Program: Computer & Data Science

This document outlines the scope of themes, which may be included in the Olympiad tests. The themes are grouped by areas and are followed by the list of recommended references in the Russian and English languages.

Olympiad winner's skill set by subject

Winners of the Olympiad in the field of Computer & Data Science should demonstrate the following competencies and abilities:

Analytical Competences
- Proficiency in understanding the theoretical foundations of computer science
- Evaluation of algorithm and data structure effectiveness using established criteria
- Knowledge of regulatory documents related to information security
- Competence in assessing evolving trends within the software market

Project-Oriented Competences
- Knowledge of software development principles
- Proficiency in multiple programming languages
- Understanding the principles governing computer organization and operation, including functional structure
- Effective utilization of information security tools
- Application of existing algorithms and data structures
- Competence in using programming tools, environments, IDEs, SDKs, and one or more related version control systems

Research Competences:
- Familiarity with various approaches for verifying software models
- Awareness of the principal trends and cutting-edge technologies in Computer and Data Science
- Application of fundamental information-theoretical models to describe information processes and objects

Content

Section 1. Applied mathematics
1. Big-O asymptotic notation.
2. Linear space: definition, examples. Dimension of a linear space. Matrices: rank, determinant, inverse matrix. Eigenvalues and eigenvectors.
3. Modular arithmetic. Fermat's little theorem. Finite fields of residues: definition, construction, performing computations in finite fields. The Euclidean Algorithm. GCDs as Linear Combinations. Bezout's Theorem.
4. Number systems (decimal, binary, hexadecimal, octal). Converting between representations in different bases.

5. Boolean algebra. Standard Boolean operations: conjunction, disjunction, negation, implication, equivalence, exclusive OR, Sheffer stroke. Standard representations of Boolean functions: DNF, CNF, simplifying expressions using distributive property, De Morgan rules, absorption laws.

6. Boolean circuits. Complexity measures: circuit size and depth. Construction of Boolean circuits for Boolean functions.

7. Predicates. Logical inference. Representing predicates with quantified formulas.

8. Rules of inference. Resolution.

9. Finite automata. Non-deterministic finite automata. Regular languages.

10. Regular expressions. Converting between a regular expression and an automaton. POSIX Extended regular expressions.

11. Recursive definitions and structural induction.

12. Divisibility properties. GCD and LCM. Euclid's algorithm.

13. Probability: basic definitions and properties.

14. Probability distributions: uniform, binomial, geometric, Poisson, normal.

15. Law of total probability.

16. Bayes' theorem.

17. Basic counting. Permutations and combinations with and without replacement.

18. Asymptotic growth of combinatorial numbers.

19. Generating combinations and permutations.

20. Inclusion-exclusion formula.

21. Graphs: undirected, directed, bipartite, complete. Subgraphs: induced subgraphs, spanning trees. Distances in graphs. Depth-first and breadth-first graph traversal.

22. Trees. Minimal spanning trees problem.

23. Planar graphs. Euler's formula

Section 2. Software engineering

1. Definition of software requirements

2. Software design process

3. Error and exception handling

4. Software security

5. Design patterns

6. User interface design process

7. Software complexity

8. Standards in software design

9. Reuse in codding

10. Executable models

11. Classification of operating systems.

12. Software system modeling, UML.

13. Basics of object-oriented programming.

14. Software testing

15. Software maintenance

16. Reverse engineering

17. Software configuration management

18. Building of software
19. Software release management
20. Software engineering management
21. Quality management
22. Risk management in software development
23. Software measurement techniques
24. Prototyping methods

