**OP 3.2.3**

**THEORY OF**

**INVENTIVE PROBLEM SOLVING**

**Version 3.0**

The training course is developed within the framework of the European Commission Erasmus + project the "Creation of the network infrastructure for the youth innovative entrepreneurship support on the platforms of production laboratories"(561536-EPP-1-2015-1-UK-EPPKA2-CBHE-JP)

<http://fablab-erasmus.eu/>

This document has been prepared with support from the European Commission.

However, it reflects views only of the authors, and the European Commission is not responsible for the information contained therein

**Information about the document**

|  |  |  |  |
| --- | --- | --- | --- |
| **Agreement number** | **561536-EPP-1-2015-1-UK-EPPKA2-CBHE-JP** | **Acronym** | **FabLab** |
| **Project title** | Creation of the network infrastructure to support the innovative entrepreneurship of young people on the platforms of production laboratories |
| **Section** | ERASMUS+ CBHA |
| **Project starting date** | **15 November 2015** | Duration | 36 months |
| **Project site** | <http://fablab-erasmus.eu/> |
| **Project coordinator** | Dr. Dorin Festeu, Buckinghamshire New University, United Kingdom |
| **Design package** | LCD - learning course development |
| **Package manager** | BNTU (П8) | Email | vtrepachko@bntu.by |
|  | Phone | +375 29 190 95 95 |
|  | Skype address | vmtrepachko |
| **Executive manager** | TNTU | Email | lazaryuk@gmail.com |
|  | Phone | +380 50 437 42 04 |
|  | Skype address | valeriylazaryuk |
| **Reviewers** | All partners |
| **Key words** | generating innovative solutions, laws of the technical systems evolution, substance-fields analysis, algorithm of inventive problem solving |

**Document history**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Version** | **Creation date** | **Status** | **Description** | **Participants** |
| 1.0 | 01/09/2017 | Draft | Course content (development of the 1st course version), revision of the 1st level | P13 (TNTU) |
| 2.0 | 05/10/2017 | Draft | Development of the 2nd course version (revision of the 2nd level) | BNTU |
|  |  |  |  |  |
|  |  |  |  |  |

**Content**

[**Course description** 4](#_Toc505007907)

[**Learning outcomes** 4](#_Toc505007908)

[**Course content** 5](#_Toc505007909)

[**Recommended reading** 5](#_Toc505007910)

[**Planned learning activities and teaching methods** 7](#_Toc505007911)

[**Assessment methods, criteria and procedure** 7](#_Toc505007912)

[**Skills and personal development** 7](#_Toc505007913)

[**1. General information about the Theory of inventive problem solving** 9](#_Toc505007914)

[**2. Methods of contradiction resolution** 10](#_Toc505007915)

[**3. Laws of technical system evolution** 12](#_Toc505007916)

[**4. Substance-fields analysis** 13](#_Toc505007917)

[5. **Algorithm of inventive problem solving** 14](#_Toc505007918)

**Course description**

|  |  |
| --- | --- |
| **Course title:** | Theory of Inventive Problem Solving |
| **Course code** | TRIZ |
| **University delivering the course** | BNTU, BSU, KhNEU, IASA «KPI», TNTU |
| **Type of course** | optional |
| **Degree of course** | Master’s degree |
| **Number of ECTS credits** | 3 credits |
| **Delivery mode** | lectures, classes, seminars, self-independent work, distance learning |
| **Requirements for admission**  | Students enrolled in this course should have educational-qualification status of Bachelor degree in engineering or computer science |

