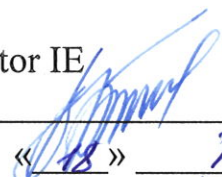


Ministry of Science and Higher Education of the Russian Federation  
Federal State Autonomous Educational Institution of Higher Education  
“Peter the Great St. Petersburg Polytechnic University”  
**INSTITUTE OF ENERGY**

APPROVED

Director IE

  
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« 18 » 2024.

V.V. Barskov

ENTRANCE EXAM PROGRAM  
for those enrolling in the first year  
for main educational programs of the major  
**13.04.02 «ELECTRICAL ENGINEERING»**

programs:

- Electrical Power Engineering (international education program)

Saint-Petersburg  
2024

## ANNOTATION

This document lists the professional cycle topics (questions) from the Bachelor's degree curriculum in Electrical Power Engineering (13.04.02), used in the Master's program entrance exam.

The entrance examination is scored out of 100 points; a minimum score of 50 (50%) is required to pass. Exams for English-taught programs will be conducted in English.

Educational program manager



S.M. Dudkin

The program is considered and recommended for publication by the Academic Council of the Institute (Minutes No. 10 of "15" November 2024).

## **1. DISCIPLINES INCLUDED IN THE PROGRAM OF MASTER'S DEGREE ENTRANCE EXAMS**

1. Theoretical foundations of electrical engineering
2. Electric machines
3. Electrical and electronic devices
4. Electrotechnical materials
5. Electrical systems and grids
6. High voltage technologies
7. Power stations

## **2. CONTENT OF ACADEMIC DISCIPLINES**

### **1. Theoretical foundations of electrical engineering**

Physical foundations of electrical engineering; electromagnetic field equations.

Electrical circuit laws; sinusoidal current circuits; three-phase circuits; circuit calculation for periodic non-sinusoidal effects.

Quadripoles (two-port network); transient processes in linear circuits; nonlinear electrical and magnetic circuits; circuits with distributed parameters.

Electromagnetic field theory; electrostatic field; stationary electric field; magnetic field; analytical and numerical methods of calculating electric and magnetic fields; alternating electromagnetic field; surface effect and proximity effect; electromagnetic shielding.

### **References**

1. Demirchan K.S., Neumann L.R., Korovkin N.V., Chechurin V.L. Theoretical Basics of Electrical Engineering, 1, 2, 3 - St. Petersburg: Piter, 2009.
2. Korovkin N.V., Selina E.E., Chechurin V.L. Theoretical Basics of Electrical Engineering: A Taskbook - St. Petersburg: Piter, 2004.

## 2. Electric machines

Fundamental physical laws and principles of energy conversion in electric machines. Types of electric machines and their classification; principles of operation, design, basic equations and characteristics of transformers, AC and DC electric machines. Loss and efficiency of electric machines. Ways to startup and regulate the frequency of rotation of different types of electric motors, the basic principles and tasks of designing electric machines. Choice of their electromagnetic and thermal loads.

### References

1. Electric Machines. Introduction to the Electromechanics. DC Machines and Transformers: / Voldek A.I., Popov V.V - St. Petersburg: Piter, 2008.
2. Voldek A.I., Popov V.V. Electric Machines. AC Machines: A Textbook for Universities. - St. Petersburg: Piter, 2008.  
<https://www.elec.ru/files/2020/01/17/voldek-ai-popov-vv-elektricheskie-mashiny-mashiny.PDF>

## 3. Electrical and electronic devices

Classification of electrical and electronic devices. Dynamic characteristics of electromagnetic mechanisms.

Nominal current, nominal shutdown current, thermal and electrodynamic withstand current of high-voltage circuit breakers. Electrodynamic forces in contacts. Heating of contacts in electrical devices.

Electric arc disconnection and arc extinguishing devices of high-voltage circuit breakers. Normalized transient recovery voltage.

Current and voltage measuring transformers, surge arresters. Automatic low-voltage circuit breakers; arc extinguishing low-voltage devices of AC and DC current; semiconductor electrical devices.

