

A Web-Based Measurement Lab for Thermal Sciences

C. C. Ngo, M. J.-F. Voon, and F. C. Lai
School of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, Oklahoma 73019

Abstract

This paper presents how multimedia technology can be implemented over the web to enhance the learning experience of students at the University of Oklahoma in a measurement lab for thermal sciences. A web-based module has been developed to present course materials in dynamic and interactive ways. This courseware not only introduces fundamental theories about measurement, but also details the experimental setup and procedure for each lab assignment. In addition, it has a unique component called “Virtual Lab” in which students can learn the operation of advanced and sophisticated instruments which are not normally available in undergraduate teaching labs. The implementation of “Virtual Lab” can better utilize the resources available while providing an excellent learning opportunity for students. With the courseware available over the internet, students have easy access to the course materials anytime, anywhere. With the preview of each lab assignment, students find the lab session can be conducted more efficiently and more effectively.

I. Introduction

Over the past few years, the availability of internet and the advancement in the multimedia technology have provided tremendous opportunities for educators to revolutionize the teaching-learning enterprise and to improve the quality of engineering education. However, most of the web-based courseware or online classes are mainly devoted to lecture-type courses. Web-based courseware for laboratories is still limited and apparently deserves more attention.

Web-based lab courseware offers many additional advantages over regular courseware. First, it provides an easy access for students to preview/review the course materials. Particularly, after preview the lab assignment with demonstration through the web, students will be able to conduct their experiment more efficiently and more effectively. This can considerably shorten the lab hours. For institutes that have limited resources in lab equipment or instrument, this can also shorten the turn-around time for equipment/instrument sharing, which allows more students to conduct an experiment in an allocated time. Another advantage is that, using multimedia

technology, advanced and sophisticated equipment can be introduced to students through a “Virtual Lab” environment where they can obtain simulated hand-on experience in using the equipment. As will be explained and demonstrated later, this can not only better utilize the resources that are available in a university, but also those in the state agencies, federal agencies and national labs.

II. Background

To fulfill the degree requirement, an undergraduate student in our school must take at least three laboratory courses. Two of them are required (Solid Mechanics Lab and Heat Transfer and Fluid Mechanics Lab) and the third one depends on the student’s own interest. They can choose from a variety of labs; IC Engines Lab, Wind Tunnel Lab, Fluid and Thermal Lab, Dynamics and Control Lab, Stress Analysis Lab and NDE Lab. For the two required laboratory courses, basic theories of measurement and instrumentation are introduced. The assigned lab sessions are designed to reinforce the theories covered in the lectures. The lectures and lab assignments of these two courses provide students the necessary knowledge that they will need for other lab courses. They are offered once a year with a typical enrollment ranging from 70 to 80.

From a survey conducted to our graduating students in 1997, it shows that all students were not satisfied with the lab equipment and instrumentation. Over the last few years, although our school has made a significant effort to improve the lab equipment and instrument, the task to refurbish the labs is still far from completion due to a limited funding. This online courseware represents a continuing effort to improve our lab teaching. It not only offers a quick alternative solution to our problem, but also enhances the learning experience for our undergraduates.

III. An Overview of the Web-based Measurement Lab

As shown in Figure 1, the main page of Measurement Lab provides a menu for navigation. In addition, important announcements are displayed on the message board in the main page. Through the menu, students can find the general information about the course (e.g., syllabus and instructor profile), lecture notes and lab assignments. The instructions for report preparation and writing tips are also available. This lab courseware is currently available online and can be accessed at the following URL, <http://coecs.ou.edu/flai/www/Labweb/home.htm>. Three main components of the courseware (i.e., Lectures, Lab Assignments and Virtual Lab) are discussed in more detail in the following sections.

A. Lectures

Lecture notes, which document the materials that are covered in class, are accessible through the menu in the main page. They are presented in a more visually appealing manner with the use of pictures, animations, and interactive simulations. They are grouped into six sections. The first five sections are related to the measurement of five most fundamental quantities in thermal sciences¹ (i.e., density, viscosity, pressure, temperature, and flow rate) while the last section is devoted to the data acquisition¹. The theories related to data analysis (e.g., error estimate,

