

PHYSICAL PROBLEMS IN UNIVERSITY EDUCATION

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ABSTRACT

There is an important aim that stands before the university today – to train creative, think for themselves specialists, capable to apply science approach to solve specific problems. The lecture as a basic form of teaching in university has to ensure students enough information about science theories. The abilities for the independence of judgment, creative approach and for solving problems have to be formed during the exercises and practical studies.

It is necessary to discriminate between terms exercise and problem from scientific point of view.

The article considers in a few words the problem in terms of psychology, physic and mathematic didactics; four methods for solving physical problems – method of solving qualitative, quantitative, graph and experimental problems; some classifications of physic problems by Bulgarian and foreign methodologists are represent.

It was devoted space to the analytic-synthetic method, used for physic problems solving.

Different understandings about general algorithmic instructions for physic problems solving are represent.

There is an important aim that stands before the university today – to train creative, think for themselves specialists, capable to apply science approach to solve specific problems. The lecture as a basic form of teaching in university has to ensure students enough information about science theories. The abilities for the independence of judgment, creative approach and for solving problems have to be formed during the exercises and practical studies. The exercises are important because they give students an opportunity to give a new meaning to practical applicability of theoretical matter, to find out dependences and to give proof of interrelations, to learn and to apply theoretical knowledge, to develop abilities for solving problems and to reach valid solutions from a scientific point of view.

It is necessary to discriminate between conception for "exercise" and for "problem" from scientific point of view. The major purpose of exercises is to build up abilities for making some operations, leading to solution of a particular problem. Though the problem cannot be considered as a sum of some exercises that take place in its solution. Each problem by contrast with exercise demands to set and choose (basing on the analysis) what operations in what succession have to be made for the problems solution. Each operation characterizes with following components: 1) purpose that represents the requirement to the condition of the problems subject, after its solving; 2) subject that transforms during the operation; 3) motive – the solving of the problem is subordinated to the motive; 4) method that realizes the operation.

According to Belich attributive analysis the scheme expression is such as shown on fig.1.

The problem is the situation that determines the action of some solving system.

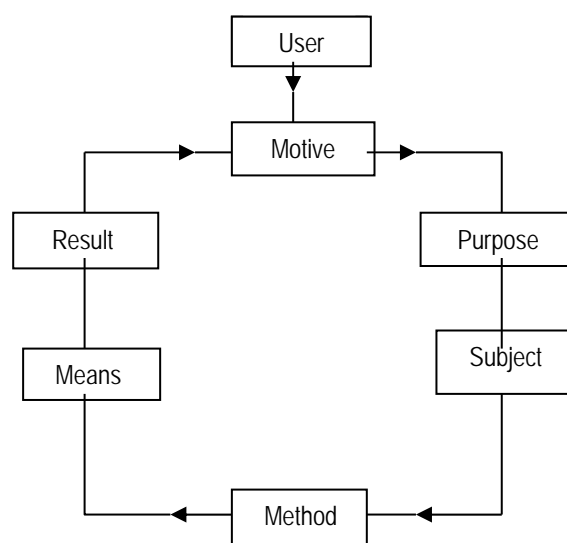


Figure1

THE CONCEPTION FOR "PROBLEM" FROM PSYCHOLOGICAL, MATHEMATICAL AND PHYSICAL POINT OF VIEW

Some definitions of the conception for "problem" exist from psychological point of view. A.N. Leontiev (1972) determines the problem as "a situation, which expects form the subject to do some action". P.Ya. Galperin (1958) determines the

problem as “a situation, which expects from the subject to operate and find an unknown quantity utilizing his connections with the other known quantities”. G.S.Kostiuk (1968) extends the problem definition adding “in the conditions, in which the subject do not know the algorithm how to do this action”. The conception “action” is in the middle of the problem definitions: the first one is the general rule, the second one is concretized for the education and science activities, and the third one is for the didactic problem situations.

V.M. Bradis, J.M. Koliagin and A.A.Stoliar (Galanov 1992) propose some definitions for the “problem” from mathematical point of view:

- The “problem” is every mathematical question, which answer expects more than simple reproduction of only one result, theorem or definition of the educated course.
- Every mathematical problem is composed from the origin conditions and the searched result, which determines the actions to perceive the aim of the problem. Some mathematical problems solution suppose that the known and unknown quantities are connected with some functional dependence.
- The mathematical problem is equal to a problem formulated with mathematical terminology. The problems, which are deposited in the practice, techniques and the science have concrete solutions, if they are described mathematically with some mathematical theory.

