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Mechanical oscillations and waves

In this article we present our educational multimedia program „Mechanical oscillation and waves", and also we refer to possibilities of using it in practice. There are also some practical experiences using it in our pilot experiment at secondary school.

Introduction

Mechanical oscillations and waves play very important role in physics at secondary school, partly because it is a basis for some other units within physics. When explaining we can demonstrate it with many practical experiments which are really easy to understand for everyone. Its understanding is being enriched by computer, however, classical oscilloscopes are losing their former importance.

In school practice explaining these parts of physics quite often includes their theoretical explanation and a brief description with a simple experiment using a spring oscillator or a mathematical pendulum. It is hard to realize more complex experiments because of missing eligible accessories and also lack of time. But at the same time we take into consideration that correct understanding of physical effects and their technical applications is useful when followed by studying alternating current, electromagnetic waves and their practical use. Mechanical events should serve as a source of analogies and a help to understand these abstract events.

On the basis of mentioned facts we have decided to create a program which will serve as an appendix to teaching books of physics. The program uses graphic models in order to explain these events in a schematic and easy-understanding way. An interface as a whole is simple and intuitive, this all should provide students an easy way to understand what is being displayed and not disturb them with heaps of additional settings and complex models. In addition, an explanation should be within reach as well.

In this article we would like to describe our program focusing on mechanical oscillation and waves and also some practical experience when bringing it into practice at school.

Graphic models in teaching

We can meet with material and thought constructions and imaginations with the character of models and modeling in the ancient time and it is logical, that they found their way in schools education. Mainly graphical models play indisputably an important role in the educational physical cognition. In last years their importance significantly increased because of computers, programming systems, which enabled modeling and processing of empirical data and their presentation by graphs. Many of them provide also a creation of simple programs, by means of which graphs of physical dependence, mathematical modeling of the physical phenomena are represented.

The unifying character of graphical models is their pictorially schematic nature. Graphical models can be various – from photographic models of objects, through schema of symbolical elements to multimedia titles which are combination of animations with other elements like

sound, video. The visualization's measure of a graphical model depends on how well the observer knows a code by means of which the exchanged information for models is assigned to various elements of the picture. The role of graphical models is not only the simplified description of reality but also the visual illustration of the physical substance of examined phenomena. Sometimes a graphical model is a base for understanding a physical principle or a theory. Some graphical models take a typical character related with a phenomenon which we examine in a modeled object.

In school physics teaching graphical models are used very often. For example: the graphical model of the Huygens principle, the model of rays movement in the geometric optics, or physical fields describing by inductive lines, streamlines, current tubes and so on. Also drawings and simplified pictures so-called schemes are graphical models. They represent simply and lucidly complicated mechanisms and their function in a way which enables to read and understand quickly the function and the various parts interaction of the model mechanism. The presentation of vector quantities by oriented lines used besides by I. Newton also belongs to the important graphical presentation.

Modeling and simulation using computer

Computer allows teacher to multiply his forces and possibilities to get his teaching and educational goals. At the same time it is important to point out, that computing technology can be used effectively in all parts of teaching, start with motivation of students and finish with feedback.

In this article we concentrate on presentation of curriculum, by means of computer modeling and simulation. Under concept of model we can imagine a system, which at some level of agreement imitates original and represents him in cognitive processes. If exist some parameters in model, which can be changed from outside, than we speak about simulation. So student chooses input parameters and on the base of these changes computer shows the result.

Simulation of vibrations and waves on computer modeling allows to integrate all students in active analyze. Such a way we not only increase attention and concentration of students, but also increase their interest in content of curriculum. Quickly and reliably we model many physical phenomena and connect them mutually. We change promptly input parameters of experiments and students immediately make sure of correctness of preconditions and hypothesis. It allows us to introduce very illustratively new quantities e. q. basic terms phase, initial phase, initial and instantaneous amplitude.

Proposal of computer program

We named the program "Physics playfully". It is a play on words, where playfully means a game and at the same time simplicity.

At proposal of program we tried to be user friendly, his control was simple and intuitively. Simultaneously we pay attention in order to the relevant curriculum was presented simple and interestingly (arresting). The proposal coming from these didactical principles [1]:

• *Principle of small steps:* Curriculum arranged in logical sequence is divided into small, parts so-called steps or units of curriculum. Each step contains explanation, assignment or assignment solving.

• *Principle of individualization:* It expresses the requirement of respect of student individuality, mainly his natural abilities and talent.

• *Principle of active behavior:* It comes out from generally valid knowledge, that student better learns if he is active.

• *Principle of instantaneous feed back*: It requires in order the student has possibility at learning to control and verify his knowledge and so to built up gained knowledge. Each such confirmation of validity is motivation and stimulation for next learning.