Parameters of sulfur hexafluoride and vacuum as an insulating and arc extinguishing environment, their disadvantages when used in high-voltage circuit breakers; complete switchgears with sulfur hexafluoride high-voltage insulation.

### References



1. Electrical Control and Automation Equipment: Study Manual. / S.M. Apollonsky, Yu.V. Kuklev, V.Ya. Frolov; St. Petersburg: Lan Publishing House, 2017. -256 p.: ill. (Textbooks for universities. Special literature).
2. High-Voltage AC Switches: Study Manual / E.N. Tonkonogov; St. Petersburg State Polytechnic University. - St. Petersburg: Polytechnical University Publishing House, 2015, p. 263. <https://elib.spbstu.ru/dl/2/si20-68.pdf/info>
3. High-Voltage Electrical Devices: Study Manual for Universities / G.N. Alexandrov et. al.; edited by G.N. Alexandrov. – 2nd ed., reworked and expanded. St. Petersburg: St. Petersburg State Technical University Publishing House, 2000, p.503.

#### **4. Electrotechnical materials**

Conductors, semiconductors, dielectrics and their classification.

Electrical conductivity of materials; polarization, dielectric losses.

Breakdown of dielectrics; aging of dielectrics, chemical structure and properties of polymers.

Classification of electrical insulation systems; requirements for electrical insulation of electric power and electrical equipment, insulation of cables, wires, electric capacitors. Typical designs and technologies for their manufacturing; capacitor insulation systems and conductive materials. Cable groups, their choice and design principles.

Uninsulated wires for power lines, power cables and cable lines; fiber optic cables.

#### **References**

1. Samusenko A.V. Stishkov Yu.K. "Electrophysical Processes in Gases Exposed to Strong Electric Fields" SPSU Publishing House. SPb. 2011. -566 p.
2. Blythe E.R., Bloor D. Electrical Properties of Polymers. Fizmatlit Publishing House - 2008 ISBN: 978-5-9221-0893-5. – 378 p.
3. Iorgachev D.V., Bondarenko O.V. Fiber Optic Cables and Communication Lines. Ecotrade Publishing House. M. 2002. – 321 p.

## **5. Electrical systems and grids**

General information about electric power systems. Characteristics of equipment of power lines and substations. Types of electrical grid configurations.

Electric loads of electrical grid nodes. Equivalent circuits of power lines, transformers and auto transformers.

Calculation of operation modes of electric power systems. Balances of active and reactive power in the power system, quality of electricity.

Voltage and frequency regulation in the electric power system.

Transient processes in electrical systems; classification of transient processes, causes of origin.

Concepts of sustainability in electric power systems, measures to increase sustainability. Short-circuit current and its properties. The method of symmetrical components.

### **References**

1. Kostin V.N. Electric Power Systems and Grids: Study Manual. - St. Petersburg: Trinity Bridge, 2015. 304 p.: ill.
2. Evdokunin G.A. Electrical Systems and Grids: Study Manual for Students of Electrical Engineering Majors of Universities. 3rd ed., corrected and expanded - St. Petersburg, Synthesis Book LLC, 2011. 288 p.: ill.
3. Electromechanical transients in electric power systems: studies. manual / A.N. Belyaev [et al.]. – St. Petersburg: Publishing House, 2017. – 156 p.
4. Electromagnetic Transient Processes in Electric Power Systems: Study Manual / A.N. Belyaev et al. St. Petersburg: Polytechnical University Publishing House, 2012. 149 p.
5. Electrical Systems and Networks: Study Manual / A.S. Brilinsky et. al. St. Petersburg: POLYTECHPRESS, 2020. 174 p.

## **6. High voltage technologies**

Types of electrical insulation of high-voltage equipment. Insulation of overhead lines.

Lightning protection of overhead lines. Insulation of electrical equipment at power stations and substations, closed and open distribution devices. Sulfur hexafluoride insulation; internal insulation of high-voltage plants.

Insulation of high-voltage cables and capacitors. Lightning protection and electromagnetic compatibility of equipment of power stations and substations. Protection of electrical insulation from internal overvoltages.

The basics of high voltage measurements and tests, high-voltage test rigs: pulse voltage generators, constant voltage and industrial frequency test rigs.