No only one definition about the “physical problem” exists. M. Kiuldjieva (1997) determines “the physical problem” as “a relatively closed problem, which may be solved by logic conclusions, mathematical operations and experiment based on the laws and the methods in the physics. P. Galanov (1992) determines the “physical problem” as “a whole complex of facts, conceptions and opinions, which describes some physical situation (with one or few physical phenomena), where some characteristics or connections between the quantities, the origins of the process and his consequences are searched. V. Orekhov and A. Usova (1977) consider the problems only as “the material for the exercises, which demanding of the application of physical conformities for the concrete conditions”.

Every physical problem is concerned to determined physical process or phenomena and search an unknown physical quantity or law. The ability to solve the problems is an important criterion for the best results during education. The systematic solving of the physical problems and the precise experiments provide to high educational effect. The basic aim of education is to use the problem solving for more fundamental understanding of the physical laws and make a science decisions in some practical situations. The solving of problems is a method for mental development, quick wits and self-dependence of the students. It helps to overcome the formality of education.

The Bulgarian students in the schools do not obtain a good training to solve the physical problems. There are many causes for this situation which exert influence on its physical preparation for the university. The lecturers in physics establish inability for self-solving the physical problems, a shortage of interest, systematization and consistency when

the students works on the physical problems. The basic problem in the university is the same – the physical problems are transferred after the theoretical considerations and they occupy a short time during the education.

To solve this problem of education the teacher must know the different kinds of physical problems and can determine the place of the every problem in the education system. To put a problem in unsuitable time disturbs the education process and it do not help to learn the physics. A generally accepted classification of the physical problems do not exist in the didactic literature. P. Galanov (1992) indicates six signs which give a possibility to group the physical problems – according to the mode of solution, according to the necessity of theoretical knowledge, according to the kind of the facts and the phenomena, included in the physical picture of the problem and depended on the unknown quantity, according to the formulation of the initial condition and solution and according to the number of the physical law taking into account in the problem solution. The physical problems are quantitative or qualitative according to the methods of their solution. The physical problems are from the kinematics, dynamics, thermodynamics, electricity, optics and combined taking into account the theoretical knowledge. To solve the problems the student must have the knowledge from the different parts of the physics. The facts and the phenomena included in the physical picture of the problem are separated in two big groups – scientific (abstract and concrete) group and the other group which conclude the historic, polytechnic, home and entertained physical problems. The character of unknown quantity determine a few kind of problems – with whole condition and with incomplete condition; the quantitative problems for determination of the numerical value of the unknown quantities and constants; the problems to finding the functional connections between the physical quantities; the algorithmic problems which might be formulated and etc. Taking into account the character of the condition and solution formulation there are text problems, graph problems, picture problems, table problems, experimental problems, and etc.

S. Nitzolova and P. Targov (1977) and M. Kiuldjieva (1997) propose some different classification for the physical problems. This classification is relatively comfortable for didactic aims:

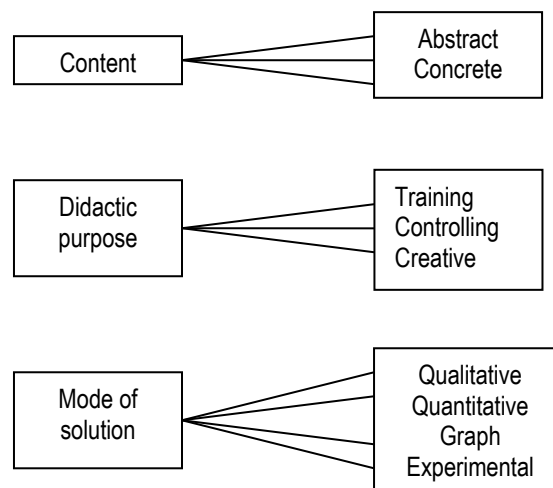


Figure2. Physical problems according to their basic indications

It is necessary to note that this classification based on three indications is very relatively, because some problems may be connected with the different groups. In the physical education we frequently use the tasks named quantitative, qualitative, graphic and experimental problems.

