

APPROVED
at the meeting of the Academic
Council of NJSC Al-Farabi
Kazakh National University
Protocol №14 dated 16.06.2026

The program of the entrance exam for applicants to the
PhD for the group of educational programs
D195 – «Cryptology»

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

Block	Points
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.

1. Procedure for the entrance examination

1. Applicants for doctoral studies in the group of educational programs D195 - «Cryptology» 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 «Organization of information security systems»

Topic: Cryptanalysis

Subtopics:

1. Classic ciphers and their opening. The shift cipher and the affine cipher and their decryption and hacking by brute force. Frequency method of opening the replacement cipher. The disadvantages of classical ciphers, the frequency analysis of such ciphers of texts in Kazakh and Russian languages.

2. Ring of integers, Euclidean algorithm and consequences. Representation of the greatest common divisor. Theory of Comparisons. Comparison properties for this module. Reversible elements for this module.

3. Euler function and its properties. Euler function on primes. The theorem on the multiplicativity of the Euler function. The formula for finding the values of the Euler function, exponentiation using the Euler function.

4. Fermat-Euler theorem and the main theorem of the RSA cipher.

5. RSA cipher, encryption and reading process, rationale. RSA encryption with the public key of the specified text. RSA decryption of the specified text with the private key.

6. RSA-electronic signature, idea and rationale.

7. Implementation of the RSA-electronic signature procedure, part of the signing of the document by electronic signature.

8. Implementation of the RSA-electronic signature procedure, part of the public key signature encryption.

9. The distribution of primes in a natural series and the evaluation of the RSA cipher.

10. The ring of polynomials over the field $\langle F_2^n ; +, * \rangle$ Euclidean algorithm, representing the greatest common divisor of two polynomials. Irreducible polynomials in this ring. Irreducible polynomials of degrees 2,3,4,5.

11. Field construction $\langle F_2^n ; +, * \rangle$ as fields constructed from residues modulo an irreducible polynomial. The addition and multiplication task in this field. Inverse elements of addition and inverse elements of multiplication for nonzero elements of this field. Build field $\langle F_{16} ;$

$+, * \rangle$.

12. The Lagrange theorem on the divisibility of the order of a group by the order of a subgroup. The corollary is that the order of an element divides the order of the group. Examples of subgroups of Z_n . The antiderivative element theorem in the field $\langle F_{2^n} ; +, * \rangle$. Primitives of the field $\langle F_{16} ; +, * \rangle$.

13. The construction of a field constructed from n-bit binary blocks. The addition and multiplication task in this field. Inverse elements of addition and inverse elements of multiplication for nonzero elements of this field, primitive elements of this field. Build a field of 4-bit binary blocks, specify the

primitive elements of this field.

14. The Difi-Hellman problem. Creating a shared secret for remote users, relying on the "unsolvability" of the Dhifi-Hellman problem. Solving the key exchange problem for remote users.

15. Al-Gamal cipher, key exchange process, encryption and decryption. Implementation by example.

Discipline «Methods and means of protecting computer information»

Topic: Models and methods of information encryption

Subtopics:

1. Brief historical information about the emergence and development of cryptology methods. Cryptography. Confidentiality. Integrity. Authentication Digital signature.

2. The Bell-Lapadula Model. Pre-distribution of keys. Key forwarding. Open key distribution. Secret sharing scheme. Public Key Infrastructure Certificate Authorities. Formal cipher models. Plaintext models. Mathematical models of plaintext. Clear text recognition criteria. Classification of ciphers according to various criteria. The mathematical model of the replacement cipher. Classification of replacement ciphers.

3. Model Low-Water-Mark (LWM). Route permutations. Elements of cryptanalysis of permutation ciphers. Replacement Ciphers.

4. Models J. Goguen, J. Meseguer. Table gambling. On the possibility of restoring the probabilities of gamma signs. Recovering texts encrypted with an unequal probability. Reuse of gamma. Cryptanalysis of the Vigenere cipher. Encryption errors.

5. Security breach detection model. Entropy and redundancy of the tongue. The distance of uniqueness. Strength of ciphers. Theoretical resistance of ciphers. Practical durability of ciphers. Issues of resistance to ciphers. Distortion-free ciphers. Ciphers that do not propagate distortions such as "replacement of characters. Ciphers that do not propagate distortions such as" skip-insert characters.

6. Block encryption systems. The principles of building block ciphers. Examples of block ciphers. American data encryption standard DES. Data encryption standard GOST 28147-89. Modes of using block ciphers. Combination of block cipher algorithms. Methods of analysis of block encryption algorithms. Recommendations for using block cipher algorithms.

