Essay Topics

1. The Role of Automation in the Development of Modern Industry
2. Prospects for the Implementation of Control Systems Based on Artificial Intelligence
3. Industrial Internet of Things (IIoT) as the Basis for Digital Production
4. Development of SCADA Systems: Challenges and Trends
5. Application of PLC in Modern Automation Systems
6. Reliability and Safety of Automated Control Systems
7. Architecture and Principles of Building Process Control Systems
8. Building Automation and Smart Cities: A Step Towards a Sustainable Future
9. The Role of Robotic Systems in Industrial Automation
10. Machine Vision in Control Systems: From Machine Learning to Practice
11. Microprocessor-Based Automated Control System
12. Identification of Control Objects
13. Smart Home System
14. Machine Vision Systems
15. Process Optimization with Automated Control Systems
16. Artificial Intelligence in Automatic Control Systems
17. Automation and Control in Medicine: From Diagnostics to Surgery
18. Automated Control of Unmanned Vehicles transport
19. Application of neural networks in the management of nonlinear objects
20. Modern trends in the automation of logistics processes

Exam questions

Block 1

1. Define the concept of "system" and explain the main features of systematicity.
2. Characterize the key categories of representing an object as a system.
3. Explain the relationship between the structure of the system and its functionality.
4. Assess the significance of the concept of the external environment in systems theory.
5. How is the organization and functionality of a technical system manifested?
6. Explain the difference between open and closed systems using technical objects as an example.
7. Justify the need for systems analysis as a methodology for solving complex interdisciplinary problems.
8. Reveal the essence of the systems approach and its role in scientific knowledge.
9. Justify the difference between systems analysis and other methods for studying complex objects.
10. Formulate and explain the main goals and objectives of systems analysis.
11. Assess the advantages of using systems analysis in the development of automated control systems.

12. Analyze the principles of system classification. Give examples for different classes.

13. List and characterize the main properties of systems: emergence, integrity, reliability, etc.

14. Characterize the system properties: reliability, adaptability, organization, integrity.

15. Reveal the essence and differences between emergent, static and dynamic properties of systems.

16. Give examples of adaptive systems and describe the mechanism of their adaptation.

17. Explain the patterns of interaction between a part and a whole. Reveal the concepts of emergence and integrativity.

18. Justify the importance of hierarchical ordering of systems. Characterize the signs of hierarchy.

19. Reveal the essence of the patterns of feasibility of systems. Explain the concepts of equifinality and necessary diversity.

20. Analyze the main patterns of system development. Explain the relationship between self-organization, historicity and synergetics.

21. Justify the importance of functional description of systems in systems analysis.

22. Explain the purpose of functional description of a system. Give examples of graphical models.

23. Compare different graphical methods of functional description of systems, including the IDEFO method and the function tree.

24. Explain the goals and methods of morphological description of systems.

25. Give an example of morphological description of a system and explain its role in structural analysis.

26. Analyze the classification of structures by the nature of the relationships between elements.

27. Describe the principles and examples of methods for describing the structure of a system.

28. Explain the goals of information description of systems and the structure of such a description.

29. Justify the need for an information description of a system. What does the pragmatic aspect of information reflect?

30. List the characteristics for assessing information flows in a technical system.

31. Explain the syntactic, semantic and pragmatic aspects of information in systems.

32. Compare morphological, functional and informational descriptions of systems by their goals, methods and results.

33. Analyze the relationship between informational, morphological and functional descriptions in systems analysis of complex objects.

34. Assess the importance of choosing an approach to describing a system (functional, morphological or informational) depending on the stage of the system's life cycle.

