APPROVED
at a meeting of the
Scientific Council
NJSC «Al-Farabi KazNU».
Protocol No. 10 dated May 13, 2023.

Programme
of the entrance examinations for the applicants to the doctoral studies on the group of educational programs D102 - «Robotics and mechatronics»

1. General provisions

1. The program was drawn up in accordance with the Order of the Minister of Education and Science of the Republic of Kazakhstan dated October 31, 2018 No. 600 "On Approval of the Model Rules for Admission to Education in Educational Organizations Implementing Educational Programs of Higher and Postgraduate Education" (hereinafter referred to as the Model Rules).

2. The entrance exam for doctoral studies consists of writing an essay, passing a test for readiness for doctoral studies (hereinafter referred to as TRDS), an exam in the profile of a group of educational programs and an interview.

№	Block	Points
1	Essay	10
2	Test for readiness for doctoral studies	30
3	Exam according to the profile of the group of the educational program	40
4	Interview	20
Total admission score		100/60

3. The duration of the entrance exam is 4 hours, during which the applicant writes an essay, passes a test for readiness for doctoral studies, and answers an electronic examination. The interview is conducted on the basis of the university before the entrance exam.

2. Procedure for the entrance examination

1. Applicants for doctoral studies in the group of educational programs D102 – «Robotics and mechatronics» write a problematic / thematic essay. The volume of the essay is at least 250-300 words.

2. The electronic examination card consists of 3 questions.

1. List of examination topics

Discipline «Robot Mechanics»

1. **Basic concepts of the theory of mechanisms and machines.** A car. Mechanisms. Problems of the theory of mechanisms. Movable and fixed links.

2. **Kinematic pairs. Kinematic chains.** Kinematic pairs and their classification. Conditional images of kinematic pairs. Simple and complex kinematic chains. Closed and open kinematic chains.

3. **The main types of mechanisms.** Flat mechanisms with lower pairs. Spatial mechanisms with lower pairs. Cam mechanisms. Gear mechanisms. Friction mechanisms. Flexible link mechanisms. Hydraulic and pneumatic mechanisms.

4. **The structure of mechanisms.** The mechanism and its kinematic diagram. General structural formula of the kinematic chain. Generalized coordinates of the mechanism. The number of degrees of freedom of the mechanism. Excessive linkage mechanisms. Structural formula of flat mechanisms. The structure of flat mechanisms. The structure of spatial mechanisms.

5. **Classification of flat mechanisms.** The basic principle of the formation of mechanisms. Assur groups. Structural classification of flat mechanisms.

6. **Kinematic analysis of mechanisms.** Kinematic analysis of flat link mechanisms by graphical method. Kinematics of the initial links of mechanisms. Analogs of speeds and accelerations. Determination of speeds and accelerations by the method of plans. Kinematic analysis of flat linkages by the analytical method.

7. **Kinematic study of gear mechanisms.** Basic kinematic relations. Friction transmission mechanisms. Gear mechanisms.

8. **Force analysis of mechanisms.** The tasks of the power calculation of mechanisms. Forces acting on the links of the mechanism.

9. **Friction in mechanisms.** Types of friction. Friction in a translational kinematic pair. Friction in the helical kinematic pair. Friction in a rotary kinematic pair.

10. **Forces of inertia of links of flat mechanisms.** Determination of the inertial forces of the links.

11. **Kinetostatic calculation of flat mechanisms.** Determination of reactions in kinematic pairs of groups. Power calculation of typical mechanisms.

12. **Bringing forces and masses in mechanisms.** Reduced forces and moments. Zhukovsky's lever. Reduced mass and reduced moment of inertia of the mechanism.

13. **Synthesis of mechanisms.** Basic concepts and definitions. Mechanism design tasks.

14. **Synthesis of flat gear mechanisms.** Basic information from the theory of links. Geometric elements of gear wheels.

15. **Basic concepts of the theory of automatic machines.** A brief introduction to the theory of automatic machines.

16. **Brief information on the theory of robots and manipulators.** Industrial robots and manipulators. Relative movements of the links of the manipulator.

17. **Feeling.** Far-field measurement sensors. Sensation in the near zone. Tactile sensors. Force-moment sensation.

18. **Systems of technical vision.** Image acquisition. Lighting methods. Image geometry. Preliminary processing of information. Recognition.

19. **Robot drives.** Types of drives. Kinematic characteristics of drives. Drive gear ratio. Placement of drives on the executive device.

20. **Mechatronics.** Definitions and terminology of mechatronics. Preconditions for the development of mechatronics and areas of application of mechatronic systems. Modern mechatronic systems.