Section 3. Information systems and computing

1. Information: collecting, transmitting, processing, accumulation, measurement; information units. Information and entropy
2. Data structures
3. The concept of the information system and information technology
4. Hardware and software information technology tools
5. Parallel processing. The main classes of parallel systems
6. The concept of a system. Systems in engineering, economics and nature. Types of systems. The control object and the control system. Information Feedback. The subject of engineering cybernetics and information theory
7. Modeling as a research method in cybernetics. Types of models. Models of technical, biological and socio-economic systems. The "black box" concept. The problem of identification. Model validity
8. Pragmatic, semantic and syntactic aspects of information
9. Programming languages. Procedure-oriented and object-oriented programming. Ways of describing algorithms. The Unified system of program documentation
10. Software life cycle
11. The principles of the structural and functional organization of computer networks. Packet-switched networks. TCP/IP protocol stack. Addressing in IP networks
12. Multithreading: basic concepts. Methods of synchronization in multithreaded applications
13. Process interaction. Shared memory, synchronization tools. Message queues and other means of data exchange
14. The reference model of open systems interaction (ISO OSI model) and its purpose. Data encapsulation. Layers of the OSI reference model.
15. Reliability of the software and hardware complex of the information system.

Section 4. Information security

1. Basic concepts of information security. Key factors affecting information security
2. Major international information security standards, their purpose and scope
3. Information security policy, its place and role in organization management
4. Information security threats. Approaches to modeling information threats and attackers
5. Approaches to information risk management. Risk assessment. Risk scales and measurement criteria
6. Security information and event management (SIEM) systems. Design principles, tasks and goals of SIEM systems

7. Intrusion, prevention and detection systems in computer systems and networks; their purpose, goals and design principles
8. Network firewall systems: principles and tasks
9. Virtual Private Network (VPN): purpose, design principles and selection criteria
10. Access control models and systems
11. Identification, authentication and authorization. Authentication and authorization techniques
12. Steganography: the purpose and tasks. Techniques for embedding hidden information in executable files
13. Symmetric encryption systems. Block ciphers, and their operation modes. Modern standards and protocols of symmetric encryption
14. Public key cryptosystems. The principles of construction. Modern standards and public-key encryption protocols
15. Public-key infrastructure, certification centres and digital certificates

Section 5. Data preprocessing and analysis
1.   Decision support systems (DSS)
2. The concept of data warehouse (DW). Their purpose. Architecture
3. Physical DW. Virtual DW. Data marts (DM)
4. Data transfer. The ETL process. Data cleansing. DW and analysis
5. Types of data warehouses. Their purposes and architectures.
6. Multidimensional data models. Representation of data as a multidimensional cube
7. Machine learning. Definition. Purposes
8. Machine learning functions: classification, regression, frequent set search, clustering
9. Machine learning models. Predictive and descriptive machine learning models. Machine learning methods
10. Knowledge discovery process. Stages of data mining
11. Classification algorithms: Naive Base, C 4.5, BackProp, Support Vector Machine, etc.
12. Clustering algorithms: hierarchical, k-Means, DBScan, SOM
13. Algorithms for frequent set search: Apriori, FPG, etc.
14. Deep learning. Definition. Deep learning and machine learning

Recommended literature
Section 1. Applied mathematics

Sources in English	Topic
1. Durrett R. Probability: Theory and Examples (Cambridge Series in Statistical and Probabilistic Mathematics Book 49) 5th Edition ISBN: 978-1108473682 https://services.math.duke.edu/~rtd/PTE/PTE5_011119.pdf Free access	2, 9, 13-16,
2. Hopcroft J.E., Motwani R., Ullman J.D. Introduction to Automata Theory, Languages, and Computation (3rd ed.). Pearson, 2013. ISBN 978-1292039053. https://e.famnit.upr.si/pluginfile.php/636821/mod_page/content/8/Automata.pdf Free access	1, 4, 5, 7-12

	Topic
3. Lipschutz S., Lipson M. Schaum's Outline of Discrete Mathematics, Fourth Edition (Schaum's Outlines) 4th Edition, 2021. ISBN: 978-1264258802 https://www.accessengineeringlibrary.com/content/book/9781264258802 Limited access	6, 12, 17, 18, 21-23
4. Rosen K. Discrete Mathematics and Its Applications. McGraw-Hill Education; 8 edition, 2018. ISBN: 978-1259676512 https://www.amazon.com/Discrete-Mathematics-Applications-Kenneth-Rosen/dp/125967651X Limited access	5, 6, 7, 12, 21, 22, 23
5. Wegener I. The Complexity of Boolean Functions. John Wiley and Sons, 1987. ISBN 3-519-02107-2. https://eccc.weizmann.ac.il/static/books/The_Complexity_of_Boolean_Functions/ Free access	3-6, 17-20