### **References**

1. High-Voltage Technologies: A Textbook for Universities in the "Technical Physics" bachelors' major / Y.N. Bocharov, S.M. Dudkin, V.V. Titkov; Urait Publishing House, Universities of Russia series, 2016  
<https://elib.spbstu.ru/dl/2/s16-41.pdf/info>
2. V.Titkov, F. Khalilov Overvoltages and Lightning Protection, study manual, "Lan," 2016.

### **7. Power stations**

Synchronous turbo and hydro generators: rotor and stator design. Engine room layout of the power plant, the excitation system, the cooling system, the basic parameters of synchronized generators.

Generators, startup and synchronization, parallel operation of generators, generator operation.

Compensation of reactive power in the power system, voltage control in the nodes of the power system using synchronous compensators.

Startup of synchronized compensators, operation of turbo- and hydro generators in the synchronous compensator mode, transition of the synchronous machine to the synchronous compensator mode, the design features of synchronized compensators.

Complete low- and medium voltage conductors; flexible and rigid busbars of high-voltage switchgears.



Static reactive power compensation devices: capacitor batteries: design, applications, commutation features; static thyristor compensators: operation principles, types. Longitudinal compensation devices in the form of serially connected capacitor batteries; shunt reactors.

### **References**

1. Foundations of Modern Energy: in 2 volumes : a textbook for universities in the majors "Heat Power Engineering," "Electrical Engineering," "Energy Engineering" / under the general ed. E.V. Amethysov. – 5th ed., stereotypical. - M.: MEI Publishing House, 2010.  
<https://elib.spbstu.ru/dl/2/si20-171.pdf/info>
2. Operation Modes of Electrical Equipment of Power Substations / Chernovets A.K., Lapidus A.A. - SPbSPU Publishing House, 2006.
3. Electrical Part of Power Supply Systems of Power Plants and Substations / Chernovets A.K., Lapidus A.A. - SPbSPU Publishing House, 2006

### **8. Language proficiency**

Ability to produce clear, detailed text on a wide range of subjects and explain a viewpoint on a topical issue giving the advantages and disadvantages of various options.

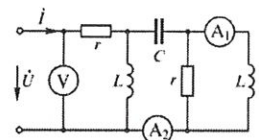
### **References**

1. <https://www.ielts-writing.info/EXAM/>
2. Complete IELTS. Bands 6-7, Brook-Hart Guy



### 3. SAMPLE TEST QUESTIONS

1. What type of power plants plays the key role in power generation in Russia?
2. At which voltages are autotransformers the most profitable to use for grid interconnection?
3. Why are there two switches per generator in a hydro-accumulating power plant?
4. On which characteristics of the switches does the success of self-startup depend?
5. Which policy documents are the key ones in determining the characteristics of overvoltages?
6. Which parameters of the equivalent circuit are affected by splitting the power line phase wires?
7. Sinusoidal current and voltage are known:
8.  $i = 28.2 \sin 314t$ ,  $u = 141 \sin(314t + \pi/6)$ .
9. What are the current  $I$  and voltage  $U$  values, the frequency  $f$  of current and voltage changes, and the phase shift  $\varphi$  between them?
10. Load power at the receiving end of the line is  $S_l = 1.0 + j0.5$  (p.u.). By how many times will the loss of active power decrease with full compensation of the reactive power of the load by compensating devices and a constant voltage at the ends of the line?
11. What is the steady state current of a short circuit of a transformer, if its  $u_{sc} = 5\%$ ?
12. What can the asymmetrical mode of network operation be caused by?
13. The breakdown voltage of the air gap measured with a sphere gap at the industrial frequency equaled 115 kV. What is the 50% discharge voltage of a given gap when exposed to a lightning voltage wave if its impulse factor is 2.5?
14. Which law is the aging insulation of low-voltage electric machines subject to?
15. What should the tripping settings of longitudinal differential protection be?
16. For the circuit, the diagram of which is depicted in the Figure, determine the readings of the ammeters A1 and A2