21. **Humanoid robots.** Definitions and terminology. Modern humanoid robots.

Discipline "Theoretical Mechanics"

1. **The subject of theoretical mechanics, basic concepts and definitions.** Point and rigid body kinematics. Methods for specifying the movement of a point. Speed and acceleration in curved motion. Expansion of acceleration along the axes of a natural trihedron.

2. **Mechanical system.** The translational motion of an absolutely rigid body. Rotational movement of an absolutely rigid body around a fixed axis. Angular velocity and angular acceleration. Velocities and accelerations of points when rotating a rigid body.

3. **Plane-parallel movement of an absolutely rigid body.** Velocities and accelerations of points of a flat figure. Instantaneous centers of speeds and accelerations.

4. **The movement of a rigid body about a fixed point.** Euler angles. Euler's kinematic equations. Euler - d'Alembert theorem. Velocity and acceleration of points of a body moving about a fixed point.

5. **Complex motion of a rigid body.** Reduction of the system of sliding vectors. The main vector and the main point. Invariants of reduction of a system of sliding vectors. Screw. Euler's kinematic motions.

6. **Motion of a free rigid body.** Chassel's theorem. Velocities and accelerations of points of a free rigid body.

7. **Complex point movement.** Absolute, relative, figurative movement. Velocity addition theorem. Coriolis theorem.

8. **Basic definitions and axioms of statics.** Moment of force relative to the center. The moment of force about the axis.

9. **System of converging forces.** Equilibrium conditions for a system of converging forces. Parallel forces system. Equilibrium conditions, equivalent equilibrium conditions. Center of gravity. Methods for finding the center of mass.

10. **The theory of pairs.** A system of forces arbitrarily located in space. Equilibrium conditions for various systems of forces. Statically undefined systems.

11. **Dynamics of a point and a system of material points.** Rectilinear oscillations of a point (harmonic, damped, forced). Differential equations of motion for a system of material points.

12. **General theorems of the dynamics of a point.** Basic dynamic quantities of the system. General theorems of system dynamics.

13. **Types of connections.** Elementary work of strength. The work of the force of gravity, elastic force, friction force. Basic concepts.

14. **Virtual and true movement.** Variation of coordinates. The number of degrees of freedom.

15. **Generalized coordinates, speeds and forces.** Conditions imposed by constraints on coordinate variations. The principle of possible displacements.

16. **The d'Alembert principle.** General theorems deduced from the d'Alembert principle. D'Alembert-Lagrange principle.

17. **Method of Lagrange multipliers.** Lagrange equations of the first kind. Holonomic and nonholonomic systems. Determination of reactions using Lagrange equations of the 1st kind.

18. **Lagrange equations of the second kind.** Lagrange equations for a system under the influence of potential forces. Lagrange function. Integral of energy.

19. **Differential equations for the rotational motion of a rigid body.** Axle pressure. Plane-parallel movement of an absolutely rigid body.

20. **The theory of deformations.** Elongation coefficient. Strain tensor. The geometric meaning of its components. Strain tensor invariants. Volumetric expansion coefficient. Deformation compatibility condition. Strain rate tensor. The formula and the Cauchy-Helmholtz theorem.

21. **Strength and destruction.** Classical theories of strength. Cracked body model. Destruction criteria. Crack mechanics. Scattered fracture mechanics.

22. **Friction.** Sliding friction laws. Rough bond reactions. Angle of friction. Rolling friction.

23. **Center of gravity.** Center of Parallel Forces. The center of gravity of a rigid body. Coordinates of the centers of gravity of homogeneous bodies. Centers of gravity of some homogeneous bodies.

24. **Kinematics of a point and a rigid body.** Point kinematics. Methods for specifying the movement of a point. Trajectory. Point velocity vector. Point acceleration vector. Solid body movements.

25. **Rectilinear oscillations of a point.** Free vibrations. Forced vibrations. Resonance.

26. **Dynamics of the system.** Introduction to system dynamics. System dynamics theorems.

27. **General theorems of the dynamics of a point.** The amount of motion and kinetic energy of a point. Impulse of power. Power work.

