NAO "KARAGANDA TECHNICAL UNIVERSITY
NAMED AFTER ABYLKAS SAGINOV"

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PROGRAM
ENTRANCE EXAM
for applicants to doctoral studies
educational program 8D07105 "Innovative mechanical engineering"

Department of Technological Equipment
Mechanical Engineering and Standardization
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The program of the entrance examination for the educational program 8D07105 "Innovative Mechanical Engineering" was developed by:

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Discussed at the meeting of the TMEandS department

Protocol No. ____ dated “____” _____ 2025

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Introduction

The entrance examination for doctoral studies consists of writing an essay, passing a test of readiness for doctoral studies, an exam on the profile of the educational program and an interview.

Individuals with a TOEFL ITP (Test of English as a Foreign Language Institutional Testing Program) certificate take additional testing of English proficiency before the entrance exam to doctoral studies. The number of test questions for additional testing of English proficiency is 100 questions. The maximum number of points is 100 points. Additional testing of English proficiency is assessed in the form of “pass” or “failure to pass”. To receive the “pass” grade, it is necessary to score at least 65 points.

Assessment of the entrance exam for doctoral studies (specialized direction):

- interview - 20 points;
- passing the test for readiness for doctoral studies - 30 points;
- exam on the profile of a group of educational programs - 40 points.

The passing score for admission to doctoral studies under the state educational order is 65 points, the passing score for admission to doctoral studies on a fee-paying basis is 65 points.

The duration of the entrance exam is 3 hours, during which a test of readiness for doctoral studies is taken and an electronic examination ticket consisting of 3 questions is answered.

The exam on the profile of the educational program includes 3 questions, of which: the 1st question determines the level and systematicity of theoretical knowledge; the 2nd question reveals the degree of formation of functional competencies; the 3rd question is aimed at determining systemic competencies.

When preparing for the exam, it is recommended to use the literature provided in the list, as well as modern periodical scientific and technical literature.

1Progressive technologies in mechanical engineering

1.1 Innovative methods and materials used for mechanical engineering enterprises.

Application of innovative methods and materials for manufacturing machine parts using modern progressive processing methods. Methods of processing parts from high-strength materials with high productivity, during the processing of which either there is no cutting tool or the tool has less strength than the material being processed. Application of additive technologies and artificial intelligence in the processing of materials in the mechanical engineering industry.

Recommended reading

1. Bely A.V. et al. Surface hardening treatment using concentrated energy flows. - Minsk: Science and Technology, 2016. - 79 p.

2. Plasma surface hardening. - Kyiv: Tekhnika, 2017. – 108 p.

3. Papshev D.D. Finishing and hardening treatment by surface plastic deformation. - M.: Mechanical Engineering, 2015 – 152 p.

4. A.A.Khvorostukhin, S.V.Shishkin, A.P.Kovalev Increasing the bearing capacity of machine parts by surface plastic deformation. - M.: Mechanical Engineering 2017.- 211 p.

1.2 Automation and digitalization of mechanical engineering enterprises

Automation involves the implementation of automated control systems and equipment, which allows for increased efficiency of production processes, reduced costs and improved product quality.

Digitalization, in turn, includes the introduction of digital technologies into all aspects of the enterprise's activities, from design and production to management and logistics. This allows for the creation of a single information space, prompt access to data, and informed decision-making based on the analysis of large volumes of information.

Recommended reading

1. Shaduya, V.L. Modern methods of materials processing in mechanical engineering: textbook / V.L. Shaduya. - Minsk: Tekhnoperspektiva, 2008. - 314 p.

2. Smolentsov, V.P. Electrophysical and electrochemical methods of materials processing: in 2 volumes / edited by V.P. Smolentsov. – M.:

Higher. school, 1983. – V.1. – Processing of materials using tools. – 247 p.

3. Smolentsov, V.P. Electrophysical and electrochemical methods of materials processing: in 2 volumes / edited by V.P. Smolentsov. - M.: Higher School, 1983. - V.2. - Materials processing using highly concentrated energy sources. - 208 p.

4. Foteev, N.K. Technology of electrical discharge machining of materials / N.K. Foteev. - L.: Mechanical Engineering, 1984. - 184 p.

