

THE LEARNING PHYSICS IMPACT OF INTERACTIVE LECTURE DEMONSTRATIONS

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Abstract

This paper deals with application of interactive lecture demonstrations (IALD) during lectures of general physics as a way for helping students to better understand functional dependences of physics phenomenon. IALD can be described as an active engagement learning environment in a lecture setting, where computer, sensors, interface and software of PASCO are used together with demonstration equipment. Demonstration results are projected on big screen using computer projector. Assumption – observation – explanation cycle is used during interactive lesson demonstration. During this study IALD was implemented into general physics (mechanics) course. Interactive demonstrations were given for students of Šiauliai University faculty of Natural Science studying Ecology and environmental studies. Lectures were given in 2009 spring semester. The same course of kinematics and dynamics were lectured traditionally for students studying Applied biology. Multiple-choice test was used to determine impact of IALD to understanding phenomena of mechanics. It was state, that in those lectures, where IALD was used, achievements of students were better than those of students learning in traditional method. Using IALD students are motivated to be not passive observers, but active participants of education process. Students, who were studying in IALD group, positively valued employment of interactive demonstrations in learning of physics.

Key words: *interactive demonstration, interactive lecture, learning physics, science education.*

Introduction

The purposes of every subject under training are high quality knowledge and abilities. Indicator of knowledge acquirement – the depth of knowledge and abilities can be characterized by stability of information fixation in memory and employment of that information in different situations. The depth of knowledge acquirement depends on properties of memory:

- Memorising (observation, unconscious memorising, conscious memorising);
- Evoking (identification, remembering without an effort of will, remembering with effort of will);
- Retaining (Беспалько, 2002).

As practical research shows images are realized easiest, then follows realization of graphical dependencies and finally combination of image and sound. (Потапова, Шахматова, 2008).

Forgetfulness rate is slower for knowledge which is truly realized. Realization of teaching material is related to association between information components, the more associations are revealed the more information remains realized.

It is essential to consciously memorise information in order to increase knowledge strength. Proper attention should be dedicated to the combination of sound and sight, to emphasize crucial features, to identify association between knowledge components and to reveal association between cause and result.

Demonstrations are in handy when teaching physics. Demonstration (lot. demonstrō – to show) – learning method in which objects or their images becomes source of information.

Using demonstrations it is easy to illustrate interpretation of new problem, educate ability to perform or observe experiments, acquire new information, form new physical concepts and define connection between them, demonstrate importance of acquired information.

During demonstration of physical experiments we can get more information about laws, concepts, and constructs of physics. Also we can analyse processes and phenomenon of nature. Knowledge acquired during demonstrational experiment is well memorized and for a long time retains in memory. Such experiments develop interest in learning subject and scientific research method, because pupils have a good chance to look thoroughly at experiments. They develop desire to study objects connected to the examined phenomenon more active and closely. Experiments helps to further emphasize studying but not teaching, importance of active studies, but not teachers provided information. Thus experiments helps to seek major problems of teaching physics (Семенов, Якута, 2002):

- Solidify and deepen knowledge about fundamental laws of nature.
- Educate scientific thinking and research skills and develop creativity and imagination.
- Deepen the world's knowledge, reveal significance of nature science in everyday life.
- Encourage pupils to study physical science, seek knowledge, self-educate.

Demonstrational experiments creates environment for learning, allows intensively and purposefully deepen material of learning subject, bring questions, check pupils understanding and aid upon arise of problems.

By using demonstrational experiments teachers of physics are forced to change their working methods, raise their qualification, improve programme of lessons and pupils activity. Advantages of this activity: increases visual aids of lessons, variety of learning paths, increases learning motivation, better lessons quality (Селиверстов, Дунин, 2002).

Scientific researches prove that, usage of demonstrations enhance base of conceptual learning, links known with still unknown, motivates to bring up hypothesis, freely interpret, explain, collaborate (Buncick, Betts, Horgan, 2001, Etkina, Heuvelen, Brookes, Mills, 2002).

On the other hand it's not enough just to demonstrate the experiment. Pupils, who watch demonstration passively, doesn't adopt information connected to the experiment better then pupils, who did not saw demonstration at all. However by changing method of demonstration by involving students to participate in it, much better learning results achieved (Crouch, Fagen, Callan, Mazur, 2004).