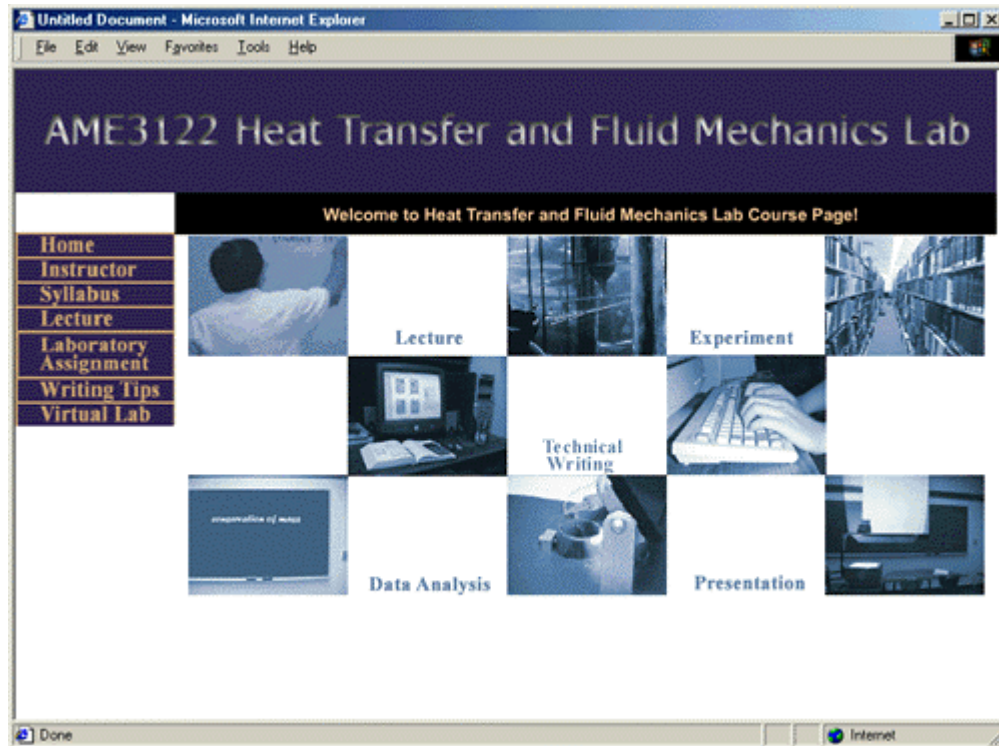


Figure 1. Main Page of the Web-based Measurement Lab.

uncertainty analysis and regression) are discussed along with the lectures. Since they have already been introduced in the prerequisite course, they are not grouped into a special section for further discussion. A sample of the lecture notes is shown in Figure 2. For a given subject, various measurement techniques are introduced. The advantages and disadvantages for each individual technique are also discussed. Numerous examples are included in the lecture notes to further illustrate the principle or theory underlying a particular measurement technique. Figure 3 shows a typical interface for examples used in this courseware. Students can navigate between the problem statement and solution using the buttons on top of the menu. Detailed solution procedures with a systematic approach are provided to improve students' problem solving skills.

B. Lab Assignments

There are five lab assignments which correspond to the five main subjects covered in the lectures. These lab assignments are used to reinforce the theories that students learned from the lectures. In each lab assignment page (Figure 4), the objectives of the experiment are first clearly stated. When clicked on the photo icon, the apparatus used in the experiment are displayed on screen so that students can familiarize themselves with these apparatus beforehand. Experimental procedures are first described in text and then demonstrated through video clips. Through the video demonstration (Figure 5), students will have a clear understanding of what to do and what the expectations are before they come to the class.