5. Babichev, A.P. Vibration processing of parts: 2nd edition, revised and enlarged. – M.: Mashinostroenie, 1974. – 133 p.

1.3 Production processes and management of mechanical engineering enterprises

Manufacturing processes in mechanical engineering include a wide range of

operations related to the manufacture of parts and assembly of machines and mechanisms.

These processes begin with the production of blanks and include various methods of material processing, such as cutting, pressure, heat treatment and others.

The management of production processes in mechanical engineering enterprises requires effective organization, planning and control. This includes resource management, optimization of technological processes, ensuring product quality and meeting order deadlines.

Recommended reading

1. Zholobov, A.A. Technology of automated production: textbook for universities / A.A. Zholobov. - Minsk: Design PRO, 2000. - 623 p.

2. Electrohydropulse processing of materials in mechanical engineering / V.N. Chachin, K.N. Bogoyavlensky. - Minsk: Science and Technology, 1987. - 231 p.

3. Kovshov, A.N. Mechanical engineering technology: textbook / A.N. Kovshov. - M.: Mechanical engineering. 1987. - 320 p.

4. Mostalygin G.P., Tolmachevsky N.N. Technology of mechanical engineering. Moscow: Mechanical Engineering, 1990. – 288 p.

5. Kolesov, I.M. Fundamentals of mechanical engineering technology: textbook. For mechanical engineering specialty universities / I.M. Kolesov. - 2nd ed., corrected. - M.: Higher. school, 2001. - 591 p.

6. Ed. by V. P. Smolentsev Electrophysical and electrochemical methods of materials processing: a textbook for mechanical engineering universities /. in two volumes. - M.: Higher School, 2017. - 255 p.

7. Ed. by L. Ya. Popilov Electrophysical and electrochemical processing of materials. Handbook. L. - M.: Mechanical Engineering, 2015. - 501 p.

8. Babichev P.P. Vibration processing of parts. - M.: Mechanical Engineering, 2013. - 390 p.

1.4 Safety and sustainability of engineering enterprises

Safety and sustainability in mechanical engineering enterprises is a multifaceted topic covering various aspects of the enterprise's activities.

Safety in this context refers to the creation and maintenance of working conditions that minimise risks to the health and safety of workers. This includes:

- Occupational safety
- Industrial safety
– Occupational Health and Safety Risk Management

Sustainability refers to the ability of an enterprise to adapt to changing conditions, minimize negative impacts on the environment and ensure long-term operation.

Both aspects, safety and sustainability, play an important role in ensuring efficient and responsible operations of mechanical engineering companies.

Recommended reading

1. Volosatov V. A. Ultrasonic treatment. - Lenizdat, 2015. - 335 p.

2. Stepanov B. I. Lasers today. - Minsk: Higher School, 2022. - 167 p.

3. Golovachev V. A et al. Electrophysical dimensional processing of complex-shaped parts. - M.: Mechanical Engineering, 2016. - 401 p.

4. Grilikhes S. Ya. Electrochemical polishing. - L.: Mechanical Engineering, 2016. - 289 p.
5. Matalin A. A. Technological methods for increasing the durability of machine parts. - Kyiv: Tekhnika, 2018. - 234 p.
6. Poduraev V. N. Cutting of hard-to-machine materials. - M.: Mechanical Engineering, 2016. - 578 p.
7. Polevoy S.N., Evdokimov V.D. Hardening of metals. Handbook. – M.: Mechanical Engineering, 2016. – 320 p.
8. Polyak M.S. Hardening technology. In 2 T. T.1. - M.: "L.V.M-SCRIPT", "Machine Building", 2015. – 832 p.
9. Hardening of parts surfaces by a combined method. - M.: Mechanical Engineering, 2015. – 144 p.

2Computer technologies in mechanical engineering

2.1 Application of computer technologies in mechanical engineering enterprises

Computer technologies have become an integral part of the activities of modern engineering enterprises. They penetrate into all stages of the product life cycle, from design to production and operation. The use of computer technologies in engineering enterprises is aimed at increasing production efficiency, improving product quality, reducing the time of development and launching new products on the market, as well as ensuring the competitiveness of enterprises in the conditions of the modern economy.

