

# COMSOL MULTIPHYSICS™ AS AN EDUCATIONAL RESOURCE FOR STUDENTS

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**Abstract:** Studies points out that interactive teaching methods create a deeper learning, students develop better thinking skills by presenting concrete examples and students demonstrate better memory and are more appreciated. This paper presents a new method of teaching and learning basic phenomena and also complex studies for students enrolled in Technical Faculties. The method consists in using a commercial simulation program for creating applications that match the various issues raised in the seminar and lab hours. Finally an application example is given in order to present the advantages.

**Key words:** new teaching method, simulation software, applications.

## 1. Introduction

Over time, it was found that teaching on blackboard with chalk and implement a written course are a minimum mandatory but not sufficient, as proven by many of today's courses are made using digital presentations. This paper proposes a new method of learning by using simulations software based applications. The software that has the capabilities to create simulations based applications is Comsol Mutiphysics version 5. The idea is simple. You create a simulation model and based on it you can create an application with a much simpler and intuitive GUI (Graphical User Interface) for students. Using the new interface the students from undergraduate years can understand different physics or phenomena without knowing how to use a complex simulation software.

## 2. The proposed simulation

The real life situation considered in this paper is shown in Figure 1.

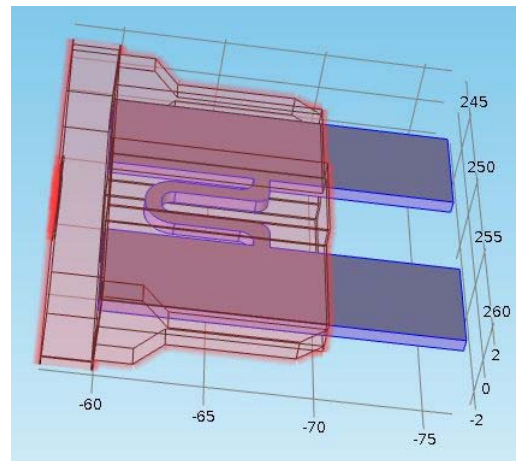


Fig. 1. Automotive fuse 60 A, made from copper

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The application proposed in this paper was created after a simulation of a Joule-Lenz effect on a 60 Amps fuse used in automotive applications. The simulation is created in steady state, which means the field variables do not change over time.

For the initial study the voltage for the simulation was considered 32 V, the current intensity was considered 40 A, in terms of electric currents and in terms of heat transfer in solids was considered a convective heat flux of 5 W/m<sup>2</sup>K and an ambient temperature of 20 °C, as can be seen in Figure 2.

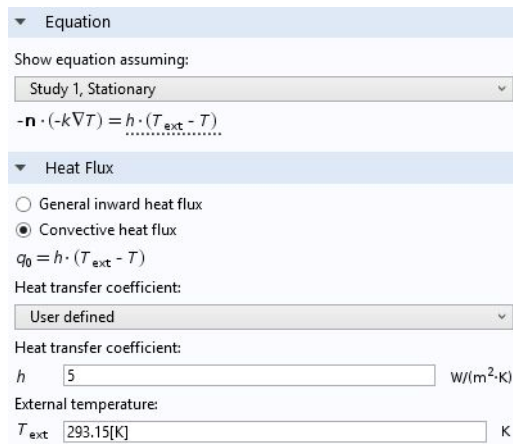


Fig. 2. Boundary conditions for the convective heat flux

For the mesh it was used a fine element size, and the result can be seen in Figure 3.

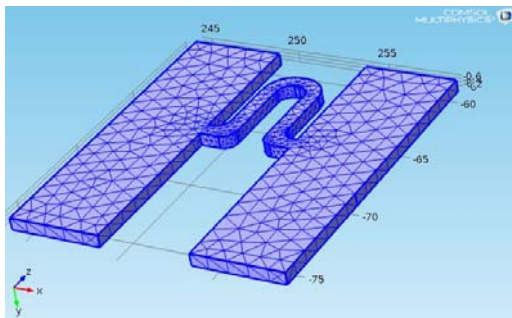


Fig. 3. The fine mesh for the copper fuse, used in the simulation

Using these input data the computer simulation software Comsol Multiphysics 5 solves the problem and the user can choose what result are important to be shown and can plot under different forms. For example in this simulation it is considered important to show the electric potential and the surface temperature over the fuse. These results can be observed in Figure 4 and 5.