We build up the program as modular (module means one classical thematic unit) and those we enrich steeply. This access allows in the future at teaching process to make available to students only some thematic units if you install only relevant module, so that students don't divert with different think. But at the end of thematic unit, end of school year or at home all modules will be fully at their disposal.

Construction of modules we started by unit "Mechanical vibrations", because in recent memory we prepared similar program [2, 3], and so with modeling of similar phenomena we have rich experience. Next module is "Mechanical waves".

Individual modules, but also the program as a whole, could be in different languages (wider application e.g. in the frame of foreign projects).

Nowadays three languages are supported (Slovak, Czech, English is preparing). Anytime it can be translated in the other languages. It needs help of other people.

Nowadays some parts are translating in the mentioned languages. Simultaneous we start to work on thematic unit "Acoustics"

The content of mentioned modules is shown in fig.1 and corresponds not only to high school textbooks of [4, 5], but also enriches content.
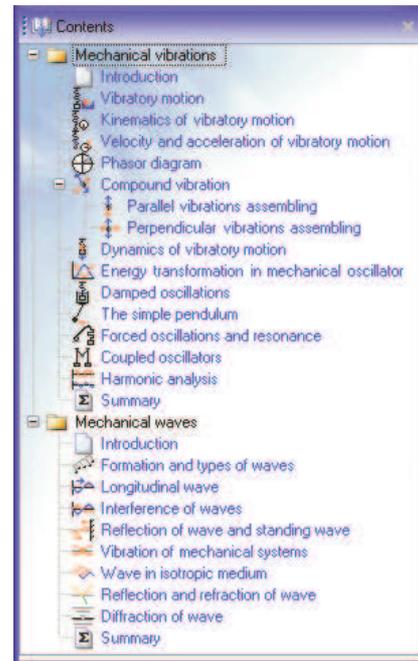
Fig.1. Contents of program.

Work with program

Program is built on the platform Microsoft NET Framework verzie 2.0. Requirements about installation, and also actual version it is possible to get (free) directly for the authors of article or you can find it in [6].

After starting the program page with content appears. There are placed items, active words on the page. After pressing them relevant chapter starts. The content characteristics of the program depend on installed modules. Of course we can work with arbitrary part of the program and we can stop running program in any time, possibly repeat some part.

To make knowledge available to students we work out the theme into series of screens, which includes text (static) part and graph (animate) part. Due to better orientation in program pressed buttons change colors. The color distinction we appreciate when we visit many chapters, and we forget which one. The color distinction also stays after switch off or switch on the program, for one user one day. You have possibility anytime to cancel it.

The pages of individual chapters have many common marks. Each, exactly almost each page consist of two basic parts: text (usually on the right) and graphic (on the left), on which curriculum is pictured (Fig.2). In the graphic part usually animations of pictures from the books occur. They help students better to imagine and understand different phenomena. Static pictures in the book make often considerable difficulties.

The pages also contain complex of buttons to control the presentation (animation). There are the buttons forward, back and repeat. Besides mentioned buttons there are also special buttons, which are related to concrete explanation (example) and so should be clear. If the button is grey, it is forbidden. Its function is no actually, or you must wait until animation will be finished.

At some examples students themselves can change size of physical quantities e. g. mass, stiffness of spring, angular frequency, amplitude) and so study their effect on behavior of physical phenomena (simulations).