Sources in Russian	Topic
1. Аляев Ю.А., Тюрин С. Ф. Дискретная математика и математическая логика. Учебник. М.: Финансы и статистика, 2006. 368 с. ISBN 5-279-03045-7 https://fileskachat.com/getfile/74321_8f8e23c2233350997e7c69c922661acb Free access	1, 4, 5, 7, 8, 11, 12, 17-23
2. Ожиганов А.А. Теория автоматов. Учебное пособие. Санкт-Петербург: НИУ ИТМО, 2013. 84 с. https://books.ifmo.ru/file/pdf/1013.pdf Free access	4, 6, 9

Section 2. Software engineering

Sources in English	Topic
1. Bass L., Clements P., Kazman R. Software Architecture in Practice, 3rd ed., Addison-Wesley Professional, 2013. https://edisciplinas.usp.br/pluginfile.php/5922722/mod_resource/content/1/2013%20-%20Book%20-%20Bass%20%20Kazman-Software%20Architecture%20in%20Practice%20%281%29.pdf Free access	12, 13, 14, 17, 18, 24
2. Bourque P., Fairley R.E. Guide to the Software Engineering Body of Knowledge (SWEBOK(R)): Version 3.0. IEEE Computer Society https://www.computer.org/education/bodies-of-knowledge/software-engineering Free access	1, 2, 4, 5, 7, 9, 10, 15, 16, 19-23
3. Naik S., Tripathy P. Software Testing and Quality Assurance: Theory and Practice. Wiley-Spektrum, 2008. https://www.softwaretestinggenius.com/download/staqtpsn.pdf Free access	14-23
4. Sommerville I. Software Engineering. 9th ed., Addison-Wesley, 2011. https://engineering.futureuniversity.com/BOOKS%20FOR%20IT/Software-Engineering-9th-Edition-by-Ian-Sommerville.pdf Free access	2, 3, 5, 6, 8, 9, 11-14, 17, 18, 24

Sources in English	Topic
5. ISO/IEC/IEEE 24765:2010 Systems and Software Engineering—Vocabulary, ISO/ IEC/IEEE, 2010. https://www.iso.org/standard/50518.html Free access	1, 2, 5, 6, 8, 11, 12, 15, 17-20
6. INCOSE, Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, version 3.2.2, International Council on Systems Engineering, 2012. https://sebokwiki.org/wiki/INCOSE_Systems_Engineering_Handbook Free access	4, 5, 6, 8, 9, 11-16, 19-23

Sources in Russian	Topic
1. Гамма Э. Приемы объектно-ориентированного проектирования. Паттерны проектирования / Э. Гамма, Р. Хелм, Р. Джонсон, Д. Влиссидес. СПб.: Питер, 2009. 366 с. http://www.sugardas.lt/~p2d/books/Priemioop.pdf Free access	1, 3-5, 8, 9, 17, 18
2. Розенберг Д., Скотт К. Применение объектного моделирования с использованием UML и анализ прецедентов.: Пер. с англ. М.: ДМК Пресс, 2002 https://www.litres.ru/book/dug-rozenberg/primenenie-obektnogo-modelirovaniya-s-ispolzovaniem-uml-i-an-22879266/ Limited access	1, 2, 5-10, 12-16, 19-24

