FUNCTIONAL COMPREHENSION OF CONCEPTS AND GRAPHICAL REPRESENTATIONS IN KINEMATICS SUPPORTED BY M.B.L. AND SIMULATIONS

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ABSTRACT

The aim of this paper is the formulation of an instructive proposal for the conceptual comprehension of phenomena of Kinematics in one dimension, in the Greek Lyceum, supported by: suitable laboratory activities with the use of MBL (Microcomputer-Based Laboratory), simulations implemented by the «Interactive Physics» and a simple and open web-based software

The reasons that impose our particular proposal are:

A. Conceptual difficulties on graphic representations, related to motion, for students at the first class of Greek Lyceum (Aged 15-16 years old).

B. Physics teachers in Greece do not have educational material with explicit educational methodology at their disposal. In addition to this, they do not exploit the interest of their students and they set problems that discourage them.

C. Students ask from their teachers, at school, provocative and interesting problems in the school laboratory.

Instructive intervention Planning

The whole process was implemented in two steps

Laboratory - instructive interventions. The activities-experiments were implemented with MBL

A post-test. Our sample was divided in an experimental group (24 students for October 2005 and 27 students for October 2006) and a group of control (40 students). In the post-test we used two questions from the FCI test (The Force Concept Inventory) (Hestenes, D., Wells, M. and Swackhamer G. (1992)) and ideas from Worksheets of C.M.S.T. (Center for Science and Mathematics Teaching - Tufts University of Massachusetts), so as that the test has bigger validity.

The questions of the post-test were selected upon the following criteria:

a. The comprehension of concepts which are related to kinematics.

b. The functional comprehension of related graphic representations.

c. The confrontation of the students' alternative ideas.

The findings of the results of the post-test indicate the supremacy of the experimental team for questions related to the comprehension of graphic representations and the capability of interpretation of their answers.

KEYWORDS

Kinematics, MBL, Simulations, Physics in Secondary Education, Conceptual understanding, Physics laboratory Graphical representations, Kinematics.

INTRODUCTION

The ascertainment of poor learning results in teaching Physics in Greece has been argued by tens of Greek researchers. (Kokkotas P. 2002, Koulaidis (1) (1995), Dimitriadis, et al,2002, in Greek). For the interpretation of these results have been various assumptions, as for example the methods of teaching, the marginalisation of laboratorial exercise etc. As a result, over the last years, a big number of proposals have been presented to the educational community aiming at the improvement of teaching. The most of them were focussed on Primary education (Koulaidis (2), 1995 in Greek).

On the contrary, a significant lack of instructive proposals exists for:

a. the conceptual comprehension and laboratorial teaching in Physics mainly in Secondary Education.
b. the development of laboratorial exercises which concern the acquisition and data processing of measurements by PC (MBL, Microcomputers Based Laboratory) at the level of the Greek Lyceum
c. the combination of simulations and MBL.
The basic weaknesses are today located

- in conceptual issues, although the higher level of knowledge and the skills in exercises' resolution that students acquire, unable them on the one hand to comprehend concepts, on the other hand to implement their knowledge on graphic representations
- in the implementation of laboratorial exercises (acquisition of measurements, data processing inference(s)).

AIM OF THIS PAPER

The aim of this paper is the formulation of an instructive proposal for the conceptual comprehension of phenomena of Kinematics in one dimension, in the Greek Lyceum, supported by: a. suitable laboratory exercises with the use of MBL (Microcomputer Based laboratory), b. simulations implemented by the «Interactive Physics» and c. a simple and open web-based software
The reasons that impose our particular proposal are the following:

- Conceptual difficulties on graphic representations, related to movements, for students at the first class of Greek Lyceum (Aged 15-16 years old).
- Physics teachers in Greece do not have educational material with explicit educational methodology at their disposal. In addition to this they do not exploit the interest of their students and they set problems that discourage them.
- Students ask for provocative and interesting problems in the school laboratory from their teachers, at school.
- Problems about the time restrictions that are imposed by the school program in the Greek Lyceum due to the examinational system.

