Course	**Electromagnetism**
Course code	Fizi1062
Scientific discipline	Physics
Credits	7
ECTS credits	10.5
Total number of study room hours *Number of lecture hours* *Seminars and practical work hours* *Number of hours of laboratory work*	112 48 32 32

Author of the course
Dr. phys., Professor Valfrīds Paškevičs

Background knowledge (course title, part of the program where the course is to be completed)
The course does not require any prior knowledge

Course abstract:
The Electricity and Magnetism course is one of the most important courses in General Physics, and mastering this course determines successful further studies in General and Theoretical Physics. This course looks at the fundamental properties of matter and shows how they interact. Thus, the aim of the course is to demonstrate the universal nature of electromagnetic processes, their manifestation in nature, their application in practice.

Course timetable:
Course structure: lectures - 48 h, seminars – 32 h, laboratory works – 32 h.

Contents and plan of the course:

Lecture topics:

1. Historical development of concepts of electricity and magnetism. Electric charges. Basic characteristics of electric charge. Atom as a charged particle system. Electric field. Charged Body Interaction, Coulomb’s Law. Units of electrical charges in SI and CGS units.
2. Electric field of charges, its intensity and induction. Graphic representation of electric field. Superposition principle. Intensity vector flow. Gauss theorem, examples of its application.
3. The charge transfer work in an electric field. Circulation of intensity vector. Potential nature of electrostatic field. Potential. The potential difference. Relationship between electric field intensity and potential. Point potential, charge system and charge field potential. Equipotential lines and surfaces. Intensity and potential distribution of charge electric field in a conductor. Conductors in an external electric field. Electrostatic induction. Electrostatic protection. Mirror image method.
4. Capacity. Capacitors. Fixed charge systems, charged driver, charged capacitor energy. Electric field energy, energy density.
5. Dipole. Dipole electric field. Polar and non-polar molecules. Dipole in a homogeneous and inhomogeneous electric field. Polarization of dielectrics, vector of polarization. The relation between the density of the surface polarization charge and

the polarization vector.
6. Electric field in dielectric. Dielectric permeability of the substance. Gaussian theorem for dielectrics. The change of electric field on the dielectric interface. Temperature dependence of dielectric permeability, Clausius-Mosoti formula. Segoelectric, piezoelectric. Electrostriction. Electret.
7. Movement of charge in electric field. Electric current, its direction, density. Ohm's law in integral and differential forms. Conductor resistance, its dependence on temperature. DC work and power. Joule - Lenz Law in Integral and Differential Form.
8. Electromotive force. Ohm's law for closed circuit and chain link containing EDS source. Charge separation at power sources. Power source efficiency. Branched chains. Kirhof's Laws. Classification of solids (conductors, semiconductors, dielectrics).
9. Charge carriers in metals. Experiments by Rikes, Mandelstam and Papaleks, Stewart and Tolman. Electron charge determination. The Milikena Experiment. Classical Electron Conductivity Theory of Metals. Derivation of Ohm and Joule-Lenz laws. The Law of Wideman-Franc. Disadvantages of classical electron theory. The concept of superconductivity.
10. Semiconductors. Independent conductivity and semiconductor conductivity of semiconductors. Temperature dependence of conductivity. Photoresistors. Thermal resistance.
11. Electron output from metal. Emission of thermo electrons. Current in a vacuum. Electron lamps (diode, triode), their use. Autoelectron emission.
12. The difference in contact potential. Volta law. Thermoelectric phenomena. Peltier, Thomson, Zebeck effect. Contact effects in semiconductors (p-n transition). Semiconductor diodes and transistors, their use.
13. Electrolytic dissociation. Conductivity of electrolytes. Own law for electrolytes. Electrolysis and its use. Faraday Laws. Electrochemical potentials. Primary cells, their polarization and depolarization. Batteries
14. Ionization and recombination processes in gases, ionization energy. Ion motility. Inconsistent and continuous discharge into gases, characteristic of gas discharge volt-amps. Types of discharges in gases (glow discharge, cathode and channel rays, spark discharges, corona discharges, arc discharges), their use. Electrical phenomena in the atmosphere. Plasma. Ionization cameras and counters.
15. Current magnetic field. The Law of Ampere. Magnetic field intensity and induction. Bio-Savard-Laplace Law. Magnetic field of straight and circular current. Circulation of magnetic field intensity (induction) vector. Full power law. Solenoid magnetic field. Ampere power. Circuit with current in magnetic field, magnetic moment of current.
16. Exposure of a magnetic field to a projectile charge. The power of Lorenz. Determination of the specific charge of an electron. Hall effect and its use. Operation principle of MHD generator. Cyclic accelerators. The magnetic field of a charge in motion. Relative nature of electric and magnetic fields. Magnetic Flow. Work of moving a conductor in a magnetic field. Generation of induction current. The Law of Faraday. Law of Lenz. Induction motor. Electromagnetic induction from the point of view of energy conservation law.
17. Whirlpool electric field. Eddy current. Skinfect. Self-induction. Self-induction EDS. Inductance. Mutual induction. Current magnetic field energy, energy density.
18. Magnets. Magnetic field in magnetics. Magnetization, magnetization vector. Magnetic permeability and magnetic susceptibility. Magnetically mechanical phenomena. Experimental determination of atomic magnetic moments (Einstein and de Hahn, Barnett experiments). Electron orbital and spin magnetic moments.