Program includes not only basic, but also enriched curriculum e. g. compound vibration, parallel and perpendicular assembling, harmonic analysis and Doppler effect.
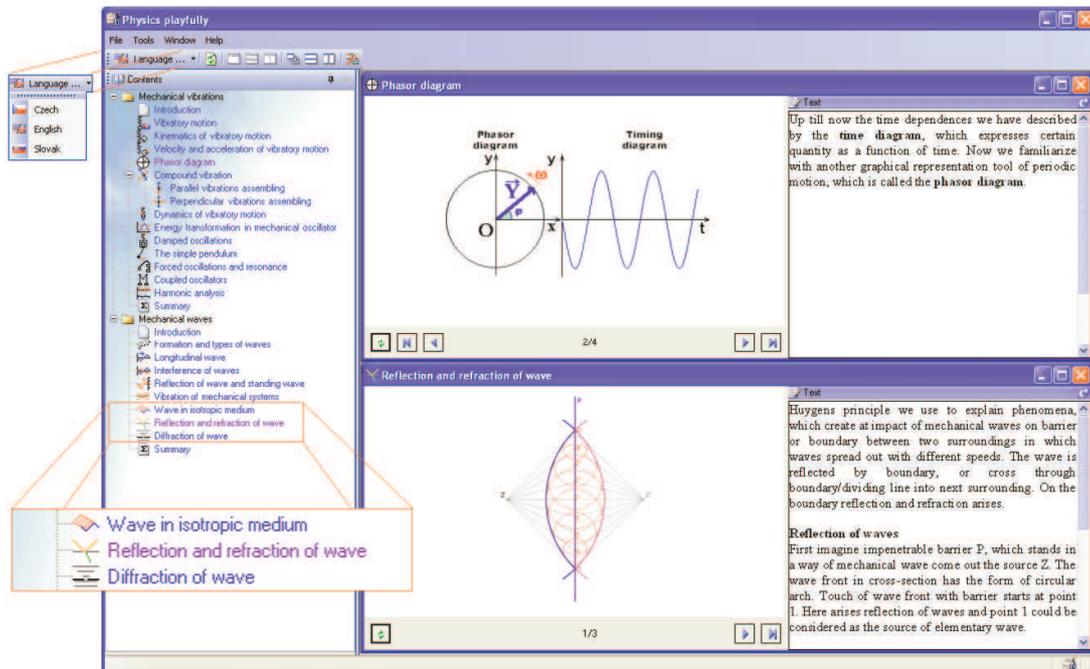

Fig.2. An example of the described program.

Recommendation for work with the program

Testing of both program modules at new platform wasn't realized in teaching process up till now, because they are in the development now. But we have experiences with previous version which correspond with module "Mechanical vibration" [2, 3]. We have made the pilot experiment at high schools. On the basis of this we show some experiences, observations and commands.

Before using of program in teaching process *we recommend* to teacher at first to be familiar with all possibilities of program, and second on their basis decided for strategy of teaching.

Before using program in practice teacher must ask himself: What are the aims I want to reach? What does the student to know? Does program increase motivation of students? Does it keep their attention? Does it contribute to understanding of phenomena? Will I use only program or will I combine it with the other teaching instruments?

We have used program at preparation to teaching, and also at lesson. We apply it in different phases of teaching: motivation, exposition new curriculum, and also for fixture and exercise of knowledge.

For using of program at lessons *we recommend*:

• *First* – teacher himself works with program (projecting on the wall, screen); he himself enter the values of physical quantities, until they understand the phenomenon; than he invites them to suggest different values of quantities. The teacher realizes himself the changes and students follow behavior of model; optimal from the standpoint of time.

• *Second* – after the first step take the students to computer room (laboratory) and there they can work themselves with program under leadership of teacher, and discuss the

problems; also in this phase of teaching we must suggest sequence (method) of work; no spontaneous unrestrained work e. g. sit down at computer and work.

During teaching, respectively learning we recommend teacher to draw some pictures on the blackboard and student in exercise book. Students fill in mathematical relations – functions to pictures. Work with program connect with demonstration experiments.

We think (our experiment shows), that about mentioned possibility of using of program is optimal for the most of students. However, for students with increased interest in physics, for work with talents, it is possible to give program for self-study.

The work with program confirms statement, that "To see is better than 100-times hear". During teaching with program the discipline increased and there were little questions as at classical teaching of this theme. There was increased activity and attention of students.

It is useful if there are maximum two students at one computer (no more), because situation becomes disorganized. Teacher looses his view.

Experiment also shows, if students only look at screen of the computer and don't make any notes in their exercise-books, the teaching is not effective in accordance to their knowledge. The same gilt for the self-work.

Conclusions

A concrete using of program depends on many factors, mainly on:
• technical possibilities of school and
• abilities of teacher to lead lessons using computer.

Next continuation of our work is focused on finishing semi-finished modules, their description, and practical verifying. Subsequently we prepare methodical instructions and booklet.

We hope, that this program will help to make the teaching process more effective and contribute to development of student skills and knowledge, in order the work at school was for the student enjoying, informative and satisfy their needs to discover surrounding world.

Actual version of program you can get (if you ask) from the authors of the article of in address [6].

We want to draw your attention to fact that using this program should not lead to suppress the real experiments of mechanical vibrations and waves.

REFERENCES
[1] Petlák, E.: Všeobecná didaktika, Bratislava: IRIS, 1997
[2] Degro, J., Marton, P.: Mechanické kmitanie. MFI Praha: Prometheus, r.13/9, 564-8, 2004
[3] http://www.marton.qsh.eu/mk
[4] Lepil, O. a kol.: Fyzika pre 3 ročník gymnázia. Bratislava: SPN, 1991
[5] Lepil, O.: Mechanické kmitání a vlnění. Praha: Prometheus, 1994
[6] http://www.marton.qsh.eu/fh