State Exam Questions

Study Programme: Innovation and Industrial Engineering

The professional discussion of the state exame is structured into four areas consisting of basic theoretical subjects of the profiling basis, 25 questions were defined for each area.

Area 1 – Methods of Innovation Engineering

Course: Innovation Engineering

1. Definition and starting points of innovation engineering. Innovation orders. Innovation cycle. Methods of innovation engineering. (description, introduction of methods)
2. Systematic planning of technical innovation I. Market analysis. Trend analysis. Technology Roadmapping. (description)
3. Systematic planning of technical innovation II. Innovation opportunities/ideas and their evaluation. Innovation Statement. (description)
4. Value analysis. The concept of function in value analysis. Cost-function matrix. Suggestions for improvement. (principle, description)
5. Specification of user and customer needs. Methods of identifying needs. Affine diagram. (description, indication of procedure)
6. QFD method (principle, procedure)
7. Methods of problem modeling and the creation of an innovative assignment. Functional-object analysis. The ISQ method. (principle, procedure)
8. Systematic survey of the state of the art. (procedures and sources for searches in patent and non-patent sources).
9. Methods of innovative creativity. Morphological matrix. Inventive principles. (introduction of methods, principle of morphological matrix, introduction of examples of inventive principles)
10. FMEA method (principle, procedure)
11. Architecture of the innovated product. Dependent and modular architecture. The MFD method. Design Structure Matrix. (description)
12. Selection of the concept of the innovative product. Pugh's method. Multi-criteria evaluation of concepts. AHP method. (description, procedure)
13. Industrial design and styling. Industrial design tools. Use of virtual and augmented reality. (description, examples)

Course: Theory of inventive problem solving (Methods of technical creative work)

1. Conventional methods for solving problems - principle of methods, examples of methods, advantages and disadvantages
2. Levels of inventions, systematic methods - presentation of levels of inventions, presentation of the essence of the TRIZ method
3. Analysis of the development phase of the technical system according to the so-called S-curve – principle, procedure
4. Analysis of functions and components of a technical system (product, device), functional-object analysis (FOA) – principle, purpose, procedure
5. Simplifying the design of the technical system while maintaining its functions (trimming) – principle, trimming rules, procedure
6. Searching for the root causes of technical system deficiencies (RCA/RCA+ analysis) – principle, procedure
7. Mapping of the state of the art and prediction of development using trends in the development of technical systems (TESE) - procedure, examples of trends in the evolution of technical systems

8. Technical contradictions and methods of solving them - defining the contradiction, specifying the solution procedure
9. Physical contradictions and methods of solving them - defining the contradiction, specifying the solution procedure
10. Inventive principles - essence, use, examples of principles
11. Separation principles - essence, use, presentation of principles
12. Functionally oriented search for known solutions in cyberspace (FOS) - principle, procedure

Area 2 – Product design

Course: Principles of product design

1. PLM, product development from the point of view of resources, methods and external influences and internal measures (basic axioms of PLM systems, PLM and the designer, the relationship between PLM and the customer, new powerful technologies, issues of globalization).
2. CAD systems and their implementation into PLM. PDM, EDM systems, Smart-team, Windchill (options of these systems, use in practice, terms client, server, roles, change management).
3. DFA (Design for Assembly) general principles (how to proceed when designing an assembly according to DFA principles, examples of practical solutions, connection issues).
4. Factors of product design dependent and independent of assembly creation principles and their procedures (methodology of product design from the point of view of its assembly, basic rules and principles for manual assembly, assessment of suitability of assembly construction).
5. Product structure, modular design solution for complex assemblies, automated assembly (methods and possibilities of product optimization using properties, modern CAD technology, what can be simulated).
6. New technologies and their use for DFA (new connecting elements and their calculations, orientation and stability of parts during their assembly for both manual and automated assembly, unusual, inadmissible design solutions of products from the point of view of assembly and production).
7. DFM (Design for Manufacturing) – design from the point of view of production (differentiate in general from the point of view of product design into piece, small-batch and large-batch production and single-purpose equipment, which are the highly productive methods of production that are often used today).
8. DFMA – methods and evaluation of two opposing views of assembly and production (price approach, minimization of production and assembly costs).
9. DFM – modern and classic materials, mechanical properties, composites, plastics, high-strength sheets (description).
10. DFM - forgings, sheet metal stampings, welded joints. (creation of sheets, pipes, distributions, pneumatic and hydraulic mechanisms in CAD systems, electrical connections and connectors).
11. DFD (Design For Disassembly) - design from the point of view of disassembly (disassembly procedures, material separation, recycling, environment, energy and water consumption).
12. DFE (Design For Environment) - design with regard to the environment (design with regard to ecological packaging, ecological production and recycling, state and describe some standards applicable to the design of products).
13. Design For Testability / Inspectability - design from the point of view of testing and control (possibility of building in sensors, types of sensors and sensors of non-electrical physical quantities, conversion of non-electrical quantities into electrical ones, give practical examples).
14. Design For Trouble Free And Reliability - design from the point of view of trouble free and reliability (testing, measuring, testing, life calculations, fatigue, resistance to wear, describe what is diagnostics, what methods does it use? Prediction of failures.)
15. Design For Maintainability / Serviceability - design from the point of view of maintenance, repairability. (5S, maintenance of management systems according to ISO standards, state the basic principles of productive maintenance).
16. Design For Transportation and Packaging - design in terms of transportation and packaging (packaging methods, packaging materials and equipment, give practical examples).
17. Design For Upgrade - design from the point of view of improvement, expansion (what are the possibilities of expanding product functions and their properties, where they are used, give practical examples).