**Learning outcomes**

|  |
| --- |
| **Course learning objectives:**to develop creative potential necessary for self-independent setting and solution of new engineering tasks, solution of the problems for searching and investigation of new design and technological solutions,to give the trainees the detailed view about the tools and methods that provide engineering support to the processes of creating innovations improving the products quality and create a competitive level of properties of the designed facilities,to teach the students modern algorithms of engineering problems solving based on the theory of inventive problems solving (TRIZ);to develop students' skills in system analysis and solving problem engineering tasks using TRIZ tools,to introduce the students to the methods of using physical, chemical and geometric effects in engineering,to introduce the students to the methods of overcoming psychological inertia and developing creative imagination.The task of this discipline is to study the basics of TRIZ, which theoretical basis are the laws of the development of technical systems, to master practical skills in using techniques, standards and methods of TRIZ to find solutions for inventive problems and the ability to generate ideas for innovation in improving investigated technical systems consciously.**On successful completion of the course, the students will know:**the laws of creative thinking, the basic methods of activating the trial-and-error method, methods for overcoming the psychological inertia of thinking;the methodology of modern methods of finding the engineering solutions and be able to use the algorithm for inventive problem solving in practice,the typical methods of engineering contradiction resolution;physical, chemical, geometric effects used in physical contradiction resolution;standards of inventive problem solving;the principles of technical systems development and the main problems accompanying each of the system development stages and the ways of solving these problems;and be able to use the methods of system analysis and synthesis for practical design tasks;the methods of substance-fields analysis, to be able to study the structure of a technical system;the main types of information tools to support the process of inventive problems solving, the principles of using the bases of methods for contradiction elimination, standard solutions, indexes of effects;the method of using the algorithm for inventive problems solving for the development of new innovative technical objects. |

**Course content**

|  |
| --- |
| 1. Types of tasks and approaches to their solution2. General information about the theory of inventive problem solving3. Methods for contradiction resolution4. Laws of the technical systems development5. Substance-fields analysis6. Algorithm for inventive problem solving |