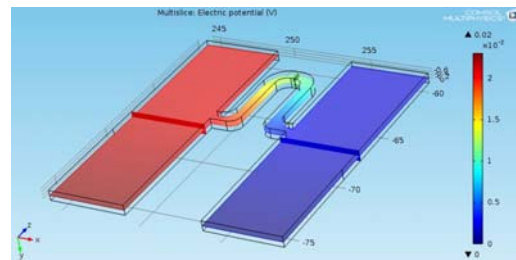


Fig. 4. Multislice electric potential results

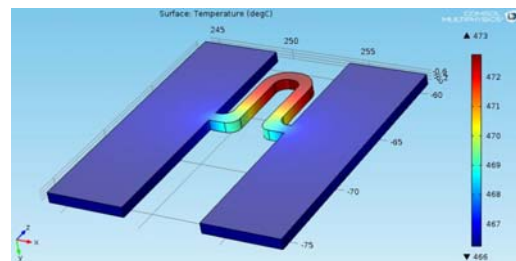


Fig. 5. Surface temperature over the fuse

In order to conclude to create this simulation the user has to follow five basic steps:

1. To create a geometry 2D or 3D;
2. To mesh it;
3. To setup the boundary conditions of the study;
4. Wait for software to compute the study;
5. Finally, to plot the results.

Following those five steps require CAD knowledge, in order to create more complex 3D models, requires that the phenomenon being studied already to be

known and understood in order to setup the correct boundary conditions, require to know how to use a complex simulation software, require a workstation PC depending on the complexity of the geometry or phenomena studied and in the end if the penultimate condition is fulfilled only partially a lot of waiting time is needed.

### 3. The Application Builder

To eliminate all these inconvenient wouldn't be easier for the users to have access to a database of ready-made applications, where they can change key parameters to see the system or the component behaviour? With the new version 5 of Comsol Multiphysics this is possible, by using the Application Builder.

A COMSOL application is a COMSOL Multiphysics® model with a user interface.

With a license of COMSOL Multiphysics, applications can be run from the COMSOL Desktop in Windows® in

this new launched version 5, but in future versions the Application Builder will be available also for OS X an Linux.

With a COMSOL Server license, a web implementation of an application can be run in many popular web browsers on platforms such as Windows®, OS X, iOS, Linux®, and Android™. In Windows®, you can also run COMSOL applications by connecting to a COMSOL Server with an easy-to-install COMSOL client, available for download from [www.comsol.com](http://www.comsol.com), as for example Amazon.com.

Files extension for Comsol Application Builder is \*.mphapp.

The Application Builder includes a comprehensive set of tools for creating and deploying applications based on COMSOL models. The main tools and desktops that you use to create applications are shown in figure 6 and are the following:

- The Application Wizard: A wizard that guides you through the steps to set up an application from an existing COMSOL Model.