Pupils, who observe traditional demonstration and independently reasons, often make mistakes and returns to initial statement. Sometimes pupils attention is distracted by unessential experiment properties (devices, design etc), and they no longer are able to answer to the raised question. They form wrong idea of concept or phenomenon by observation and summarization of unessential properties of experiment. Thus, if results of demonstration will be left unexplained, and conclusions won't be emphasized and realized, demonstrational experiments won't achieve their goals. It is essential to give proper attention to the way demonstrational

experiments are performed.

The **purpose** of this work was to apply interactive lecture demonstrations (IALD) during lectures of general physics as a way to help students to better understand functional physical phenomenon dependence. IALD can be described as an active engagement learning environment in a lecture setting, where computer-based data acquisition and analysis tools are used together with demonstration equipment.

Methodology of Interactive Demonstrations

Thornton and Sokoloff (1998) idea was adapted and applied for interactive lecture demonstrations (IALD) during physics lectures in Siauliai University's faculty of Natural Sciences. Demonstrations were absolutely different and depended on equipment owned by Faculty of Natural Sciences of Siauliai University. IALD has lots of similarities to computer-based real lab works (CBRLW), which are used in physics laboratories in SU (Šlekienė, Ragulienė, 2009).

Both and computer-integrated experiment work, and interactive demonstrations apply data collection from real experiment. Computer, sensors, interface and experimental equipments are used in both methods. IALD experiment results are projected on big screen using computer projector. Only one set of equipment is necessary for IALD, and that is essential difference between IALD and CBRLW methods.

Students are passive observers, during the traditional lessons, and don't want to attract attention. Content of interactive demonstrations is directed to understanding of students. Assumption – observation – explanation cycle is used during interactive lesson demonstration.

During this work IALD was implemented into general physics (mechanics) course. Interactive demonstrations were given for students of SU faculty of Natural Science studying Ecology and environmental studies. Lectures were given in 2009 spring semester. The same course of kinematics and dynamics were lectured traditionally for students studying Applied biology.

Interactive lesson usually consist two activities.

Firstly, lecturer with students using equipment demonstrates interactive demonstration. The specific technical equipment and software of PASCO scientific were applied in lecture activities. It provided to integrate modern science tools into physics teaching and made it possible to prepare and carry out interactive demonstration with a maximum of technical comfort. An attachment of interface (Figure 1) with a suitable sensor to the computer created very powerful system for collection, analysis and display of demonstration data. The associated software is easy to use and allows the experimental data to be displayed as graphs and tables. The hardware and software tools are, in general, independent of the experiments. The varieties of sensors use the same interface box and the same software format.

Secondly, as ordinary during physics lectures, lecturer explains theoretical principles of mechanics.

Therefore we can state, that interactive lecture consists of two parts: interactive demonstration and lecture. We are paying attention only to the computer technologies which are actively used only during demonstration.

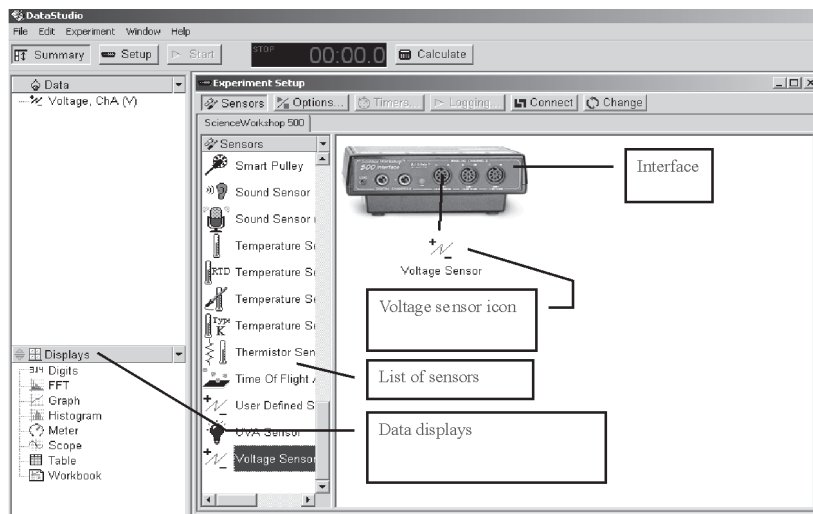


Figure 1. Data Studio software window as seen on the computer screen.