**Recommended reading**

|  |
| --- |
| **Main:**1. Altshuller G.S., To Find an Idea: Introduction to TRIZ. – 4-е изд. — М.: Aplpina Publishers, 2011. — 400p. (in Russian)2. Altshuller G. The Innovation Algorithm. TRIZ, Systematic Innovation and Technical Creativity - Worcester, Technical Innovation Center Inc., 2007. - 296 p.3. Petrov V.M. Theory of inventive problems solving- TRIZ: textbook for discipline «Algorithms of nonstandart problem solving». М.: Solon-Press, 2017 - 500 p. (in Russian)4. Orlov M. Easy TRIZ. Universal Practical Course. М.: Solon-Press, 2011. — 384 p. (in Russian)5. Rubin M.S., Kiyaev V.I. Basis of TRIZ and innovations. Application of TRIZ in Software and IT systems: Textbook – St.Petersburg,. St.Petersburg Univ., 2011. – 278 p. (in Russian)6. Murzabulatov А. S. Theory of inventive problems solving: Practical work – Orenburg : OSMI, 2014. – 40 p. (in Russian) 7. Meerovich M.I. Theories of inventive problems solving/ M.I. Meerovich, L.I. Shragina. - Minsk: Kharvest, 2003. — 428 p. (in Russian)8. Orlov M.A. Basis of standard TRIZ. A Practical Guide to Inventive Thinking. — 2nd ed., Rev. and add..— М.: Solon Press. 2006. - 432 p. (in Russian)**Additional:**1. INSIDE THE BOX: a Proven System of Creativity for Breakthrough Results by Drew Boyd and Jacob Goldenberg, Digest Media, 2016. - 350 p. 2. Dmitriev, S. А. Algorithms of nonstandart problem solving: tutorial / S.A. Dmitriev, О. А. Krayev, V. А. Fedorov; SSAU. – Krasnoyarsk, 2015. – 142 p. (in Russian)3. Frick E., Tardini S. & Cantoni L. (2014). Lego Serious Play applications to enhance creativity in participatory design. In Fredricka K. Reisman (ed.). Creativity in Business. Research Papers on Knowledge, Innovation and Enterprise. Volume II. Pp. 200-210. Riga (Latvia). July 22-24, 2014.4. Lemberg B. Creative Problem Solving. How to develop creative thinking: Vector; St.Petersburg; 2014. - 162 p. (in Russian)5. Ivanov G.I. Formulas of creativity. How to learn to invent?, Forum, 2012, 304 p. (in Russian)6. Fundamentals of technical creativity: tutorial for HEI students / E.Ya Prasolov, S. А. Brazhenko, О. P. Novickii. - Sumy : Univ. book, 2014. - 127 p. (in Ukrainian)**Internet based materials:**1. E-Book, Introduction to TRIZ: Basic Concepts and Approaches (in Russian). The website of the Official G.S. Altshuller foundation, http://altshuller.ru/e-books/, http://www.altshuller.ru/world/eng/e-books.asp2. Petrov V.M. Fundamental of Theory of Inventive Problems Solving. Textbook – [E-Resources]. http://triz.natm.ru/articles/petrov/8.2.0.htm (in Russian) 3. Zlotin E., Petrov V. Introduction to Theory of Inventive Problems Solving. Textbook. Tel-Aviv, 1999. https://ru.wikibooks.org/wiki/%D0%9E%D1%81%D0%BD%D0%BE%D0%B2%D1%8B\_%D0%A2%D0%A0%D0%98%D0%97 (in Russian) 4. Rubin M.S., Kiyaev V.I. Basis of TRIZ and innovations. Application of TRIZ in Software and IT systems: Textbook – St.Petersburg,. St.Petersburg Univ., 2011. – 278 p. (in Russian) http://intuit.ru/EDI/09\_03\_17\_3/1489011625-31268/tutorial/936/objects/1/files/triz.zip5. On-line course. TRIZ - Theory of Inventive Problem Solving, https://4brain.ru/triz/ (in Russian) 6. Cases for Theory of Inventive Problems Solving. https://trizland.ru/cases/ (in Russian) 7. Free Ebooks, Exercises and Teaching materials. TRIZ Power Tools. http://opensourcetriz.com/main/page\_ebooks.html8. Petrov V. Algorithm of Inventive Problem Solving. http://trizland.ru/trizba/pdf-books/ariz.pdf9. Petrov V. Structural Substance-Field Analys. http://trizland.ru/trizba/pdf-books/vepol.pdf10. Examples of student finished FabAcademy Projects, http://academy.cba.mit.edu/classes/project\_development/index.html11. Archive of student FabAcademy Projects, http://archive.fabacademy.org/ **Video materials:**1. Video-lectures. Michail Rubin. Introduction to Theory of Inventive Problem Solving for Programmers.http://intuit.ru/studies/courses/3671/913/info (in Russian) 2. Video-lectures. Course «Theory of Inventive Problem Solving», Dmitriev V.A., (in Russian) http://tube.sfu-kras.ru/video/157 3. Video-lectures. Modern technology of innovation design, Salamatov Yu. P. (in Russian) http://tube.sfu-kras.ru/video/6324. Film "Invention Algorithm" (in Russian),https://youtube.com/watch?list=PL566Sj-mNLtUZVpdFPP2QZoBh88VD9yKM&v=y6Kwx5ezlVY5. Lecture, Vikentiev I.L.: TRIZ. G. S. Altshuller, (in Russian), https://youtube.com/watch?v=NtkIx7ns4XI6. TRIZ. Theory of Inventive Problem Solving. Business-lesson on TRIZ, S. Kuranov, (in Russian), https://youtube.com/watch?v=fcCpLTnIeik**Sites on theory of inventive problems solving:**The Official G.S. Altshuller Foundation, www.altshuller.ru TRIZ - internet school, www.triz.natm.ru Center ОТSМ-TRIZ technologies, www.trizminsk.orgPortal "Creative world", www.trizland.ruThe European TRIZ Association http://etria.eu/ |

**Planned learning activities and teaching methods**

|  |
| --- |
| Planned educational activities and methods of teachingThe practical students training is offered. It is maintained and developed through:1. Discussion of projects;2. Development of projects offered by students;3. Collaborative learning;4. Self and peer assessment;5. Guest lecturers;6. Group discussions, reviews and criticisms;7. Work on live projects;8. Mentoring;9. Self-independent study.***For flexible learning***:Web-based sessions led by the lecturer provide methodological and conceptual framework for students’ learning. The slides and materials for the class will be available electronically. Web-based seminars will be used to strengthen the knowledge of newly learned methods and concepts, and to explore their application to particular complex cases. Students are encouraged to ask questions and discuss the material in “live” mode online. There will be a web-based message board for the course. Students are welcome to post questions on this board and these discussions will be monitored by the lecturer. The main accent will be made on self-independent learning. |