35. Explain the importance of modeling in systems analysis. Classify models.

36. List the types of models used in systems analysis. Give examples.

37. Describe the general requirements for models used in technical systems.

38. Describe the main stages of modeling technical systems. Indicate the importance of each stage.

39. Name and briefly describe the stages of systems analysis when solving an engineering problem.

40. Justify the use of the decomposition strategy in the analysis of complex technical systems.

41. Describe the synthesis stage in systems analysis. How is a generalized representation of a system formed?

42. Justify the role of systems analysis in decision-making when modeling technical systems.

43. What is the role of stability in the dynamics of complex control systems? Give examples.

44. Describe the integrative properties of a system. How do they affect controllability?

45. Provide a definition of a system state set and describe methods for its formalization.

46. Give an example of assessing the measure of fuzziness of a system state set.

47. Explain the content of the set-theoretical approach to systems analysis. What is a constraint function?

48. What aspects of a system structure can be described using multiple models?

49. Explain the concept of system complexity. What measures of its assessment exist?

50. Analyze the concept of system complexity. Explain approaches to its assessment and methods for simplifying systems.

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2 Block

1. Build a functional model of the power supply dispatching system for an industrial complex using IDEF0 notation. What key functions and information flows have you reflected? What are the limitations of such a model in practical application?
2. Build a functional model of an automated system for monitoring and regulating the microclimate in a greenhouse using IDEF0 notation. What are the main control and regulatory functions reflected? What are the inputs, outputs, mechanisms and controls?
3. Develop a functional model of a water purification and drinking water distribution system in a residential area using IDEF0 notation. Specify which key blocks ensure functioning and characterize the possible limitations of the model when scaling the system.
4. Using the example of an automated system for managing a fleet of autonomous drones, decompose the system into hierarchical levels. What layers have you identified? Provide arguments on how the chosen structure improves the controllability of the system.
5. Using the example of an automated control system for an electronics assembly line, perform a hierarchical decomposition. What control levels are distinguished (operational, tactical, strategic)? Justify how the structure affects the reliability and adaptability of control.
6. Perform a decomposition of the intelligent video surveillance system at an enterprise with division by control levels (from the sensor layer to the analytical level). Provide arguments on how the structure contributes to scalability and integration with other systems.
7. Analyze a simple technical system - an automatic washing machine using a structural and functional model. Specify: system elements, connections between them, input/output parameters, functions and goals of the system.
8. Consider an automatic lighting control system in a "smart" home. Conduct its structural and functional analysis: determine the composition of components, logical connections, control signals and the intended purpose of the system.
9. Consider an adaptive ventilation control system in a smart building. Perform its structural and functional analysis: define the system elements, input and output parameters, interactions between components, and control goals.
10. Consider an automatic temperature control system in an intelligent office building. Analyze the system architecture: specify the composition of components, types of sensors and actuators, interactions with other building systems, as well as the functional purpose and key control parameters.
11. Build a Use Case diagram for an intelligent lighting control system in a smart building. Specify the actors (operator, light sensor, controller), their interactions with the system. Analyze the completeness of the coverage of user scenarios for lighting control when external conditions change.
12. Build a Use Case diagram for an automated access control system at an enterprise using biometric data. Identify users (staff, security, administrator) and

describe their interaction scenarios with the system. Justify the completeness of the scenarios in terms of security and ease of use.

13. Build a Use Case diagram for a SCADA system for monitoring a water supply pumping station. Specify the actors (operator, pressure sensors, controller, emergency module). Analyze how the covered use cases ensure reliability and timely response to emergencies.

14. Develop a Class Diagram for an automatic temperature and pressure control system in the production of sterilized products. Identify the main entities (temperature sensor, pressure regulator, actuator), their attributes and methods. Justify how the class structure contributes to the modularity and fault tolerance of the system.

15. Develop a Class Diagram for an automated control system for a package sorting production line. Describe the classes (sorter, conveyor, controller, packaging object) and their relationships. Justify the system architecture in terms of scalability and integration.

16. Develop a Class Diagram for a medical system for automatic monitoring and regulation of artificial lung ventilation (ALV) parameters. Specify the attributes, methods, and relationships between the classes: flow sensor, pressure regulator, alarm module. Explain how the class structure implements the principle of reliability and patient safety.

