PROGRAM of the course "Physics"
for group EM-15-2
II semester

Electrodynamics
1. Theory

Electrostatics

1. Electric charge, its discretion. Charge conservation law. Coulomb law. Electrostatic field and its strength. The point charge field. The superposition principle and its application to calculation of the field strength of arbitrary charges configuration

2. Graphic representation of an electrostatic field. Electrostatic field strength lines. Flux of the electrostatic field strength lines. Gauss theorem for the electrostatic field strength vector and its application.

3. The work performed by moving the charge in an electrostatic field; potential. The circulation of the electrostatic field strength vector. The potential character of an electrostatic field. Equipotential surfaces. Connection between the field strength and potential.

4. *The electrostatic field in dielectrics. Dielectrics polarization. The polarization of the dielectric. Ferroelectrics. Piezoelectric effect and its application.*

5. Conductors in the electrostatic field. Electrostatic screening. Conductor and capacitor electrocapacity.

6. Energy and volume energy density of the electrostatic field.

Direct electric current

7. *Conditions of a direct electric current existence. Current strength and current density. Electric field of a direct current. Exstraneous forces. Electromotive force and voltage.*

8. Ohm's law in integral and differential forms. Kirchhoff's rules and their application.

9. Work and power of an electric current. Joule's and Lenz's law in integral and differential forms.

10. Electric current in gases, ionization and recombination. The concept of the plasma. Thermoelectronic emission; electrovacuum devices.

Stationary magnetic field

11. Field of a moving charge. Magnetic field and its relativistic origin. Magnetic field action at the conductor with a current. Ampere's law. The concept of magnetic field induction.

12. Lorentz force. Motion of charged particles in the magnetic field. Hall effect and its application.

13. Circuit with a current in the magnetic field. Magnetic moment of the circuit with a current. The principle of an electric motor action. Work performing by moving a conductor and a circuit with a current in the magnetic field.

14. Law of Biot - Savart - Laplace for current element and its application to the calculation of the fields of the simplest configurations of currents. Field of straight and circular currents.

15. Circulation of magnetic induction vector. Vortex nature of the magnetic field. The solenoid magnetic field. The flux of a magnetic induction vector. Gauss theorem for a magnetic induction vector.

16. *Magnetic field in matter. Types of magnets. Magnetic field strength. Magnetization. The failure of classical explanation of the matter magnetic properties. Ferromagnets and their properties. Application of ferromagnets.*

The phenomenon of electromagnetic induction. The basics of Maxwell's theory of electromagnetic field

17. Faraday's experiments. Electromotive force (EMF) of induction, Lenz's rule. Generators of electric current. Mechanisms of EMF induction initiation; vortex electric field.

18. The phenomenon of self-induction, inductance, long solenoid inductance. Concept of the mutual induction. Trasformers. Magnetic field energy. Volume energy density of the magnetic field.

19. The displacement current. The relative nature of the electric and magnetic fields; electromagnetic field. Maxwell's equations in integral form as a complete system of classical electrodynamics equations.

2. Control tasks to self-study on electrodynamics /7/.

N	Individual task №2	N	Individual task №2	N	Individual task №2	N	Individual task №2
1	Variant 1	9	Variant 9	17	Variant 7	25	Variant 5
2	Variant 2	10	Variant 10	18	Variant 8	26	Variant 6
3	Variant 3	11	Variant 1	19	Variant 9	27	Variant 7
4	Variant 4	12	Variant 2	20	Variant 10	28	Variant 8
5	Variant 5	13	Variant 3	21	Variant 1	29	Variant 9
6	Variant 6	14	Variant 4	22	Variant 2	30	Variant 10
7	Variant 7	15	Variant 5	23	Variant 3	31	Variant 1
8	Variant 8	16	Variant 6	24	Variant 4	32	Variant 2

Oscillatory and wave processes

1. Theory

Oscillatory processes

20. Periodic processes in nature and technology. Spectral decomposition of an arbitrary periodic process. Harmonic oscillations as the simplest component of arbitrary periodic process. Natural (free) oscillations. The concept of a harmonic oscillator. The differential equation of a harmonic oscillator oscillations and its solution.