**Assessment methods, criteria and procedure**

|  |
| --- |
| Progress and learning are assessed not only at the end but also throughout the entire course. The evidence of the abilities to think and critically analyze challenges will be highly appreciated in the assessment..The students’ grades will be determined by students’ reports on individual assignments after each section and final report at the end of the entire course. The relative weight of each report will be set at 100% and certain assessment weight: clearly defined report objective – 20%, coherence of arguments and reflection – 19%, description – 40%, use of adequate terminology – 20%, evidence of activity.  |

**Skills and personal development**

|  |
| --- |
| The course “Theory of inventive problem solving” provides the students abilities to: 1) use professional knowledge and skills in practice in order to solve engineering and practical problems of creating innovative objects;2) use methods of system analysis to solve applied design problems; 3) analyze, discuss, formulate and solve problematic situations of the development and design of new objects and technologies, solve non-standard problems and create fundamentally new approaches in the creation of innovations;4) master new knowledge and skills, to improve and self-learn, to continue professional development;5) be able to work in team, work on finding new ideas in a team, understand the functions of participants in the creative process; 6) improve communication skills, including oral and written communication; 7) organize their own activities and effective time management; 8) form a stable world outlook, pluralism, correct perception of modern problems of the development of society. |

**Types of tasks and approaches to their solution**

In the modern business world, it is necessary to develop or closely monitor modern technological and scientific achievements and be aware of the rapid changes in society's needs in order to survive in a highly competitive environment, creating productive, efficient and profitable industries. Products, services and related processes that need to be constantly created and modified, develop technical and non-technical tasks, which are gradually becoming more complex. Inventive and innovative approaches are needed to solve problems that can not be solved by traditional methods.

There are two groups of tasks: with known solutions and with unknown solutions.

Problems with known solutions, as a rule, can be solved with the help of information found in books, technical journals or by expert. Traditional approaches in such problems solutions are: trial- and-error method, brainstorming, analysis, use of diagrams, histograms, etc.

Another type of problem has no known solutions because of the contradictions contained in them and is called "inventive tasks". Their solution requires creative (innovative) approach. Inventive approaches to problems solution are: structuring (deploying) the quality function, Taguchi methods, Six Sigma methodology, analysis of causes and consequences of failures, experimental modeling.

The inventive task is the complex task, for which solution it is necessary to identify and resolve a contradiction lying deep in the problem, that is, to identify the root cause (the root of the problem) and eliminate this cause. In fact, a contradiction is a situation where the attempt to improve one feature of a system causes change of other function.

The types of tasks are shown in Table 1.1.

Table 1.1.

| Type of tasks | Known tasks | New tasks |
| --- | --- | --- |
| Engineering tasks(design, construction, modeling) | Existing solutions are applied to known problems.Example:Typical engineering tasks with known solutions | Existing solutions do not provide a satisfactory result - an inventive task.A new approach is needed! |
| Scientific tasks  | New solutions are applied to known problems.Example:New plastics can create durable, lightweight products | New solutions are applied to new tasks.Example:Various applications and functional applications for lasers |

1. **General information about the Theory of inventive problem solving**

In 1946, Genrich Altshuller wanted to simplify the solution of complex inventive problems and developed a special tool - The Theory of Inventive Problem solving (TRIZ/TIPS).

The main point of TRIZ is the identification and use of laws, regularities and trends in the development of technical systems.

The traditional technology for inventive problems solving is based on the trial-and-error method or the method of enumeration of possibilities. The knowledge and experience of a specialist suggest already known solutions imposed by psychological inertia. But time consuming solutions are not, as a rule, fundamentally new.

TRIZ is a system of methods allowing to improve existing technical devices, create new ones, evaluate the prospects of technical developments and much more. TRIZ allows: to identify accurately the problem content; to identify the main areas of search, not missing many of the moments that are usually passed by; to systematize the search of information on the choice of tasks in the workplace; to find ways of withdrawal from the standard (traditional) solutions; the ability to think logically and systematically; significantly increase the efficiency of the work of designers; to reduce the time to find the solutions; to interpret the things and phenomena in new way; this is the impulse for inventive activity; widening of horizons.

TRIZ opens the following opportunities:

1. The solution of inventive tasks of any degree of complexity in different areas without a search of thousands of options.

