APPROVED
at a meeting of the Academic Council of
NJSC «KazNU named after al-Farabi»
Protocol № 11 from 23.05.2025 y.

The program of the entrance exam for applicants to the PhD
for the group of educational programs
D107 – «Space Engineering»

I. 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, an exam in the profile of a group of educational programs and an interview.

Блок	Баллы
1. Interview	30
2. Essay	20
3. Exam according to the profile of the group of the educational program	50
Total admission score	100/75

3.The duration of the entrance exam is 3 hours 10 minutes, during which the applicant writes an essay and answers the electronic examination ticket. The interview is conducted at the university premises before the entrance exam.

II. Procedure for the entrance examination

1. Applicants for doctoral studies in the group of educational programs D107 – «Space Engineering» write a problematic / thematic essay. The volume of the essay is at least 250words.

The purpose of the essay is to determine the level of analytical and creative abilities, expressed in the ability to build one's own argumentation based on theoretical knowledge, social and personal experience.

Types of essays:

- motivational essay revealing the motivation for research activities;
- scientific-analytical essay justifying the relevance and methodology of the planned research;
- problem/thematic essay reflecting various aspects of scientific knowledge in the subject area.

2. The electronic examination card consists of 3 questions

Topics for exam preparation according to the profile of the group of the educational program:

Discipline **"Mechanics"**

1. The subject of theoretical mechanics, basic concepts and definitions. Point and Rigid body Kinematics. Methods for specifying the movement of a point. Velocity and acceleration in curved motion. Expansion of acceleration along the axes of a natural trihedron.
2. Mechanical system. Translational motion of an absolutely rigid body. Rotational motion of an absolutely rigid body around a fixed axis. Angular velocity and angular acceleration. Speeds and accelerations of points when rotating a rigid body.
3. Plane-parallel motion 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 around 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 a sliding vector system. The main vector and the main point. Invariants of reduction of a system of sliding vectors. Screw.
6. Motion of a free rigid body. Chasles' Theorem. Velocities and accelerations of points of a free rigid body.
7. Complex movement of a point. 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. Theory of couples. 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 point oscillations (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 constraints. Elementary Force Work. The work of the force of gravity, elastic force, friction force. Basic concepts.
14. Virtual and true displacements. Variation of coordinates. The number of degrees of freedom.
15. Generalized coordinates, velocities and forces. Conditions imposed by constraints on coordinate variations. The principle of possible displacements.
16. D'Alembert principle. General Theorems Derived from the D'Alembert Principle. D'Alembert-Lagrange principle.
17. Method of Lagrange multipliers. Lagrange Equations of the 1st 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 Action of Potential Forces. Lagrange function. Integral of energy.
19. Cyclic coordinates. Method of ignoring coordinates. Routh function. Routh's equations. Cyclic integral.
20. Canonical equations. Canonical Conversions. Advantages of Canonical Equations.

21. Geometry of the masses. Huygens-Steiner Theorem. Moment of inertia about intersecting axes. Tensor and ellipsoid of inertia. Principal axes of inertia.

22. Differential equations of the rotational motion of a rigid body. Axle Pressure. Plane-parallel movement of an absolutely rigid body.

23. The movement of an absolutely rigid body with one fixed point. Basic dynamic quantities. Koenig's theorems. Euler's dynamic equations.

24. General formulation of the problem of the motion of a heavy rigid body with a fixed point. Differential Equations of Motion. Special cases of integration: the cases of Euler, Lagrange, Kovalevskaya.

Discipline "**Actual problems of space flight dynamics**"

1. Coordinate systems for studying the motion of an artificial Earth satellite.
2. Equations of unperturbed motion of a spacecraft (SC).
3. Orbit equations. Orbit parameters.
4. Spacecraft velocity, its dependence on various parameters.
5. Determination of the undisturbed orbit for given motion conditions.
6. Classification of orbits by eccentricity, energy and initial velocity.
7. General properties of unperturbed spacecraft motion.
8. Spacecraft orbital transfer maneuvers.
9. Time of spacecraft flight.
10. Calculation of trajectories of interplanetary spacecraft.
11. Descent of the spacecraft from the orbit of an artificial Earth satellite.
12. Lambert's formula and its modifications depending on the type of orbit.

Discipline "**Spacecraft attitude control systems**"

1. Statement of the problem of determining the orientation of the aircraft.
2. Tasks and methods for determining the orientation of the aircraft. Coordinate systems used to determine the position of the aircraft and its orientation. Their properties.
3. Determination of the angular position of the aircraft. Euler angles and their purpose. Benefits and limitations of use. Determination of the angular position of the aircraft in the Euler angles.
4. Quaternions. Determination of the angular position of the aircraft in quaternions. Their advantages and disadvantages.
5. The gravitational field of the Earth and its models.
6. The Earth's magnetic field and its models.
7. Modeling the Earth's atmosphere.
8. Solar radiation, solar wind and their influence on the movement of the aircraft.
9. Derivation of differential equations of motion of the aircraft for various force fields and perturbations.
10. Stabilization and orientation of the aircraft. Uniaxial stabilization and orientation of the spacecraft. Methods for determining the uniaxial orientation of a spacecraft.
11. Triaxial stabilization and orientation of the spacecraft.
12. Passive methods of motion and attitude control of the aircraft.
13. Solar sensor and its components. How it works. Existing solar sensors.
14. Magnetometers. Principles of operation of a magnetometer. Existing magnetometers.

15. Gyroscopes. Principles of gyroscope operation. Gyroscopic stabilization.
16. Electromagnetic executive bodies. Existing electromagnetic executive bodies.
17. On-board computers, their purpose. The structure of on-board computer systems.
18. Composition and description of telemetric information of the spacecraft and its transmission to the Earth.
19. Orbital maneuvers of the aircraft.

III List of references

Main:

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