Recommended reading

1. Cherepashkov A.A., Nosov N.V. Computer technologies, modeling and automated systems in mechanical engineering. - Volgograd: In-Folio, 2009. - 592 p.
2. Alyamovsky A.A. SolidWorks. Computer modeling in engineering practice. - SPb: BHV-Petersburg, 2012. - 1040 p.
3. Kovshov A.N. Information support for the life cycle of mechanical engineering products: principles, systems and technologies CALS/IPI. - M.: Academy, 2017. - 304 p. 4. Dudareva N.Yu., Zagayko S.A. SolidWorks 2014 on examples. - St. Petersburg: BHV-Petersburg, 2014. - 544 p.
5. Beisembaev K.M. Practical and research aspects of development of mining machines in 3D: a textbook for universities. - Karaganda: KarSTU, 2012. - 135 p.

2.2 Application of CALS technologies in mechanical engineering

In mechanical engineering, CALS technologies play an important role, ensuring effective information management at all stages of the product life cycle.

CALS (Continuous Acquisition and Lifecycle Support) is a strategy aimed at increasing the efficiency of information exchange between all participants in the process of product creation and support.

In mechanical engineering, this is especially relevant, since the production of complex equipment requires the coordination of efforts of many departments and suppliers.

Recommended reading

1. Bolshakov V.P., Bochkov A.L., Lyachek Yu.T., Solid modeling of parts in CAD systems: AutoCAD, KOMPAS-3D, SolidWorks, Inventor, Creo. —SPb: Piter, 2015. – 480 p.
2. Goncharov P.S., Eltsov M.Yu., Korshikov S.B., Laptev I.V., Osiyuk V.A. NX for the machine-building designer. - Moscow: ID DMK Press, 2009. - 376 p.
3. Goncharov P.S., Eltsov M.Yu., Korshikov S.B., Laptev I.V., Osiyuk V.A. NX for the machine-building designer. - Moscow: ID DMK Press, 2010. - 504 p.
4. Scientific and practical conference "Additive technologies in Russian industry". Moscow, 2015.
5. Khrustalev, D. On the specifics of using imported components in military and special equipment / D. Khrustalev // Components and technologies. – 2001. – No. 7. – P. 4–5.
6. Yakubaitis, E.A. Information networks and systems / E.A. Yakubaitis. - M.: Finance and Statistics, 1996. - 234 p.
7. Lee, K. Fundamentals of CAD/CAM/CAE / K. Lee. – St. Petersburg: Piter, 2004. – 560 p.
8. SolidWorks::http://www.solidworks.com/sw/products/details.htm?productid=514
9. ASCON – comprehensive solutions for automation of engineering activities and production management. CAD/AEC/PLM. http:// ascon.ru/
10. Top Systems – developer of the PLM software package T-FLEX CAD/CAM/CAE/CAPP/PDM.http://www.tflex.ru/
11. Nei Nastran in Russia and the CIS – Finite element analysis system CAD/FEA/CAE.http://www.nenastran.ru/
12. Welcome to ANSYS, Inc. – Corporate Homepage.http://www. ansys.com
13. ANSYS, Inc. Products.http://www.ansys.com/products/default.asp
14. LS-DYNA.RU – calculation results, training courses, newshttp://www.ls-dyna.ru
15. TechnologiCS 6|TechnologiCS.http://www.technologics.ru
16. Consistent Software.http://www.consistent.ru/soft

3 Automated design systems for machines and processes

3.1 Basic principles of operation of computer-aided design systems in mechanical engineering

Computer-aided design (CAD) systems have become an integral part of modern mechanical engineering. They are a complex of software and hardware tools designed to automate the processes of design, construction and analysis of engineering objects.

Recommended reading

1. Malyukh V.N. Introduction to modern CAD: lecture course. – Moscow: DMK Press, 2010. – 190 p.
2. Kudryavtsev E.M. Computer-aided design systems for machines and equipment. – Moscow: ASV, 2013. – 383 p.
3. Muromtsev D.Yu. Mathematical support for CAD. / D.Yu. Muromtsev, I.V. Tyurin. – Moscow: Lan, 2014. – 464 p.
4. Ryabov Yu.V., Computer technologies in automated design of mechanical

engineering products: a tutorial / Ufa State Aviation Technical University. - Ufa: Ufa State Aviation Technical University, 2008. - 128 p.