21. A spring, mathematical and physical pendulums. Electrical oscillating circuit in the absence of active resistance.

22. *The energy of the harmonic oscillation. Energy conversion during the oscillation process*.

23. Damping mechanical and electromagnetic oscillations. Attenuation coefficient, logarithmic decrement, Q-factor. Aperiodical processes.

24. The addition of harmonic oscillations of the same direction and the same frequencies. The beatings. The addition of mutually perpendicular oscillations with equal and different frequencies. Lissajous figures, their using for measurement of the frequency of the oscillations.

25. Forced oscillations, the differential equation of forced oscillations (mechanical and electromagnetic), its solution. The amplitude and the phase of the forced oscillations. Resonance, its application in the science and engineering. Resonant curves, their analysis.

Wave processes

26. The mechanism of mechanical waves formation in the elastic medium. Longitudinal and transverse waves. A travelling wave. Stationary, monochromatic, sine waves. The wave surface, wave front, the wavelength, the wave number, the wave vector, the phase velocity. Plane and spherical waves. Equation of a travelling wave, the wave equation.

27. *Wave propagation in media with dispersion. The concept of a wave packet and of a group velocity.*

28. The principle of superposition. Interference of monochromatic waves; coherence.

29. Standing waves. Nodes and antinodes. The eigenfrequencies of a bounded medium.

30. *Elements of acoustics. Characteristics of sound waves. Ultrasound and its using. Refraction and reflection of sound.*

31. Maxwell's equations in the absence of electrical charges and conductivity currents; electromagnetic waves, the speed of their propagation in dielectric. Differential equation of the electromagnetic wave. Energy of the electromagnetic wave. Pointing vector. Transmission and receivement of electromagnetic waves.

32. *The scale of electromagnetic waves, their basic properties. Using of electromagnetic waves of the different range*.

Wave optics

33. Overview of the development of ideas about the light nature. Lightwaves, light vector, optical path length. Coherence and monochromaticity of lightwaves.

34. Interference of light; methods of observation of light interference. Interference in thin films. Application of the light interference.

35. Diffraction of lightwaves. The Huygens-Fresnel principle. Concept of Fresnel zones method. Fresnel diffraction on a round hole and on the disk. Fraunhofer diffraction on a slit and

diffraction gratings; diffraction grating as spectral device. *A concept of optical devices resolution. The idea about the holography*.

36. Polarization of lightwaves. Natural and polarized light; partially polarized light; the degree of polarization of light. *Polarization of light by reflection and by refraction.*

37. Double refraction in crystals; physical nature of double refraction. *Polarizing prisms and polaroids. Malus law. Using of polarized light in science and technology.*

38. Dispersion of light. The concept of electronic dispersion theory. Dispersion and absorbtion.

Elements of quantum optics

39. Thermal radiation, its equilibrium character. Total and spectral emissivity; absorbtive ability. Blackbody; Kirchhoff's law.

40. Incapacity of the classical theory of the blackbody thermal radiation. Quantum hypothesis and Planck formula for the distribution of energy in the spectrum of the blackbody radiation.

41. The law of Stefan-Boltzmann, Wien's displacement law; the relationship of these laws with Planck formula. *Optical pyrometry. Thermal light sources*.

42. External photoelectric effect, its experimental regularities. Incapacity of classical physics during explanation of experimental regularities of external photoelectric effect. *Application of external photoeffect; photocells, photorelay.*

43. Corpuscular-wave dualism of electromagnetic radiation. Photons, their energy, mass and momentum. The concept of the quantum theory of the external photoelectric effect. Einstein's formula for the external photoelectric effect. The Compton effect, its theory.

44. *Environment with inverted population of the energy levels. Spontaneous and stimulated emission. The principle of laser operation.*

2. Practical works of the oscillatory and wave processes, wave and quantum optics.

3. Control tasks to self-study on the oscillatory and wave processes. wave and quantum optics. /7/

N	Individual task №4	N	Individual task №4	N	Individual task №4	N	Individual task №4
1	Variant 1	9	Variant 9	17	Variant 7	25	Variant 5
2	Variant 2	10	Variant 10	18	Variant 8	26	Variant 6
3	Variant 3	11	Variant 1	19	Variant 9	27	Variant 7
4	Variant 4	12	Variant 2	20	Variant 10	28	Variant 8
5	Variant 5	13	Variant 3	21	Variant 1	29	Variant 9
6	Variant 6	14	Variant 4	22	Variant 2	30	Variant 10
7	Variant 7	15	Variant 5	23	Variant 3	31	Variant 1
8	Variant 8	16	Variant 6	24	Variant 4	32	Variant 2

Foundations of quantum physics

1. Theory

Elements of quantum mechanics

45. Complications of classical physics. Experimental evidence of the presence of wave properties of microparticles; corpuscular-wave dualism of matter properties. De Broglie formula.