17. Build a state diagram for a portable device for monitoring patient respiratory functions. Specify the possible states: on, data collection, alarm state, information transmission, waiting. Explain how transitions between states ensure a timely response of the system to deterioration of the patient's condition.

18. Build a state diagram for an automatic liquid supply device in a heat irrigation system

19. Build a State Diagram for an industrial robot sorter on a packaging line. Specify the states: waiting for an object, gripping, moving, laying down, returning. Evaluate the system's behavior when an actuator malfunctions.

20. . Build an Activity Diagram for the process of collecting and transmitting soil moisture data from sensors to the irrigation controller. Show the key stages: sensor activation, measurement, processing, data transmission, decision making on irrigation. Analyze possible failure points and suggest ways to eliminate them.

21. Build an Activity Diagram for an automated fuel metering and supply system at a thermal power plant. Specify the steps: flow measurement, balance metering, supply, control, signaling. Justify the logic and completeness of the route in the context of energy efficiency.

22. Build an Activity Diagram for the failure prediction algorithm in the equipment vibration diagnostics module. Reflect the actions: signal collection, filtering, feature extraction, condition assessment, warning. Justify the applicability of the sequence of actions to a real industrial environment.

23. Develop a Sequence Diagram for a scenario of automatic vibration data analysis for spindle bearing condition diagnostics. Specify the interaction: sensor → processing module → predictive model → warning system → operator. Analyze how

the time sequence of data exchange affects the timeliness of diagnostics and failure prevention.

24. Develop a Sequence Diagram of interactions between modules of the control system of an autonomous mobile robot in a production workshop. Specify the sequence: sensors → navigation module → route planner → actuator. Explain the importance of the order of interactions for ensuring traffic safety.

25. The company plans to implement a new automated production management system. Describe which methods of system analysis should be applied at the stage of examining the current system and forming requirements. How to evaluate the effectiveness of implementing a new system?

26. Build a semantic network representing the fact "If the machine has finished processing a part, the robot loads the parts onto the machine, which transports them to the warehouse."

27. Build a semantic knowledge structure about the event "The Director of the Salut plant stopped workshop No. 4 on March 30, 2019, to replace the equipment."

28. Using the corresponding arcs, build a semantic network related to the diagnosis of eye diseases (arcs: disease categories, pathophysiological condition, observations, symptoms).

29. Using the corresponding arcs, build a semantic network related to the recognition of chemical structures (arcs: substance formula, substance properties, area of application, precautions).

30. Using the corresponding arcs, construct a semantic network concerning the procedure for searching for minerals (arcs: name of the mineral, location of the deposit, depth of occurrence, extraction methods).

31. Build a model of a frame system that helps in planning conferences in various areas: information technology, economics, ecology, etc. The following must be taken into account: date, location, topic, organizers, participants.

32. Build a model of a frame system for selecting a product for use in a technical system complex. Input data: organization, development of a technological solution, study of the "physical effect", methods of creating a product.

33. Build a model of a frame system that helps in organizing a logistics chain, using knowledge of product classification. Input data: name, area of application, storage method, transportation method.

34. Build a model of a frame system that helps in analyzing database information in mechanical engineering with the following components: physical effects, technical solutions, products, product delivery object, devices and stands, standards.

35. Using a frame model of knowledge representation, implement a structure of relationships that describe the following situations: use of a product with the following components: organization, development of a technological solution, study of the "physical effect", methods of creating a product.

36. There are observations of the parameter for 7 hours: $y=\{15,16,14,17,18,16,19\}$. Construct a forecast for the 8th hour using the moving

average method of order 3. Explain how the choice of order affects the sensitivity of the forecast.

37. There are observations for 6 hours: y={18, 19, 17, 20, 21, 22}. Forecast the value of the parameter for the 7th hour. Explain why the moving average method can lose sensitivity with a sharp change in the parameter.

