

Virtual Physical Laboratory and its Intranet Application

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Abstract – The goal of the paper is to present Web based exercises in physics. An algorithm for determining the sound’s velocity in air by the method of standing waves is described

Keywords – Web Application, Distance Education, Intranet Application

I. INTRODUCTION

The module “Physical laboratory” is a part of a Web book in physics for training the students and cadets from Naval Academy “N. J. Vaptsarov”. It is in the process of development and has the following structure: list of the laboratory exercises, the choice of one of them leads to the following blocs: theory of the physical phenomenon, scheme (photography) of the laboratory setting, tasks for observation, research and measuring, demo version (animation, film or interactive model), table for the experimental data, form for survey, control tests and links to the calculator and graphical program.

The paper presents a software realization of the laboratory exercise “Determining of the sound’s velocity by the method of the standing waves”.

II. SUMMARY OF THE EXERCISE

The task of the exercise is to determinate the sound’s velocity in dry air by the method of standing waves.

The experiment setting consists of a glass tube with a piston. A loudspeaker, connected to a high-frequency generator is attached to the left end of the tube. A microphone is attached to the other end of the tube and it is connected by means of an amplifier to an ampermeter.

The method of the standing wave consists in [1]: the standing wave in the air column closed at both ends springs up from the interfeeration of the traveling and the reflected longitudinal waves. It can be received in two ways and they are used for determining the sound’s velocity.

First method. The frequency ν is fixed and the length of the tube L is changing until the standing wave starts in the tube. The length of the standing wave is equal to the distance between two neighbouring nodes. The task is to register two neighbouring nodes of the piston, determining the length of the tube, for which for the given frequency the standing wave starts. The sound’s velocity will be equal to:

$$V = 2(L_2 - L_1)\nu \tag{1}$$

The places of the nodes are localized according to the situation of the condensing and dispersing of the dots, alternating with the change of phase. Attentive students will also easily localize the nodes by the dots with minimal amplitude.

Second method. The length of the tube L is fixed and the frequency is changing. The task is to find two consecutive resonance frequencies. The difference between them is equal to the basic natural frequency. The sound velocity will be:

$$V = 2(\nu_2 - \nu_1)L \tag{2}$$

III. DESCRIPTION OF THE ALGORITHM OF THE INTERACTIVE MODEL OF THE EXERCISE

A Web page of the interactive model of the exercise from the first task is presented on fig. 1. The Web page of the second task is analogical, and each row of the table containing one measurement of the length of the tube and two measurements of the frequency.

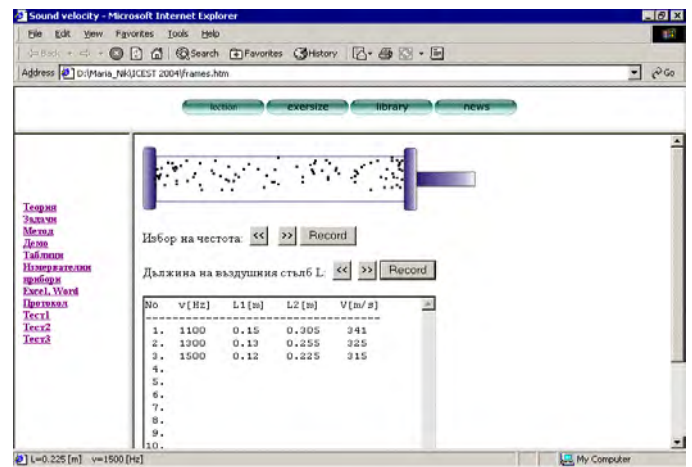


Fig. 1. Web page of the site

At the beginning of the Web page a computer simulation is made of the movement of the dots in the sound wave, spreading in the glass tube.

For each one of 100 dots with random initial position along the tube a movement along the horizontal line is given according to the formula:

$$y = 2A \sin kx \cos 2\pi\nu t \tag{3}$$

where y is the distance from the initial position x , A is the

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amplitude, $k = 2\pi / \lambda$, t is the time, V - is the frequency.