The solution to this problem is, in our opinion, the construction of a conceptual framework for the comprehension of basic concepts of Physics (De Kleer I and Brown I., 1983), and the connection of these concepts with processes of everyday life and the achievements of modern technology. The layout of this framework must support the active attendance of students during the process of learning and to develop with the most optimal way the New Technologies (ICT) in combination with the process of modelling, that constitutes a basic characteristic of the scientific method (Doerr H., 1997), (Dimitriadis P., et al., 2000).
The endorsement of laboratorial activities with the ICT can improve the conceptual comprehension in the phenomena of motion. More specifically, the use of sensors, for the acquisition of measurements in the study of movements, provides the potentiality of:

- acquisition of measurements and then their elaboration by the PC
- depiction in real time of measurements via graphic representations
- the multilevel representation of phenomenon
- derivative of an experimental curve
- integration (finding areas)
- flattening of an experimental kampy'lis
- adaptation of a theoretical curve in experimental points
- comparison of two graphic representations
- In the Microcomputer-Based Laboratory (MBL) the following advantages appear:
- Students carry out in real time, a real experiment and with the PC obtain measurements, contrary to simulations where the experiment is pictorial.
- Students watch simultaneously the development of graphic representations with the development of the phenomenon.
- Students focus on the development of the phenomenon and do not deal with the (sometimes) inanimate or time-consuming process of data collection.
- Students have the potentiality of many repetitions of the whole processes.

- Students have the potentiality of interaction and dialogue.
- Students have the potentiality of continuous control of their assumptions.
- According to Amend (Amend et al., 1989)
- MBLs allow students to do the steps in the experimental process faster, more thoroughly and more accurately, and
- MBLs involve the student in more of the scientific process.
- Also large scale testing at various sites indicate that laboratory curricula incorporating MBL and the instructional strategies proposed by Arons and McDermott are considerably more effective in teaching basic kinematics (mechanics) concepts than standard lectures (Thornton, et al 1990).

INSTRUCTIVE INTERVENTION PLANNING

We used two different groups, an experimental group and a group of control. The experimental group comprised 24 students for 2005 and 27 students for 2006 and the group of control of 40 students. The instructive interventions were different for the two groups. For the group of experimentation the school laboratory was used which included a Fourier MBL device (that exists in the Greek Lyceum) and a data-projector. Four laboratorial activities were carried out of total duration of three school hours. The group of control followed the traditional teaching.
Firstly, we recorded the alternative perceptions (misconceptions) of the students as they were reported by various researchers. A lot of researchers (Gilbert, Osborne and Fensham, 1982), support that these ideas of children, which are called and science of students, do not constitute usual errors without particular importance, but intellectual constructions which the children use to interpret the physical phenomena. According to several researches (Duit R.1993*)* focused mainly on the alternative perceptions of students, even after age-long teaching, most of them do not acquire a functional perception of physics concepts
Synoptically we quote the alternative perceptions (misconceptions) of the students for motion.

- «Two neighbouring objects should have the same speed» or «The same position means the same speed» (The control in post-test was done with questions 11 and 12)
- «Acceleration and velocity always have the same direction» (the control in post-test was done with the questions 5,.6, 10)
- «Speed is a force»
- «If speed is zero, then the acceleration is zero» (The control in post-test was done with the question 6)
- «The body that goes before is faster than the body that follows» or «the body that follows is slower than the body that that goes before» (The control in post-test was done with questions 11 and 12).
- The students confuse the graphic representation of the position and the speed of a body with his trajectory. (The control in post-test was done with questions 3, 7, 8, 9, 13).
- The students cannot distinguish the concepts of position, speed and acceleration. As a result students consider that two bodies, with the same precise position, at a time moment, will also have the equal speed, and proportionally two bodies with equal speeds (at a time moment) will also have equal accelerations (The control in post-test was done with questions 4, 7,.8,.9, 10,11, 12).

A part of the post-test questions is mentioned at the end of our paper.

The whole process was implemented in two steps A and B.

A1. Laboratory - instructive interventions.
Instructional materials have been specifically designed to help the conceptual understanding and reasoning, skills necessary to teach science as a process of inquiry (Rosenquist and McDermott, 1987). The activities-experiments were implemented with MBL
Students worked in groups of 2, filling in worksheets. Each group was given four worksheets. Worksheets were based upon ideas from worksheets of C.M.S.T. (Center for Science and Mathematics Teaching - Tufts University of Massachusetts) and known handbooks properly designed for acquisition and elaboration of measurements by MBL.