Section 3. Information systems and computing

Sources in English	Topic
1. Hopcroft J. E., Motwani R., Ullman J. D. Introduction to automata theory, languages, and computation. 2006 https://e.famnit.upr.si/pluginfile.php/636821/mod_page/content/8/Automata.pdf Free access	1, 5, 7
2. Rainer R.K., Prince B., Cegielski C. G. Introduction to Information Systems. John Wiley & Sons Singapore Pte. Limited, 2015. https://humdiana.files.wordpress.com/2018/03/introduction-to-information-system-edisi-5-tahun-2014.pdf Limited access	1, 4, 5, 6, 7, 9, 10, 15
3. Tanenbaum A.S. et al. Computer networks. Prentice-Hall international editions, 1996. 813 p. https://theswissbay.ch/pdf/Gentoomen%20Library/Networking/Prentice%20Hall%20-%20Computer%20Networks%20Tanenbaum%204ed.pdf Free access	1-4, 8, 11 - 15

Sources in Russian	Topic
1. Акимова Е.В. Вычислительная техника. Учебное пособие для СПО Издательство: Лань, 2022 https://lanbook.com/catalog/informatika/vychislitelnaya-tekhnika/ Limited access	1, 3, 6 - 10
2. Голицына О.Л., Максимов Н. В., Попов И. И. Информационные системы, 2014. 496 с. http://library.lgaki.info:404/2019/%D0%93%D0%BE%D0%BB%D0%B8%D1%86%D1%8B%D0%BD%D0%B0%20%D0%9E.%20%D0%9B_%D0%98%D0%BD%D1%84%D0%BE%D1%80%D0%BC%D0%B0%D1%86%D0%B8%D0%BE%D0%BD%D0%BD%D1%8B%D0%B5%20%D1%81%D0%B8%D1%81%D1%82%D0%B5%D0%BC%D1%8B.pdf Free access	1, 3, 4, 6 - 9
3. Олифер В.Г, Олифер Н.А. Компьютерные сети. Принципы, технологии, протоколы. Учебник для вузов, 2020 http://naymov.com/edu/ukit/olifer.pdf Free access	1, 2, 5, 11 - 15
4. Хопкрофт Д.Э., Мотвани Р., Ульман Д. Введение в теорию автоматов, языков и вычислений, 2-е изд.: Пер. с англ. М.: Издательский дом "Вильямс", 2008. https://files.nazaryev.ru/ifmo/third-year/%D0%90%D1%80%D1%85%D0%B8%D0%B2%203/6%20%D1%81%D0%B5%D0%BC%D0%B5%D1%81%D1%82%D1%80/%D0%A2%D0%B5%D0%BE%D1%80%D0%B8%D1%8F%20%D0%B0%D0%B2%D1%82%D0%BE%D0%BC%D0%B0%D1%82%D0%BE%D0%B2/%D0%9B%D0%B8%D1%82%D0%B5%D1%80%D0%B0%D1%82%D1%83%D1%80%D0%B0/%D0%94%D0%B6%D0%BE%D0%BD%20%D0%A5%D0%BE%D0%BF%D0%BA%D1%80%D0%BE%D1%84%D1%82,%20%D0%A0%D0%B0%D0%B4%D0%B6%D0%B8%D0%B2%20%D0%9C%D0%BE%D1%82%D0%B2%D0%B0%D0%BD%D0%B8,%20%D0%94%D0%B6%D0%B5%D1%84%D1%84%D0%94	1, 2, 3, 5, 9,

Sources in Russian	Topic
[1%80%D0%B8%20%D0%A3%D0%BB%D1%8C%D0%BC%D0%B0%D0%BD%20%D0%92%D0%B2%D0%B5%D0%B4%D0%B5%D0%BD%D0%B8%D0%B5%20%D0%B2%20%D1%82%D0%B5%D0%BE%D1%80%D0%B8%D1%8E%20%D0%B0%D0%B2%D1%82%D0%BE%D0%BC%D0%B0%D1%82%D0%BE%D0%B2,%20%D1%8F%D0%B7%D1%8B%D0%BA%D0%BE%D0%B2%20%D0%B8%20%D0%B2%D1%8B%D1%87%D0%B8%D1%81%D0%BB%D0%B5%D0%BD%D0%B8%D0%B9%20(2008).pdf](#) Free access	10

