

Computer Simulations of Physics Phenomena Using Flash

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Abstract. *One of the most powerful tools used in both teaching physics concepts and developing measurement and analysis skills are software simulations. This paper describes physics simulations designed for the study of the virtual evolution of physics phenomena, based on Adobe Flash CS3 computer applications. The simulations help the students understand several important physics phenomena and laws more easily while improving their abilities of making measurements and information' processing. The simulations also provide the students with the opportunity of using the experimental data for performing calculations and plotting. They can also be considered tools for checking the results obtained from experimental work.*

Keywords. Computer simulations, Flash, Physics learning, Physics phenomena.

1. Introduction

In the last decade the great development of the programmable web and new computational technologies lead to the development of specific platforms like HTML, JavaScript, Flash and Ajax. This had also an important influence on the implementation of the new computational methods in engineering education. The use of

computational methods does not require a complete renunciation of the traditional methods. Even in the next future a quick and efficient way of improving knowledge would consist in the using at large scale of the Web technology. Recent developments in this area have shown that computer assisted learning processes [3], [4], [5], [6], [14], [15], [16], [17] are one of the most promising ways to improve the educational results.

Our experience in the field of physics [7], [8] has demonstrated that processing data using the computational methods is of great help for our students in the learning process. In the last years we have focused our efforts to the acquisition of new computational programs designated to improve the study of physics. In this way, we are able to use a powerful teaching methodology [10] for developing students' abilities [1], [2], [7], [8], [9], [12], [13] to understand the scientific content of our courses, and use the computational programs for simulatying physical phenomena. Our main goal is to improve our physics course and laboratory, and this implies providing a framework for the integration of new computational tools, and especially of the computer simulations of physics phenomena. A first step was done by adding to our seminars some "teaching-while-quizzing" tests [10] that

were proposed for improving the physics learning and which are already on use by our students. Also, this computational method has improved the teaching of physics and developed the students' abilities. The next step consists in the implementation of the computer simulations [11], which will do not replace completely the traditional methods of learning physics, but will allow the good understanding of physics laws and phenomena, and will develop skills of measurement and analysis. Very important is their property of being not affected by the errors generated by the measurement process and the sensibility of apparatus.

At our physics laboratory, the students use the computers as tools for collecting, analyzing, visualizing and modeling real data which are picked up during experiments. For our students, it is very important to get familiar with both the laws of physics and the phenomena in the theoretical lectures and some computer programs that can make the understanding of physics concepts easier. These activities facilitate the development of the students' ability to apply these concepts to physical situations and reason with them. As a result, the students will be able to use these theoretical ideas and the newly acquired skills in practice. For us, it was important to decide which are the laboratory activities that need computer simulation applications, and which of them are the most important.

In this paper we provide a concise description of a set of physics simulations elaborated in Adobe Flash CS3 for the study of Stefan-Boltzmann law of thermal radiation and the determination of Planck's constant using the photoelectric effect. These computer simulations discussed here have been implemented and tested at our physics laboratory, and for their elaboration we used modern software and technologies [18].

2. Computer Simulations for Physics Phenomena

We realized a set of physics interactive simulation computer applications that describes some important phenomena and laws of physics, and which are used in our physics laboratory. We have a suite of 10 simulations of our laboratory works based on various physics phenomena, which cover many of the areas of physics studied in our course of physics. Very important has

been to decide what are the physics laboratories that needs a computer simulation application, and among them which are the priorities. We established the most important experiments, and after this elaborated the computer simulations with respect that the experimental results must be the same as the results yielded by the computer simulations. The software can be run during or after the experiment and allowing the students of making a comparative study between experiment and simulation.

The simulations were elaborated in the animation and programming environment Adobe Flash CS3 [18]. This is professional software by means of which applications, animations and web pages may be created and processed. The operations, the functions and the easy handling give to the ones who develop Flash applications the access to many possibilities. This makes Flash to be a good environment in developing applications. Our computer simulation applications were implemented using the data obtained further to physical experiments to simulate as accurately as possible the behavior/the indications of the lab equipment. There have also been used the physical formulas necessary to obtain the wanted results. By means of experimental data taken from certain sites within a given span of time, an interpolation of 1st degree could be implemented in these applications, so that the user has the possibility to use values from the same span of time that he would have used with the lab equipment. This gives the user the freedom to choose a value, being not constricted to use a limited number of values or even the used experimental values. We notice that these applications have a menu in Romanian and English, which may be used depending on necessity of preference. As examples, we present the applications for the study of Stefan-Boltzmann law of thermal radiation and determination of Planck's constant using the photoelectric effect. Each of these applications allows the students to verify the experimental data and to perform the calculation and carry out the graphs.