2. Identification of problems, difficulties and tasks while working with technical systems.

3. Identify the causes of defects and accidents.

4. Maximum efficient use of nature and technology resources to solve many problems.

5. Forecasting the development of technical systems.

6. Obtaining promising solutions, including fundamentally new ones (which have no analogues).

7. Objective evaluation of existing devices.

8. Development of creative imagination and thinking.

9. Development of the qualities of a creative personality.

The basic postulates of TRIZ:

1. Technology develops regularly. While solving problems and developing systems, it is necessary to use the laws of the development of technical systems.

2. Any inventive problem can be classified and, in accordance with the type of task, the type of solution can be chosen.

3. To solve complex inventive problems, it is necessary to identify and resolve the contradiction that lies deep in the problem.

TRIZ includes:

1. Laws for the development of technical systems.

2. Methods for resolving technical contradictions.

3. Methods of system analysis and synthesis.

4. Substance-fields analysis of technical systems.

5. Algorithm for inventive problem solving - ARIZ

6. Information fund.

7. Methods of creative imagination development.

**Recommended video-materials:**

Video-lectures, Dmitriev V.A., Course «Theory of Inventive Problem Solving», Lecture 1: Trial and error method. The basic postulates of TRIZ, <http://tube.sfu-kras.ru/video/134?playlist=157>

Video-lectures, Dmitriev V.A., Course «Theory of Inventive Problem Solving», Lecture 2: Five levels of inventions, evaluation criteria for inventions, <http://tube.sfu-kras.ru/video/135?playlist=157>

Video-lectures, Dmitriev V.A., Course «Theory of Inventive Problem Solving», Lecture 3: Methods for activating the search of variants. Brainstorming, synectics, the method of focal objects,

<http://tube.sfu-kras.ru/video/136?playlist=157>

Film "Invention Algorithm",

<https://youtube.com/watch?list=PL566Sj-mNLtUZVpdFPP2QZoBh88VD9yKM&v=y6Kwx5ezlVY>

Video-lectures. Michail Rubin. Introduction to Theory of Inventive Problem Solving for Programmers. Lectures 1: Fundamentals of TRIZ, <https://youtube.com/watch?v=_spmeJYG98o&feature=youtu.be>

**Recommended reading:**

Petrov V.M. Theory of inventive problems solving- TRIZ: textbook for discipline «Algorithms of nonstandart problem solving». М.: Solon-Press, 2017 - 500 p. (in Russian)

Petrov V.M. Fundamental of Theory of Inventive Problems Solving. Textbook – [E-Resources]. http://triz.natm.ru/articles/petrov/8.2.0.htm (in Russian)

David Gauntlett. Introduction to LEGO® SERIOUS PLAY®. LSP Open Source Brochure. <http://davidgauntlett.com/wp-content/uploads/2013/04/LEGO_SERIOUS_PLAY_OpenSource_14mb.pdf>

E-Book, Introduction to TRIZ: Basic Concepts and Approaches (in Russian). The website of the Official G.S. Altshuller foundation, http://altshuller.ru/e-books/, http://www.altshuller.ru/world/eng/e-books.asp

Su-Field Analysis by: John Terninko, https://triz-journal.com/su-field-analysis/

1. **Methods of contradiction resolution**

One of the sections of TRIZ is a system of methods for contradiction resolution of different nature.

Three categories of technical contradictions are defined in TRIZ:

1) Administrative contradiction - when only the shortcomings are indicated. For example: "I do not like the situation, I do not know how to change it." "The academic progress has decreased." "The class is beyond the control." "I do not have enough time to explain all the material provided by the program". With such an "amorphous" formulation, the task is difficult to solve.

2) Technical contradictions are classical engineering compromises, when one (ones) technical parameter is (are) improved, and the other (others) is (are) worsened. Examples of technical contradictions:

the durability of the structure increases, but its weight increases;

increasing the accuracy of the measuring instrument results in its design complexity;

the response speed of the car airbag increases, but this increase in speed results in the passenger injury or even death.

