

## Postgraduate Master Study Programme

# MACHINES AND EQUIPMENT DESIGN

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### A. Thematic areas for the expert discourse in the field of "MECHANICS"

1. Mechanics of rigid bodies (system of forces, friction forces, statics of bodies and systems of bodies, static solution of beam structures, center of gravity of bodies, etc.).
  2. Kinematics of translational and rotational body motion.
  3. Principles of creation of an equations of motion.
  4. Dynamics of translational and rotational body motion. Moments of inertia and their use in mechanics.
  5. Uniaxial and multiaxial state of stress and strain (normal and share stress, Hooke's law., allowable stresses, Mohr's circle, strain energy, hypotheses of equivalent allowable stresses, temperature and prestrain effects, etc.)
  6. Beams in bending. (Internal forces and moments in beams in bending, differential equation of the deflection curve, etc.).
  7. Balancing principles. Static and dynamic balancing.
  8. Fundamentals of vibration systems. Resonance and its effect on mechanical structures (identification and solution method). Causes of Machine Vibration (shafts, gears, unbalance etc.).
  9. Fundamentals of thermodynamics (thermodynamic properties of substances, energy, law of entropy, reversible changes in the state of ideal gases and vapors, reversible and irreversible processes, mixtures of gases and moisture, etc.).
  10. Basic methods of measuring pressure and temperature.
  11. Fundamentals of fluid mechanics (transport properties of substances, Euler's equation of hydrostatics, incompressible and compressible fluid flow, losses in fluid flow through pipes, continuity equation, equation of motion, energy equation, speed of sound and Mach number, one-dimensional stationary isentropic flow of compressible fluid, one-dimensional flow of compressible fluids through tubes of variable cross-section, etc.).
  12. Heat transfer (conduction, convection, radiation).
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### B. Thematic areas for the expert discourse in the field of "CONSTRUCTION"

1. Boundary conditions in structural problems.
2. FEM adaptive algorithms.
3. Methods of determining the position accuracy of the driven member of the mechanism.
4. Motion transformation and transmission angle of mechanism.
5. Creation of kinematic chains, degree of freedom of planar and spatial mechanisms.
6. Synthesis of planar mechanisms for 2 prescribed positions of a general member.
7. Synthesis of cam mechanism.



8. Design of straight line mechanism. Mechanisms of discontinuous motion.
  9. Methods of creative work - construction method, design methodology and construction systematics. Their importance in terms of effective work of CAD designer.
  10. Explain the meaning of manufacturability, general principles of designing technical objects.
  11. Main principles of construction process. (parallel engineering, industrial law protection, CAD data purity).
  12. Principles of non-electrical quantities measurement. Basic types of sensors for measuring kinematic and force quantities.
  13. Sensors in the design of single-purpose machines.
  14. Pneumatic drives, electropneumatic circuits. Vacuum circuits.
  15. Overview of transport lines. Conveyors, roller and pulley tracks. Trolley transport systems, mobile robots, AGV systems.
  16. Industrial robots (types of structures, application possibilities, positioning accuracy). Layouts, peripherals of robotic technological workplaces.
  17. Electric drives, types and properties of servo drives, principles of dimensioning.
  18. Effectors.
  19. Basic types of image sensors. Basic operations of image analysis.
  20. CNC systems. Basic machine coordinate system, machine reference points, basics of programming
  21. Measuring systems. Direct and indirect, incremental and absolute measuring. Principle and function of photoelectric sensors.
  22. Dynamic model of position servo-drive, principles and design of position, speed and current control. Positional deviation, transient characteristic, impact and frequency dynamic stiffness. Speed and current feedforwards.
  23. Dynamic interpolation errors during linear and circular interpolation and basic principles of their compensation.
  24. Design principles of position servo-drives. Optimal gear ratio. Stiffness of mechanical parts, prestressed and non-prestressed connections.
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## C. Thematic areas for technical discussion in the field of "MACHINES DESIGN"

Questions for students focusing on single-purpose and textile machines

1. Requirements for the design of single-purpose machines. Significance, types and use of standardized components in the design process of single-purpose machines.
2. Sensors, automation and safety components in the design of single-purpose machines.
3. Single-purpose machine as a part of automated and robotic workplaces. Objects manipulation in the textile industry.
4. Principles of production of nanofibers and nanofiber structures.
5. Devices for production of nanofibers and nanofiber structures.
6. Automatic regulation of sliver evenness.
7. Spindles for spinning and plying machines.
8. Systems of spinning rotor support and construction of rotor spinning machine.
9. Winding systems for rotor spinning machines.
10. Winding types and their comparison, package formation, ribboning.