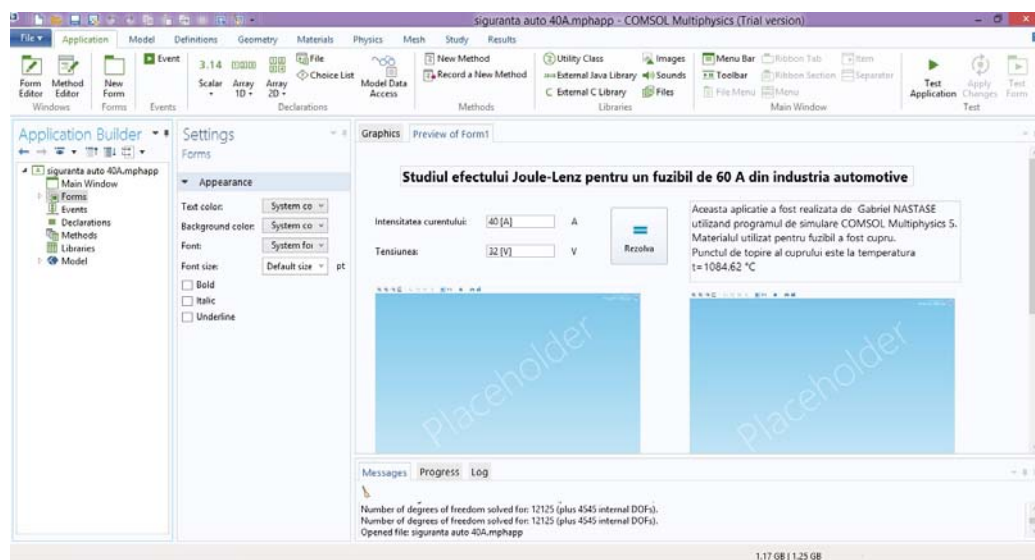


Fig. 6. The Main Window Branch in Comsol Multiphysics 5 Application Builder

- The main COMSOL Desktop with the Application Builder window, which contains a tree with the model nodes and the nodes that define the application, and

an Application ribbon toolbar with tools for creating applications.

- The Form Editor for creating and designing forms (user interfaces) with various form components (user interface controls) that are adapted for the application in mind.

- The Method Editor for creating and editing methods and classed for including custom code that can be connected to user interface events, for example.

Based on the simulation proposed and using Comsol Multiphysics 5 Application Builder interface we created a simple user friendly application example.

#### 4. A simple application example

In this simple example students can change the electrical current intensity and the voltage and see quickly the effects in terms of thermal heating. This way it becomes easier for them to understand the theoretical aspects of the problem and used also with some aspects of simulations, but without creating one. The application created for the simulation described in this paper is shown in Figure 7, bellow.

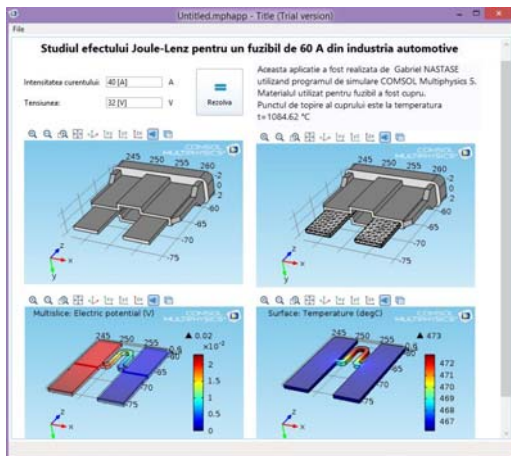


Fig. 7. The Joule-Lenz application created using the simulation described

After the application is created it can be

run by students from the COMSOL client for Windows® or through a web browser.

To get the most out of the Application Builder, consider these six logical steps:

- Consider what the application should include: parameters are of interest, outputs that a user would like to see, plots are useful, specific numerical results are important;

- Make a sketch of the user interface and its controls and objects, outlining what type of inputs, menus, buttons, plots, and so on that the application should include and making a layout of the form or forms in the application;

- Create a COMSOL model of the application, including the parameters that you want to use as inputs in the applications and the derived values and plots that you want to use as the outputs and results when running the application;

- Use descriptions for all the parameters that you want to include in the application.

- Solve the COMSOL model, and consider what studies you want to include that the application should then run to produce the output that is of interest to the users;

- Save the COMSOL model as a Model MPH-file that you will then use as a starting point for the application.

#### 5. Conclusions

In our current society, there is a dynamic process which requires all walks of life to keep up with the evolution of society and therefore education. The application of new learning methods require time, diversity of ideas, commitment to action, discovery of new values, teaching responsibility, confidence in personal ability to apply them creatively to streamline the educational process.

#### References

\*\*\*Comsol Multiphysics version 5 Help