Discipline "Algorithmization and Programming, CAD / CAM"

1. **Algorithmization.** The concept of an algorithm, properties of the algorithm. Basic algorithmic structures. Linear aogorhythm. Branching. Cycles. Nested loop structures. Iterative structures.
2. **Fundamentals of programming.** Stages of solving problems on a computer. The structure of the program in a high-level language. Basic operators.
3. **Typical computing processes.** Branches and loops. Condition check operators, jump operator. Logical operations. Relationship operations. Selection operator. Cyclic computing processes. Loop operator with parameter, precondition, postcondition. Nested loops. Iterative cyclical computational processes.
4. **Operations with indexed variables.** Operations with indexed variables. One-dimensional arrays. Two-dimensional arrays.
5. **Subprograms.** Organization of function. Passing arguments and calling a function.
6. **High-level programming languages.** Evolution of programming languages. Classification of programming languages. Translators, compilers, interpreters. Integrated programming environments.
7. **Regulatory and technical documents.** Types of products and stages of development of design documentation. Types of design documents.
8. **Assembly and detailing drawings.** Assembly and detail drawings. Specifications.
9. **Commands of the AutoCAD system.** Entering the command of the AutoCAD system.
10. **Units of measurement in the AutoCAD system.** Setting the units of measurement for the AutoCAD system.
11. **Types of primitives in the AutoCAD system:** segment, point, ray, line, circle, arc, ellipse. Examples of primitives are line, point, ray, line, circle, arc, ellipse of AutoCAD system.
12. **Methods for entering the coordinates of points in the AutoCAD system.** An example of entering the coordinates of points in the AutoCAD system.
13. **Modes used in the AutoCAD system.** An example of modes used in the AutoCAD system
14. **Types of primitives in the AutoCAD system:** polyline, rectangle, polygon, multiline, labels. An example of primitives polyline, rectangle, polygon, multiline, labels of the AutoCAD system.
15. **Three-dimensional construction.** Setting the coordinate system, level and height. Examples of setting the coordinate system, level and height in the AutoCAD system. Methods for creating three-dimensional models of parts in AutoCAD.
16. **Modeling robotic and mechatronic systems.** Definition and purpose of modeling. Classification of modeling methods by model type. Automated modeling of technical objects. Visual modeling packages for robotic and mechatronic systems.
17. **Control of robots.** Control tasks for manipulation robots. Robot control systems.
18. **Artificial intelligence and task planning in robotics.** Artificial Intelligence. Foundations of the theory of neural networks. Artificial neural networks. Self-learning in neural networks. Robot training.
19. **Robot programming languages.** Characteristics of robotic languages.
20. **Arduino.** General information about the Arduino platform. Hardware Arduino boards.

2. Bibliography

The main:

1. Артоболевский И.И. Теория механизмов и машин: Учеб. для втузов. – 4-е изд., перераб. и доп. - М.: Наука. Гл. ред. физ. -мат. лит., 1988. – 640 с.
2. Левитская О.Н., Левитский Н.И. Курс теории механизмов и машин. М.: «Высшая школа», 1995.
3. Теория механизмов и машин. Под ред. Фролова К.В. М.: «Высшая школа», 2003.
4. Теория механизмов и механика машин. Под ред. Фролова К.В. М.: «Высшая школа», 1998.
5. Жолдасбеков Ө.А. Машиналар механизмдерінің теориясы. Алматы.: «Мектеп» баспасы, 1972.
6. К. Фу, Р. Гонсалес, К. Ли. Робототехника. - М.: Изд. Мир, 1989. - 621 с.
7. Опадчий, Ю. Ф. Аналоговая и цифровая электроника (полный курс): учебник для вузов / Ю. Ф. Опадчий, О. П. Глудкин, А. И. Гуров; под ред. О. П. Глудкина. – М.: Горячая линия – Телеком, 1999. – 768 с.: ил.

8. Работнов Ю.Н. Механика деформируемого твердого тела. – М.: Наука, 1988. – 712 с.

9. Ахмедханлы Д.М., Ушмаева Н.В. Основы алгоритмизации и программирования: электрон. учеб.-метод. пособие / Д.М. Ахмедханлы, Н.В. Ушмаева. - Тольятти: Изд-во ТГУ, 2016. – 1 оптический диск.

10. Макаров В.Л. Программирование и основы алгоритмизации: Учеб.пособие. – СПб.: СЗТУ, 2003. -110 с.

11. Бутенин Н.В., Лунц Я.Л., Меркин Д.Р. Курс теоретической механики. – 11 изд., стер. – С-Пб: Лань, 2009. – 736 с.

12. Бухгольц Н.Н. Основной курс теоретической механики. Ч.1. – 10 изд., стер. – С-Пб: Лань, 2009. – 480 с.

13. Бухгольц Н.Н. Основной курс теоретической механики. Ч.2. – 7 изд., стер. – С-Пб: Лань, 2009. – 336 с.