46. Uncertainty relations for coordinates and appropriated to them momenta projections of microparticle as a manifestation of its wave properties. Uncertainty relation for energy and time; the concept of a stationary state of a quantum mechanical system. Applicability bounds of the classical mechanics.

47. The wave function and its statistical sense. Schrodinger’s equation as an equation of motion in quantum mechanics. Stationary Schrodinger’s equation. The tunnel effect, its manifestations; the particle transition coefficient through the potential barrier.

48. Microparticle in the one-dimensional rectangular infinitely deep potential well. Quantization of energy as a manner of extraction of energy stationary states of a quantum system. Particle zero-energy.

49. Schrodinger’s equation for an electron in a hydrogen atom. Mechanical and magnetic momenta of the orbital motion of an electron. Spin mechanical and magnetic momenta of an electron; Bohr magneton. The energy spectrum of hydrogen atom and the hydrogen-like atoms. The concept of the many-electron atoms energy spectrum. Concept of the spectral analysis.

50. *X-rays; a solid and characteristic x-ray spectra. Shortwave border of the x-ray spectrum. Obtainment and using of x-rays*.

Elements of quantum statistics and solid state physics

51. The concept of quantum statistics; Fermi-Dirac and Bose-Einstein statistics; Pauli principle. Quantum distribution functions. Ideal gas Fermi at T = 0; Fermi energy (level). Changing of Fermi quantum distribution function with increasing of temperature; Fermi temperature and its physical meaning. Electron gas in metal as an object of Fermi-Dirac statistics using.

52. The concept of quasi-particles; the conductivity electrons in an electric field of a crystal lattice and phonons as the quasi-particles. The concept of quantum theory of heat capacities of crystals; Debye's temperature. Electrical conductivity of metals, the nature of the resistance of metals from a quantum point of view. Metal resistance dependence on the temperature. Concept of superconductivity.

53. Splitting of the energy levels of the valence electrons in the isolated atoms at the formation of crystal lattices and the emergence of energy zones. Division of solids in the conductors, dielectrics and semiconductors from the zonal point of view.

54. Intrinsic semiconductor, dependence of its conductivity on the temperature. Extrinsic semiconductors, the donor and the acceptor levels. Electrons and holes; semiconductors of *p* - and *n* - type. Valvular contact properties of semiconductors of *p* - and *n* - type. The electrical double layer (*p* - *n* - transition). *Semiconductor diodes, transistors*.

55. Internal photoelectric effect and its using.

Physics of atomic nucleus

1. Theory

The structure and the coupling energy of the nucleus;nuclear reactions; radioactivity

56. Experimental facts, which evidence to the compound structure of the atomic nucleus, its composition; nucleonic model of atomic nucleus. The basic static characteristics of nuclei: mass, size, charge and magnetic moment, mass and charge number of the atomic nucleus. Mass defect and the coupling energy of the nucleus, the stability of atomic nuclei. Nuclear forces as a manifestation of the strong interaction between the nucleons

57. The concept of nuclear models; liquid drop model. Nuclear reactions, their classification. Threshold and energy of the reaction. Conservation laws in nuclear reactions.

