COURSE DESCRIPTION CARD - SYLLABUS

Course name
Physics of Dielectrics [S2FT2>FizDiele]

Course

Field of study
Technical Physics

Year/Semester
1/2

Area of study (specialization)
–

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

Knowledge of the science of electricity and condensed phase physics in the scope of the curriculum content of the subjects at the 1st degree of education in the field of Technical Physics. The ability to solve elementary problems in electricity based on the acquired knowledge, as well as obtain information from the indicated sources.

Course objective

Provide students with the knowledge of the theory and basic properties and applications of dielectrics.

Course-related learning outcomes

Knowledge:
1. Has extensive knowledge of dielectrics, necessary for assessing their potential applications.
2. Has an understanding of the current state of knowledge regarding dielectric materials.

Skills:
1. Is able to select dielectric materials for their applications in modern electronics and optoelectronics.

Social competences:
1. Understands the need for continuous updating and supplementation of knowledge in the field of modern technology using dielectric materials.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

In terms of the methods used to verify the achieved learning outcomes, the following grading thresholds are applied:
50.1-60% - satisfactory;
60.1-70% - satisfactory plus;
70.1-80% - good;
80.1-90% - good plus;
from 90.1% - very good.
The grade is based on an individual written assignment and/or the assessment of an oral response.

Programme content

Maxwell's theory as applied to dielectrics, basic concepts of dielectric physics, molecular description of dielectric polarization, theory and selected models of dielectrics, dielectric relaxation, nonlinear effects in dielectrics.

Course topics

1. Maxwell's equations, electric current density, electric field intensity of a point charge, potential energy of two point charges, electric field flux, Coulomb's law.
2. Electric moment of a system of charges, electric dipole, moment of forces acting on an electric dipole, work of forces during dipole rotation, potential energy of a dipole in a constant electric field.
3. Electric potential, electric field intensity derived from an electric dipole, Laplace and Poisson equations, electric potential of many point charges, multipole moments.
4. Capacitor with a dielectric in an alternating current circuit, electric capacitance, complex electric susceptibility and permittivity, electric loss tangent.
5. Dielectric in a constant electric field, charge induced on the surface of a dielectric, relationship between polarization vectors, electric field intensity and induction, surface charge density.
6. Molecular description of electric polarization, local field, permanent and induced electric dipole moment, electronic, atomic, orientational (dipole) polarizability, space charge polarization.
7. Lorentz local field model, derivation of the Lorentz-Mossotti local field formula, relationship between electric susceptibility and polarizability - Clausius-Mossotti and Lorentz-Lorentz equations.
8. Induced and orientational polarizability, Langevin theory, dipole polarizability in Langevin theory, molar polarizability, dependence of molar polarizability on temperature, frequency characteristic of molecular polarizability, Mossotti catastrophe, Curie-Weiss temperature.
9. Onsager model, model assumptions, definition of local field in the model, definitions of internal field and reaction field, Laplace equation and boundary conditions for electric field potential, derivation of general formulas for internal field and reaction field.
10. Relationships between electrical susceptibility and permanent dipole moment for a dipole gas, a dilute solution of dipole molecules and for a dipole liquid in the Onsager model.
11. Assumptions of Fröhlich theory, Fröhlich equation defining the statistical dependence of the electrical susceptibility of a dielectric on the electric dipole moment of a particle and the resultant electric dipole moment of the molecules from its environment, filling a spherical cavity.
12. Assumptions of the Kirkwood model, derivation of the Kirkwood equation, electrical susceptibility for water.
13. Debye model of dielectric relaxation, Debye dispersion equations, dielectric relaxation models taking into account the distribution of relaxation times (Cole-Cole, Davidson-Cole and Havriliak-Negami models), Cole-Cole graphs, Kramers-Kronig equations.
14. Polarizability anisotropy and the electro-optic Kerr effect.
15. Theories of light scattering in dielectrics: Rayleigh, Einstein-Smoluchowski, turbidity (extinction) coefficient.

Teaching methods

Lecture: multimedia presentation, presentation illustrated with examples given on the board.

Bibliography

Basic:
1. A. Chełkowski, Fizyka dielektryków, PWN, Warszawa, 1993

Additional:
1. A.R. von Hippel, Dielektryki i fale, PWN, Warszawa, 1963
2. C.J.S. Boettcher, Theory of electric polarization, vol. 1 and 2, Elsevier, Amsterdam, 1978
3. B. Hilczer, J. Małecki, Elektrety i piezopolimery, PWN, Warszawa, 1992

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	32	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	43	1,50