18. Design For Install ability - design from the point of view of install ability, (installation of machines and products in their destinations, supplied energy).
19. Design For Safeness And Guarantee - design from the point of view of safety and guarantee (state the principles).
20. Dependence of dimensional, geometric tolerances and surface roughness, RPS points. Precision of engineering production, methods and possibilities of measurement on products and marking on drawings.
21. Tolerance analysis, drawing documentation. Gaussian curve equation, influence of individual parameters on its shape. Production settings, waste minimization.
22. Optimization of the product, the process of creation and evaluation of solutions by other methods without the use of FEM. Options for creating control elements in the part tree, assemblies, Topological optimization.
23. Static calculations, modal analyses, natural oscillations, natural oscillations with input of boundary conditions, dynamic loading (indicate the procedure for FEM calculations, boundary conditions, loads, results, evaluation).
24. Calculations of service life, fatigue and notches of components, probability classically and in FEM. Haigh diagram, static and dynamic stress, Wohler curve - use in product design. Difference between classic solution and FEM.
25. Cleanliness of CAD data, basics and principles, data exchange between suppliers, file types. Data acquisition, options, areas of control.

Area 3 – Technology

Course: Design Materials

1. Structural materials (classification, considerations for the choice of materials, principles of their inclusion in structural documentation, material standards).
2. Steels (relationship between chemical composition and properties, characteristics and principles for the choice of steel, current trends in the development of steels, steels with specific physical properties).
3. Cast irons (classification of cast iron, influence of composition, wall thickness and metallurgy on structure and properties – description).
4. Heat treatment of steels (annealing, hardening (quenching) and tempering).
5. Surface treatments of materials (classification, characteristics and examples of use, degree of increase in beneficial properties - description).
6. Light metals (Al, Mg and Li) and their alloys (properties and structural applications).
7. Non-ferrous metals and their alloys (properties and structural applications).
8. Polymer materials (properties and structural applications of plastics).
9. Ceramics and glass (classification, properties, application).
10. Composite materials (properties and structural applications).

Course: Additive Technology

1. Additive manufacturing – definition, advantages and disadvantages compared to other manufacturing technologies, possibilities of additive manufacturing in relation to design, materials, quality, etc.
2. The input data format used for additive technologies, its characteristics and the possibilities of obtaining these data. Requirements for a design using CAD systems.
3. Manufacturing preparation, the effect of different print parameter settings on the final properties of the models. Common steps of manufacturing preparation using additive technologies based on 2D layering.
4. Overview of additive technologies – classification of additive technologies, possibilities and differences of each method, suitability of use.
5. Overview of the most important methods of additive technologies based on 3D printing from liquid photopolymers – principles of 3D printing, basic properties of printed parts, characteristics of the technologies, possibilities of application.
6. Overview of the most important methods of additive technologies based on 3D printing from powders – principles of 3D printing, basic properties of printed parts, characteristics of the technologies, possibilities of application.
7. Overview of the most important methods of additive technologies based on 3D printing from solid state materials – principles of 3D printing, basic properties of printed parts, characteristics of the technologies, possibilities of application.

