

VIRTUAL LABORATORY OF OSCILLATIONS

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**Abstract:** *In the present paper we have tried to reinforce the knowledge regarding oscillations, especially those with viscous damping, for the groups of students or classes that have expertise in algorithms and computer programming. This method implies using a software application, which contains an interface for visualizing the charts to the motion laws for different types of oscillations with fluid friction. The component, which conveys originality, consists in the user's possibility to simulate different motion laws for reduced friction, by introducing and testing some new initial conditions. In addition to this, the application may be extended by the student to simulate the motion laws for heavy friction and critique damping. These facilities may be also used during the processes of assessment and self assessment.*

**Keywords:** *oscillation, Virtual Laboratory, viscous damping*

## 1. Introduction

The information theory represents an integrant part of social training, while information represents an intrinsic compartment of the instructive-educational process. The informatization of this instructive and educational process comes as the result of the necessity to ensure people's access to society informational resources and it has a double aspect: for education, on one hand and for scientific and creative activity on the other.

In the educational process, computer based learning is different from any other types of using the computer in two essential aspects: the computer participates directly at the teaching process and there is a permanent interaction between the computer and the student. In the universe of education, one can distinguish various directions of using the computer: computer managed instruction, computer based learning, computer assisted training, and computer assisted testing.

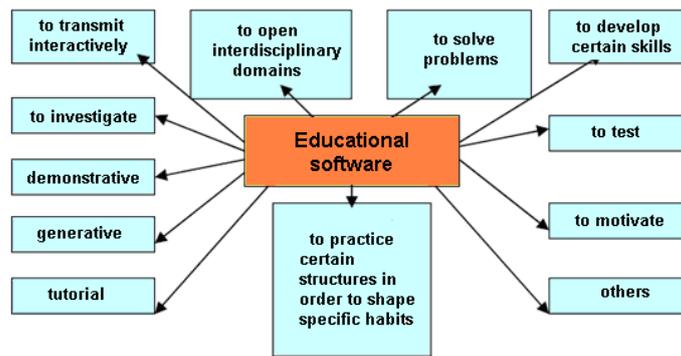
## 2. Pedagogical concepts for choosing the educational software

According to the theories of learning, creating software is based on two strategies:

a) rigorously structured, based on behaviourism and the theory of processing the information. They aim at practising rules and forming basic abilities.

b) Unstructured, built on heuristic and constructivist theories. These aim at forming abilities at a high level of complexity, focusing on search and discovery to sustain the complex application.

A general classification of educational software, which might be completed, is represented in Figure 1.



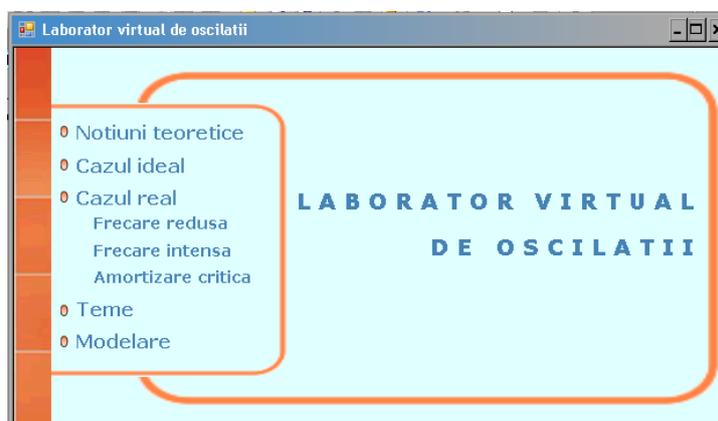
**Figure 1. Classification of educational software.**

Choosing a software means following the next steps: decision on what the programme has to do; establishing the aim, objectives end stages; establishing the ideal programming language for the respective aims; the study of literature in which the programmes can be presented; establishing the programme qualities and imperfections; students’ motivation in using and creating programmes. The abilities of those who choose the software may be enumerated as follow: responsibility and capacity to adapt; communication abilities; collaboration and interpersonal relation; creativity and intellectual curiosity; critical and systematically thinking; information and media ability; self training; social responsibility.

### 3. The activities of Virtual Laboratory of Oscillations

Simulation and display on charts allow a better materialization and understanding of the lesson content from this chapter, the computer contributing in this way to the optimization of the learning process.