38. There are data: y={12, 13, 14, 15, 15, 16, 17}. Build a forecast for the 8th hour using the moving average method of order 3. Compare the result with the forecast for order 5 and draw a conclusion about the effect of the smoothing window length.

39. As part of monitoring a technological process, the values of a controlled parameter were obtained for six consecutive hours: y = {10,12,11,13,12,14}. Forecast the value for the 7th hour using the simple moving average method of order 3. Explain how the choice of a lower order affects the sensitivity of the forecast to random fluctuations.

40. Data on product output for 5 days were recorded: y = {120,125,130,128,127}. Forecast the value for the 6th day using the moving average method of order 3. Justify what limitations of the method appear in the presence of a trend in the data.

41. The temperature values in the reactor are recorded for 7 hours: y={72,75,74,76,78,77,79}. Determine the forecast for the 8th hour using the moving average method of order 4. Analyze to what extent the obtained value reflects the real trend of the parameter change.

42. The pressure indicators in the pipe are considered for 6 time intervals: y={2.1,2.4,2.2,2.3,2.5,2.6}. Find the forecast for the 7th interval using the moving average method of order 2. Explain in which cases such an order can lead to a "noisy" result.

43. The gas consumption indicators (in m^3/h) are known for 5 hours: y={310,305,312,308,311}. Build a forecast for the 6th hour using the moving average method of order 3. Compare the result with the forecast for order 2 and draw a conclusion about the effect of increasing the "averaging window" on smoothing out sharp deviations.

44. Using the exponential smoothing method with the coefficient $\alpha = 0.4$, calculate the forecast for the 7th step for the series: y = {20,21,19,22,21,23}. Take the initial smoothed value equal to the first observation. Explain how the coefficient α affects the adaptation of the method to trend changes.

45. Using the exponential smoothing method with the coefficient $\alpha = 0.3$, calculate the forecast for the 6th step for the series: y = {10,11,13,12,14}. Take the initial smoothed value equal to the first observation. Explain how the choice of smoothing coefficient affects the model's response to fluctuations in the data.

46. Given a series of observations: y={30, 32, 31, 33, 34}. Calculate the forecast for the 6th step using the exponential smoothing method with $\alpha=0.2$. Justify why a low value of α is preferable at a high level of random fluctuations.

47. Given a series y={25, 27, 26, 28, 29}, calculate the forecast for the 6th step using the exponential smoothing method with α=0.6. Analyze how quickly the method responds to changes in the series with this value of α.

48. Given an AR(1) model: yt=0.6yt−1+2 and the value y5=10. Calculate the forecast y6, y7. Explain how the model parameters affect the forecast behavior. How can the adequacy of the model be assessed?

49. The AR(1) model is given: yt=0.75yt−1+1. The value y4=16. Calculate the forecasts y5, y6. Compare the nature of the forecast when the autodependency coefficient is greater than and less than 1. What does model stability mean?

50. The AR(1) model is given: yt =−0.5yt−1+12. It is known: y3=8. Construct forecasts for the 4th and 5th steps. Explain how the sign of the autodependency coefficient affects the shape of the forecast (damped oscillations/stable trend).

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3 Block

1. List and describe the main categories of artificial intelligence: weak, strong and specialized. What are their key differences?

2. Analyze which categories of artificial intelligence - weak, strong and specialized - are applicable in control systems and why. Give examples.

3. Justify the choice of a certain approach to modeling artificial intelligence for adaptive control tasks in real time.

4. Analyze the directions of development of artificial intelligence and justify their applicability for solving technological challenges in the field of automation. Give examples.

5. Construct a logical diagram of the algorithm for setting a problem in artificial intelligence systems and comment on it using a specific subject area as an example.