58. *Radioactivity. The law of radioactive decay. Alpha- and beta-decays, their mechanisms, the origin of γ-radiation. Induced radioactivity, its types. Obtainment and using of radioactive nuclides. The chain reaction of nuclear fission. A nuclear reactor operation. Fission products of nuclear fuel. Advantages and disadvantages of nuclear power. Fusion of atomic nuclei. The problem of controlled fusion reaction.*

Fundamental particles and interactions; contemporary physical picture of the world

59. *Fundamental interactions. Leptons and quarks; gauge bosons. Hadrons; quark structure of hadrons. Hadronic families.*

60. *Substance and field. An idea on the contemporary problems of physics.*

2. Practical works of the fundamentals of the quantum and nuclear physics.

3. Control tasks to self-study on of the fundamentals of the quantum physics. /7/

N	Individual task №5	Problems numbers	N	Individual task №5	Problems numbers
1	Variant 1	1; 3; 7	17	Variant 7	1; 3; 7
2	Variant 2	1; 3; 7	18	Variant 8	1; 3; 7
3	Variant 3	1; 3; 7	19	Variant 9	2; 4; 6
4	Variant 4	2; 4; 6	20	Variant 10	2; 4; 6
5	Variant	1; 3; 7	21	Variant 1	1; 3; 7
6	Variant 6	2; 4; 6	22	Variant 2	2; 4; 6
7	Variant 7	1; 3; 7	23	Variant 3	1; 3; 7
8	Variant 8	2;4;6	24	Variant 4	2; 4; 6
9	Variant 9	1; 3; 7	25	Variant 5	1; 3; 7
10	Variant 10	2; 4; 6	26	Variant 6	2; 4; 6
11	Variant 1	2; 5; 7	27	Variant 7	2; 5; 7
12	Variant 2	1;3;6	28	Variant 8	1; 3 ;6
13	Variant 3	2; 4; 6	29	Variant 9	2; 4; 6
14	Variant 4	3; 5; 7	30	Variant 10	1; 3; 7

15	Variant 5	1; 3; 7	31	Variant 1	3; 5; 7
16	Variant 6	1; 4; 7	32	Variant 2	1; 4; 7

4. Control tasks to self-study on of the fundamentals of the quantum statistics, solid state physics and atomic physics nucleus. /7/.

N	Individual task №6	Problems numbers	N	Individual task №6	Problems numbers
1	Variant 1	1; 3; 7	17	Variant 7	1; 3; 7
2	Variant 2	1; 3; 7	18	Variant 8	1; 3; 7
3	Variant 3	1; 3; 7	19	Variant 9	2; 4; 6
4	Variant 4	2; 4; 6	20	Variant 10	2; 4; 6
5	Variant 5	1; 3; 7	21	Variant 1	1; 3; 7
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7	Variant 7	1; 3; 7	23	Variant 3	1; 3; 7
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11	Variant 1	2; 5; 7	27	Variant 7	2; 5; 7
12	Variant 2	1;3;6	28	Variant 8	1; 3; 6
13	Variant 3	2; 4; 6	29	Variant 9	2; 4; 6
14	Variant 4	3; 5; 7	30	Variant 10	1; 3; 7
15	Variant 5	1; 3; 7	31	Variant 1	3; 5; 7
16	Variant 6	1; 4; 7	32	Variant 2	1; 4; 7

Literature

Principal

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2. Курс фізики (під редакцією Лопатинського І.Є.). – Львів.: ”Бескід Біт”, 2002

3 Савельев И.В. Курс общей физики. – М.: Наука, 1977-1978, т.1,2,3

4 Савельев И.В. Курс физики. – М.: Наука, 1988-1989, т.1,2,3

5. Детлаф А.А. Курс физики. – М.: Высшая школа, 1989, 2001

6. Трофимова Т.И. Курс физики. – М.: Высшая школа, 1990, 1997, 2005.

7. Гаркуша І.П., Курінний В.П., Мостіпан Л.Ф. Фізика. – Дніпропетровськ: НГУ. 2008, 2011.

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8. Яворский Б.М., Пинский А.А. Основы физики – М. Наука, 1969, 1972, т.1,2.

9. Гаркуша І.П., Мокляк З.П., Буслов Ю.О. Фізика. Задачі з розв'язаннями. Дніпропетровськ. НГУ. 2003.

10. Гаркуша І.П. Физика. Ч.3. Электростатика. Учебное пособие. Днепропетровск. ДВНЗ. НГУ. 2013.

11. Гаркуша И.П. Элементы физики полупроводников. – Дніпропетровськ: НГУ. 2013.

Notation. Items typed by italic are supposed to be studied by self-work.