“The Virtual Laboratory of Oscillations” is part of the educational software of simulation. It allows the students to develop abilities, which they can then apply in new real situations. The interface contains a main menu, from which the user can choose to study theoretical concepts related to free and damp oscillation, can see graphically the equation of the oscillation movement on the ideal and real case. The topics that might be given to students to study and a simulator, with the help of which they can study the oscillation behaviour in different practical situations are included here. The interaction with the user is effortless, the interface is intuitive, and the number of operations necessary for simulation is minimum. The text of the lesson is easy to read. The student has the possibility to approach selectively the content, without having to previously go over other sections.



**Figure 2. The main menu of the application.**

In the section “Theoretical concepts” (Figure 3) there are presented some aspects related to mathematical device necessary when discussing the following cases of oscillations:

- free oscillations without damping
- free oscillations with viscous damping – inferior friction
- free oscillations with viscous damping – high friction
- free oscillations with critical damping

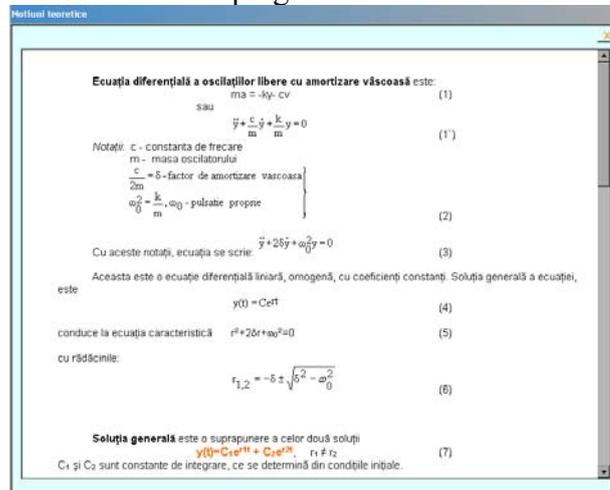


Figure 3. Representation of a sequence from the mathematical device for oscillations with viscous damping

### I. Ideal Case

To study the oscillations in the ideal case, the motion equation is graphically illustrated and it has the form  $y=A \sin(\omega t+\varphi_0)$  (Figure 4).

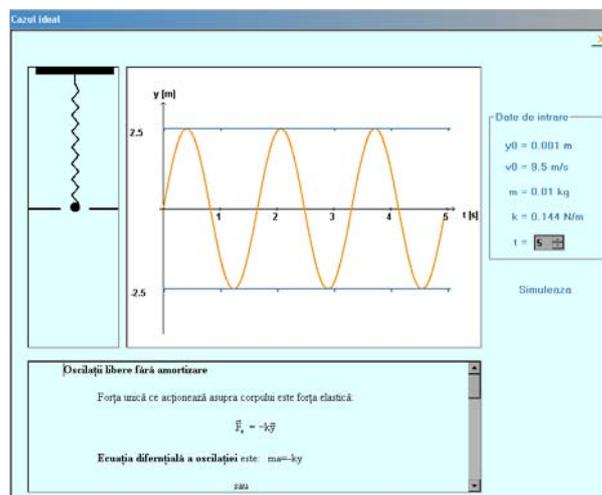


Figure 4. Representation of free oscillations without friction

### II. Real Case

**a. Free oscillations with viscous damping – inferior friction.** In the real case of the oscillations with inferior viscous damping, the motion equation is graphically represented and it has the form  $y(t)=A_0 e^{-\delta t} \sin(\omega t+\varphi_0)$ .

The student can see in the chart he has available (Figure 5) the general form of the equation, the values for the initial conditions and the chart obtained according to the imposed conditions. From the chart, one can conclude that the amplitude declines in time after an equation with the form  $A(t)=A_0 e^{-\delta t}$ .

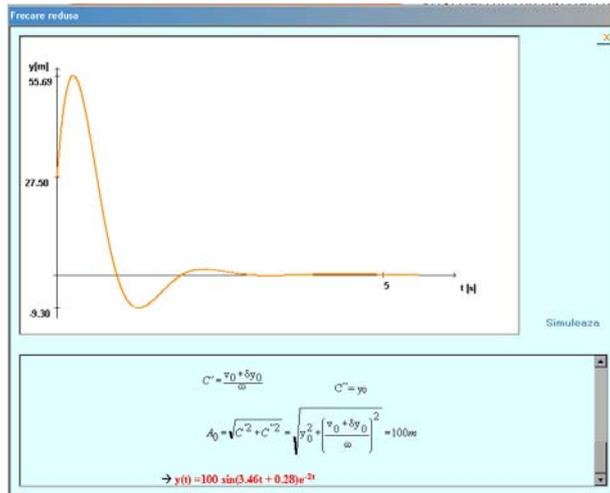


Figure 5. Representation of free oscillations with inferior viscous damping

**b. Free oscillations with high viscous damping.** The graphical representation of the motion law is available in 3 cases: the velocity higher than 0, the velocity equals to 0 and it is less than 0. It has a theoretical background the general forms of motion equations and the initial conditions for each case. The user may choose the situation which he wants to analyze, using a number of radio buttons. The results are graphically represented in Figure 6, 7 and 8.