5. Berliner E.M., Taratynov O.V. CAD in mechanical engineering. – M.: FORUM, 2008. – 448 p.

3.2 Application of CAD for design and analysis in mechanical engineering enterprises

The use of computer-aided design (CAD) systems in mechanical engineering enterprises is radically changing the design and analysis processes, bringing significant benefits.

CAD allows you to create three-dimensional models of parts and assemblies, which provides a visual representation of the object. This, in turn, facilitates the design process and allows you to identify potential problems at an early stage.

Recommended reading

1. Ushakov D.M. Introduction to the Mathematical Foundations of CAD [Electronic resource]: lecture course. – Moscow: DMK PRESS, 2011. – 208 p.

2. Vasilyeva T.Yu. Computer graphics. 3D modeling using the AutoCAD computer-aided design system: laboratory practical training / T.Yu. Vasilyeva, L.O. Mokretsova, O.N. Chicheneva; National University of Science and Technology (MISiS). – Moscow: MISiS, 2013. – 48 p.

3. Malyukh V. N. Introduction to modern CAD: Lecture course. - M.: DMK Press, 2010. - 192 p.

4. Ushakov D.M. Introduction to the mathematical foundations of CAD: a course of lectures. - M.: DMK Press, 2011. - 208 p.

5. Lee, K. Fundamentals of CAD/CAM/CAE / K. Lee. – St. Petersburg: Piter, 2004. – 560 p.

Appendix 1

Questions for the entrance exam

1Progressive technologies in mechanical engineering

1. List the innovations used in the field of materials for mechanical engineering today.
2. Determine how additive manufacturing technologies impact manufacturing processes?
3. Identify the advantages and disadvantages of computer technology in mechanical engineering.
4. List the materials processing technologies that are most promising for use in mechanical engineering.
5. List the new materials that have found application in mechanical engineering in recent years.
6. Determine how digitalization impacts design and manufacturing processes in mechanical engineering.
7. List what new methods of heat treatment of materials are used in mechanical engineering.
8. List what nanoprocessing technologies are used in modern mechanical engineering.
9. List the methods and technologies in the field of artificial intelligence used in mechanical engineering.
10. Determine what new quality control technologies are used in mechanical engineering to ensure high precision and reliability of products.
11. Determine how progressive technologies in mechanical engineering influence the competitiveness of enterprises in the global market.
12. List modern high-performance methods for obtaining blanks.
13. List innovative cutting technologies.
14. Define high speed cutting.
15. List the combined methods of mechanical processing.
16. Provide a definition of innovative technologies for physical and technical processing of materials.
17. Fundamentals of additive technologies for forming parts and units.
18. List the methods for obtaining high-temperature coatings.
19. List the methods for obtaining nanocoatings.
20. List the methods for obtaining polymer coatings.
21. What composite materials are used in modern mechanical engineering and what are their advantages?
22. Describe laser processing technology and its application in mechanical engineering.
23. What are the features of the use of ceramic materials in mechanical engineering?
24. What methods of surface hardening of parts are the most effective and why?

25. Determine the role of nanomaterials in the creation of new generations of machines and mechanisms.

26. What innovations exist in welding and joining technologies in mechanical engineering?

27. Describe modern powder metallurgy methods and their application in the production of parts.

28. What "green" materials and technologies are used in mechanical engineering to reduce the impact on the environment?

29. What is the role of the Industrial Internet of Things (IIoT) in automation of mechanical engineering production?

30. Determine how robotics affects productivity and safety in mechanical engineering.

31. What computer-aided design (CAD) and computer-aided manufacturing (CAM) systems are used in modern enterprises?

32. Describe the concept of digital twin and its application in mechanical engineering.

33. How is Big Data analyzed and used to optimize production processes?

34. Define the role of cloud technologies in the development of mechanical engineering.

35. What virtual and augmented reality (VR/AR) technologies are used in mechanical engineering?

36. How can blockchain technologies be used in the mechanical engineering industry?

37. Define what lean manufacturing is and how it is implemented in mechanical engineering enterprises?

38. What modern quality management methods are used in mechanical engineering to ensure product reliability?

39. Describe the concept of flexible manufacturing systems (FMS) and their advantages.

40. What are the trends in the development of additive technologies towards serial production?

41. Determine how Industry 4.0 principles change the organization and management of production in mechanical engineering.