19. Atom and magnetic moment. Diamagnetism and paramagnetism. Ferromagnetism. Magnetic hysteresis. Curly point. Domain structure. Permanent magnets. Magnetic circuits. Magneto-driving force. Magnetic Circuit Laws.
20. Rouland and Eichswald Experiments. Shear current. Electromagnetic field. Maxwell's equations in integral and differential forms.
21. Variable EDS acquisition. Quasi-stationary current. Mean and effective value of AC. Active, inductive and capacitive resistance in AC circuit. Vector diagrams. Ohm's law for AC circuit. Voltage and current resonance. AC work and power, active and reactive power.
22. Circuit of oscillation. Free, unstoppable oscillation. Thomson's formula. Sluggish fluctuations. Damping logarithmic decrement. Forced fluctuations. Resonance. Outline benefit and bandwidth. Forced oscillations in related circuits. Transformer. Electricity transmission. Car vibration.
23. Electromagnetic wave equation. Flat electromagnetic wave. Energy density of the electromagnetic field. Energy flow. Pointing vector.
24. Electromagnetic wave radiation. Duke experiments. Principle of Radio communication and Radar. Electromagnetic wave propagation along wires and waves. Standing waves. Electromagnetic wave scale.

Seminar themes:
1. Solving Electrostatic Problems (Coulomb's Law, Field Intensity)
2. Problem solving of electrostatics (potential, work in electric field.
3. Gauss theorem and its application in electric field calculations.
4. Electrical field conductors. Capacities, capacitors. Capacitor connections.
5. Electric field in dielectrics.
6. DC and its laws.
7. Current in conductors and semiconductors
8. Current in gases and electrolytes.
9. The magnetic field of power, Law of Ampere.
10. Magnetic field circulation theorem and its application in calculations.
11. Magnetic field motion of charged particles. Hall effect.
12. Electromagnetic induction.
13. Maxwell's equations.
14. Magnets.
15. AC circuits. AC work and power, active and reactive power.
16. Electromagnetic waves.

Laboratory works:
1. Studying electrostatic field.
2. Determination of capacitor capacity by ballistic galvanometer.
3. Determination of power supply EDS by the compensation method.
4. Determination of internal resistance of galvanometer and current cell by shunt method.
5. Determination of internal resistance of galvanometer and current cell with Wittston bridge.
6. Determination of resistance with Wittston bridge and DC bridge.
7. Determination of thermal coefficient of copper resistance.
8. Determining Battery Power and Efficiency.
9. Ammeter and voltmeter calibration.
10. Investigation of thermoelectron emission and determination of electron output.
11. Determination of the horizontal component of the earth's magnetic field.

12. Determination of magnetic field of solenoid on its axis.
13. Determination of e / m ratio by magnetron effect.
14. Measurement of coil inductance by bridge scheme.
15. Investigation of magnetic hysteresis by oscilloscope.
16. Investigation of AC circuit with series of closed consumers.

Students' independent work: Studying scientific literature, preparing for seminars, solving tasks, completing homework.

