ENTRANCE EXAMINATION PROGRAM
FOR PHYSTECH SCHOOL OF RADIO ENGINEERING AND COMPUTER TECHNOLOGY
PHYSICAL SCIENCES
COMPETITIVE GROUP
FOR APPLICANTS ENTERING PHD PROGRAMS

The exam ticket includes 2 questions. The first question is from the section of the program corresponding to the scientific specialty in which the applicant intends to study. The second question is about the applicant's future dissertation work: subject, existing groundwork, presence of a supervisor, publications. Questions can also be asked about the content of the final qualifying work (master's or specialist’s).

1 hour is given for preparation and it is allowed to use books, with the exception of electronic media. It is not allowed to use different means of communication or the Internet. The applicant answers the exam ticket in the form of an oral interview, during which additional questions on the relevant section of the program may be asked.

Section 1. Radiophysics

1. Equations of the electromagnetic field. Constitutive equations. Border conditions.
2. Plane homogeneous and inhomogeneous waves. Electromagnetic waves in a medium with conductivity. Energy flow. Polarization.
3. Properties of electromagnetic waves in anisotropic media. Faraday effect, Cotton-Mouton effect, ordinary and extraordinary waves, their polarization.
4. Vector operations in curvilinear orthogonal coordinates. Bromwich method. Equations for Bromwich functions. Debye potentials. Abraham potentials.
5. Cylindrical electromagnetic waves. Spherical electromagnetic waves.
6. Approximation of geometric optics. Eikonal equations. Differential equation of a beam.
7. Electromagnetic waves in metal waveguides. Critical frequency and critical length of the waveguide. TE, TH, and TEM waves.
8. Dielectric waveguides, light guides. Lens lines and open resonators. Gaussian beams.
9. Waves in one-dimensional and two-dimensional periodic structures. Floquet theory.
10. Green's function for an unbounded space. Retarded potentials. Radiation conditions.
11. Electromagnetic field of elementary sources. Electric and magnetic dipoles of Hertz. Near and far zones. Directional diagram. Resistance and conductivity of radiation.
12. Field in a limited area of space. Equivalence theorem. Vectorized Kirchhoff formula. Huygens-Fresnel principle.
13. Formulation of the boundary value problem. Diffraction of a plane wave on a plane interface between two media. Fresnel formulas. Skin effect. Leontovich boundary conditions.
14. Methods for matching a flat interface between two media and a dielectric layer.

15. Rigorous methods for solving boundary value problems in electrodynamics. Problems of scattering on a cylinder and a sphere.
16. Numerical methods for solving boundary problems of electrodynamics. Method of integral equations. Finite element method. Projection methods.
17. Kirchhoff's method in the theory of diffraction. Diffraction in the Fresnel and Fraunhofer zones.
18. Antennas for LW, MW and microwave bands, their main characteristics. parabolic antennas. Phased arrays.
19. Antennas in receive mode. Effective area and noise temperature of the receiving antenna.
20. Problems of optimal signal reception. Posterior probability density. Likelihood function. Statistical testing of hypotheses. Bayes, Neyman-Pearson and Wald tests of hypotheses.
21. Noise sources and their classification. Quantitative characteristics of noise. Noise-equivalent temperature (NET). Noise figure.
22. A priori information about the signal and noise. Observation and communication. Problems of interpolation, filtering and extrapolation.
23. Noise temperature of the receiver. Antenna noise temperature. Noise temperature of the atmosphere. Signal band, noise band.
24. Linear Kolmogorov-Wiener filtering based on minimizing the error variance. The principle of orthogonality of error and observation. Realizable linear filters and the Wiener-Hopf equation. Separation of signal from noise. matched filter.
25. Correlation and spectral characteristics of stationary random processes. Wiener-Khinchin theorem. White noise and other examples of spectra and correlation functions.
26. Physical foundations and principles of operation of microwave transmitting devices. Spatio-temporal diagrams of grouping of electrons. Phase and energy relations.
27. The principle of operation of generators on avalanche transit time diodes, generators on Gunn diodes, generators and amplifiers on microwave transistors.
28. Random variables and processes, methods of their description. Stationary random process. Statistical and time averaging. Ergodicity. Measurement of probabilities and averages.
29. Correlation and spectral characteristics of stationary random processes. Wiener-Khinchin theorem. White noise and other examples of spectra and correlation functions.
30. Models of random processes: Gaussian process, narrow-band stationary noise, impulsive random processes, shot noise.