Section 4. Information security

Sources	Topic
1. Eagle C., Nance V. The Ghidra Book: The Definitive Guide. No Starch Press, 2020. 608 p. https://www.amazon.com/Ghidra-Book-Definitive-Guide-ebook/dp/B0852N9Y4Q Limited access	1, 2, 3, 5, 6,
2. Easttom W. Computer Security Fundamentals. 4th Edition. Pearson IT Certification; 4th edition, 2019. 512 p. https://www.oreilly.com/library/view/computer-security-fundamentals/9780135774854/ Free access	1, 2, 6, 7, 10
3. Ferguson N., Schneier B., Kohno T. Cryptography Engineering: Design Principles and Practical Applications 1st Edition, Wiley, 2011. 386 p. https://www.schneier.com/wp-content/uploads/2015/12/fortuna.pdf Free access	11 - 15
4. Rhodes-Ousley M. Information Security: The Complete Reference, Second Edition 2nd Edition Publisher: McGraw-Hill Education; 2nd edition, 2013. 896 p. https://d.cxcore.net/InfoSec/Information%20Security%20The%20Complete%20Reference,%202nd%20Edition/Information%20Security%20The%20Complete%20Reference,%202nd%20Edition.pdf Free access	1, 2, 4, 7, 9, 10, 11
5. Schultz C. P., Perciaccante B. Kali Linux Cookbook - Second Edition: Effective penetration testing solutions. Packt Publishing; 2nd Revised edition, 2017. 438 p. http://dl.hellodigi.ir/dl.hellodigi.ir/dl/book/Kali%20Linux%20Cookbook%20%28Second%20Edition%29.pdf	6-11

Sources	Topic
Free access	

Sources in Russian	Topic
1. Баранова, Е. К. Информационная безопасность и защита информации : учебное пособие. Москва : РИОР : ИНФРА-М, 2022. ISBN 978-5-369-01761-6 https://znanium.com/catalog/document?id=393765#bib Limited access	1-6, 10
2. Бондарев В. В. Введение в информационную безопасность автоматизированных систем : учеб. пособие – МГТУ им. Н. Э. Баумана. М. : Изд-во МГТУ им. Н. Э. Баумана, 2016. ISBN 978-5-7038-4414-4. https://www.labirint.ru/books/559227/ Limited access	7-9, 11-15

Section 5. Data analysis and machine learning

Sources	Topic
1. Alpaydin E. Introduction to Machine Learning. London: The MIT Press, 2010. ISBN 978-0-262-01243-0 https://kkpatel7.files.wordpress.com/2015/04/alppaydin_machinelearning_2010.pdf Free access	6-9
2. Bishop C.M. Pattern Recognition and Machine Learning, Springer, 2006. ISBN 978-0-387-31073-2 http://users.isr.ist.utl.pt/~wurmd/Livros/school/Bishop%20-%20Pattern%20Recognition%20And%20Machine%20Learning%20-%20Springer%20%202006.pdf Free access	7-12
3. Hastie T., Tibshirani R., Friedman J. The Elements of Statistical Learning. Springer, 2001 https://link.springer.com/content/pdf/10.1007/978-0-387-84858-7.pdf Limited access	2-6, 10
4. Ian W., Elbe F. Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations. Department of computer science University of Waikato. 3th ed, 2011 https://www.researchgate.net/publication/30876208_Data_Mining_-_Practical_Machine_Learning_Tools_and_Techniques_with_JAVA_Implementations Free access	1, 7, 8, 9, 11, 12, 13
5. Michelucci U. Advanced Applied Deep Learning. Convolutional Neural Networks and Object Detection. Publisher: Apress Berkeley, 2019. 285 p. https://link.springer.com/content/pdf/10.1007/978-1-4842-4976-5.pdf Limited access	14
6. Mohri M., Rostamizadeh A., Talwalkar A. Foundations of Machine Learning. USA, Massachusetts: MIT Press, 2012 ISBN 9780262018258. https://cs.nyu.edu/~mohri/mlbook/	7-12

