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

The program of the entrance exam for applicants to the PhD for the group of educational programs D086 - «Meteorology»

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	100/75

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 D086 - «Meteorology» 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.

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

Discipline **"Physical Meteorology"**

Topic 1. General information about the atmosphere.

1.1. The composition of the atmosphere.
1.2. Equation of state of atmospheric air.
1.3. The structure of the atmosphere.

Topic 2. Atmospheric static.

2.1. The basic equation of static.
2.2. Barometric formulas.

Topic 3. Radiation regime of the atmosphere.

3.1. Solar radiation.
3.2. Attenuation of solar radiation.
3.3. Laws of radiation.
3.4. Radiation of the Earth and atmosphere.
3.5. Radiation balance of the earth's surface, atmosphere, and earth-atmosphere system.

Topic 4. The thermal regime of soil.

4.1. Thermophysical characteristics of the soil.
4.2. Processes of heating and cooling of the soil.
4.3. Propagation of temperature fluctuations deep into the soil. Fourier laws.
4.4. The effect of natural cover on the soil temperature.

Topic 5. Thermodynamics of the atmosphere.

5.1. The first law of thermodynamics.
5.2. Adiabatic process.
5.3. Criteria for the stability of the atmosphere by the particle method.
5.4. Wet-adiabatic processes.
5.5. Stratification of the atmosphere with respect to the wet-adiabatic and dry-adiabatic motion of the particle.
5.6. Thermodynamic graphs.

Topic 6. The thermal state of the atmosphere.

6.1. The turbulent state of the atmosphere. Ground layer.
6.2. The daily course of the air temperature in the boundary layer of the atmosphere.
6.3. Interaction of the atmosphere with the underlying surface
6.4. Thermal regime of the troposphere, stratosphere and mesosphere.
6.5. Temperature inversions in the atmosphere.
6.6. Thermal balance of the underlying surface.
6.7. Small gases and impurities in the atmosphere. Ozone.

Topic 7. Air humidity.

7.1. Equation of water vapor transport in a turbulent atmosphere
7.2. Distribution of humidity characteristics by height.
7.3. Distribution of humidity in the troposphere and stratosphere.
7.4. Evaporation and evaporability.

Topic 8. Clouds, fogs, and precipitation.

8.1. General conditions of phase transitions of water in the atmosphere.
8.2. The dependence of the heat of the phase transition and the pressure of saturated water vapor on the temperature. Phase equilibrium diagram.
8.3. Physical conditions of formation and classification of fogs.
8.4. Cloud classifications (morphological and genetic).
8.5. Atmospheric processes leading to the formation of clouds.
8.6. Cloud structure (main levels). Microphysical characteristics of clouds.

8.7. Evolution of cloud forms. Transition forms.
8.8. Stratospheric and mesospheric clouds
8.9. Frontal cloud systems.
8.10. Precipitation formation and classification.
8.11. Ground condensation.
8.12. Condensation nuclei and their classification.

Topic 9. The basis of the dynamics of the atmosphere.

9.1. Strengths acting in the atmosphere.
9.2. Movement of free atmosphere.
9.3. Features of air movement in the boundary layer atmosphere.
9.4. Local winds.

Topic 10. Optical and electrical phenomena in the atmosphere.

10.1. Optical phenomena caused by the scattering of light in the atmosphere.
10.2. Optical phenomena caused by the refraction of light in the atmosphere.
10.3. Optical phenomena caused by reflections and reflections of light in droplets and crystal clouds.
10.4. Optical phenomena caused by diffraction of light in clouds and fog.
10.5. Ionization of the atmosphere.
10.6. Ionosphere.
10.7. Aurora Borealis and their classification.

Discipline **"Synoptic meteorology"**

Topic 1. Meteorological information and methods of its presentation.

1.1. Types of meteorological information.
1.2. Methods of presenting meteorological information.
1.3. Basic means of synoptic analysis.

Topic 2. Baric field and wind field.

2.1. Atmospheric pressure field. Spatial distribution of pressure.
2.2. Forms of baric relief. Characteristics of low- and high-pressure systems.
2.3. The ratio of forces in a cyclone and an anticyclone.
2.4. Features of the analysis of the wind field and its characteristics.
2.5. Geostrophic and gradient models of the relationship between pressure and wind fields. The relation of the geostrophic wind to the actual wind.

Topic 3. Air temperature and humidity field.