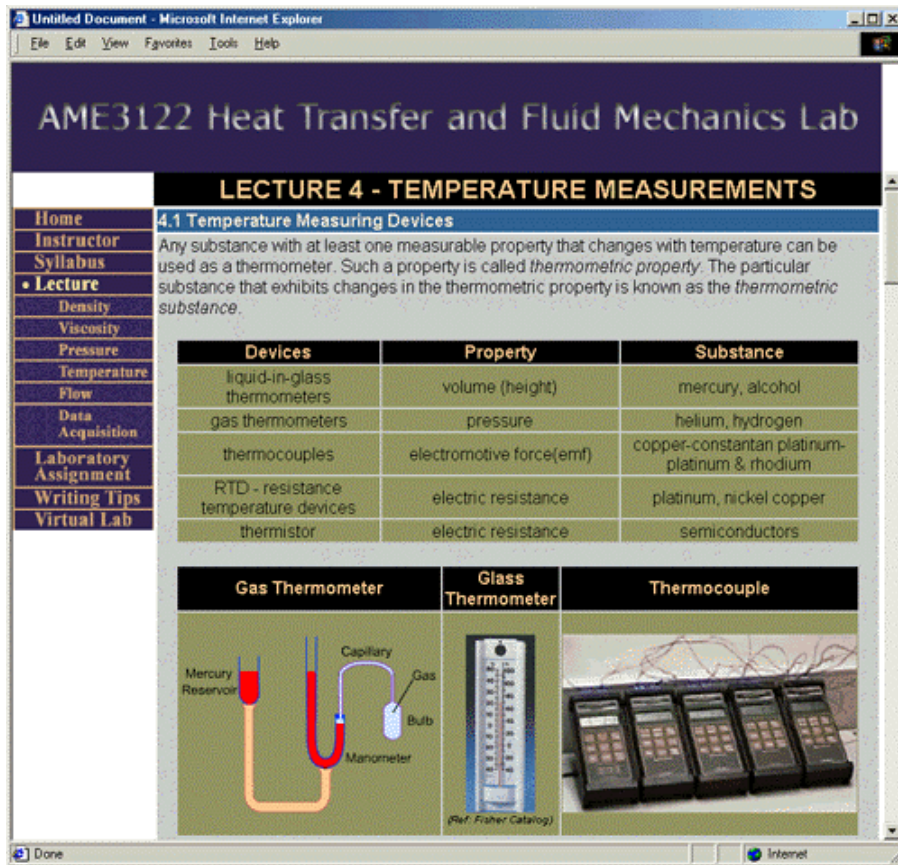


Figure 2. A Typical Interface for Lecture Notes.

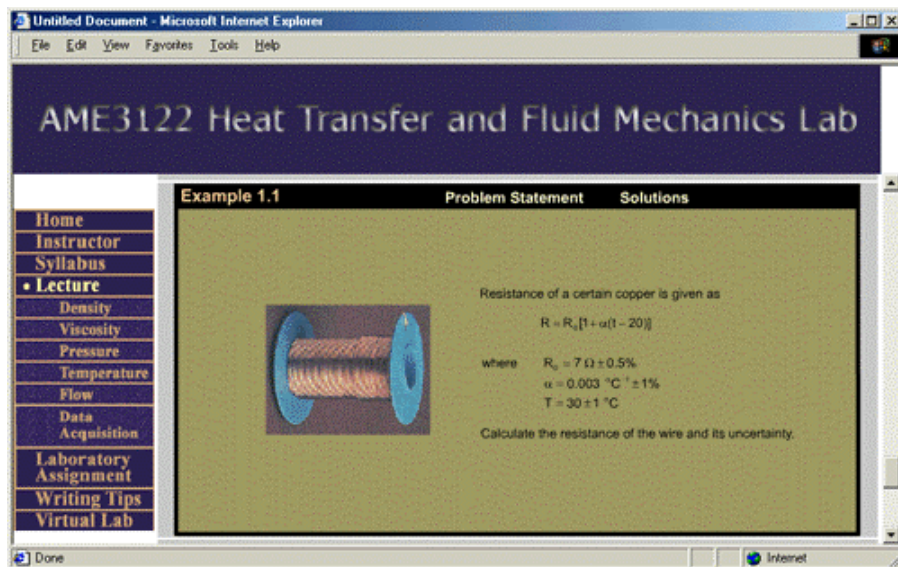


Figure 3. A Typical Interface for Examples.