8. Hybrid technologies – overview of technologies combining additive manufacturing with machining, advantages and disadvantages, description of basic methods used.

Course: Industrial Engineering

1. Principles of Lean Manufacturing (types of the wastes and their examples, definition of KANBAN – types, calculation of size and number of Kanban cards, definition and examples of JIT/JS, TPM – pillars)
2. Key performance indicators and their calculation (definition, variables and way of determining KPI – OEE, PLT, Throughput, WIP, BTS, VA-index, FTT/FPI)
3. Tools of manufacturing systems analysis (definition, steps and process of calculation, visualization and evaluation of – process diagram, Sankey and Spaghetti diagram, Pareto, ABC and XYZ analysis)
4. Value Stream Mapping (indicators, pictograms, steps of value stream mapping, definition of value and non-value added operations, variables and calculation of VA-index, optimization of value stream map, optimized value stream)
5. Lean manufacturing optimization (Poka-Yoke – definition, types, examples, 5S – definition and steps, SMED – definition and steps, KAIZEN – steps and tools of continuous improvement process)
6. Design of manufacturing system workshops (description of process and space composition of workshops, tools of design of manufacturing systems)
7. Human Labor standardization and ergonomics (tools of work standardization and their steps – work measuring and sampling, predetermined motion time systems – MTP, MOST, basic ergonomic rules, ergonomic screening)
8. SixSigma Tools (description of itself DMAIC method and methods used inside, description of steps and tools used, analysis of DMAIC applicability based on the project type)
9. Principles of manufacturing system management automation (tools and basic principles description – Jidoca, CIM, Industry 4.0)

Area 4 – Project Management

Course: Project Management

1. Introduction to project management – project definition, three imperatives, project life cycle and phases, project management in organizations with different types of management, project interest groups, project manager competencies – description
2. Starting the project - setting SMART goals, charter of the project - description
3. Logical framework matrix (LRM) – explanation of the purpose, procedure for constructing the matrix
4. Analysis of project risks – explanation of the purpose, procedure for carrying out the analysis
5. Methods of evaluating the value and payback of the project - payback period of the project, discounted cash flows, net present value, internal rate of return, profitability of the project - introduction of relations for calculation
6. Project planning - WBS work structure, methods for determining the duration of tasks, time planning methods (network charts, Gantt chart, milestone chart), responsibility matrix - demonstration of tools
7. Methods of network analysis - critical path method (CMP) - principle, assembly procedure
8. Value generated analysis (EVA) – principle, drawing S-curves, calculation of deviations and costs

Course: Technical communication

1. Technical communication – definition of the term technical communication (means, principles, methods of implementation)
2. Basic assumptions of technical communication - creators (e-data, their creation and use)
3. Communication skills – main category (short description of each area)
4. Safety elements of technical communication – main areas (communication system, installation and functions, communication operation)
5. International technical communication – main principles (directive of the European Union)
6. Plan-Do-Check-Akt approach – (explain the principle)

7. ITIL and COBIT standards - the main differences in IT technology life cycle management
8. Artificial intelligence - definition (implementation methods, characteristic features, virtual reality)

Course: Information systems

1. Definition and description of each class (MRP I, MRP II, ERP, APS, SCM, MES, WMS) of information systems of production planning and management, description of their primary functions and examples of their applications on specific problems in practice.
2. Bill of Material Processing (description of significance for production planning, its function and content).
3. Master production schedule and due date planning (steps of MPR I and MPS calculations, input and output information, application suitability from manufacturing system type points of view)
4. Material requirements planning (inventory classification, Inventory theory models, ways of setting ordering size including its calculation based on inventory model)
5. Definition and structure of manufacturing and non-manufacturing times (Czech and REFA standard, types of times definition, ways of finding out their duration as well as relations between them)
6. Setting of minimal and optimal batch size (definition of variables and coefficients, calculation of minimal batch size, setting optimal batch size base on constraints)
7. Resource utilization calculation (definition and calculation of resource demands, definition and calculation of available capacity, utilization definition and calculation)
8. Short-term planning, scheduling and production management (APS – steps and tools of plan making, MES – tools and systems in production management, data gathering from manufacturing, definition and analysis of tools of making the schedule and its visualization).
9. Production management systems (definition and description of production management systems - push, pull, theory of constraints resp. TOC) and its suitability of application with the respect to manufacturing systems parameters (volume of production, technology, routing through manufacturing system).