11. Weaving machines and their classification, basic mechanisms of weaving machine, their basic parameters.
12. Picking and shedding mechanisms of weaving machines.
13. Patterning device of weft knitting machines for individual needles selection
14. Design of lock systems of knitting machines. Operational device of warp knitting machines.
15. A method for producing nonwoven fabrics. Machines and equipment for the production of nonwovens.
16. Basic systems of sewing machines with lock and chain stitch. Design of the stitching device.

#### Questions for students focusing on glass machines and robotics

1. Glass structure. Properties of glass and glass melt.
2. Raw materials for glass production. Glass batch. Charge loading. Equipment for batch and charge preparation.
3. Glass melting. Glass melting furnaces. Refractory materials. Glass feeding.
4. Forming of glass melt. Pressing machines. Squeezer pressing machines. Machines for container glass production, individual section machines. Machine for thin-walled glass production, production line for tableware glass. Equipment for production of flat glass.
5. Glass annealing.
6. Glass processing and finishing. Influence of glass processing on the strength of the final product, methods of increasing the strength of glass.
7. Basic types of image sensors, image acquisition, image function, three-dimensional world.
8. Line, 2D and 3D cameras, lenses, exposition, basic principles and types of illumination.
9. Basic operation of image processing: transformations (geometric, discrete, filtration, etc.), mathematical morphology, object skeletonization, granulometry.
10. Overview of basic types of robotic structures.
11. Fundamentals of solving kinematics and dynamics of robots.
12. Industrial robot and manipulator drives, their design and dimensioning.
13. Classification, dimensioning and design of robot effectors.
14. Application of industrial robots in practice, their integration into technological workplaces.
15. Collaborative robotics.
16. Sensors used in robotics.

#### Questions for students focusing on production machines

1. 3D digitization of objects (contact and optical) – terminology, equipment, accuracy of measurement / digitization.
2. Processing of measured 3D data – basic procedures of dimensional and shape inspection.
3. Reverse engineering - principle, usage.
4. Additive technologies – principle, materials.
5. Process preparation using additive technologies.
6. Hybrid technologies – an overview of technologies combining additive manufacturing with machining.
7. Machine tools. New trends in machine tool design.
8. Drives for machine tools.
9. Machine tool spindles.





10. Mechanisms and guides in machine tools.
11. Forming machines - presses, hammers, forming machines. Basic principles of construction of
12. forming machines.
13. Mechanical presses. Basics of construction and calculations of friction presses.
14. Clutches and brakes in forming machines.
15. Hydraulic presses.
16. Forming machines, hammers.
17. Single-purpose machines and their parts

#### Questions for students focusing on energy equipment

1. Power machinery (derivation of the basic equation of a heat engine, thermodynamic efficiency, open and closed cycle, basic equations of a rotary machine, expansion without losses with heat supply, expansion with losses, adiabatic expansion).
  2. Steam turbines; theoretical thermal efficiency, increasing efficiency.
  3. Steam turbines; turbine losses and thermodynamic efficiency in diagrams.
  4. Steam turbines; increasing thermal efficiency through steam pressure and temperature.
  5. Steam turbines; regenerative heating of water supply.
  6. Steam power plants.
  7. Heating plants systems.
  8. Gas turbines.
  9. Combustion engines.
  10. Refrigeration (working substances, their diagrams, inverse Carnot cycle, ideal compressor cycle).
  11. Multistage cooling systems (cooling factor, industrial use, absorption cooling systems).
  12. Heat transfer (heat pumps of water-water, air-air, water-air, and air-water, heating factor).
  13. Positive displacement compressors.
  14. Aerodynamic compressors. Vane compressors.
  15. Hydrostatic pumps.
  16. Hydrodynamic pumps.
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