3.1. The field of air temperature and humidity used in synoptic analysis. Factors of their local change.
3.2. Advective change in temperature and humidity.
3.3. Temperature changes associated with vertical air movements.

Topic 4. Vertical movements in the atmosphere and their calculation.

4.1. Types of vertical air movements, their spatial-temporal scale, and their relationship to weather conditions.
4.2. Convective vertical movements.
4.3. Ordered vertical movements.
4.4. Qualitative assessment of the sign and intensity of ordered vertical air movements according to the structure of the baric field.

Topic 5. Air masses

5.1. The concept of air mass, the center of its formation.
5.2. Conditions for the formation of air masses.
5.3. Classification of air masses.
5.4. Characteristics of the weather in warm and cold air masses of different stratification in different seasons of the year.

5.5. Transformation of air masses.

Topic 6. Atmospheric fronts

6.1. Classification of atmospheric fronts.

6.2. Features of the distribution of meteorological variables and cloud systems in the area of various types of fronts.

6.3. Characteristics of warm and cold fronts, occlusion fronts.

6.4. Moving the fronts.

6.5. Evolution of the spatial structure of atmospheric fronts.

6.6. Frontolysis and frontogenesis.

6.7. Influence of orography on the movement and spatial structure of atmospheric fronts. Masking atmospheric fronts.

6.8. The main stages of synoptic analysis of fronts.

6.9. Methods of forecasting the movement of fronts.

Topic 7. High-altitude frontal zones and jet streams.

7.1. Definition and main characteristics of high-altitude frontal zones.

7.2. Classification of high-altitude frontal zones.

7.3. System of planetary frontal zones of the northern hemisphere.

7.4. Classification of jet flows. Parameters of jet flows.

7.5. Features of the distribution of vertical movements and clouds in jet streams.

7.6. Energy of jet streams.

Topic 8. Changes in surface pressure and heights of isobaric surfaces over time.

8.1. Local change in the height of the isobaric surface over time.

8.2. Qualitative assessment of the sign and intensity of cyclo-and anticyclogenesis by the structure of the baric field and its change over time.

8.3. Modern theory of cyclo-and anticyclogenesis.

Topic 9. Cyclone and anticyclone

9.1. Classification of cyclones and anticyclones. The stages of their development.

9.2. General information about extratropical cyclones and anticyclones.

9.3. Conditions of occurrence and development of thermal and frontal cyclones of extratropical latitudes. Stages of development of frontal cyclones.

9.4. Structure of the thermobaric field and weather conditions in different stages of the cyclone development. A family of cyclones.

9.5. Conditions of occurrence of extratropical anticyclones. Stages of development of anticyclones.

9.6. Structure of the thermobaric field and weather conditions in each stage of the anticyclone development. Regeneration of anticyclones.

9.7. Blocking anticyclones.

9.8. Regeneration of cyclones and anticyclones.

9.10. Influence of orography on the movement of baric formations. Rules for the movement of cyclones and anticyclones.

9.11. Forecast of the movement of cyclones and anticyclones.

9.12. Forecast of the evolution of baric formations.

9.13. Influence of orography on the occurrence, evolution and movement of cyclones and anticyclones.

Discipline **“Climatology”**

Topic 1. The main factors of climate formation

1.1. The concept of climate.

1.2. Climate system and its characteristics.

1.3. Astronomical and geophysical factors of climate formation.

1.4. Energy factors of climate formation.

1.5. Distribution of solar radiation at the upper boundary of the atmosphere. Solar climate.
1.6. The arrival of solar radiation on the Earth's surface. Radiation balance of the Earth's surface.
1.7. Thermal balance of the Earth's surface and the earth-atmosphere system.
1.8. The main patterns of geographical distribution and time variability of the components of the radiation and heat balance of the Earth's surface.
1.9. Active surface and its influence on climate formation.
1.10. The influence of snow and ice cover on the climate.
1.11. Influence of land and sea distribution on climate.
1.12. Volcanic eruptions as a climate-forming factor.