The qualitative problems are known as logic problems, problems for quick wits, oral problems-questions, entertained physical problems and etc. The common character for this kind of problems is its solution which do not use the mathematical means. Their correct solution demands on a precision using the physical knowledge for the phenomena and laws to build the physical conclusions.

The qualitative physical problems are known as calculation problems. They are used very often in the education. Their solution is not possible without mathematical formulae. The role of mathematics in the other sciences is described from Leonardo da Vinci: "No science reliability in the things where there are not any mathematical applications and which are not connected with mathematics." According to N. Lobachevska "The mathematics is the language for whole accurate sciences". A matter in fact is that the physics uses the mathematics as science and education, but it exists the other moment according to Einstein: "Where the mathematics takes possession of the relative theory, I stop to understand it." The conclusion that may be extracted is that the solving of qualitative physical problems require abilities for mathematical actions with physical quantities. These abilities are oriented to more deeply enter into a physical problem, functional dependencies and into the physical phenomena and processes.

The functional dependencies between the quantities characterizing the physical phenomena and processes may be expressed with graphs. This presentation gives a clearness of the dependence and it develops the imagination and the logic thinking of the students. They acquire a mastery to draw graphs for different functional dependencies and they can uncover the unknown dependencies taking into account their graphs. The graphical problems are:

- Problems with a initial deposited graph – analyzing the graph the students obtain the initial data to solve the problem;
- Problems with a graph for physical process used in the concrete stage of the solution;
- Problems with the graphical view translated from one coordinate system to the other. This kind of problems is very important for the students in technical universities.

The experimental problems are a part of physical problem system and a part of education physical experiment. Its important role is due to the fact that they reveal the physics as experimental science. To solve the problem the students do obligatory physical experiment. Even the qualitative experimental problems, where the solution wants to expect some physical phenomena or process, the correctness of the expected result is controlled by experiment.

For the place of real experiment and its role in the solution of the experimental problem Dr. Ivanov (1988) proposes the following classification:

- Problems which require to measure some physical quantities in advance;
- Problems where the experiment is described in the initial condition and his result must be foreseen;
- Problems where the connections between the physical quantities must be established by the real experiment;
- Problems where the experimental devices exist but the experimental procedures are not described;
- Problems that solve practical situations.

The experimental problems must be used for physics education in the high schools and they can stimulate the creative abilities of the student, their own activity and research interest.

The methods that were used in many European countries (UdSSR, Poland, Germany, Bulgaria) indicate the expedience of algorithmic approach for the solving of physical problems (S. Nitzolova, P. Targov 1977; A. Manolov 1972). The educational practice shows that the students cannot solve problems although they know the physical theory. The reason is that the students have not the practice to analyze the problem condition and they cannot use the data in the condition.

In the mathematics algorithm is every system of calculation, which are realized by following strong rules leading to the solution of the problem. The algorithmic approach prescribes the operations that might give the final result in strict sequence (A. Manolov 1972). Every algorithm might be determined clearly and exactly. It might be applicable at different variations of the initial conditions and to bring to the ultimate aim. The effect of the application of algorithm depend on the average quantity of the operations, on the time of every operation and on the time between two consecutive operation.

L.N. Landa describes the "educating algorithm" as a rule to conduct the didactic process where the content and the aim of education are determined exactly. In this rule the activity of the teacher and the students is segmented in consecutive operations and the actions of the student answering to the teacher questions are determined exactly (Manolov 1972).

The differences between the mathematical concept of algorithm and the educational algorithm conduct to new concept "algorithmic instructions". To solving physical problems the algorithmic instructions might include clear and exact rules applicable for many problems. S. Nitzolova and P. Targov (1977), A. Manolov (1972) proposes two kinds of algorithm applied in the education for physical problem solving: a general algorithm for every kind of problems and the separate algorithms for the different kinds of problems. The general algorithm contents:

1. Writing or reading the initial condition of the problem;
2. Analyze the condition for initial orientation;
3. Analyze the physical "picture" for initial orientation in the problem.
4. Short recording of the condition;
5. Full analysis of physical "picture" of the problem;
6. Obtaining the general solution;
7. Verifying the general solution;
8. Choosing the units of the physical quantities;

9. Calculating the quantities in the result.
10. Evaluating the data in the result.

Koerner and Kissling (1987) propose the general algorithm with five steps:

1. Analyze of the condition and making the problem clear;
2. Making the quantitative description of the problem situation and make up an equation system which has a solution;
3. Obtaining the general solution of the problem;
4. Calculating the quantities;
5. Discussing the obtained result if it corresponds to the initial condition.