Such cycle is used in order to force students to participate actively in interactive lessons:

- Lecturer describes demonstration and makes experiment without data acquisition.
- Students are asked to do individual predictions (assumptions).
- Assumptions are written on the board and short discussion is made.
- Demonstration is performed; data and graphics are shown on the screen.
- Discussion is made why such results were obtained and how they relate with assumptions that were made.
- Typical mistakes are emphasized and discussion how to avoid them is being made.

One of the first topics in a physics course is motion, including the concepts of position, velocity and acceleration. Another one is – force.

Principals of physics didactics predict that students, which understand function dependencies of kinematics well, are able to understand laws of dynamic as well. Therefore first IALD lessons are assigned to research dependencies of linear motion.

First interactive demonstration is *Investigation of students' movements by using motion sensor*. Few students are asked to move forth and back along the classroom. Their movements are registered using motion sensor and data are transmitted to the computer. Graphical results of student's acceleration, velocity and position (Figure 2) are showed on the screen.

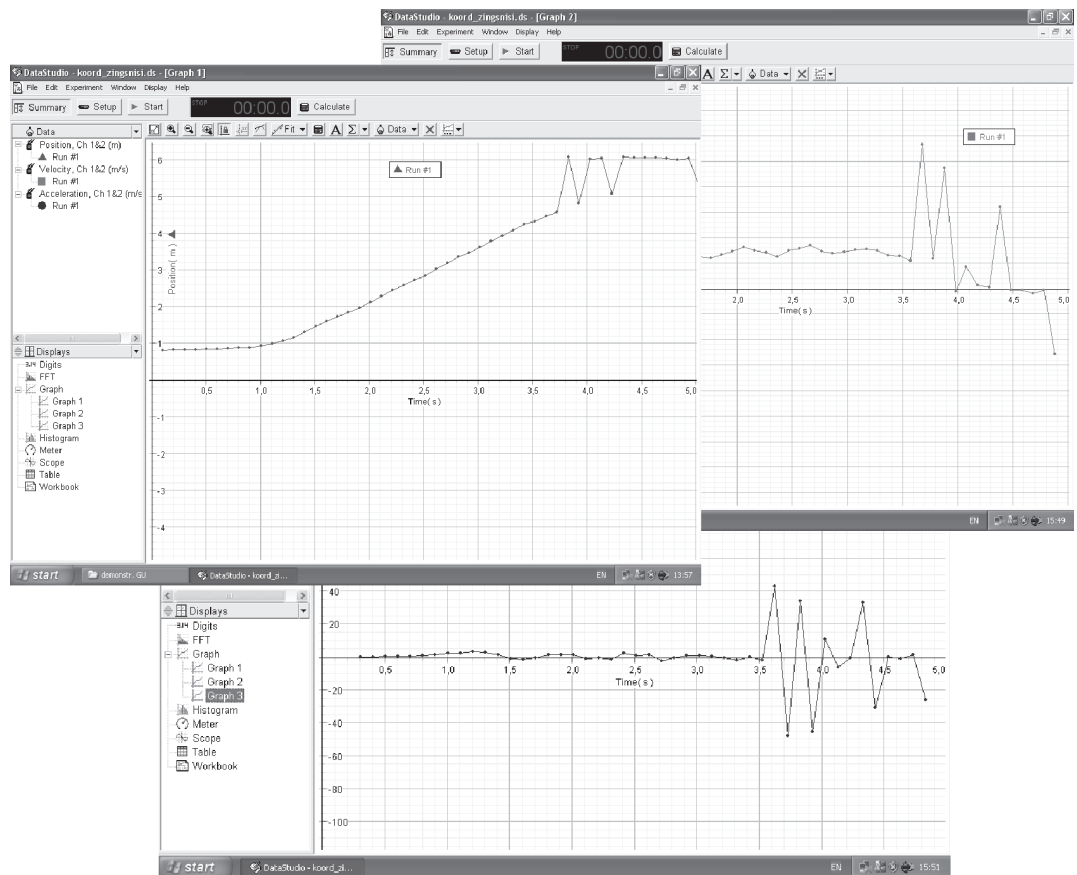


Figure 2. Graphical results of student's position, velocity and acceleration.