Course outcomes:

• Students have acquired knowledge of basic laws of electricity and magnetism and their realization in nature.
• Students can apply theoretical knowledge in problem solving and physical experiments.
• Students are able to independently study and analyze individual issues of electromagnetism.
• Students are able to explain natural phenomena related to electromagnetism and simple principle of operation of electromagnetic devices.
• Students are able to discuss and defend their opinion in seminars and conferences.

Requirements for obtaining credit points:

Credit: participation in seminars - 30%, laboratory work - 40%, completion of 3 tests 30%
Exam - Participation in lectures - 30%, oral presentation of two course questions - 70%. Study methods and forms to be used - lectures, seminars, consultations, individual work, presentations, discussion, argumentation.

Reference literature, study materials:

1. Platacis J. Elektrība. - R.: Zvaigzne, 1974. - 502 lpp.
2. Apinis A. Fizika. - R.: Zvaigzne, 1972. - 706 lpp.
3. Fizika. A.Valtera redakcijā. - R.: Zvaigzne, 1992. - 643 lpp.
4. Grabovskis R. Fizika. - R.: Zvaigzne, 1983. - 644 lpp.
5. K. Tabaka red. Elektrotehnikas teorētiskie pamati. – R: Zvaigzne, 1991, 284 lpp.
6. Riekstiņš E. Matemātiskās fizikas metodes. - R.: Zvaigzne, 1969. - 630 lpp.
7. Okmanis A. Praktikums elektrībā. - R.: Zvaigzne, 1971. - 207 lpp.
8. Jansons L., Zambrāns A., Badūns A., Ginters M., Jansone A. Fizikas praktikums. - R.: Zvaigzne, 1979. - 504 lpp.
9. Krūmiņš J., Lemberga B., Platacis J., Students O. Uzdevumu krājums vispārīgajā fizikā. - R.: Zvaigzne, 1971. - 420 lpp.
10. Volkenšteine V. Uzdevumu krājums fizikā. - R.: Zvaigzne, 1968. - 353 lpp.
11. Krūmiņš J., Ertele B., Zambrāns A. Fizikas uzdevumu risināšanas metodika. - R.: Zvaigzne, 1980. - 412 lpp.

Additional literature:

1. Munir H. Nayfeh, Morton K. Brussel. Electricity and Magnetism.- Singapoure: J.Willey & Sons, 1985, 619 pp.
2. H. C. Ohanian. Physics, Vol 2. New York: W.W. Norton & Company, 1985, 1012 pp.
3. D.K. Cheng. Fundamentals of Engineering Electromagnetics. – USA: Addison – Wesley Publishing Company, Inc., 1993, 488 pp.

4. J.D. Cutnell, K.W. Johnson. Physics. (5-th) – New York: John Wiley & Sons, 2001., 1002 pp.
5. D. Halliday, R. Resnich, J. Walker. Fundamentals of Physics (Extended) – New York: John Willey & Sons, Inc., 1997., 1142 pp.
6. A.L. Standford, J.M. Tanner. Physics for Students of Science and Engineering. - Orlando, Florida: Academic Press, Inc., 1985, 804 pp.
7. E. Jones, R. Childers. Contemporary College Physics. – USA: McGraw-Hill,1999, 1025 pp.
8. A.Hobson. Physics. Concepts and connections. – New Jersey: Prentice-Hall, 1999., 536 pp.
9. M. Merken. Physical science with modern application. 5-th edition. – Saunders College Publish, 1993, 680 pp.
10. R.A. Serway, R.J. Beichner. Physics for Scientists and Engineers. Vol. 1. – Saunders College Publishing: 2000., 705 pp..
11. R.A. Serway.Physics For Scientists & Engineers with Modern Physics, 3-rd edition - Orlando, Florida: 1992, 1444 pp.
12. RR.T. Weidner, M.E. Brown. Physics. – Massachusetts: Simon @ Schuster,1989, 945 pp.
13. С. Г. Калашников. Электричество.- Москва : Наука, 1964, 666 с. 14.И.Е. Тамм. Основы теории Электричества.- М: Наука, 1989. 504 с..

Recommended periodical literature
1. „Nature. Physics.” Nature publishing group.

Remarks:
Extensive and high quality information on selected course topics can be obtained from the web. ABSP Physics Part A.