Other variation of the general algorithmic instructions applicable in every part of physics is proposed from I. Staneva and K. Yanakieva. It concludes eight stages:

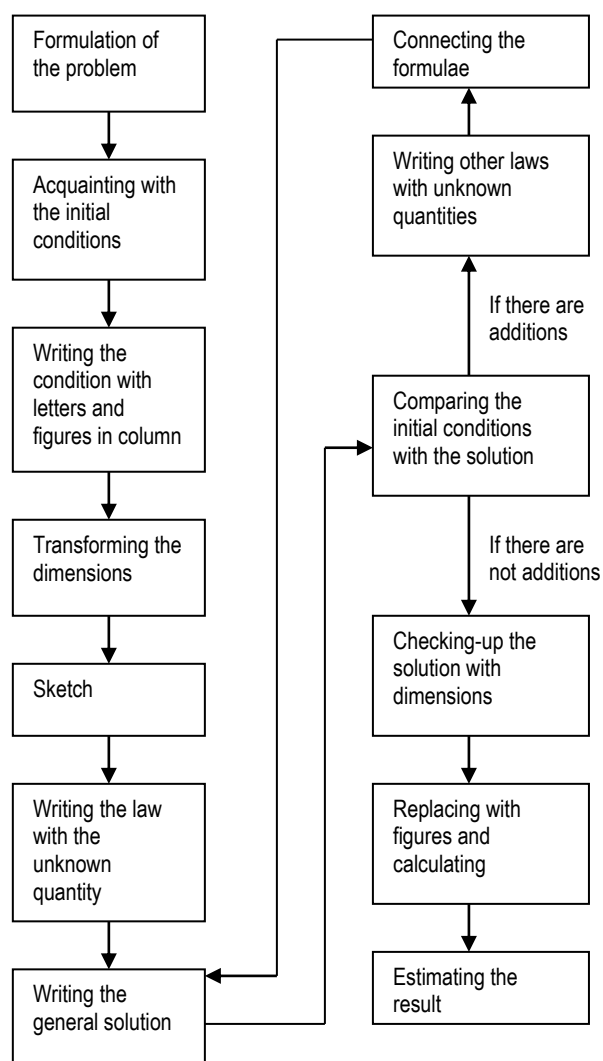


Figure 3. Technology for solving every physical problem (I. Staneva and K. Yanakieva)

Every kind of physical problem has own method for solving. The qualitative problems are frequently in use and they can be solved using the general algorithmic instruction.

The solving of qualitative problems passes through the following steps:

1. Acquainting with the problem formulation: careful reading of the text; showing up the known from the unknown; discriminating between the basing and secondary assumption.
2. Giving a meaning to the aim of the problem.
3. Making a plane for solving using analytic or synthetic method. Graphical and experimental methods are able too.
4. Verifying the solution: to make experiment or discovered other variant for solving, compare with practice, and etc.

There are some difficulties to give general algorithmic instructions for solving experimental problems, because the place of the experiment is not accurately regulated in the process of solving. The methods for solving experimental problems are developed in the methodical literature, nevertheless it is able to draw a general conclusions that most of the experimental problems can be formulated in such way that during the solving we primary make assumptions then solve theoretically and third the conclusions are drawn from experiment.

The algorithmic instructions apply generally during the course in physics in school, where standard problems are solving. The students in the universities have to direct their efforts to the creative problems. It is often unable to make algorithms in detail for this kind of problem. According to Fuler (1987) one problem is creative when it solves with more then one law. Each creative problem has own method for solving, but it is able to give some general methodical directions. These directions partially coincide with the described ones. This is understandable, because each physical problem refers to certain physical process and during it's solving unknown physical quantity or law is found. The necessity of general algorithmic instructions is dictated by the fact that no instructions in the specific literature concerning physical problems exist. In most cases there are problem's formulations and final solutions in the books. These books can be used only if students have understood the usefulness of the algorithmic instructions in complicated situations; they have built up skills for correct application of these algorithms with aim to get searched results and abilities for making decisions. The instructions used in a concrete physical situation demands consideration, valuation and to make many decisions. The last one consists in: choosing algorithm, in how much details the instructions could be, in what order of steps and how to apply each step into the concrete situation.