42. What new approaches to logistics and supply chain management are being applied in mechanical engineering?

43. How are engineering companies adapting to the demands of product customization and personalization?

44. Determine the role of standardization and certification in ensuring the competitiveness of engineering products?

45. What innovative solutions are used to ensure occupational safety at mechanical engineering enterprises?

46. Determine how sustainable development principles are integrated into mechanical engineering production.

47. What technologies are used to reduce energy consumption and production waste in mechanical engineering?

48. How does mechanical engineering contribute to the development of a circular economy?

49. Determine what measures are taken to reduce noise and vibration exposure in production.

50. What modern equipment monitoring and diagnostic systems are used to prevent accidents and breakdowns?

2Computer technologies in mechanical engineering

1. List the advantages of using computer technologies in mechanical engineering compared to traditional design methods.
2. Assess how computer technologies influence the reduction of machine design time.
3. List the modeling methods used to analyze stresses and deformations in machine parts using computer technology.
4. Determine the role of computer technology in optimizing machine design.
5. List the virtual testing methods used in machine design.
6. Identify how computer technology helps in improving manufacturing processes in mechanical engineering.
7. List the software products used to create 3D models of machines.
8. Assess the role of computer modeling in the design of machines and machine control systems.
9. Determine how computer technology affects the reduction of costs for the creation and testing of prototype machines.
10. Determine how computer technologies are used in vibration and noise analysis in mechanical engineering.
11. List the methods of computer modeling used to analyze the dynamics of machines.
12. Determine how computer technology helps in simulating machine assembly and maintenance processes.
13. Identify how computer technologies influence the capabilities of designers and engineers in creating innovative solutions in mechanical engineering.
14. List the prospects associated with the development of computer technologies in mechanical engineering in the near future.
15. Application of CALS technologies in mechanical engineering.
16. Computer support and life cycle support of products.
17. PLM systems in mechanical engineering.
18. Rapid prototyping technologies
19. Application of CAD/CAM/CAE technologies in mechanical engineering.
20. List the software tools used in the design of machines using computer technologies.
21. How are computer technologies used to simulate casting processes in mechanical engineering?
22. Describe the application of computer technologies in the design and production of welded structures.

23. What computer tools are used to analyze thermal processes in machines and mechanisms?

24. Determine the role of computer technologies in the creation of automated control systems (ACS) for mechanical engineering equipment.

25. What optimization methods are used in CAD to achieve the best performance of the designed products?

26. How does computer technology help in product data management (PDM) throughout its life cycle?

27. Describe the integration of CAD/CAM systems to automate the process of manufacturing parts on CNC machines.

28. What computer technologies are used for the design and analysis of hydraulic and pneumatic systems in mechanical engineering?

29. How is computer modeling used to optimize logistics processes in mechanical engineering enterprises?

30. Determine how computer technologies facilitate the creation of virtual prototypes of machines for testing under various operating conditions.

31. What software is used to develop control programs for robots in mechanical engineering?

32. Describe the application of computer technologies in the design and production of micro- and nanomechanical systems.

33. How are computer technologies used to create interactive technical manuals and documentation for engineering products?

34. Determine how computer technologies help in organizing the joint work of engineers and designers when designing complex mechanical engineering objects.

35. What artificial intelligence methods are used in CAD to automate the decision-making process?

36. Describe the use of computer technologies for monitoring and diagnosing the condition of mechanical engineering equipment.

37. How are computer technologies used to model and analyze the ergonomic characteristics of machines and workstations?

38. Determine how computer technologies facilitate the creation of parametric models of parts and assemblies to speed up the design process.

39. What computer technologies are used to manage product quality in mechanical engineering enterprises?

40. Describe the use of computer technologies to create simulation systems for production processes.

41. How are computer technologies used to design and analyze ventilation and air conditioning systems in mechanical engineering shops?

42. Determine how computer technologies help in managing projects for the development and implementation of new engineering products?

43. What software is used to create and manage databases of materials used in mechanical engineering?

44. Describe the use of computer technologies for modeling the processes of transportation and movement of goods at mechanical engineering enterprises.

