

## Engineering & Technology Program outline

This document outlines the scope of themes that may be included in the Olympiad test. They are grouped by areas and followed by recommended references in English.

### Skill set of the winner of the Olympiad in Engineering & Technology

To win the Open Doors Olympiad in Engineering & Technology, you must have analytical, technological and research competencies. Those listed below are in line with the focal points of master's programs offered at Russian universities.

#### Research competencies

- basic knowledge, skills and abilities to employ modern research methods, present findings, and advance arguments in their support

#### Design competencies

- basic knowledge, skills and abilities to design algorithms and digital systems for devices, parts and assemblies of varying complexity

#### Production and technology competencies

- basic knowledge, skills and abilities to create and simulate technological processes for the modeling and production of parts, assemblies and systems of varying complexity

Competency	The winner of the Open Doors Olympiad in Engineering & Technology must:		
	know	be able to	have skills in
<b>Research competencies</b>	the principles of selecting and processing data for calculating and evaluating measured values; methods for	choose data processing tools appropriate to research objectives; apply information processing tools, use building and	working with data; statistical analysis; interpreting the results of mathematical modeling of

	obtaining and analyzing the results of experiments and observations; basic tools for processing experimental and theoretical data, namely the fundamentals of mathematical modeling in physics, including optimization methods, the foundations of probability theory and mathematical statistics	research models; analyze main distribution parameters, understand the statistical properties of estimates, test statistical hypotheses; advance arguments in support of the findings	physical processes; calculating and evaluating physical quantities based on standard techniques; modern tools of presenting findings
<b>Design competencies</b>	the basic techniques and tools of engineering drawing; rules for projecting a 2D image onto the orthogonal plane; axonometric images; types of products and the main types of engineering documentation required to manufacture them; standards for making engineering drawings	determine the geometric shapes of simple parts based on their images (from life and assembly unit drawings); create engineering graphics according to international standards	employing methods of image production (including orthogonal, isometric and dimetric projections) for simple objects while meeting international standards; using packages of modern digital engineering graphics tools
<b>Production and</b>	basic concepts and	choose appropriate	employing

<b>technology competencies</b>	<p>definitions used in the technology of modeling and production of parts, assemblies and systems of varying complexity;</p> <p>the methods of rational design of technological processes for the manufacture of parts and assemblies;</p> <p>the technological capabilities of various methods for obtaining blanks and machine processing of parts</p>	<p>materials and manufacturing and inspection processes for critical parts and assemblies;</p> <p>take into account the influence of various factors on the properties of materials;</p> <p>use dependencies between the composition, structure and properties of metallic and non-metallic materials</p>	<p>methods of comprehensive automation of production;</p> <p>developing automation tools for mass production;</p> <p>devising automation strategy for single and small batch production;</p> <p>using various methods for obtaining blanks and machine processing of parts</p>
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## Content

### Section 1. Theoretical mechanics

- 1 Equilibrium of a rigid body under the influence of a concurrent, plane or spatial force system; friction
- 2 Kinematics of a particle; translation and rotation of a rigid body
- 3 The velocity and acceleration of the planar motion of a rigid body and the complex motion of a particle
- 4 Differential equations of particle motion
- 5 General theorems of particle and mechanical system dynamics; applications to rigid body dynamics

### Section 2. Engineering graphics

- 1 The basic concepts of descriptive geometry (coordinate system, rectangular projection, Monge plot, particle, line, plane, higher-order surfaces)
- 2 Projection drawing, axonometric projection
- 3 Classification of drawings (part drawing, assembly drawing, general arrangement drawing, theoretical drawing, dimensional drawing, wiring diagram, assembly drawing, packing drawing, specification)
- 4 Drawing works

### **Section 3. Strength of materials**

- 1 Types of deformations: elastic and plastic deformation
- 2 Strength, rigidity, structural stability
- 3 External forces (loads): classification. Internal forces
- 4 The section method
- 5 Roller support, hinged support, fixed support
- 6 Calculations of the strength and stiffness of rods under tension-compression, torsion, bending
- 7 Geometry of plane sections
- 8 Stress-strain behavior
- 9 Displacements and deformations of statically determinable and statically indeterminate rods and rod systems
- 10 Combined stress

### **Section 4. Fundamentals of materials science**

- 1 Mechanical properties of materials
- 2 Heat treatment of materials
- 3 Phase diagrams of two-component systems

### **Section 5. Fundamentals of Electrical Engineering**

- 1 Calculation of resistive R-circuits
- 2 Transient processes in linear circuits
- 3 Sinusoidal steady state
- 4 Three-phase circuits