Section 2. Laser Physics

1. Thermal radiation and Planck equation.

2. Laws of the photoelectric effect. Photon concept.
3. Spectrum of the hydrogen atom, Balmer's formula.
4. N. Bohr theory of the hydrogen atom.
5. Dipole-allowed transition in an atom and a two-level system.
6. Phototransition cross section and spectral shape of the line.
7. Basic photoprocesses in a two-level system.
8. Photoexcitation and photoionization of matter.
9. Radiation scattering: Rayleigh, Raman, Compton.
10. Two-level system in the field of thermal radiation, Einstein coefficients.
11. Quantum states of the electromagnetic field.
12. Maxwell's equations in the medium.
13. Propagation of electromagnetic waves in matter.
14. Physical principle of laser operation.
15. Balance equations describing the operation of a laser.
16. Basic properties of laser radiation.
17. Schematic diagram of the laser.
18. Laser resonator, longitudinal and transverse modes.
19. Main types of lasers and their features.
20. Various laser operation modes.
21. Generation of harmonics of laser radiation.
22. Parametric radiation amplifier.
23. Generation of ultrashort laser pulses.
24. Coherent processes in the laser field.
25. Application of lasers in science and technology.

References

Radiophysics

1. Никольский В.В. Электродинамика и распространение радиоволн: учебное пособие для радиотехнических специальностей вузов/ В.В.Никольский, Т.И. Никольская. – 6-е изд. – М.: Эдиториал УРСС, 2012 . – 544 с.
2. Л. А. Вайнштейн, Электромагнитные волны. М.: Радио и связь, 1988.
3. А. Ю. Гринев, Численные методы решения прикладных задач электродинамики. М.: Радиотехника, 2012.
4. Г. Т. Марков, А. Ф. Чаплин, Возбуждение электромагнитных волн. М.: Радио и связь, 1983.
5. C. A. Balanis, Advanced engineering electromagnetics. N.Y.: John Wiley & Sons, 1989.

6. С. М. Рытов. Введение в статистическую радиофизику. Часть 1. Случай-ные процессы. – М.: Наука, 1976.
7. С. М. Рытов, Ю. А. Кравцов, В. И. Татарский. Введение в статистическую радиофизику. Часть 2. Случайные поля. – М.: Наука, 1978.
8. М. Букингем. Шумы в электронных приборах и ситемах. – М.: Мир, 1986.
9. С.З. Кузьмин, Основы проектирования систем цифровой обработки радиолокационной информации. М.: Радио и связь, 1986.
10. Д.М. Сазонов, Антенны и устройства СВЧ. – М.: Высш. шк., 1988.
11. Устройства СВЧ и антенны. Проектирование фазированных антенных решеток. – Учебное пособие для ВУЗов. Под ред. Д.И. Воскресенского, М.,»Радиотехника», 2012.
12. М. В. Вамберский, В. И. Казанцев, С. А. Шелухин, Передающие устройств СВЧ. М.: "Высшая школа", 1984.

Laser Physics

1. В.А.Астапенко Взаимодействие излучения с атомами и наночастицами. Долгопрудный: Интеллект 2010, 492 с.
2. В.А.Астапенко Электромагнитные процессы в среде, наноплазмоника и метаматериалы. Долгопрудный: Интеллект 2012, 583 с.
3. В.А.Астапенко, Ю.С. Протасов. Введение в квантовую электронику. ч.I. М.: из-во Янус-К, 2013, 476 стр.
4. В.А.Астапенко, Е.Ф.Ищенко, Ю.С. Протасов. Введение в квантовую электронику. ч.II. М.: из-во Янус-К, 2013, 477 стр.
5. В.А.Астапенко. Взаимодействие электромагнитных импульсов с классическими и квантовыми системами. Учебное пособие. Изд. МФТИ, Москва, 2013 г., 232 с.