ENTRANCE EXAMINATION PROGRAM

FOR
PHYSTECH SCHOOL OF AEROSPACE TECHNOLOGY
INFORMATION TECHNOLOGY AND TELECOMMUNICATIONS
COMPETITIVE GROUP

FOR APPLICANTS ENTERING PHD PROGRAMS

The entrance examination is conducted in the form of an interview.
The interview consists of two parts:

- interview on the content of the final qualifying work written by the applicant at the end of the specialist's or master's degree - in accordance with Part I of this Program;

- interview on general theoretical questions of the chosen specialty- in accordance with Part II of this Program.

PART I

Questions on the final qualifying work of the applicant

(Master or specialist's degree)

1. Main provisions.
2. Novelty.
3. Relevance.

Specialty 2.3.1.
System Analysis, Management and Information Processing

PART II

1. Basic concepts of system analysis. Characteristic features of complex systems. Forecasting the time of change of states in complex systems as a moment of change in integral characteristics. Limits of the principle of reductionism.
2. Main tasks, methods of system modeling. Components of system modeling. Stages of modeling. Modeling forms: synthesis, assembly, model adjustment, parameter identification.
3. Input, output and control variables in system modeling, tasks and methods of aggregation and disaggregation. Sensitivity to control variables.
4. Choice of parameters in modeling the dynamics of complex systems. Identification of parameters in models. Dependence of the simulation result on the choice of parameters. Sensitivity to parameters.
5. Trajectory tubes. Scenario research. Optimization, dimension reduction. Interpretation and presentation of results.
6. Traditional methods of system analysis of complex systems. Matrix, system-dynamic, diffuse, stochastic models.
7. Linear programming - problem definition. Simplex algorithm.

8. Bayesian method. A priori and a posteriori distributions of parameters: continuous and discrete cases.
9. The maximum likelihood estimation and its relation to the maximum a posteriori probability in Bayesian estimation in the asymptotic case.
10. Identification of models' parameters on the example of parameters' identification in the model of paired linear regression and homogeneous Cobb-Douglas production function. Identification of parameters in a linear regression model with autocorrelated first and second order errors.
11. Problems of estimating the state of the control object. Problems of interpolation, filtering and extrapolation. Mathematical formulation of the filtration problem. Kalman filter for discrete and continuous cases.
12. Optimal control. Classification of optimal control problems. Euler-Lagrange multiplier method. Pontryagin's maximum principle. Linear Regulator.
13. Basic concepts of applied system analysis. Classification of decision-making problems proposed by G. Simon. Features of weakly structured decision-making problems.
14. Classification of multi-criteria decision-making methods. Features of the application of multi-criteria decision-making methods in logistic problems. Methods of verbal decision analysis (VDA). Classification of VDA methods.
15. Concept of cryptographic methods of information protection. Cryptographic protocols and algorithms. Fundamentals of cryptanalysis. Cryptographic hardware.
16. The main tasks of modern CIS (satellite communication systems, navigation systems and information systems for Earth remote sensing).
17. Architecture and hierarchy of building CIS. Division scheme. Functional analysis and synthesis of CIS.
18. Modular design. The concept of sustainable design. Technological readiness.
19. Concepts of systemic risks. Principles and methods for ensuring the reliability of CIS.
20. Validation and verification of the results of CIS system design.
21. Technological stages of managing the process of design work: network diagrams, performance control, reporting forms.
22. Linear filtering theory. Deterministic signals, ways of their description. Convolution integral. Fourier transform and its functional properties. Analysis of linear imaging systems using the Fourier transform. Central limit theorem in the analysis of linear systems.
23. Random signals and ways to describe them. Random functions and fields. Numerical characteristics. Distribution function and probability density functions. Stationarity, homogeneity, ergodicity. Autocorrelation function and spectral density. Correlation and spectral analysis. Types of one-dimensional spectra. Transformation of spectral density by linear links. Probabilistic description of continuous images.
24. Methods of image transmission. Characteristics of the image transmission system. Using vision models when encoding images. Encoding by pulse code modulation. Statistical coding. Predictive coding. Transform coding. Hybrid coding. Interframe coding with conditional replacement. Reducing redundancy in binary images.
25. Methods of image processing. Representation of images in digital form. Discretization and reconstruction of continuous images. Mathematical description of discrete images. Linear operators. Superposition operator. Two-dimensional unitary transformations. Fourier transform. Cosine transform. Sine transform. Hadamard, Haar transform. Singular transformation. Two-dimensional methods of linear processing. Processing using transformation. Superposition with transformation. Convolution with the use of the fast Fourier transform. Filters based on the Fourier transform.

References

For questions 1-10

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3. Афанасьев М.Ю. Исследование операций в экономике: модели, задачи, решения / М.Ю. Афанасьев, Б.П. Суворов. – М.: Инфра-М, 2003.
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10. Лагоша Б.А. Оптимальное управление в экономике. - М.: Финансы и статистика, 2003. – 192 с.
11. Майер-Шенбергер В. Большие данные. Революция, которая изменит то, как мы живем, работаем и мыслим / Виктор Майер-Шенбергер, Кеннет Кукьер; пер. с англ. Инны Гайдюк. – М.: Манн, Иванов и Фербер, 2014. – 240 с.
12. Моисеев Н.Н. Математические задачи системного анализа. М.: Наука, 1981, 487 с.
13. Осипов Г.С. Лекции по искусственному интеллекту. - М.: КРАСАНД, 2009. - 272 с.
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15. Ширяев В.И., Баев И.А., Ширяев Е.В. Экономико-математическое моделирование управление фирмой. М.: КомКнига, 2007. – 224 с.

For questions 11-14

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2. Колос М.В., Колос И.В., Методы линейной оптимальной фильтрации. М.: МГУ, 2000.
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For questions 15-25

1. Гонсалес Р., Вудс Р. Цифровая обработка изображений. Издание 3-е, испр. и дополн. Пер. с англ. М.: Техносфера, 2012 – 1104 с.
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3. Залманзон Л.А. Преобразование Фурье, Уолша, Хаара и их применение в управлении, связи и других областях. 1989 г. - 496 с.

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