3) physical contradictions are situations in which one parameter is presented with opposite requirements simultaneously. Examples of physical contradictions:

the reconnaissance aircraft must fly fast enough to reach the destination faster, but also slowly enough to have time to collect data directly over the target for long periods of time;

the software must be complex to implement many functions, but also easy to use;

coffee should be hot for a pleasant drink, but also cold to some degree, so as not to get burned.

Non-technical contradictions include social contradictions - these are conflict interactions between people in all spheres of their activity, when desires and opportunities do not coincide. For example, personal conflicts. These are the conflicts between the desires of one person: I want, but I can not; I want, but I can not (there is not enough resource), etc.

A particular case of social contradictions are pedagogical contradictions - these are conflict interactions between people's desires in the sphere of education. For example: the conflict between the interests of adults and children.

After the formulation of the physical contradiction, it is necessary to outline the methods for it solution and begin to search for the solution itself.

The more perfect solution can be obtained by applying technological effects, since physical contradiction is resolved at the same time. Technological effects include: physical, chemical; biological; mathematical (geometric). Henry Altshuller developed the effects indexes - tables for applying technological effects.

One of the main concepts of TRIZ is the ideal final result (IFR).

IFR is the least expensive (zero cost), with the least (zero) number of undesirable effects problem solution. IFR is necessary to determine the purpose of technical problem solution. It is suggested to formulate IFR immediately after the statement of the problem. It answers the question: what should happen after solving the problem?

IFR should be formulated in order to:

1. Identify the purpose, direction of the solution.

2. Get rid of deliberately empty samples when searching for a solution.

3. Ensure the high quality of the future solution.

 **Recommended video materials:**

Video-lectures. Michail Rubin. Introduction to Theory of Inventive Problem Solving for Programmers, Lecture 2: Techniques for resolving technical contradictions, <https://youtube.com/watch?v=XKYsteB-KPk>

Video-lectures, Dmitriev V.A., Course «Theory of Inventive Problem Solving», Lecture 6: Standard Techniques of Inventive Problem Solving, <http://tube.sfu-kras.ru/video/140?playlist=157>

**Recommended reading:**

Altshuller, G.S. Standard techniques for resolving technical contradictions, <http://altshuller.ru/triz/technique1.asp>

E-Book, Introduction to TRIZ: Basic Concepts and Approaches (in Russian). The website of the Official G.S. Altshuller foundation, http://altshuller.ru/e-books/

Petrov V.M. Theory of inventive problems solving- TRIZ: textbook for discipline «Algorithms of nonstandart problem solving». М.: Solon-Press, 2017 - 500 p. (in Russian)

Petrov V.M. Fundamental of Theory of Inventive Problems Solving. Textbook – [E-Resources]. http://triz.natm.ru/articles/petrov/8.2.0.htm (in Russian)

Dmitriev, S. А. Algorithms of nonstandart problem solving: tutorial / S.A. Dmitriev, О. А. Krayev, V. А. Fedorov; SSAU. – Krasnoyarsk, 2015. – 142 p. (in Russian)

Zlotin E., Petrov V. Introduction to Theory of Inventive Problems Solving. Textbook. Tel-Aviv, 1999. https://ru.wikibooks.org/wiki/%D0%9E%D1%81%D0%BD%D0%BE%D0%B2%D1%8B\_%D0%A2%D0%A0%D0%98%D0%97 (in Russian)

1. **Laws of technical system evolution**

Thinking and the activity of the inventor allows to organize the system analysis, the main concept of which is the system - a set of interacting elements, with the following properties: integrity, isolation from the environment, the presence of links with the environment, the presence of parts and connections between them (structured), subordination of the entire organization system to some purpose.

Emergence is characteristic for all systems – the peculiarity of the systems is the fact that the properties of the system do not reduce to the totality of the properties of the parts from which it consists, and are not derived from them.

The evolution of technical systems is carried out according to certain laws. Any system has a certain structure - a set of links between the elements of the system. Any system is developed in successive stages. Initially, slowly (stage I), then accelerates (stage II), then the growth rate decreases and eventually the growth of the system parameter stops (stage III), and at the end the system parameters begin to decrease (stage IV) - the system "dies". This pattern is called the S-shaped law of any system evolution. The development of the S-shaped curve was originally discovered for biological systems.