7. Stream encryption systems. Synchronization of stream cipher systems. The principles of building stream cipher systems. Examples of stream cipher systems. Encryption system A5. Gifford cipher system. Linear shift registers. Berlekamp – Messi Algorithm. The increasing complexity of linear recurrence sequences. Filter generators. Combining generators. Linear shift register compositions. Schemes with dynamic change of the law of recursion. Schemes with memory elements. Methods of analysis of stream ciphers.

8. Security management. Standards, security audit. Features of speech signals. Scrambling. Frequency signal conversions. Temporary signal conversions.

Resistance of temporary permutation systems. Digital Telephony Systems.

9. Public Key Encryption Systems. RSA encryption system. Al-Gamal encryption system. McEliece Cipher System. Encryption systems based on the "backpack problem."

10. Identification. Rules for compiling passwords. The complexity of the password verification procedure. "Salted" passwords. Passphrases. Attacks on fixed passwords. Password reuse. Total password guessing. Dictionary attacks. Personal identification numbers. One-time passwords. "Request-response" (strong identification). "Request-response" with using symmetric encryption algorithms. "Request-response" using asymmetric encryption algorithms. Zero-disclosure protocols. Attacks on authentication protocols.

11. Cryptographic hash functions. Hash functions and data integrity. Key hash functions. Keyless hash functions. Data integrity and message authentication. Possible attacks on hash functions.

12. Digital signatures. General Provisions Digital signatures based on public key cryptosystems. Digital signature of Fiat Shamir. Digital Signature of El Gamal. Disposable digital signatures.

13. Key distribution protocols. Key transfer using symmetric encryption. Bilateral protocols. Tripartite Protocols. Key transfer using asymmetric encryption. Protocols without the use of digital signatures. Protocols using digital signature. Public Key Certificates. Open key distribution. Pre-distribution of keys. Schemes of preliminary distribution of keys in a communication network. Secret sharing schemes. Methods for establishing keys for conferencing. Possible attacks on key distribution protocols.

14. Key management. The life cycle of keys. Services provided by a trusted third party. Setting time stamps. Notarization of digital signatures.

15. Some practical aspects of using cipher systems. Message flow analysis. Operator errors. Physical and organizational measures when using cipher systems. Quantum-cryptographic protocol of open key distribution. Quantum channel and its properties. Key distribution protocol.

Discipline «Elements of information security tools»

Topic: Information protection of computer systems.

Subtopics:

1. Computer system (CS). Basic concepts. Electronic Document (ED). Types of information in the CS.

2. Vulnerability of computer systems. The concept of access, subject and object of access. The concept of unauthorized access (UAA). Classes and types of UAA.

3. Security policy in computer systems. The concept of security policy and its basic concepts. Security rating.

4. Identification of users of CS subjects of data access. User identification task. The concept of an authentication protocol. The concept of identifying information

5. Means and methods of restricting access to files. The main approaches to protecting data from unauthorized access. Ways of fixing access facts. Access logs.
6. Access to data by the process. Features of data protection from change. Reliability of access control systems. An approach based on the formation of a hash function, construction requirements, and implementation methods.
7. Software and hardware encryption. Building hardware and software encryption systems. Designing cryptographic conversion modules based on signal processors.
8. Methods and means of restricting access to computer components. PC components. Classification of protected components of the PC: alienable and inalienable components of the PC.
9. Protecting programs from unauthorized copying. Approaches to the task of copy protection. Binding software to the hardware environment and physical media as the only means of protection against copying software.
10. Storing key information. Passwords and keys. Secret information used for access control: keys and passwords.
11. Management of cryptographic keys. Key Generation. Key distribution.
12. Key distribution authentication protocol for symmetric cryptosystems. Basic concepts and definitions, types of cryptographic protocols, examples.
13. Protocol for asymmetric cryptosystems using public key certificates.
14. Key storage organization (with implementation examples). Direct access magnetic disks. Magnetic and intelligent. TouchMemory Tool
15. Protecting programs from learning. Learning and reverse engineering software. Goals and objectives of studying the work of software. Ways to study software: static and dynamic learning.

3. List of references

Main:

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3. Goutam Paul , Subhamoy Maitra. Publisher. RC4 Stream Cipher and Its Variants (Discrete Mathematics and Its Applications). : CRC Press; 1st edition 2019. 311 pages.
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16. А. А. Бирюков, "Информационная безопасность. Защита и нападение", ДМК Пресс, 2017г., 434с.

Additional:

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