapters of the book can be found on moodleUCL

Bibliography	
Other infos	**Depending on the health conditions, the methods of teaching AND the exam could be reassessed according to the situation and the rules in force.**
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Minor in Physics	MINPHYS	10		🔍
Bachelor in Physics	PHYS1BA	10		🔍