Topic 2. Circulation factors of climate formation

2.1. The main features and properties of the general circulation of the atmosphere.
2.2. Characteristic features of the prevailing zonal circulation. Zonal circulation in the troposphere and stratosphere.
2.3. Quasi-two-year cyclicity, its nature.
2.4. Cyclonic activity, pressure field and air circulation near the earth.
2.5. Atmospheric circulation in the tropical zone: trade winds, intra-tropical convergence zone, tropical cyclones.
2.6. Monsoon circulation. Monsoons of tropical and extratropical latitudes.
2.7. Planetary long waves (Rossby waves).
2.8. Repeatability of cyclones and anticyclones. The centers of action of the atmosphere.
2.9. Climatological fronts.

Topic 3. General ocean circulation and its impact on climate

3.1. The main ocean currents of the World ocean, heat transfer by ocean currents.
3.2. El Nino and La Nino phenomena.
3.3. Large-scale fluctuations in the water temperature of the World ocean.
3.4. North Atlantic and North Pacific fluctuations, their role in climate formation.
3.5. The Arctic oscillation and its influence on the climate.
3.6. Energy-active zones of the ocean.

Topic 4. The temperature field and its determining factors

4.1. Geographical distribution and temporal variability of air temperature on the Globe.
4.2. Zonal field of temperature in the lower layers of the atmosphere and at altitudes.
4.3. Influence of thermal properties of continents and oceans on the temperature field.
4.4. Oceanic and continental types of climates.
4.5. Continentality indices.

Topic 5. Humidity and cloud fields, their role in climate formation

5.1. The main characteristics of the humidity field.
5.2. Spatiotemporal distribution of humidity and precipitation characteristics.
5.3. Combined influence of the thermal regime and the humidification regime on the climate. Droughts.
5.4. Horizontal transport of moisture in the atmosphere.
5.5. Moisture content of the atmosphere. Moisture turnover in the atmosphere.
5.6. Moisture balance on the continents. Semi-empirical theory of moisture turnover.

Topic 6. Classification of climates

6.1. Assignment of climate classifications for scientific and applied tasks.
6.2. The difference between the concepts of "classification" and "zoning".
6.3. First climate classifications.
6.4. Köppen classification, its advantages and disadvantages.
6.5. Landscape-botanical classification of L. S. Berg.
6.6. Genetic classifications (B. P. Alisova, M. I. Budyko, and A. A. Grigorieva).
6.7. Botanical climate classifications.

6.8. Distribution of the main characteristics of the climate in different parts of the globe according to the results of classifications.

Topic 7. Meso-and microclimate

7.1. The concept of meso-and microclimate.

7.2. Microclimate as a phenomenon of the surface layer of the atmosphere.

7.3. Influence of topography, vegetation, reservoirs, buildings on the microclimate.

7.4. Mesoclimate of the city.

7.5. The influence of a large city on the distribution of temperature, cloud cover, and precipitation.

Topic 8. Climate change and fluctuations

8.1. Climate variability, climate changes and fluctuations.

8.2. Modern natural and anthropogenic climate changes.

8.3. Changes in the nature of the Earth's active surface; urbanization, aerosol, gas and thermal pollution of the atmosphere.

8.4. Changes in the concentration of CO2 and other small impurities as a result of human activity.

8.5. General atmospheric and ocean circulation models

8.6. Current scenarios of climate change in the future.

8.7. Global and regional changes in the current climate.

Discipline **"Features of the general circulation of the atmosphere and long-term weather forecasts"**

Topic 1. Types and indices of atmospheric circulation

1.1. Types of circulation of B. L. Dzerdzeevsky.

1.2. Classification of atmospheric processes by G. J. Wangenheim – A. A. Girs.

1.3. Types of synoptic processes of M. H. Baydal.

1.4. Forms of atmospheric circulation of A. L. Katz.

1.5. Indexes of atmospheric circulation of Rossby.

1.6. E. N. Blinova circulation index.

1.7. A. L. Katz general circulation Index.

Topic 2. Basic patterns of general atmospheric circulation in long-term weather forecasts

2.1. The use of generalized indicators of the general circulation of the atmosphere and their characteristics in the forecast schemes.

2.2. Quantitative indices of the intensity of the general atmospheric circulation (Rossby, Blinova, Katz) as predictors in the forecast schemes.

2.3. Circumpolar vortex, its features for the winter and summer seasons. Use of the dates of the spring and autumn rearrangement of the circulation in the stratosphere in predicting dangerous weather events.

2.4. General atmospheric circulation and solar activity.

2.5. The nature of solar-earth connections. Heliophysical effects on the Earth's baric field.

2.6. Connection of extreme weather conditions with solar activity. Droughts and severe winters in the 11-year solar cycle. Geomagnetic disturbance as an indicator of the probability of droughts and severe winters.