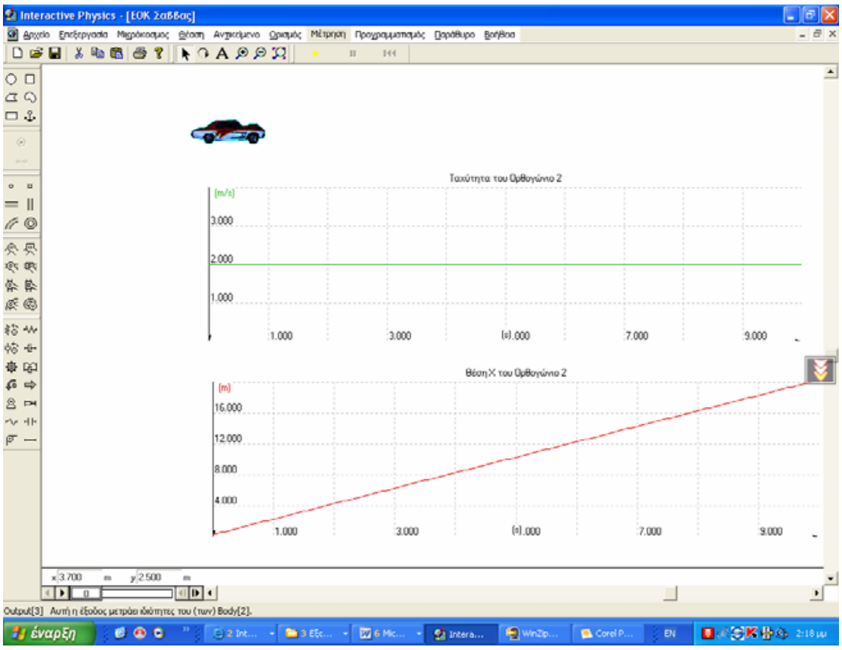
Worksheets and activities aimed at the functional comprehension of concepts and graphical representations for the familiarization of students with the processes of acquisition and elaboration of measurements with use of PC, the functional discrimination of concepts (like position-velocity) and the functional comprehension of graphical representations (reading and inference of graphic representations).

A.2 Simulations

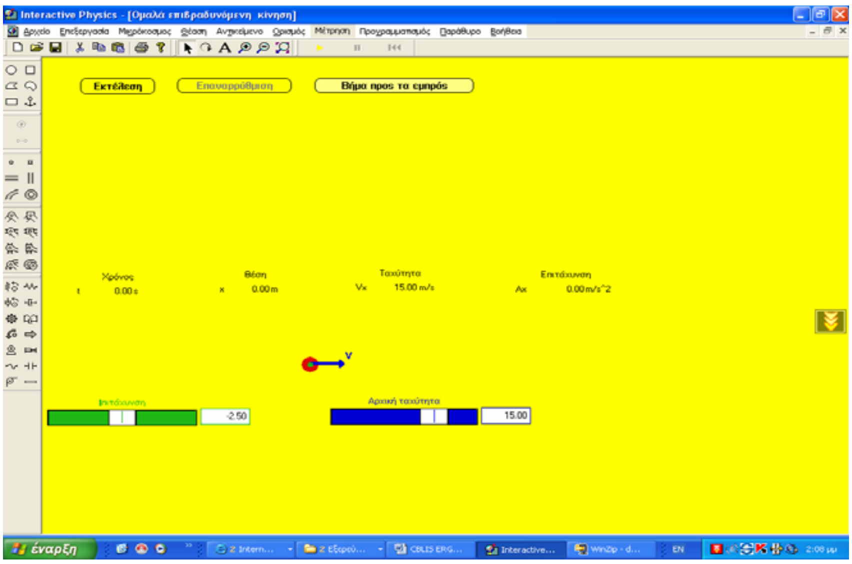
Except for the laboratory activities we designed three simulations (rectilinear uniform motion, rectilinear uniformly accelerated motion (positive and negative acceleration)) with Interactive Physics. In the figures (Figures 1 and 2) below appear the PC screens from a

1. Rectilinear uniform motion
2. Uniform accelerated motion with negative acceleration.

Students worked in pairs with worksheets.



Figures 1. Screens from IP



Figures 2. Screens from IP

We also designed a web-based software which was not used in the classroom because Greek Lyceum does not have Physics classrooms with more than one computer.