First we describe the application for the Stefan-Boltzmann law of radiation. The screenshots of the applications interface are presented in Fig. 1 and Fig. 2. In Fig. 1 is given the computer interface image for the lab objectives, the apparatus and equipment, and the measurements and procedure. The aim of the computer simulation is the verification of the

Stefan-Boltzmann law of radiation. When opening this application, the students have to press the switch of the circuitry. After that, they have to enter values for the feeding voltage U and the variable resistance R_3 , yet these values shall enter the specified range beside the data input area. Otherwise, a warning indicated by a red box flashing next to the wrongly entered value will be provided. After the values that observe the possible value ranges are entered, the button Upgrade will be pressed as it displays the newly obtained values of R , I and T , upgrading at the same time the graphic and the indication of the galvanometer. The user should try to adjust R_3 for a certain value of U , so that the reading of the galvanometer should be 0.

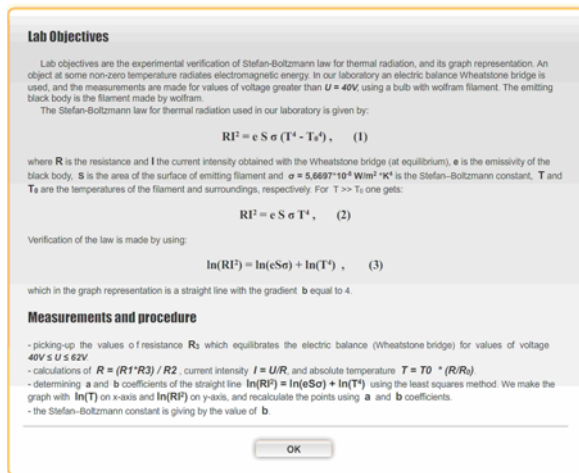


Figure 1. Lab objectives, measurements and procedure for the Stefan-Boltzmann law.

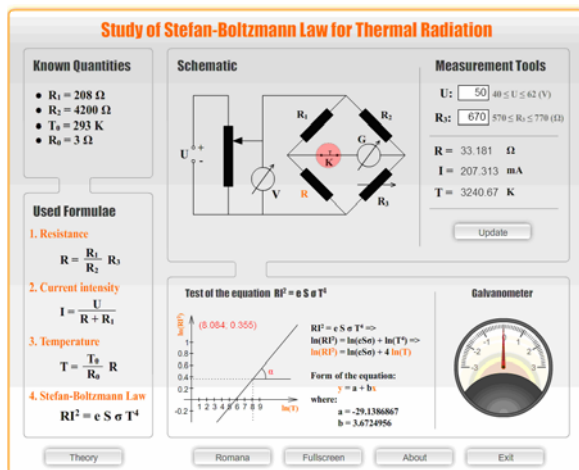


Figure 2. Screen-shot of the application interface.

The next example is the one of the computer simulation of the determination of Planck's constant using the photoelectric effect.

For the determination of Planck's constant the Einstein's equation for the photoelectric effect is used. The lab objectives, the apparatus and equipment, and the measurements and procedure are presented below as the computer interface image in Fig. 3. The students learn about the theory and experimental method.

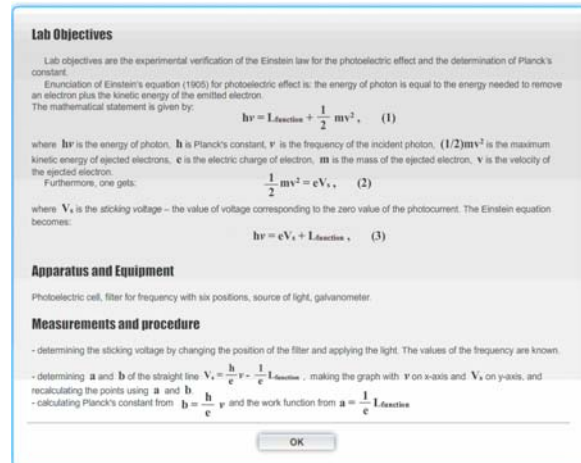


Figure 3. Lab objectives, apparatus and equipment for the photoelectric effect.

The second computer interface image for this program is presented in Fig. 4. The user should first choose a certain value of the wave length of the color to be experimented, after which he should adjust the value of the sticking voltage V_s (or another denotation in Romanian is V_b), so that the reading of the galvanometer should be 0. When this requirement is met, the obtained frequency may be extracted.

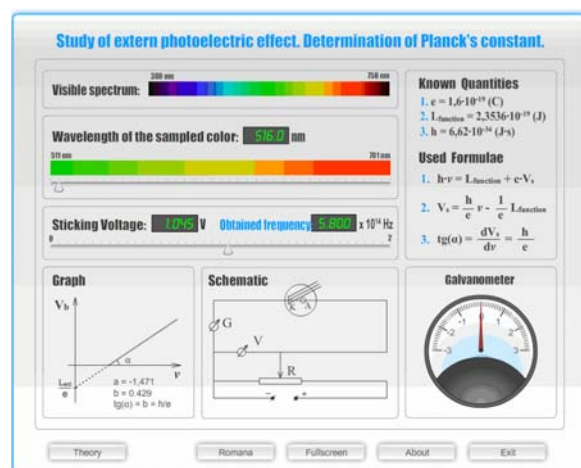


Figure 4. Computer interface image for the photoelectric effect.

