Project Year

2014-2015

Project Title

Development of Computational Simulations to Support Undergraduate ME Thermal-Fluids Labs

Project Team

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Audience

The targeted audience for this project is undergraduate Mechanical Engineering students who are enrolled in the following (required) laboratories: (1) 530.232 *Thermodynamics Lab,* (2) 530.329 *Introduction to Fluid Mechanics Lab,* and (3) 530.335 *Heat Transfer Lab*. Based on previous years' enrollments, 150-200 students will benefit from this project each year.

Pedagogical Issue

Mechanical Engineering undergraduates are required to take a sequence of three laboratory courses in the thermal-fluid sciences (thermodynamics, fluid mechanics, and heat transfer). In each course groups of 3-5 students perform experiments, collect data, and analyze and report on their measurements. Since most of the analysis and learning occurs when the report is being written, the lab becomes more of a data logging exercise than an interactive learning experience. Additionally, many of the lab activities require the students to wait for extended amounts of time while the experimental systems "warm-up" or come to steady state. The intangible nature of the subject matter (temperature, rate of energy transfer, etc.) does not help in keeping the students' interest. Students' feedback from the past 5-6 years suggests the need to make these experiments more interesting.

Solution

We propose to develop interactive computational models of the various laboratory experiments using COMSOL & MATLAB software to enable the students to explore the underlying concepts of the experiments. This will greatly enhance the learning experience of the students as they will be able to visualize the phenomena while the experiments are being performed. The computational models will also allow the students to explore the experiments under more extreme parameters than can be achieved with the actual physical equipment. We will also provide simulations of similar, but more complex, experiments for the students to explore. Since the duration of each experiment (approximately one to two hours) involves significant waiting time between observations, the students will be able to use these models and simulations during these waiting periods without having to add more time in their schedules.

Assessment Strategy

Feedback will be required from the students after each laboratory to assess how well the models and simulations helped them to understand the laboratory concepts and keep their interest in the subject matter during the lab. This will act as a continuous, formative assessment of the effectiveness of the proposed project. Additionally, the quality of the laboratory reports from the students who were exposed to the models and simulations will be compared to those from previous years.

Faculty Statement

The current Mechanical Engineering undergraduate thermal-fluids labs consist of experiments of one to two hour durations, most with extended waiting times between data collection points. Understandably the students tend to get distracted during these waiting periods and lose interest in the experiment. The experiments also involve the measurements of intangible and non-visual parameters, such as temperature and pressure, which makes the laboratories even less interesting to the students.

Our goal is to extend the scope of the experiments by using computational models which will enable the students to explore the underlying concepts during the experimental waiting periods. Students will be able to visualize the experimental phenomena and will be encouraged to explore the experiments under more extreme parameters than can be achieved with the actual physical equipment. Since the students perform the experiments in groups of 3-5, collaborative learning using the models will naturally occur. The proposed project is unique and exciting as it combines the rigorous nature of experimental measurements along with computational simulations, allowing students to compare and contrast results obtained from both in order to get a holistic learning experience.

The fellows will assist in all aspects of the project. They are well versed with the use of the simulation software, i.e. COMSOL and MATLAB; one of them has expertise in working with web-applications as well. They are both familiar with the laboratory experiments having been TAs for these courses in the past. My role will be to supervise their work and advise them on how to best present their models to the students.

The project will require approximately 20-25 hours per week of work during the summer, split equally between the fellows.

Each laboratory course supports a three-credit lecture course. It is hoped that these models and simulations will improve the students' performances in the courses in addition to the laboratories. Although the models developed for this project will be particular to the mechanical engineering undergraduate thermal-fluids labs, similar models could be developed for laboratory courses in other departments. This project will help to determine the benefits of such efforts.

Once the models have been developed, very little work should be required to maintain them. As the laboratories evolve over the years (e.g., a new wind tunnel was recently installed for the fluids labs), future students will be hired as needed to update the models. It is expected that the Mechanical Engineering department will be able to fund these smaller projects when the time comes.