## Section 6. Fundamentals of Electronics

- 1 Semiconductor devices
- 2 Analog electronic devices
- 3 Basics of digital technology
- 4 Digital devices

## Recommended literature

### Section 1. Theoretical mechanics

- 1 William G. McLean, et al. Engineering Mechanics, Statics and Dynamics, McGrawHill (1962).
- 2 Nimal Rajapakse, et al. Engineering Mechanics 1: Statics, Springer Berlin Heidelberg (2009)
- 3 Hand, Louis; Finch, Janet (1998). Analytical Mechanics. Cambridge University Press.
- 4 Kibble, T. W.; Berkshire, F. H. (2004). Classical Mechanics. Imperial College Press.
- 5 Kleppner, Daniel; Kolenkow, Robert (1973). An Introduction to Mechanics. McGraw-Hill.
- 6 Morin, David (2005). Introduction to Classical Mechanics: With Problems and Solutions. Cambridge University Press.
- 7 Taylor, John (2005). Classical Mechanics. University Science Books

### Section 2. Engineering graphics

- 1 M. Maitra, Gitin (2000). Practical Engineering Drawing. 4835/24, Ansari Road, Daryaganj, New Delhi - 110002: New Age International (P) Limited, Publishers. pp. 2-5, 183. ISBN 81-224-1176-2.
- 2 Brian Griffiths. "Engineering Drawing for Manufacture". 2002.
- 3 "Farm Planners' Engineering Handbook for the Upper Mississippi Region", 1953.
- 4 Farhad Ghorani. Title Block. 2015.
- 5 Paul Munford. Technical drawing standards: Grid reference frame, August 2010
- 6 Basant Agrawal and C M Agrawal (2013). Engineering Drawing. Second Edition, McGraw Hill Education India Pvt.

Ltd., New Delhi.

### Section 3. Strength of materials

- 1 Ashby, Michael; Hugh Shercliff; David Cebon (2007). Materials: engineering, science, processing and design (1st ed.). Butterworth-Heinemann.
- 2 Askeland, Donald R.; Pradeep P. Phulé (2005). The Science & Engineering of Materials (5th ed.). Thomson-Engineering.
- 3 Callister, Jr., William D. (2000). Materials Science and Engineering – An Introduction (5th ed.). John Wiley and Sons

### Section 4. Fundamentals of materials science

- 1 Cahn R.W. The Coming of Materials Science. Elsevier Science Ltd., 2001. 598 p.
- 2 Mittemeijer E.J. Fundamentals of Materials Science. Berlin: Springer, 2010. 617 p.
- 3 Hummel R.E. Understanding Materials Science. History. Properties. Applications. Springer, New York, 2005. 452 p.
- 4 Materials Science and Engineering: Concepts, Methodologies, Tools, and Applications. New York: IGI Global, 2017. 1837 p.
- 5 Saka H. Introduction to phase diagrams in materials science and engineering. World Scientific Publishing, 2019. 177p.
- 6 Ashby M.F., Jones D.R.H. Engineering Materials 1: An Introduction to Properties, Applications and Design. 3rd Edition. Butterworth-Heinemann, 2005. 438 p.  
Ashby M.F., Jones D.R.H. Engineering Materials 2: An Introduction to Microstructures, Processing and Design. 3rd Edition. Butterworth-Heinemann, 2005. 464 p.
- 7 Physical Foundations of Materials Science. Günter Gottstein. Springer, 2004.
- 8 Materials chemistry. Bradley D. Falhman. Springer, 2011.

### Section 5. Fundamentals of Electrical Engineering

- 1 Alexander, Charles K. Fundamentals of electric circuits / Charles K. Alexander, Matthew N. O. Sadiku. – 5th ed
- 2 Ljiljana Trajković, "Nonlinear circuits", The Electrical Engineering Handbook (Ed: Wai-Kai Chen), pp. 79–81, Academic Press, 2005 ISBN 0-12-170960-4

- 3 Nilsson, J W, Riedel, S A (2007). Electric Circuits (8th ed.). Pearson Prentice Hall. p. 94. ISBN 978-0-13-198925-2.

## Section 6. Fundamentals of Electronics

- 1 The Art of Electronics (3rd Edition) Paul Horowitz Winfield Hill Cambridge University Press 2015.
- 2 Low Level Measurements Handbook Precision DC Current, Voltage, and Resistance Measurements, SEVENTH EDITION, Copyright 2013 Keithley Instruments, Inc.
- 3 Op Amps For Everyone. Ron Mancini, Editor in Chief. Design Reference. August 2002. Advanced Analog Products. (2007). Electric Circuits (8th ed.). Pearson Prentice Hall. p. 94. ISBN 978-0-13-198925-2.