In our physics laboratory we use a filter with six known frequencies and we pick up the corresponding values for the sticking voltage,

and after this we determine Planck's constant using the least square method. The computer simulation gives the possibility to determine by interpolation the corresponding values of the sticking voltage for a large number of values of wavelength.

We present the function "my update" of the interface in the case of the application for the Stefan-Boltzmann law of radiation (partially in romanian):

```
function my update():void
{
  if(k_mc.currentLabel=="inchis")
  {
    var u:Number = (Number)(u_txt.text);
    var r3:Number = (Number)(r3_txt.text);
    var r3Ideal:Number = 0;
    var i:uint = 0;
    var divRez:Number = 0;

    var R:Number = 0;
    var I:Number = 0;
    var T:Number = 0;

    if(u>=40 && u<45)
      i = 0;
    if(u>=45 && u<50)
      i = 1;
    if(u>=50 && u<55)
      i = 2;
    if(u>=55 && u<60)
      i = 3;
    if(u>=60 && u<=62)
      i = 4;

    divRez = (arrR3[i+1] - arrR3[i]) / (arrU[i+1] - arrU[i]);
    r3Ideal = Math.round(divRez * (u-arrU[i])) + arrR3[i];

    rotatie = Math.round((r3Ideal - r3) * divRot);
    galv_mc.indicator_mc.rotation = rotatie;

    const R1:Number = 208;
    const R2:Number = 4200;
    const T0:Number = 293;
    const R0:Number = 3;
    const a:Number = -29.1386967;
    const b:Number = 3.6724956;

    R = (R1/R2) * r3;
    I = u/(R+R1);
    T = (T0/R0) * R;
```

```
r_txt.text = R.toFixed(3);
i_txt.text = (I*1000).toFixed(3);
t_txt.text = T.toFixed(3);

//pentru grafic
lnT = Math.log(T);
lnRI2 = Math.log(R*I*I);

grafic_mc.panta_mc.x = Math.round((90 * lnT)/9);
grafic_mc.panta_mc.y = Math.round(-(75 * lnRI2));
grafic_mc.xy_txt.text = "(" + lnT.toFixed(3) + " + " + lnRI2.toFixed(3) + ")";
}}
```

and, also for the determination of Planck's constant using the photoelectric effect

```
function myupdate():void
{
  var lu:Number = luSlider_mc.value;
  var vb:Number = vbSlider_mc.value;
  var vbIdeal:Number = 0;
  var frecv:Number = 0;
  var i:uint = 0;
  var divVb:Number = 0;
  var divLU:Number = 0;

  //[701, 637, 577.5, 528.5, 520, 511];
  if(lu<=701 && lu>637)
    i = 0;
  if(lu<=637 && lu>577.5)
    i = 1;
  if(lu<=577.5 && lu>528.5)
    i = 2;
  if(lu<=528.5 && lu>520)
    i = 3;
  if(lu<=520 && lu>=511)
    i = 4;

  divLU = (arrLU[i] - arrLU[i+1]) / (arrVb[i+1] - arrVb[i]);
  divVb = (arrVb[i+1] - arrVb[i]) / (arrFrecv[i+1] - arrFrecv[i]);
  vbIdeal = Math.abs(lu - arrLU[i])/divLU + arrVb[i];
  //trace(vbIdeal);

  //divFrecv = (arrFrecv[i+1] - arrFrecv[i]) / (arrVb[i+1] - arrVb[i]);
  frecv = Math.abs(vb-vbIdeal)/divVb + arrFrecv[i];
```

```
//trace(frecv);  
rotatie = Math.round((vbIdeal - vb) * divRot);  
//trace(rotatie);  
galv_mc.indicator_mc.rotation = rotatie;
```

```
frecvVal_txt.text = frecv.toFixed(3);  
}.
```

It is worth emphasizing that we have noticed an improvement in the understanding of physics phenomena and laws due to the implementation of computer simulations in our physics laboratory.

3. Discussion and Conclusions

In recent years the development of efficient and accurate tools for physics computer simulations has become of great interest for both students and physicists. In this paper we present two physics simulation computer applications elaborated in Adobe Flash CS3 program that we developed for our physics laboratory. They are used for the study of the Stefan-Boltzmann law of thermal radiation and the determination of Planck's constant using the photoelectric effect. Moreover, they are part of a set of physics simulations elaborated in Adobe Flash CS3, which help our students to achieve a better understanding of physics phenomena and laws.

There are some important arguments that support the necessity of introduction of this way of physics study. First, picking up experimental data is a process that can be perturbed by errors, and this can be avoided by using virtual tools like computer simulations. Moreover, the computer applications also work as checking tools of the results yielded by experimental work. Future computer simulations can be envisioned for improving the learning process. Thus we open a window for the students to the virtual labs and simulations, and they can learn to use a comparative mode of learning and how to experiment and use software applications. The set of physics simulations they use can be further implemented in the distance learning via the Internet (e-learning), which is partially or entirely based on Web and Internet courses and assignments.

Moreover, at our courses, seminars and laboratories, we are just beginning to develop this kind of new learning activities, as for long time we missed the necessary resources, equipment and technical systems. Our simulation

programs themselves are inexpensive aids in the study of physics.

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5. References

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