14. Маркеев А.П. Теоретическая механика. – М.-Ижевск: НИЦ «Регулярная и хаотическая динамика», 2001. – 592 с.

15. Яблонский А.А., Никифорова В.М. Курс теоретической механики. Статика, кинематика, динамика. – М.: КноРус, 2011. – 608 с.

16. Жолдасбеков Ө.А., Сағитов М.Н. Теориялық механика. Алматы, 2002 – 575 бет.

17. Зенкевич С. Л., Ющенко А. С. Управление роботами. Основы управления манипуляционными роботами: Учеб. для вузов – М.: Изд-во МГТУ им. Н. Э. Баумана, 2004. – 400 с.

18. Юрьевич Е. И. Управление роботами и робототехническими системами. Санкт-Петербург, - 171 с. 2000.

19. Станкевич Л.А. Искусственный интеллект и искусственный разум в робототехнике : учеб. пособие / Л.А. Станкевич, Е.И. Юревич. – СПб. : Изд-во Политехн. ун-та., 2012. – 167 с.

20. Фролов И.И. Системы технического зрения : учеб.-мето. Пособие / И.И. Фролов, М.М. Лукашевич, А.Л. Яночкин. – Минск : БГУИР, 2016. – 70 с. : ил.

21. Луис Педро Коэлью, Вилли Ричарт. Построение систем машинного обучения на языке Python. 2-е издание / пер. с англ. Слинкин А.А. – М.: ДМК Пресс, 2016. – 302 с.: ил.

22. Блум Джереми. Изучаем Arduino: инструменты и методы технического волшебства: Пер. с англ. – СПб.: БХВ-Петербург, 2015. – 336 с.: ил.

23. Воронин А.В. Моделирование мехатронных систем: учебное пособие. – Томск: Изд-во Томского политехнического университета, 2008. – 137 с.

24. Подураев Ю.В. Мехатроника: основы, методы, применение. - М.: Машиностроение, 2006. -256 с.

25. Жұмашева Ж.Т. Мехатроника. Оқу құралы. - Алматы.: ҚазҰТУ, 2009, 80 б.

26.Хейфец, А. Л. Инженерная компьютерная графика. AutoCAD / А.Л. Хейфец. - М.: Диалог-Мифи, 2014. - 432 с.

27.Шипова, Г. М. Моделирование и создание чертежей в системе AutoCAD / Г.М. Шипова, В.Г. Хрящев. - М.: БХВ-Петербург, 2016. - 218 с.

28. Rakisheva Z.B., Sukhenko A.S. Textbook on Theoretical Mechanics – 2d ed. – Almaty: Qazaq university, 2017. – 354 p.

Additional:

1.Кирсанов М.Н. Maple и Maplet. Решение задач механики: Учебное пособие. – СПб: Издательство «Лань», 2012. – 512 с.: ил. – (Учебники для вузов. Специальная литература).

2.Абдрахманов М.И. Python. Уроки. 2-е издание - 2019. – 156 с.

3. Хабловскии И., Скулимовски, В. Электроника в вопросах и ответах: Пер. с польского. / И. Хабловски, В. Скулимовски; под ред. В.И.Котикова. – М.: Радио и связь, 1984. – 304 с.: ил.

4. Фишер, Дж.Э., Гетланд, Х.Б. Электроника от теории к практике / Дж.Э.Фишер, Х.Б.Гетланд. – М.: Энергия, 1980. – 400 с.: ил.

5. Новиков, Ю.Н. Электротехника и электроника. Теория цепей и сигналов, методы анализа: Учебное пособие. / Ю.Н.Новиков. – СПб.: Питер, 2005. – 384 с.: ил.

6. Клюшников В.Д. Физико-математические основы прочности и пластичности. – М.: МГУ, 1994. – 190 с.

7. Феодосьев В.И. Сопротивление материалов. – М.: Наука, 1986. – 512 с.

8. Бабаков Н.М. Теория колебаний. – М.: Дрофа, 2004. – 591 с.

9. Тимошенко С.П. Прочность и колебания элементов конструкций. – М.: Наука, 1975. – 704 с.

10. Медведев В.А., Шиянов А.И. Управление роботами: учебное пособие. Воронеж, ВГТУ, 2003. 187 с.

11. Медведев В.С., Лесков А.Г., Ющенко А.С. Системы управления манипуляционных роботов. -М.: Наука, 2008. – 416 с.

12. Николенко С.И., Тулупьев А.Л. Самообучающиеся системы. – М.: МЦНМО, 2009. – 288 с.: 24 илл.