B. post-test.

We divided our sample of students into an experimental group and a group of control. In the post-test we used two questions from the FCI test (The Force Concept Inventory) (Hestenes, D., Wells, M. and Swackhamer G. (1992)), so that the test has bigger validity.

The questions of the post-test were selected upon the following criteria:

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The findings of the results of the post-test indicate the supremacy of the experimental team for questions related to the comprehension of graphic representations and the capability of interpretation of their answers.

Indicatively we outline the worksheet which is reported in the designing of the position-time graphic representation of a body.

We ask a student, who is standing at a certain distance from the motion detector (distance sensor)

- to remove with "constant" speed away from the motion detector,
- to approach with "constant" speed the motion detector. In every case students are called to draw the graphic representation of the position of their schoolmate vs time in an empty diagram of position-time on their worksheet.
- We ask from the student to repeat his motion with greater speed

Then we record the motion of the student with the motion detector and the graphic representation is presented on the PC screen. We ask the students to compare the graphic representation that appears on the screen with the one that they have drawn. Then they discuss what they have drawn and the possible fault. The aim of this activity, among others, is that students compare in a real-life activity the depiction of positive and negative velocity in a diagram x-t.

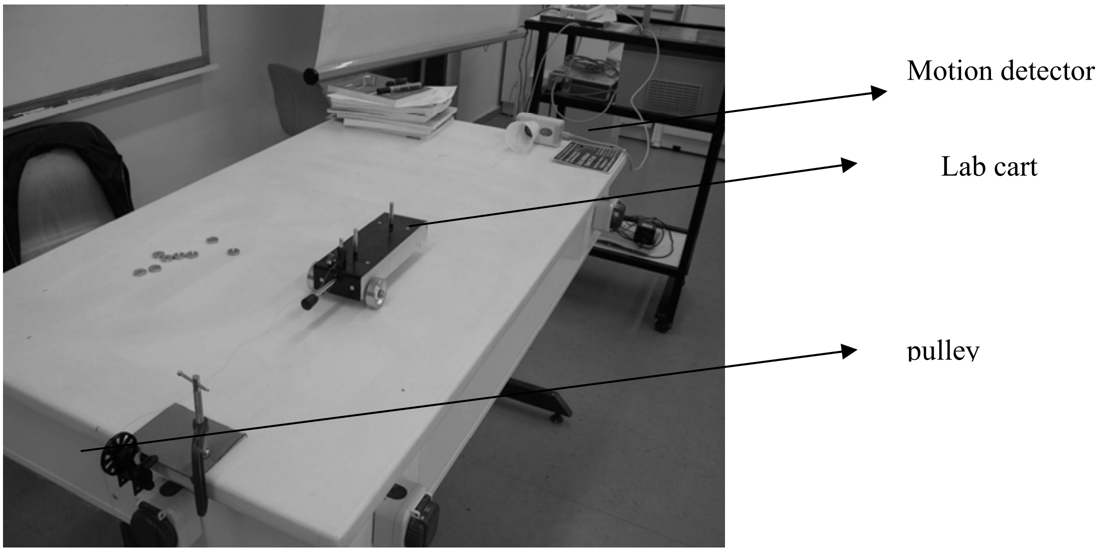
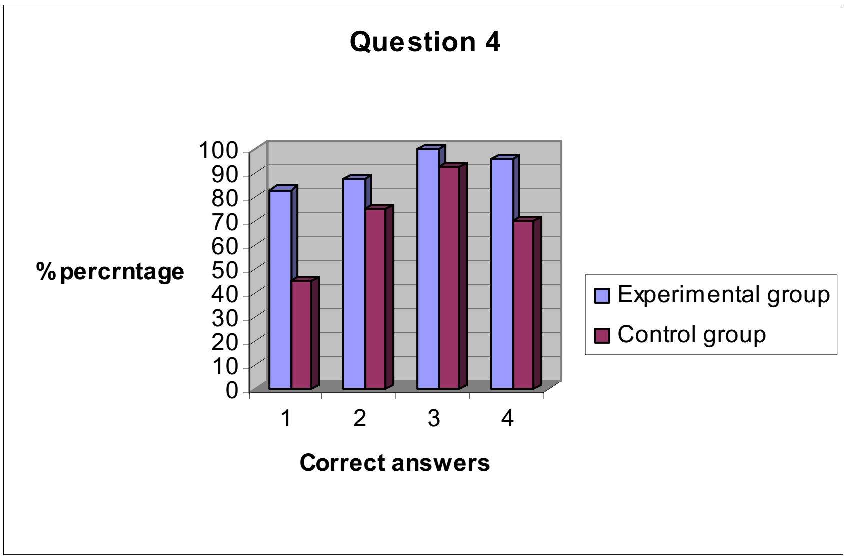