The image of the tube is realized through GIF-file, included in the code of HTML. The dots are realized through GIF-file with a small size as objects with unique names, initial position and visibility, included in the tag <DIV>. The initialization of the objects and the movement of the dots is carried out through two functions, written in Java Script [4] setVariables() and startMove() respectively. They are loaded consecutively in the tag <BODY> by the attribute ONLOAD. Initialization of part of the variables used in startMove() is carried out before its calling.

The algorithm of the function startMove(), through which the computer animation on the screen is realized, includes the following steps:

1. Choice of L and V . Visualization of their values in the status bar. Setting the step of time $\text{deltat} = T/20$, by which the new position of each dot is computed (each period is described in 20 steps).

2. Computing the y values for the 100 dots – array $y[j]$ and the absolute coordinate of each of the objects $xstep[j]$

3. Using the function eval of Java Script for determining the movement of each dot to position $xstep$ along the horizontal.

4. Increase of t with deltat and check if $t \leq T$? If yes – calling of setTimeout function with parameters startMove() and 100 - interval of time 100 ms (the movement velocity of all dots on the display is given in this way) and returning to step 1. If no – initialization of variables, calling of setTimeout and returning to step 1.

With the help of “Choice of frequency” and “Length of air column L ” buttons, students can change the values of the frequency V and the tube length L . Clicking each of the buttons Record (fig. 1) leads to the automatic writing of the values chosen in the table and to automatic computing of the sound velocity by formula (1). The values in frequency are in [Hz] and change in the interval [1000, 2000] by step 25 [Hz], while the values of L are changed from 0.100 [m] to 0.500[m] with a step of change 0.001[m]. After three or more measurements the average velocity \bar{V} and the mean error ΔV are computed. There is a possibility of correction of the input values of L . Every click of the RECORD button places alternate with the value input before. Inserting a new row in the table is made only by clicking the button for frequency record. There is a possibility for the student to give up a certain measurement (row), for which the computed velocity differentiates with a mean error of than $3\Delta V$ from the average value, as this difference is considered to be a rough error. The mean error ΔV is computed by the formula (4):

$$\Delta V = \sqrt{\frac{\sum_{i=1}^n (V_i - \bar{V})^2}{n(n-1)}} \quad (4)$$

Canceling a measurement is carried out by choosing the number of row in the table by a drop-down menu under the table, including the numbers from 1 to 10 (maximum number of measurements is 10). Then the button DELETE should be clicked. The row with the number chosen is deleted and the following rows automatically go up.

The visualization and processing of the table data is realized by the function Inform, written in Java Script within the body of each of the function zapisf() and zapisL(). These functions process the event OnClick of each of the buttons Record for the frequency and the wave length respectively.

IV. TESTS WITH THE EXERCISES OF THE VIRTUAL PHYSICAL LABORATORY

The tests are developed in Java Script и HTML. After clicking on the hyperlink for test, a random choice of test from several variants is realized. There could be several true answers to one question. The realization of the test is by HTML form. Besides a clock is visualized, which counts the time in minutes, during which the student should finish the test in order to get a maximum grade. The number of minutes is determined by the professor depending on the complexity of the test. At the bottom of the form is the button “Grade”, which should be clicked by the student to show the grade. Clicking this button, the student starts the function written in Java Script, which “checks” the answers of the test and visualized a grade between 2 and 6, formed on the basis of the number of true and false answers and the algorithmically determined importance of the questions.

In the presence of database on Apache server [3] in the Intranet, including names, grades and other student’s data, the grade is supposed to be directly recorded back in the database. In this case it is necessary to use MySQL и PHP [2].

V. CONCLUSION

The laboratory exercise described above as an element of the virtual physical laboratory can be used for:

- introduction to an exercise in real experiment setting;
- instead of a real laboratory exercise, when its setting is impossible;
- as an exercise for self-training for distance education.

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