2.7. Fluctuations in the parameters of the earth's rotation (angular velocity, nutation of the earth's axis) and their influence on the processes of the general circulation of the atmosphere and weather.

2.8. The El Nino phenomenon and its role in the formation of extreme weather conditions on the continent.

Topic 3. Accounting the influence of underlying surface in long-term weather forecasts

3.1. Features of using the characteristics of the underlying surface in long-term weather forecasts: synoptic-climatic and statistical studies.
3.2. Interaction of the ocean and the atmosphere. Types of interaction: small-scale and large-scale interactions, thermal machines of the 1st and 2nd kind according to Shuleikin.
3.3. Large-scale interaction of the ocean and the atmosphere. The Duvanin Model
3.4. The role of the North Atlantic in the formation of weather in Kazakhstan.
3.5. The role of the Pacific Ocean in the formation of weather in Kazakhstan.
3.6. The influence of Arctic sea ice on the formation of weather on the continent.
3.7. Models of the general circulation of the atmosphere and the ocean.

Discipline **"Modern statistical methods in meteorology"**

Topic 1. Pre-processing of data

1.1. Testing the hypothesis of normality, amplitude, and unbiased values of the kurtosis and skewness coefficients.
1.2. Approaches to the transformation of empirical asymmetric distributions to the normal law.
1.3. Testing the hypothesis of the normality of the distribution by χ^2 and by the Kolmogorov-Smirnov criterion.
1.4. Nonlinear regression.

Topic 2. Nonlinear and multiple correlations

2.1. Selection of the discriminant function analysis.
2.2. Classification based on discrimination of observations. Application of generalized discriminant analysis to classify data.
2.3. Clustering by the K-means method.

Topic 3. Analysis of variance

3.1. Clustering with Data Mining.
3.2. Step-by-step regression and interpretation of indicators.
3.3. Variance analysis of single-factor complexes of small groups.
3.4. Nonparametric criteria.

Discipline **"Forecast of natural disasters"**

Topic 1. General scientific problems of forecasting

1.1. Methodological problems of forecasting natural disasters.
1.2. Forecast and hypothesis, their essence.
1.3. Theoretical aspects of forecasting.

Topic 2. Natural disaster forecast

2.1. Medical and demographic assessment of the territory.
2.2. The possibilities of deterministic forecasting of natural hazards.
2.3. Analysis of methods for predicting dangerous convective phenomena.
2.4. Methods of probabilistic forecasting of natural hazards.
2.5. Interpretation of the results of synoptic and statistical methods for forecasting dangerous weather events.

Topic 3. Natural emergencies

3.1. Classification of emergency situations.
3.2. Quantitative assessment of the scale of disasters.
3.3. Geographical component of the index of potential losses in natural hazards.
3.4. Determine the average loss of the consumer when it is oriented to the predicted value of the weather element.

Discipline **“Global atmospheric monitoring”**

Topic 1. Atmospheric monitoring

1.1. Global monitoring of the atmosphere in the context of a comprehensive analysis of the natural environment.

1.2. Analysis of the environmental burden on a regional scale.

1.3. Permissible load on the elements of the biosphere. Threshold of the impact effect. The "dose-response" relationship.

1.4. Sustainability and reserves of the ecological system. Ecological approaches to the regulation of anthropogenic loads.

1.5. Principles of environmental regulation taking into account multiple ways of exposure to pollutants

Topic 2. Organization of global atmospheric monitoring

2.1. General approaches to environmental quality management. Ecological and economic aspects of regulation.

2.2. Organization of observations of changes in the state of the atmosphere, sources and factors of anthropogenic impacts. Assessment and forecast of anthropogenic changes.

2.3. Classification of global monitoring of anthropogenic changes in the state of the atmosphere.

2.4. Climate monitoring. Satellite climate monitoring.

Topic 3. Applied aspects of global atmospheric monitoring

3.1. Transboundary air pollution and its monitoring.

3.2. Global Environmental Monitoring System.

3.3. Global and regional forecasts of the state of the atmosphere.

3.4. Measures at various levels to reduce emissions into the atmosphere.

3.5. The concept for improving air quality management in the Republic of Kazakhstan and the implementation of the selected protocols to the Convention on Long-range Transboundary Air Pollution.

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