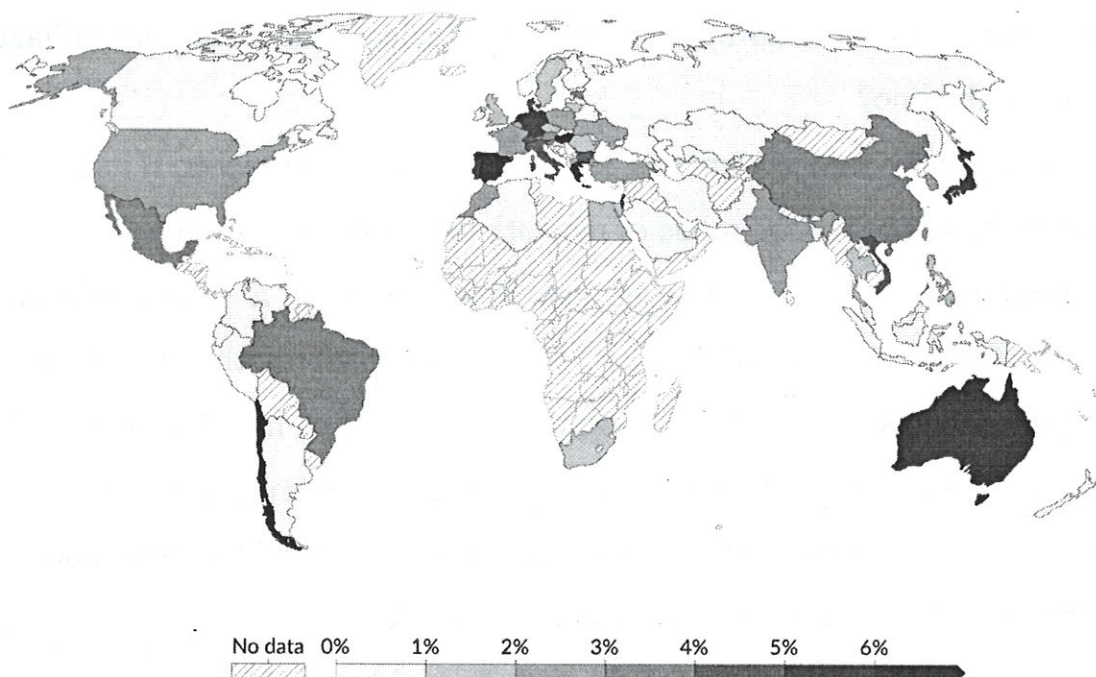
and the voltmeter V if  $r = x_C = x_L = 1 \text{ Ohm}$  and  $I = 10 \text{ A}$ .

17. What is the electrodynamic withstand current of a switch?
18. What should the resistance of the startup rheostat connected serially with the armature be so that the startup current of the parallel excitation motor  $I_p = 2I_{\text{nom}}$ , if we know that  $U_{\text{nom}} = 220 \text{ V}$ ,  $I_{\text{nom}} = 10 \text{ A}$ , and armature resistance  $R_a = 0.1 \text{ Ohm}$ ?
19. What is the magnetic flow of the armature transverse reaction at the nominal excitation current?
20. What is the optimal switching in a DC machine?
21. Why is boosting the excitation up to the ceiling voltage for synchronized generators needed?
22. What are the ratios between phase and linear voltages and currents in the symmetric load connected triangularly?
23. Data Analysis: Describe the provided data graph in approximately 150 words. Highlight key features, trends, and comparisons.

## Share of primary energy consumption from solar, 2023

Measured as a percentage of primary energy<sup>1</sup>, using the substitution method<sup>2</sup>.

Our World  
in Data



Data source: Energy Institute - Statistical Review of World Energy (2024)

OurWorldinData.org/energy | CC BY

24. Critical Essay: Write a short opinion essay on a current issue within the field of Nuclear Power engineering **“The future of electricity transmission and distribution in a decarbonized world.”** Clearly state your position and support it with reasoned arguments.
- 25.

#### 4. FINAL PROVISIONS

After the interdisciplinary exam, the applicant is informed about the results of the interdisciplinary exam.

If the applicant does not agree with the result of the entrance exam, the applicant may appeal the results of the entrance exam.