Sources	Topic
Free access	

Sources in Russian	Topic
1. Парамонов И. Ю., Смагин В. А., Косых Н. Е., Хомоненко А. Д. Методы и модели исследования сложных систем и обработки больших данных Издательство: Лань, 2020. http://i.uran.ru/webcab/system/files/bookspdf/metody-i-modeli-issledovaniya-slozhnyh-sistem-i-obrabotki-bolshih-dannyh-monografiya-1-e-izd/metody.pdf Free access	1-6, 10

Recommended online courses

Section 1. Applied mathematics
1. Mathematical Thinking in Computer Science (Coursera) https://www.coursera.org/learn/what-is-a-proof
2. Combinatorics and Probability (Coursera) https://www.coursera.org/learn/combinatorics
3. Single Variable Calculus (Coursera) https://www.coursera.org/learn/discrete-calculus
4. Data Science Math Skills (Coursera) https://www.coursera.org/learn/datasciencemathskills
5. Algorithms on Graphs (Coursera) https://www.coursera.org/learn/algorithms-on-graphs

Section 2. Software engineering
1. Software Development Lifecycle(Coursera) https://www.coursera.org/specializations/software-development-lifecycle
2. IBM DevOps and Software Engineering Professional Certificate (Coursera) https://www.coursera.org/professional-certificates/devops-and-software-engineering
3. IBM Full Stack Software Developer Professional (Coursera) https://www.coursera.org/professional-certificates/ibm-full-stack-cloud-developer
4. Software Engineering Specialization (Coursera) https://www.coursera.org/specializations/software-engineering
5. Software Design and Architecture Specialization (Coursera) https://www.coursera.org/specializations/software-design-architecture

Section 3. Information systems and computing
1. Information Systems (Coursera) https://www.coursera.org/specializations/information-systems
2. Fundamentals of Network Communication (Coursera) https://www.coursera.org/learn/fundamentals-network-communications
3. Introduction to Computer Science and Programming (Coursera) https://www.coursera.org/specializations/introduction-computer-science-programming
4. TCP/IP and Advanced Topics (Coursera) https://www.coursera.org/learn/tcp-ip-advanced?specialization=computer-communications

5. How to Code: Simple Data (edX) https://www.edx.org/course/how-to-code-simple-data
6. Information Technology Foundations (edX) https://www.edx.org/course/information-technology-foundations
7. Проектирование информационных систем (ИНТУИТ) https://intuit.ru/studies/courses/2195/55/info

Section 4. Information security

1. Introduction to Cybersecurity & Risk Management (Coursera) https://www.coursera.org/specializations/information-security
2. IBM Cybersecurity Analyst Professional Certificate (Coursera) https://www.coursera.org/professional-certificates/ibm-cybersecurity-analyst
3. IT Security: Defense against the digital dark arts (Coursera) https://www.coursera.org/learn/it-security
4. Information Systems Auditing, Controls and Assurance (Coursera) https://www.coursera.org/learn/information-systems-audit
5. Data, Security, and Privacy (Coursera) https://www.coursera.org/learn/data-security-privacy

Section 5. Data analysis and machine learning

1. Free Machine Learning Course (fast.ai) https://www.fast.ai/
2. Machine Learning Course by Stanford University (Coursera) https://www.coursera.org/learn/machine-learning
3. Deep Learning Course (deeplearning.ai) https://www.coursera.org/specializations/deep-learning
4. Free Machine Learning Data Science Course (Harvard University) https://www.edx.org/professional-certificate/harvardx-data-science
5. Free Machine Learning Introduction Course (Udacity) https://www.udacity.com/course/intro-to-machine-learning-nanodegree--nd229
6. Machine Learning Course (Stanford School of Engineering) https://online.stanford.edu/courses/cs229-machine-learning
7. Data Analysis Essentials (edX) https://www.edx.org/course/data-analysis-essentials
8. Data Processing and Analysis with Excel (edX) https://www.edx.org/course/data-processing-and-analysis-with-excel
9. Machine Learning Specialization (Coursera) https://www.coursera.org/specializations/machine-learning-introduction

ONE CLICK TO OPEN ALL DOORS

od.globaluni.ru