Figure 3. The arrangement for the study of accelerated motion

THE RESULTS

A part of the questions of the pos-test are at the end of this paper: **Question 4 (Appendix)**

In question 4 we observe that the students of our experimental team answer roughly all the individual questions, In the same question more than half students of the control team answer wrongly, that mobile A has greater velocity than B. Consequently the answers to the remaining questions have as basis the wrong estimattion of question (1). In any case most students of both groups answer correctly to the question (3), about time of mobiles' meeting (t_1)



Question 8 (Appendix)

We mention the correct answers for question 8

Experimental group	Question 8a: 48/51	94,1 %
	Question 8b: 19/51	37,25 %
Control group:	Question 8a: 31/40	77,5 %
	Question 8b: 17/40	42,5 %

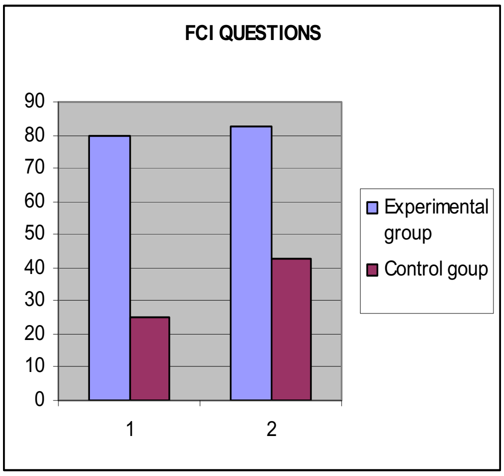
REMARKS

We distinguish the low percentage of right answers for the experimental group in relation to the control group for question 8b. On the other hand we noticed a significant weakness of the control group to justify their answers. More specifically in question 8a hardly 9 students of the control group from the 31 justify their answers. In the experimental group 41 of the 48 justify their answer.

In question 8B, in which the team of control barely surpasses, 2 of the 17 from this particular group justify their answers. On the contrary, in the experimental team only 3/19 are unable to justify their answer. This fact reveals insufficient comprehension of corresponding concepts.

Question 11 and 12 of the post test (number 19 and 20 respectively in FCI test).

In questions 11 and.12 from FCI, (results are depicted in the left figure) the supremacy of the experimental group with regard to the control group is obvious. 41 students of the experimental group from 51 that is to say a percentage of 80 %, gave the correct answer for question 11 and 42 from 51, that is to say a percentage of 82,35 %, gave the correct answer for question 12, while 10 students of the control group from 40, that is to say a percentage 25% answered question 11, and 17 from the 40, that is to say a percentage 42,5% answered question 12.



CONCLUSIONS

The findings of the results of the post-test indicate the supremacy of the experimental team for qustions related to

1. the functional comprehension of graphical representations about movements.
2. the capability of interpretation of their answers about movements.
3. better comprehension of concepts about motion
4. The comprehension of experimental results that is also connected with our daily life and practice.

A further analysis is required of course for results and generalisation of conclusions with the use of similar instructive methodology and in other sections of school Physics.

APPENDIX: A part of the questions from the post test

Question 4

In the figure appears the graphical representation of the position x of two objects A and B with time t.

a. Which of the two objects has greater velocity?

b. At the moment $t_2 < t_1$

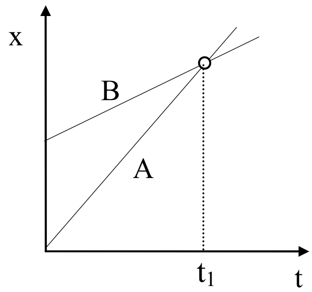
i. A goes before B
ii. B goes before A
iii. A and B are at the same position

c. At the moment t_1

i. A goes before B
ii. B goes before A
iii. A and B are at the same position

d. At the moment $t_3 > t_1$

i. A goes before B
ii. B goes before A
iii. A and B are at the same position



Question 6

Which of the next proposals is correct and which is wrong?