45. How are computer technologies used to design and analyze lighting systems

in machine shops?

46. Determine how computer technologies contribute to the creation of energy management systems in mechanical engineering enterprises?

47. What software is used to create and manage archives of design documentation?

48. Describe the use of computer technologies for modeling the processes of corrosion and wear of machine parts and mechanisms.

49. How are computer technologies used to design and analyze safety systems for mechanical engineering equipment?

50. Determine how computer technology will develop and be applied in mechanical engineering in the long term?

3 Automated design systems for machines and processes

1. List the basic principles of operation of computer-aided design systems in mechanical engineering.
2. List the types of computer-aided design systems that exist in mechanical engineering.
3. List the software products related to computer-aided design systems in mechanical engineering.
4. Assess the role of CAD (Computer-Aided Design) in computer-aided design systems.
5. Determine how computer-aided design systems contribute to production optimization in mechanical engineering.
6. List the main functions performed by computer-aided design systems in mechanical engineering.
7. Evaluate the advantages of computer-aided design systems over traditional design methods.
8. List the main stages of design when using computer-aided design systems in mechanical engineering.
9. Define the role of CAM (Computer-Aided Manufacturing) in computer-aided design systems in mechanical engineering.
10. Evaluate the development trends that can be identified in the field of automated design systems in mechanical engineering.
11. Determine how computer-aided design systems influence the processes of maintenance and repair of machines and equipment.
12. Identify the problems that may arise when implementing computer-aided design systems in mechanical engineering and how they can be overcome.
13. Assess how computer-aided design systems affect the timing and quality of design in mechanical engineering.
14. Find outThe prospects for the development of automated design systems in mechanical engineering can be expected in the near future.
15. Provide a definition of CAD/CAE systems. A set of software tools that are part of CAD/CAE systems.
16. Describe the block-hierarchical and structural approaches to designing technical objects.
17. Conduct an analysis of the functional capabilities of CAD/CAE systems.

18. Provide a definition of software, information, linguistic and methodological support for CAD.

19. History of development of systems for automation of design and production preparation.

20. Surface modeling. List the advantages and disadvantages of surface modeling.

21. Describe the role of CAE (Computer-Aided Engineering) in computer-aided design systems.

22. What types of geometric models are used in CAD and their features?

23. What are the features of hybrid modeling in CAD systems?

24. Determine how CAD integrates with manufacturing execution systems (MES).

25. What visualization methods are used in CAD to represent 3D models?

26. How does CAD support product configuration management?

27. Describe the use of CAD for designing process equipment.

28. What data exchange standards are used to ensure interoperability between different CAD systems?

29. Determine how CAD systems help in creating technical documentation in accordance with the Unified System for Design Documentation (ESKD).

30. How are CAD systems used to design and analyze the kinematics of mechanisms?

31. What APIs do modern CAD systems provide to extend functionality?

32. Describe the use of CAD for mold and die design.

33. How are CAD systems used to model and analyze thermal processes in machine parts?

34. Determine how CAD systems help optimize the material consumption of a design?

35. What methods are used in CAD to automatically generate control programs for CNC machines?

36. Describe the use of CAD systems for the design and analysis of hydraulic and pneumatic systems.

37. How are CAD systems used to create digital twins of products?

38. Determine how CAD systems support product reengineering and redesign processes?

39. What virtual and augmented reality technologies integrate with CAD?

40. Describe the use of CAD for the design and analysis of machine control systems.

41. How are CAD systems used to create interactive catalogs and user manuals?

42. Determine how CAD systems influence the organization of work of design offices and engineering departments?

43. What project management methods integrate with CAD to plan and control product development?

44. Describe the use of CAD for the design and analysis of strength and stiffness of welded joints.

45. How are CAD systems used to model product assembly processes?

46. Determine how CAD contributes to the creation of ergonomic and safe

machine designs?

47. What software tools are used for collaborative work on a CAD project?

48. Describe the application of CAD to the design and analysis of composite materials in mechanical engineering.

49. How are CAD systems used to create training simulators and training aids for mechanical engineering equipment?

50. What new features and capabilities will CAD provide in the future, driven by advances in artificial intelligence and cloud technologies?