The laws of the technical system evolution (LTSE) were formulated on the basis of the patent fund analysis. LTSE are largely of a social nature. They describe not only the nature of technical systems, but also the ways of their design. Conscious use of LTSE sufficiently simplifies the work of the inventor and designer. The use of LTSE in the technical systems design and optimization should be supplemented by methods of system analysis, for example, by analyzing the structure of the system, determining the main useful functions, etc.

The basic laws of the technical systems development according to Altshuller G.S.

1. The law of system completeness

2. The law of the system "energy conductivity"

3. The law of harmonizing of the system parts rhythm

4. The law of increasing degree of ideality

5. The law of non-uniform evolution of sub-systems

6. The law of transition to the super-system

7. The law of transition from macro-level to micro-level

8. The Law of increasing Substance-fields interactions

**Recommended video materials:**

Video-lectures, Michail Rubin. Introduction to Theory of Inventive Problem Solving for Programmers, Lecture 4: Increase of ideality, <https://youtube.com/watch?v=C5-7vKdPMs0>

Video-lectures, Dmitriev V.A., Course «Theory of Inventive Problem Solving», Lecture 4: The law of increasing degree of ideality, <http://tube.sfu-kras.ru/video/137?playlist=157>

Video-lectures, Salamatov Yu. P. Modern technology of innovation design. Lecture 5: Analytical stage. The law of uneven development of technical systems, <http://tube.sfu-kras.ru/video/624?playlist=632>

Video-lectures, Salamatov Yu. P. Modern technology of innovation design. Lecture 6: Genetic analysis, analysis of alternative systems. The law of human displacement from the technical system, the law of S-shaped evolution of systems, <http://tube.sfu-kras.ru/video/625?playlist=632>

**Recommended reading:**

E-Book, Introduction to TRIZ: Basic Concepts and Approaches (in Russian). The website of the Official G.S. Altshuller foundation, http://altshuller.ru/e-books/

Petrov V.M. Theory of inventive problems solving- TRIZ: textbook for discipline «Algorithms of nonstandart problem solving». М.: Solon-Press, 2017 - 500 p. (in Russian)

Petrov V.M. Fundamental of Theory of Inventive Problems Solving. Textbook – [E-Resources]. http://triz.natm.ru/articles/petrov/8.2.0.htm (in Russian)

1. **Substance-fields analysis**

Substance-fields (Su-Fields) analysis (VePole analysis in Russian) or structural real-field analysis is a section of TRIZ which studies and transforms the structure of technical systems. Substance-fields analysis is a schematic language that allows to present the initial technical system in the form of a definite (structural) model. Due to special rules, the properties of this technical system are defined. Then, according to specific patterns, the original model of the problem is transformed and a solution structure is obtained which eliminates the drawbacks of the original system.

Substance-fields analysis is designed for:

representing the initial problem structure (system);

determining the structural problem solution;

identifying the prospects for the development of the system structure

The known types of inventive problems are solved using, first of all, typical solutions - standards for a solution of inventive problems, developed by G. Altshuller in 1975. They represent the interconnected set of techniques, physical or other effects, having a certain Substance-fields structure. This is a kind of formula for solution of problems. The classification of standards is based on the laws of the evolution of technical systems and, above all, on the law of increasing the Substance-fields degree. Due to the system of 76 standards it is possible not only to solve, but also to determine new tasks to predict the development of technical systems.

**Recommended video materials:**

Video-lectures. Michail Rubin. Introduction to Theory of Inventive Problem Solving for Programmers, Lecture 5: Electric fields and standards, <http://intuit.ru/studies/courses/3671/913/lecture/14335>

Video-course, Sibiryakov V., Lecture 14: Substance-fields analysis, Part 1 <https://youtube.com/watch?v=lIyEi4Mbig8>

Video-course, Sibiryakov V., Lecture 15: Substance-fields analysis, Part 2 <https://youtube.com/watch?v=tBOHc7pM21k&list=UUgp4sr5nH_DiiLfiNNJWZNg&index=10>

**Recommended reading:**

E-Book, Introduction to TRIZ: Basic Concepts and Approaches (in Russian). The website of the Official G.S. Altshuller foundation, http://altshuller.ru/e-books/