Analysis of these graphics induces big interest among students and encourages lots of discussions. It becomes obvious from these figures how long students didn't moved, how long moved, how varied their velocity and acceleration and when they stopped again. Analysis of noises in velocity's and acceleration's graphics when students try to stop is being made.

Other typical IALD used during the lecture is *Investigation of linear motion using an Atwood's machine*. Demonstrational equipment are made of experimental equipment (Atwood's machine) and measurement equipment (in this case Photogate/Pulley System, interface, computer with software of PASCO scientific and a screen on which the results are displayed) gathering and showing data in real time. Use the Photogate Head is very easy and convenient. There is no need for intermediate calculations for drawing graphics. The apparatus is precisely measure the time changes. The computer immediately draws all the desired drawings. In addition, the error is very small: if the body 1 cm segment is moving with velocity 10 m/s, track error is less than 1mm.

IALD *Investigation of linear motion using an Atwood's machine* where student is being asked to explain graph of velocity is shown in Figure 3.

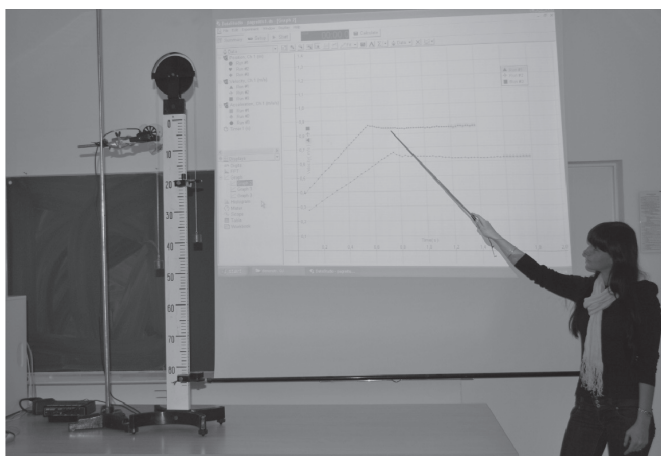


Figure 3. IALD Investigation of linear motion using an Atwood's machine: Student explains graph of velocity

By examining graphs of position vs. time, velocity vs. time, acceleration vs. time and force vs. acceleration students have to answer the questions such as:

- What is the appropriate unit for the slope of the velocity vs. time plots?
- Is the acceleration in the acceleration vs. time graph constant? (a nearly horizontal line of fit (near zero slope) indicates a constant value.)
- Why is the acceleration vs. time plot so much “noisier” than the other plots?
- How does the force vs. acceleration plot relate to Newton's Second Law?

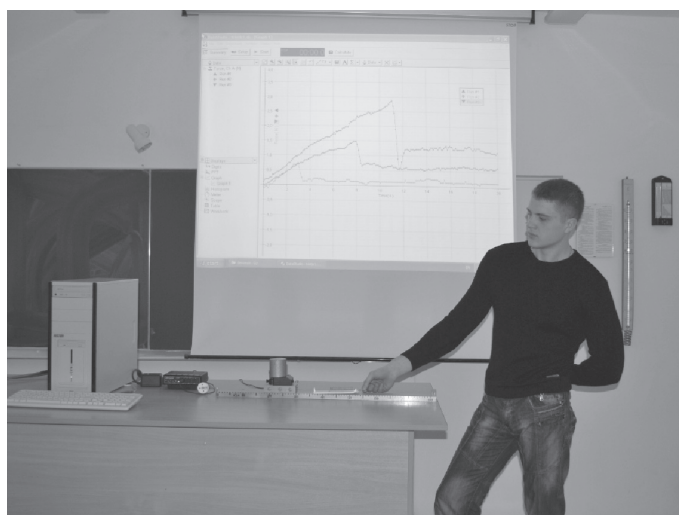


Figure 4. LIAD Investigation of Frictional Force.

Afterwards students must determine the meaning of constant, variable and negative speed.

The questions described above are designed to meet common learning difficulties in kinematics. In physics laboratory it is common to use equipment with very low friction to show the “truth” of Newton's laws. However our life world is not free from friction, rather students' should learn to consider friction within a Newtonian framework.

IALD *Investigation of frictional force* is shown in Figure 4.

Equipment needed for this demonstration: Force sensor, Friction Block, Table, Interface, and Computer.

A force sensor and a block with a friction attachment are pulling along a horizontal table.