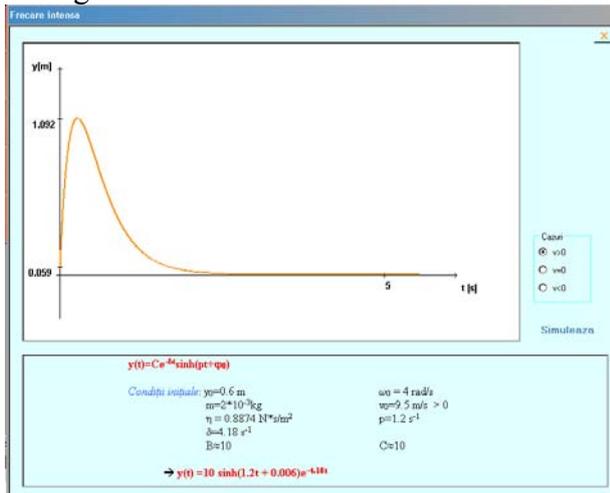


Figure 6. Representation of free oscillations with viscous damping – high friction,  $v > 0$

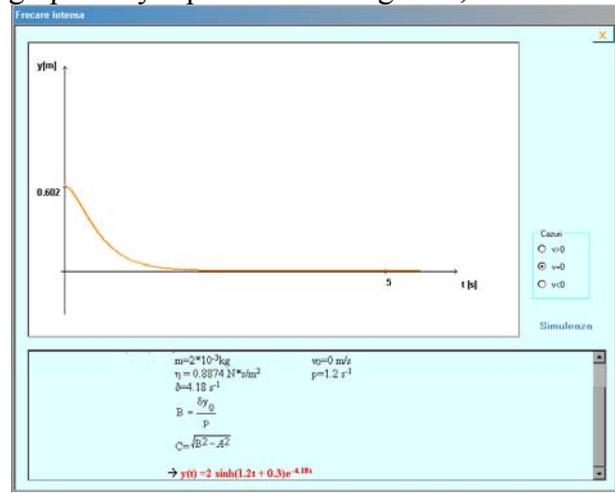


Figure 7. Representation of free oscillations with viscous damping – high friction,  $v = 0$

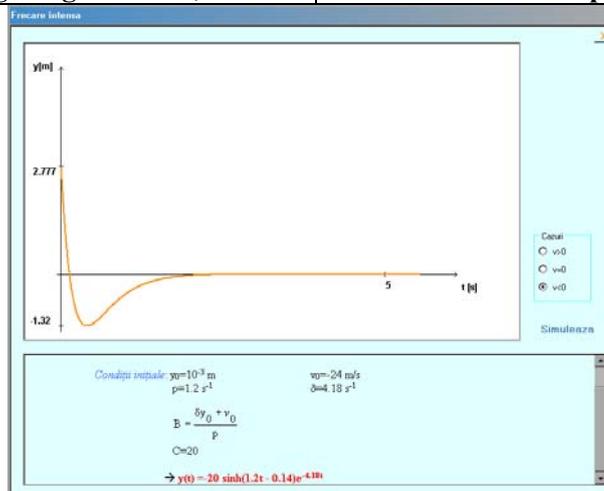
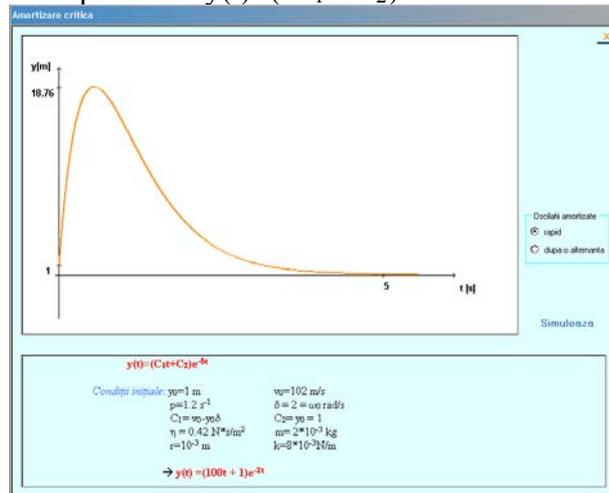