A. If at a certain moment the velocity of a body is zero, then its acceleration is also zero

correct ☐ wrong ☐

Justify your answer

………………………………………………………………………………………………
………………………………………………………………………………………………

B. If at a certain moment the acceleration of a body is zero, then its velocity is also zero

correct ☐ wrong ☐

Justify your answer

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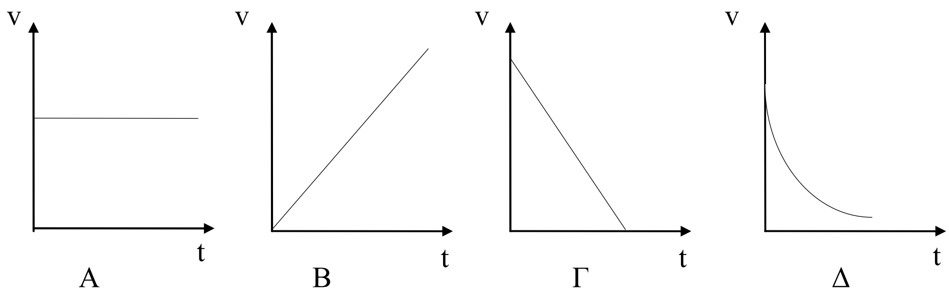
Question 7

A car driver moves at a specific speed by his car. At some moment he conceives an obstacle and steps on the brake instantaneously. Which of the next



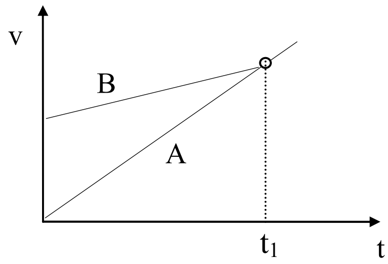
graphical representations of velocity (v) - time (t) expresses the car' movement, from the moment when the driver saw the obstacle until (it) or he stops.

Question 8

In the figure appears the graphical representation of the velocity v of two objects A and B with time t.

a. Which object has greater acceleration A or B and why?

b. Which object has covered a greater distance from moment $t = 0$ until moment t_1 and why?



Question 9

The diagram of velocity-time in uniform rectilinear movement with initial velocity is:

a. straight line parallel in (or to) the axis of time

b. parabola' that does not pass from the beginning of axes

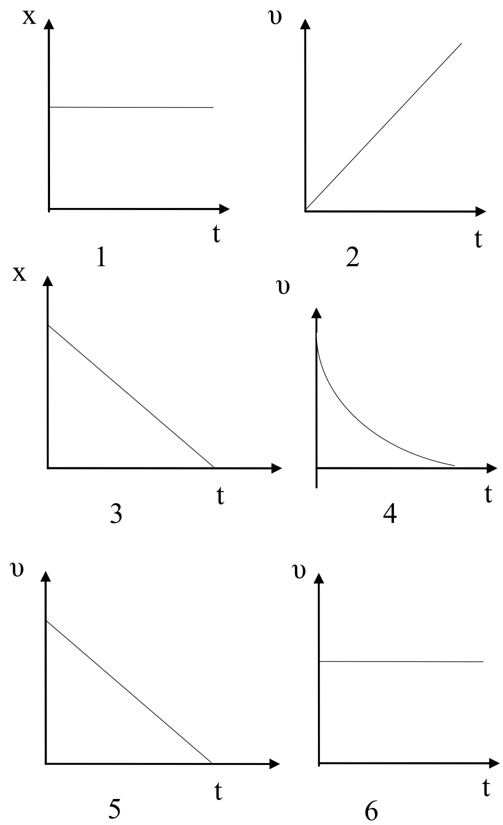
c. straight line that passes from the beginning of axes

d. straight line that does not pass from the beginning of axes

Question 10

Check the numbers that exist under the next diagrams with the letter that corresponds to their movement that appears in the frame. In the space of the answer you will write letter (a, b, c or d) and beside it the corresponding number (1, 2, 3, 4, 5 or 6).

a. Uniform rectilinear motion
b. Immobility.
c. Rectilinear motion, in which the measure of the object velocity is increasing with constant rate
d**.** Rectilinear motion, in which the measure of the object velocity is decreasing with constant rate



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