Petrov V.M. Theory of inventive problems solving- TRIZ: textbook for discipline «Algorithms of nonstandart problem solving». М.: Solon-Press, 2017 - 500 p. (in Russian)

Petrov V. Structural Substance-Field Analys. http://trizland.ru/trizba/pdf-books/vepol.pdf

Altshuller G.S. Standard inventive problem solutions, <http://altshuller.ru/triz/standards0.asp>

1. **Algorithm of inventive problem solving**

Algorithm of inventive problem solving (ARIZ) is a section of TRIZ intended to solve complex non-standard problems. ARIZ is an acronym for the Russian phrase “Algorithm of Inventive Problem Solving.”

ARIZ is a systematic procedure for determining solutions without apparent contradictions. Depending on the nature of the problem, the number of cycles needed to be carried out to solve the problem varies because of the uncertain technical problem that can be identified through ARIZ.

ARIZ which structure is shown in Figure 1.1, is a multi-step cyclic process.

Analysis of

Technical

Contradictions

Solution was not found

Separation into Simple (Mini) Problems

Formulation of

Technical

Contradictions

Formulation of Optimal Solution

Resolution of

Physical Contradictions

Re-Formulation of

Mini-Problem

Standard Solutions Base for Problem Solving

Formulation of

Physical

Contradictions

Problem statement

Solution was found

Figure 1.1 – ARIZ structure

The latest ARIZ modifications include three main components: the program, information support and methods of psychological factors management.

The ARIZ program is the sequence of operations to identify and resolve contradictions, analyze the initial situation and select the task for the solution, synthesize the solution, analyze the solutions obtained and select the best one, develop the solutions obtained, accumulate the best solutions, and generalize this material to improve the way to solve other problems. The structure of the program and the rules for its implementation are based on the laws and rules of the technology development.

Information support is supplied from the information fund, which includes the system of standards for the inventive problem solving; technological effects (physical, chemical, biological, mathematical, particularly geometric); methods of contradictions resolution; methods of nature and technology resources use.

Methods of psychological factors management are necessary due to the fact that the ARIZ program is not designed for a computer and tasks are not solved automatically, but by a person. Therefore, the solver often has psychological inertia, which must be controlled. In addition, these methods allow us to develop the creative imagination necessary to solve complex inventive problems.

The ARIZ program of ARIZ-85-V modification is a sequence of operations to identify and resolve contradictions:

1. Problem analysis.

2. Problem model analysis.

3. Ideal Final Result and Physical Contradiction determination.

4. Mobilization and application of material-field resources.

5. Application of the information fund.

6. Changing and / or replacing the task.

7. Analysis of the way to eliminate Physical Contradiction.

8. Application of the received answer.

9. Analysis of the decision progress.

While solving inventive problems of the highest level it is necessary to have knowledge not only of some technology, but also, for example, additional knowledge in mathematics, physics, chemistry. In this regard, scientific advances in these areas make it possible to have more information about the objects in future.

**Recommended video materials:**

Video-lectures, Dmitriev V.A., Course «Theory of Inventive Problem Solving», Lecture 8: Algorithm for inventive problem solving, <http://tube.sfu-kras.ru/video/137?playlist=157>

Video-lectures. Michail Rubin. Introduction to Theory of Inventive Problem Solving for Programmers, Lecture 7: Function-oriented search, <https://youtube.com/watch?time_continue=1&v=vIro71uk1KE>

Video-lectures, Dmitriev V.A., Course «Theory of Inventive Problem Solving», Lecture of АRIZ-85, <https://youtube.com/watch?v=fo-azoiX6PU&t=82s>

**Recommended reading:**

E-Book, Introduction to TRIZ: Basic Concepts and Approaches (in Russian). The website of the Official G.S. Altshuller foundation, http://altshuller.ru/e-books/

Petrov V.M. Theory of inventive problems solving- TRIZ: textbook for discipline «Algorithms of nonstandart problem solving». М.: Solon-Press, 2017 - 500 p. (in Russian)

Petrov V.M. Fundamental of Theory of Inventive Problems Solving. Textbook – [E-Resources]. http://triz.natm.ru/articles/petrov/8.2.0.htm (in Russian)