Students are asked to determine the difference between the repose and the kinetic frictional force and to study the parameters of what the coefficient of kinetic friction for an object depends on.

The difference between the repose and the kinetic friction is determined by analyzing the graph of friction force vs. time (Figure 5).

By examining the graph of friction vs. time, students have to answer the questions such as:

- What is the difference between the repose and the kinetic friction?
- When the mass of the block is increased, does the force of kinetic friction increase? Why?
- What is the relationship between the coefficient of kinetic friction and the mass, surface area, or speed of the object?

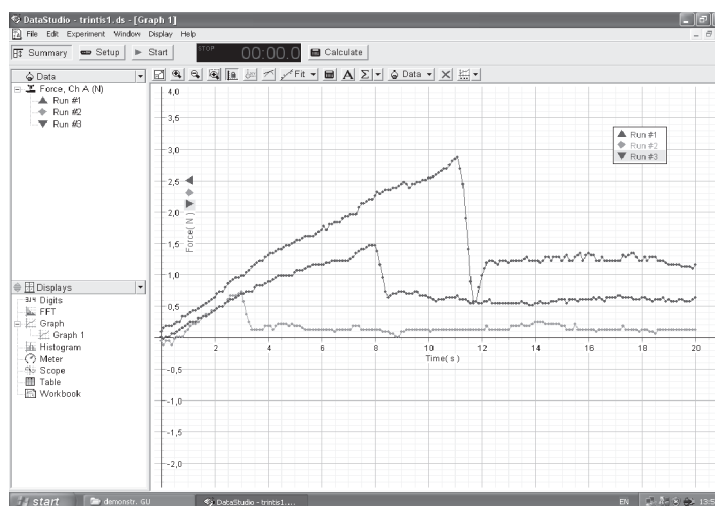


Figure 5. Graph of friction force vs. time.

Results from Control Tests

Multiple-choice test was used to determine impact of IALD to understanding phenomena of mechanics. Test was given to students of Ecology and environmental studies (studying using interactive demonstrations IALD) and to students of Applied biology (studying using traditional course TRAD). Test was given two times. The first time test was presented in the first lecture (pre-test), second – was introduced when kinematics and dynamics course was finished (post-test).

Every answer to the test was evaluated dichotomically (1 – correctly, 0 - wrongly). Difficulty of pre-test (Z_{pre}) and post-test (Z_{post}) questions were calculated by formulae:

$$Z_{pre} = N_{+}/N_{0}, \quad Z_{post} = N_{+}/N_{0},$$

where N_{+} – number of students correctly answered to question,
 N_{0} – total number of students answered to question.

Results of TRAD and IALD group’s pre-test and post-test are shown in figure 6.

From fig. 6 we can easily see that both group’s results of pre-test are similar. However IALD group post-test results are better.

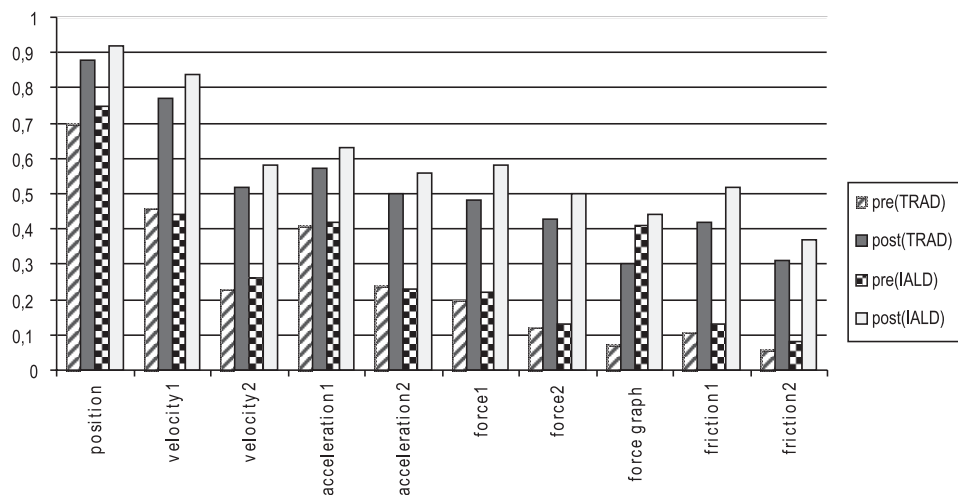


Figure 6. Results of TRAD and IALD group’s pre-test and post-test

In order to evaluate difference in achievements of both groups “achievement gain” of each test question Z_{TRAD} and Z_{IALD} and test’s mean “achievement gain” Z were calculated for both groups of students (Table 1):

$$Z_{TRAD} = (Z_{postTRAD} - Z_{preTRAD}),$$

$$Z_{IALD} = (Z_{postIALD} - Z_{preIALD}),$$

Table 1. “Achievement gain” of each test question and mean “achievement gain” in TRAD and IALD groups.