Figure 8. Representation of free oscillations with viscous damping – high friction,  $v < 0$

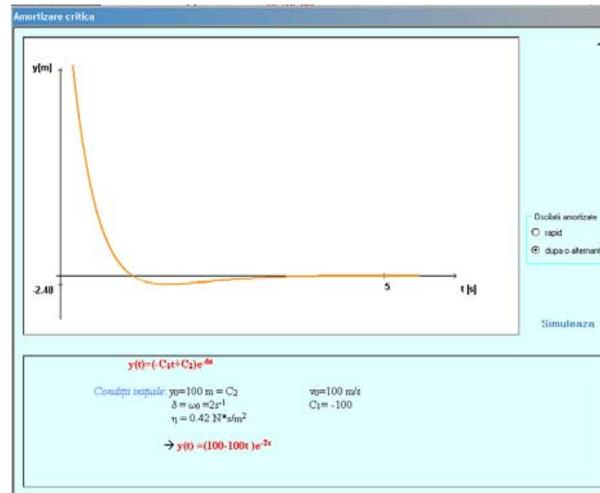
**c. Free oscillations with critical damping**

The case of critical damping may be analyzed taking into consideration two situations: oscillations rapidly damped and after an alternance. Corresponding to each case there is presented the motion law and the initial conditions for which the graphical representation of the motion law was made.

For the oscillations rapidly damped, the motion equation is  $y(t)=(C_1t+C_2)e^{-\delta t}$ . The graphical representation of the motion law in the two cases indicates in the first case a sudden drop of the amplitude (Figure 9a) and in the second case (Figure 9b) a variation of amplitude after the oscillator carried an alternance out. For the damped oscillations after an alternance, the equation is  $y(t)=(-C_1t+C_2)e^{-\delta t}$ .



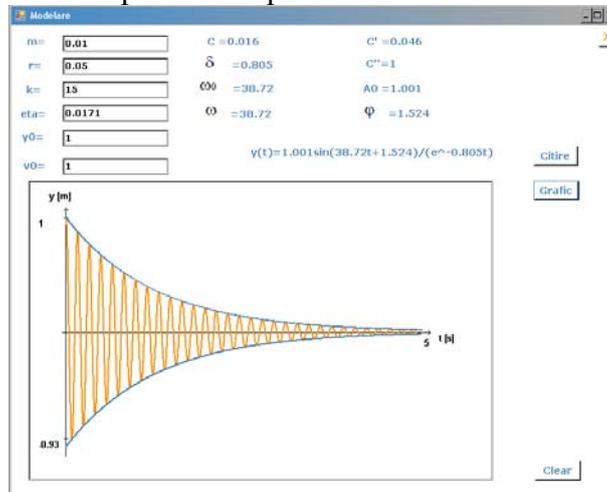
**Figure 9a. Critical oscillations rapidly damped**



**Figure 9b. Critically damped oscillations after an alternance**

The topics which can be given to students for study aim at acquiring knowledge consciously, stimulating logical thinking (analogical, algorithmic, heuristic), increasing internal motivation for students in the process of individual learning, diversification of learning and evaluation strategy.

Students may randomly choose the initial conditions to represent graphically the motion law. With the help of a form (Figure 10) they are required to introduce numerical values for  $m$ ,  $r$ ,  $k$ ,  $\xi$ ,  $y_0$  și  $v_0$ . The application calculates the values  $\delta$ ,  $\omega_0$ ,  $\omega$ ,  $\varphi$  and if they are valid, the application represents graphically the motion equation. When the values are chosen incorrectly, corresponding error messages are generated. In this way, students may establish a relation between the practical aspect and the theoretical background.



**Figure 10. Modelling oscillations under arbitrary chosen initial conditions.**

## 4. Conclusions

- There should exist as many parameters to study physical phenomena when creating a software.
- By using computer application, an ideal working environment is created and inevitable human errors are eliminated.
- The virtual laboratory of oscillations leads to: the development of the investigation capacity, creativity, simulation, analyzing, interpretation confirmation and generalization of the physical phenomena being studied.
- The real laboratory should not be eliminated from the student's learning process. The two types of laboratories (real and virtual) should intervene and complete each other.

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