It is necessary to develop the universal general algorithm that could not be applied mechanically without any controlling and evaluating operations. An algorithm that gives abilities to choose a method for solving a problem is represented as a scheme (fig.4). It is more general then other ones that have been described.

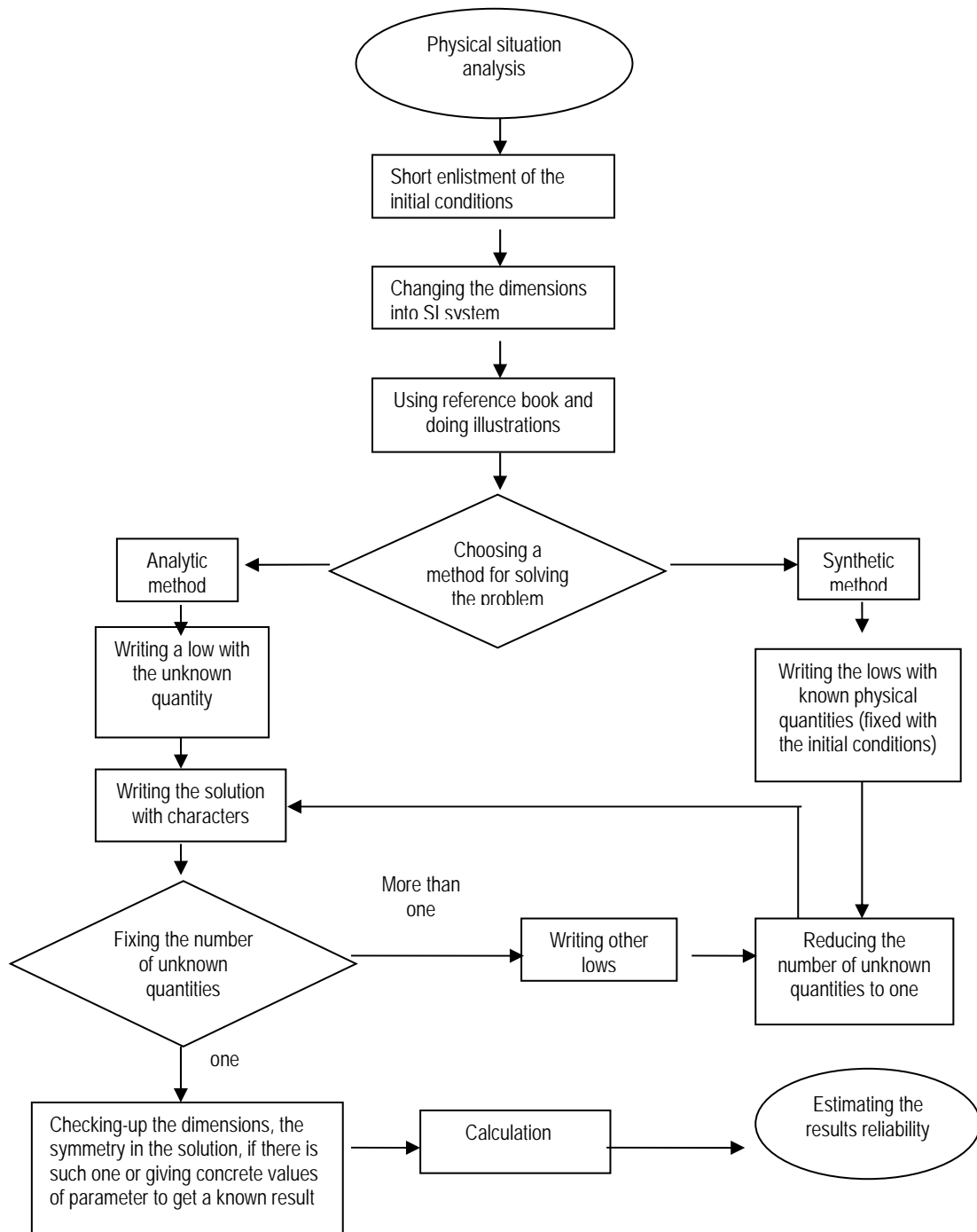


Figure 4

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