	Position	Veloc1	Veloc2	Accel1	Accel2	Force1	Force2	Fgraph	Fric1	Fric2	Z
Z(TRAD)	18	31	29	16	26	28	31	23	31	25	25,8
Z(IALD)	17	40	32	21	33	36	37	33	39	29	31,7

“Achievement gain” of every group was compared between traditional and IALD learning groups and “achievement gain ratio” were calculated using formula:

$$N = (Z_{IALD} - Z_{TRAD})/Z_{TRAD}$$

$N = 23\%$ achievement gain ratio was calculated in IALD group favour.

From presented results and calculated “achievement gain ratio” we can state, that in those lectures, where IAPD was used, achievements of students were better than those of students learning in traditional method.

Conclusions

It can be stated that IALD method is useful for students and helps to understand new material. Using IALD students are motivated to be not passive observers, but active participants of education process. The data are displayed in graphical form in real time, so that students get immediate feedback and see the data in an understandable form that can be discussed. Students, who were studying in IALD group, positively valued employment of interactive demonstrations in learning of physics. They acknowledged that their activeness and interest in subject has increased.

Thus the question whether IALD is worth to recommend to include into the teaching programme. Thought this question doesn't have unambiguous answer. From one side – better learning results was achieved. But from the other side – this is related to additional equipment required for that. Besides, we shouldn't forget that every IALD requires extra time before every lecture. Also it is worth to mention, that in order to achieve better learning results it is essential to be able to involve all of the students to the discussion. It is easy to do so in small groups, as in faculty of Natural Sciences of Siauliai University. Though risk arises, when groups are large, that part of students will remain passive and benefits of IALD will be small. IALD is really useful in such general physics subjects where results aren't obvious and additional precise equipment is necessary to view results on the screen.

References

- Buncick M. C., Betts P. G., Horgan D. D. (2001). Using demonstrations as a contextual road map: enhancing course continuity and promoting active engagement in introductory college physics. *International Journal of Science Education*, Vol. 23, No. 12, pp. 1237–1255(19).
- Crouch C., Fagen A.P., Callan J.P., Mazur E. (2004). Classroom demonstrations: Learning tools or entertainment? *American Journal of Physics*, Vol. 72, No. 6, pp. 835–838.
- Etkina E., Van Heuvelen A., Brookes D.T., Mills D. (2002). Role of experiments in physics instruction—a process approach. *The Physics Teacher*, Vol.40, No. 6, September, pp. 351–355.
- Šlekienė V., Ragulienė L. (2009). Computer based real lab work as a cognitive tool in physics education. *Problems of Education in the 21st Century (Information & Communication Technology in Natural Science Education – 2009)*, Volume 16, pp. 102–110.
- Thornton R.K., Sokoloff D.R. (1998). Assessing student learning of Newton's laws: The Force and Motion Conceptual Evaluation and the Evaluation of Active Learning Laboratory and Lecture Curricula. *American Journal of Physics*, Vol. 66, No. 4, pp. 336–352.
- Беспалько В. П. (2002). Образование и обучение с участием компьютеров (педагогика третьего тысячелетия). Москва: изд-во МПСИ; Воронеж: изд-во НПО „МОДЕК“.
- Потапова М.В., Шахматова В.В. (2008). Факторы, влияющие на качество знаний и умений выпускников. *Физика в школе*, №. 8.

Семенов М.В., Якута А.А. (2002). Измерение ускорения свободного падения баллистическим методом в рамках демонстрационного эксперимента. *Физическое образование в вузах*. Т. 8, № 3.

Селиверстов А.В., Дунин М.С. (2002). Использование устройств видеозахвата в лекционном эксперименте по физике. *Физическое образование в вузах*. Т. 8, № 3.

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