6. Classify artificial intelligence methods and compare them with the levels of complexity of control problems.

7. Suggest a classification of automation problems in terms of the applicability of various artificial intelligence models.

8. Justify the choice of one of the artificial intelligence methods for predictive diagnostics tasks in industry.

9. Explain how the use of artificial intelligence allows implementing adaptability and sustainability in cyber-physical systems.

10. Assess the risks and limitations of using artificial intelligence in critical technical systems.

11. Compare the requirements for knowledge representation models when building an expert system under complete and partial uncertainty.

12. Compare the requirements for knowledge representation models in intelligent systems when working under complete and partial uncertainty.

13. Assess the applicability of the semantic network for representing knowledge about the subject area in intelligent systems.

14. Analyze the role of link types in the semantic network in logical inference.

15. Assess the role of the frame model of knowledge representation in formalizing the subject area as part of an intelligent system.

16. Analyze the applicability of the frame model for representing and using structured knowledge in intelligent systems.

17. Explain how the frame specification and attached procedures affect the flexibility of the artificial intelligence system in control.

18. Compare the approaches of the semantic and frame models of knowledge representation in solving diagnostic analysis problems.

19. Determine under what conditions the semantic or frame model of knowledge representation is preferable for diagnostic analysis problems.

20. Formulate the key elements of the knowledge representation structure to support decision making in process control systems.

21. Compare knowledge representation models according to the criteria of extensibility and scalability.

22. Develop a production model describing the behavior of the system in case of deviations from the norm. Analyze the advantages of such a model.

23. Explain how structuring the rule base using AND/OR graphs affects the performance of the expert system.

24. Compare the principles of construction and inference in production and formal models. When and why is each preferable?

25. Suggest criteria for choosing a knowledge representation model depending on the subject area and available data.

26. Give an example of a problem in which the use of formal logic provides better results than a heuristic approach.

27. Explain how production rules can be combined with trainable elements (e.g. neural networks).

28. Build a formal system based on given axioms and inference rules to describe a technical procedure.

29. Analyze how the limitations of predicate calculus affect the applicability of the formal model to real-world problems.

30. Assess the applicability of the production model of knowledge representation for constructing logical inference in intelligent systems.

31. What are the capabilities and limitations of the production model when solving problems related to knowledge management in intelligent systems?

32. Justify the use of fuzzy logic in controlling dynamic systems with a high level of uncertainty.

33. Compare the methods of representing unreliable and fuzzy knowledge. In which cases is each method more applicable?

34. Analyze the architecture of a system with fuzzy logic: from data input to obtaining a result.

35. Build an example of a fuzzy rule base for a climate control system and describe the process of fuzzification and defuzzification.

36. Name and explain the main limitations of fuzzy logic as applied to artificial intelligence problems.

37. What methods are used to overcome the limitations of fuzzy logic in modern artificial intelligence systems? Give examples.

38. Build the structure of a fuzzy control system for a mobile robot. Specify the roles of each component.

39. Explain the mechanism for constructing a fuzzy rule base based on expert assessments and statistical data.

40. Analyze how fuzzification affects the resilience of an intelligent system to data noise.

41. Suggest criteria for assessing the quality of fuzzy inference in technical systems.

42. Compare adaptive and static fuzzy systems in terms of application to nonlinear controlled objects.

43. Classify expert systems by type of task and level of interaction with the user. Give examples.

44. Describe the structure of an expert system for monitoring the technical condition of a complex object and justify the choice of its components.

45. Evaluate the stages of expert system development technology and suggest approaches to improving their efficiency.

46. Explain how the structure of the expert group affects the quality and reliability of the knowledge obtained.

47. Analyze the use of expert systems in a changing subject area. What mechanisms allow the system to adapt?

48. Suggest an architecture for a distributed expert system and indicate the advantages of this approach.

49. Evaluate methods for coordinating expert knowledge in the event of conflicting assessments.

50. Explain how the knowledge base of an expert system can be verified and validated.

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