## Recommended online courses

### Section1. Theoretical mechanics

1. Introduction to Engineering Mechanics <https://coursera.org/learn/engineering-mechanics-statics>
2. Rigid Body Dynamics <https://www.coursera.org/learn/rigid-body-dynamics>
3. Particle Dynamics <https://www.coursera.org/learn/particle-dynamics>
4. Physics 101 - Rotational Motion and Gravitation <https://www.coursera.org/learn/physics-101-rotational-motion-gravitation>
5. Physics <https://stepik.org/48615>

### Section 2. Engineering graphics

1. <https://www.makeuk.org> How to Read Engineering Drawings – a Simple Guide | Make ..
2. <https://www.sciencedirect.com> › Engineering Drawing - an overview | ScienceDirect Topics
3. Nihar Ranjan Patra. Engineering Graphics. <https://www.classcentral.com/course/swayam-engineering-graphics-5305>
4. NPTEL. Diploma in Engineering Drawing and Computer Graphics. <https://alison.com/course/diploma-in-engineering-drawing-and-computer-graphics>

5. Engineering Graphics and Design  
<https://www.classcentral.com/course/swayam-engineering-graphics-and-design-43589>

### Section 3. Strength of materials

1. Strength of Materials <https://freevideolectures.com/course/96/strength-of-materials>
2. Strength of Materials <https://freevideolectures.com/course/2361/strength-of-materials>
3. Mechanics of Materials I: Fundamentals of Stress & Strain and Axial Loading <https://www.coursera.org/learn/mechanics-1>
4. Mechanics of Materials III: Beam Bending <https://www.coursera.org/learn/beam-bending>
5. Mechanics of Materials IV: Deflections, Buckling, Combined Loading & Failure Theories <https://www.coursera.org/learn/materials-structures>

### Section 4. Fundamentals of materials science

1. Materials Science and Engineering. MISIS. <https://www.classcentral.com/course/edx-materials-science-and-engineering-8150>
2. Shackelford J. Materials Science: 10 Things Every Engineer Should Know. University of California. <https://ru.coursera.org/learn/materials-science>
3. Reddy K.M., Jing L., Guo Q. Fundamentals of Materials Science. Shanghai Jiao Tong University. <https://www.coursera.org/learn/fundamentals-of-materials-science>
4. Irvine D., Marzari N. Fundamentals of Materials Science. MIT. <https://ocw.mit.edu/courses/materials-science-and-engineering/3-012-fundamentals-of-materials-science-fall-2005/>
5. Material Behavior <https://www.coursera.org/learn/material-behavior>

### Section 5. Fundamentals of Electrical Engineering

1. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/>



2. Circuit Analysis  
Techniques <http://holbert.faculty.asu.edu/ece201/recipes.html>
3. Circuit Analysis Related Laws, Examples and Solutions  
<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/dcex.html>
4. Basic Electrotechnics for Beginners  
<https://www.youtube.com/watch?v=xwFacS9PsCE>
5. Circuits and Electronics 1: Basic Circuit Analysis  
<https://www.edx.org/course/circuits-and-electronics-1-basic-circuit-analysis>
6. Linear Circuits 2: AC Analysis <https://www.coursera.org/learn/linear-circuits-ac-analysis>
7. [https://www.open.etu.ru/courses/course-v1:kafedra-teoreticheskikh-osnov-elektrotehniki+TOE-101+2021\\_C1\\_of/about](https://www.open.etu.ru/courses/course-v1:kafedra-teoreticheskikh-osnov-elektrotehniki+TOE-101+2021_C1_of/about)

## Section 6. Fundamentals of Electronics

1. Basic Electronics For Beginners <https://youtu.be/uXr4lXYjXuU>
2. Beginner Electronics  
<https://youtube.com/playlist?list=PLah6faXAagguOeMUIxS22ZU4w5nDvCl5gs>
3. Introduction to Electronics <https://www.coursera.org/learn/electronics>
4. Semiconductor Fundamentals <https://www.edx.org/course/semiconductor-fundamentals-course-v1purduex69502x1t2021>
5. Principle of Semiconductor Devices Part I: Semiconductors, PN Junctions and Bipolar Junction Transistors <https://www.edx.org/course/principle-of-semiconductor-devices-part-i-semicond>