13. Гафаров Ф.М. Искусственные нейронные сети и приложения : учеб. пособие /. Ф.М. Гафаров, А.Ф. Галимянов. – Казань: Изд-во Казан. ун-та, 2018. – 121 с.

14. Николенко С., Кадурин А., Архангельская Е. Глубокое обучение. – СПб.: Питер, 2018. – 480 с.: ил. – (Серия библиотека программиста).

15. Дэвид Форсайт, Жан Понс. Компьютерное зрение. Современный подход. Пер. с англ. – СПб.: БХВ-Петербург, 2004. – 336 с.: ил.

16 Шапиро Л., Стокман Дж. Компьютерное зрение, 2006

17. Гонсалес Р., Вудс Р. Цифровая обработка изображений, 2005.

18. Пол Бэрри. Изучаем программирование на Python. Пер. с англ. – СПб.: БХВ-Петербург, 2018. – 336 с.: ил.

19. Марк Лутц. - Изучаем Python. Пер. с англ. Санкт-Петербург: издательство «БХВ-Петербург», 2014г.

20. Билл Любанович. Простой Python. Современный стиль программирования. – СПб. – Питер, 2016.

21. В. Петин. Проекты с использованием контроллера Arduino 1-ое изд. - Санкт-Петербург: издательство «БХВ-Петербург», 2014г.

22. В. Петин. 77 проектов для Arduino. - Санкт-Петербург: издательство «БХВ-Петербург», 2014г.

23. Капитонов А.А. Введение в моделирование и управление для робототехнических систем / под редакцией д.т.н., проф. А.Л. Фрадкова. – М. – Ижевск: Институт компьютерных исследований, 2016. – 108 с.

24.Таугер В.М. Конструирование мехатронных модулей. Екатеринбург, 2009.

25. Дробот Ю.Б. Введение в систему Maple 10. – Хабаровск: Изд-во ДВГУПС, 2006.

26. Мусалимов В.М., Г.Б. Заморуев, И.И. Калапышина, А.Д. Перечесова, К.А. Нуждин. Моделирование мехатронных систем в среде MATLAB (Simulink / SimMechanics): учебное пособие для высших учебных заведений. – СПб: НИУ ИТМО, 2013. – 114 с.

27.Герман-Галкин С.Г. Matlab&Simulink. Проектирование мехатронных систем на ПК. –СПб.: КОРОНА-Век, 2008.-368 с.

28. Подураев Ю.В. Основы мехатроники: Учебное пособие. - М.: МГТУ "СТАНКИН", 2000 -80 с.

29. Т. Исии, И. Симояма и др. Мехатроника .- М.: Изд. Мир, 1988.- 317 с.

30.Б. Хайманн, Б. Герт. и другие. Мехатроника. – Новосибирьск.: Изд-во СО РАН, 2010.- 602с.

31. Новожилов О.П. Информатика : учеб. пособие для студ. вузов, обуч. по спец. группы «Экономика и управление» и направлению «Информатика и вычислительная техника» / О.П. Новожилов. – М.: Юрайт, 2011. – 564 с. – (Основы наук).

32. Прохорова О.В. Информатика : учебник [Электронный ресурс] / О.В. Прохорова. – Самара: СГАСУ, 2013. – 109 с.

33. Выжигин А.Ю. Информатика и программирование: учебное пособие [Электронный ресурс] / А.Ю. Выжигин. – М.: МосГУ, 2012. – 294 с.

34. Погорелов, Виктор AutoCAD 2009. 3D-моделирование / Виктор Погорелов. - М.: БХВ-Петербург, 2009. - 400 с.

35.Веретенников В.Г., Синицын В.А. Теоретическая механика (дополнения к общим разделам). – М.: Изд-во МАИ, 1996. – 360 с.

36.Голубев Ю.Ф. Основы теоретической механики. – М.: Изд-во МГУ, 2000. – 719 с.

37.Лойцянский Л.Г., Лурье А.И. Курс теоретической механики. В 2-х томах. – С-Пб: Лань, 2006. – Ч.1: Статика, кинематика. – 352 с. – Ч.2: Динамика. – 640 с.

38.Лидов М.Л. Курс лекций по теоретической механике. – М.: Физматлит, 2010. – 496 с.

39.Архангельский Ю.А. Аналитическая динамика твердого тела. – М.: Наука, 1977. 328 с.

40.Kolovsky M.Z., Evgrafov A.N. Semenov Yu. A., Slousch A.V., Lilov L. Advanced Theory of Mechanisms and Machines. Springer, 2000, 394p.

41. W. Bolton, Mechatronics: Electronic Control Systems in Mechanical Engineering, Longman, 1995.