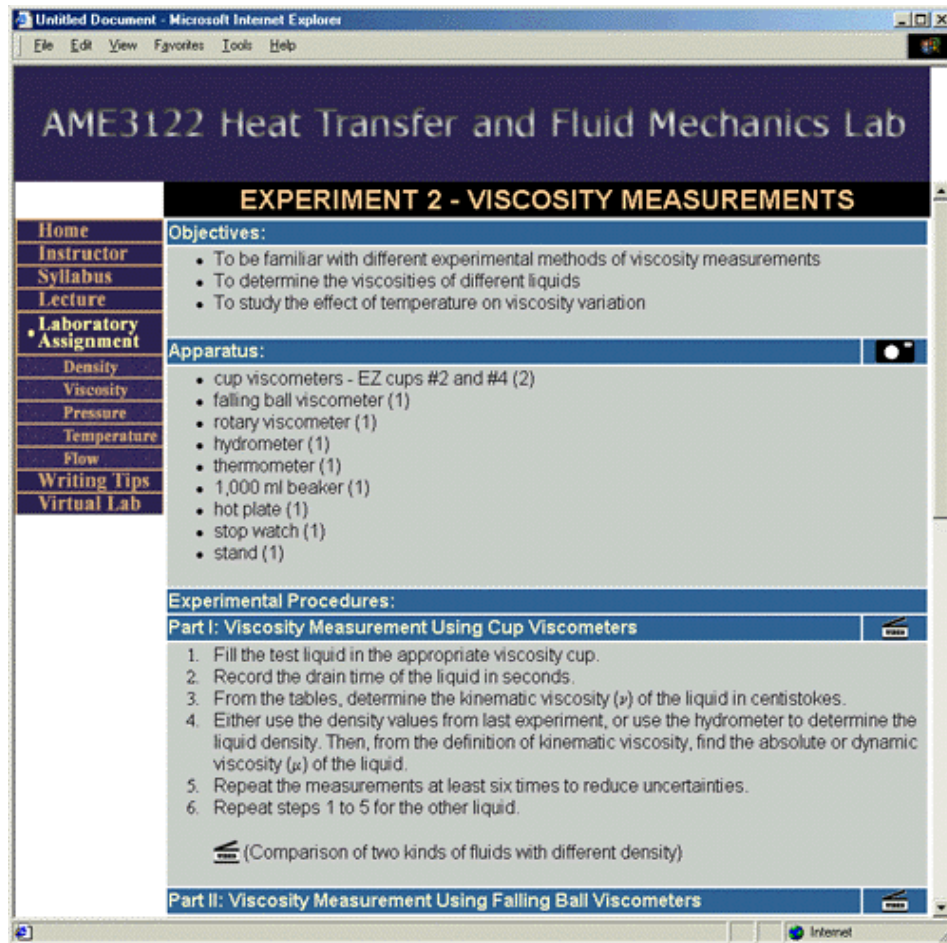


Figure 4. A Typical Interface for Lab Assignments.

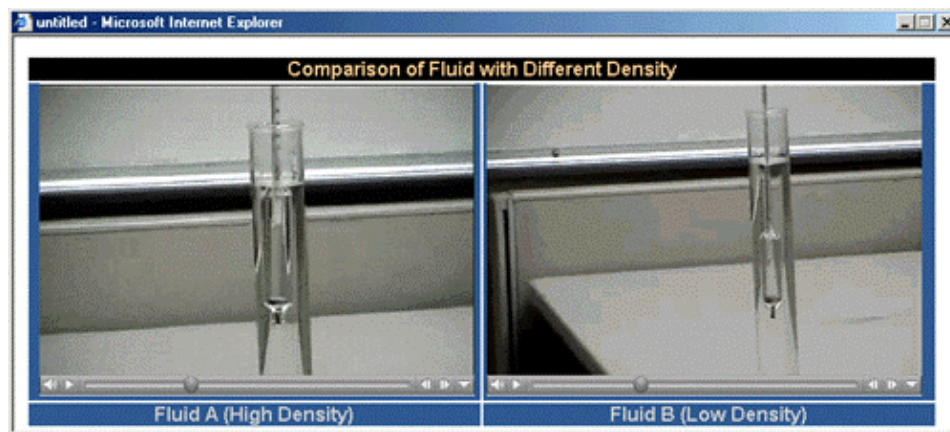


Figure 5. Demonstration of Experimental Procedures through Video Clips.

C. Virtual Lab

In addition to the multimedia presentation of lecture notes and lab assignments, the courseware features a unique design of “Virtual Lab” which is intended for enhancing students’ learning experience. The “Virtual Lab” is a special multimedia presentation on the web. It provides a simulated lab environment for students to learn the operation of special equipment. With an increase in the research funding, many schools have acquired new and advanced equipment. Although these usually are the top-of-the-line products with the state-of-the-art technology, they are accessible only to limited people. With the aid of multimedia technology, it is now possible to create a “Virtual Lab” from which students can learn how to operate these equipment even if they are not physically present in the lab. The idea of “Virtual Lab” is particularly attractive for introducing a dedicated (and often expensive) equipment or an experiment in which safety is a major concern.

To prove the concept, we use an experiment with a Laser Doppler Velocimeter (LDV) as an example for demonstration. A Laser Doppler Velocimeter is a piece of advanced equipment for velocity measurement and flow visualization. It is widely used in industry and research labs for precise velocity measurement. Despite of its popularity, most undergraduate students do not have a hand-on experience with this equipment because of the cost of the equipment and the concern of safety. Using the multimedia technology, it is possible that students can learn how to operate this equipment even without actually touching it. The two-component LDV (3-Watt Argon-ion laser) used in the demonstration is capable of measuring two velocity components simultaneously.

The opening page of this special project has a format that is consistent with those of the regular lab assignments. Immediately followed the objectives of the experiment, the apparatus (the laser and its accessories) are introduced through a series of still photos (Figure 6). They are also introduced later in a video clip which shows a complete view of the laser and optical table. The schematics for the experimental setup are also available for reference². To learn how to operate the argon-ion laser in the experiment, a series of demonstrations are provided through video clips. For this particular experiment, students are asked to measure the particle-laden jet velocity in a quiescent water tank. They can direct the laser beam to some specified locations and measure the jet velocity at those points. The measured value will be displayed on the screen and the results are presented in a graphic format (Figure 7).

LDV is just one of the possible equipment that can be introduced through “Virtual Lab.” Other equipment such as Schlieren and interferometer will also be included in the library of “Virtual Lab” in the near future. With well-planned collaboration, “Virtual Lab” not only can better utilize the resources available within one university, but also share those in other universities, national labs, and government agencies. It is our objective to continuously build and expand the content of our “Virtual Lab” so that all students will get the best education possible. With the successful implementation of “Virtual Lab,” we believe that education will break the barrier of geography and resources.

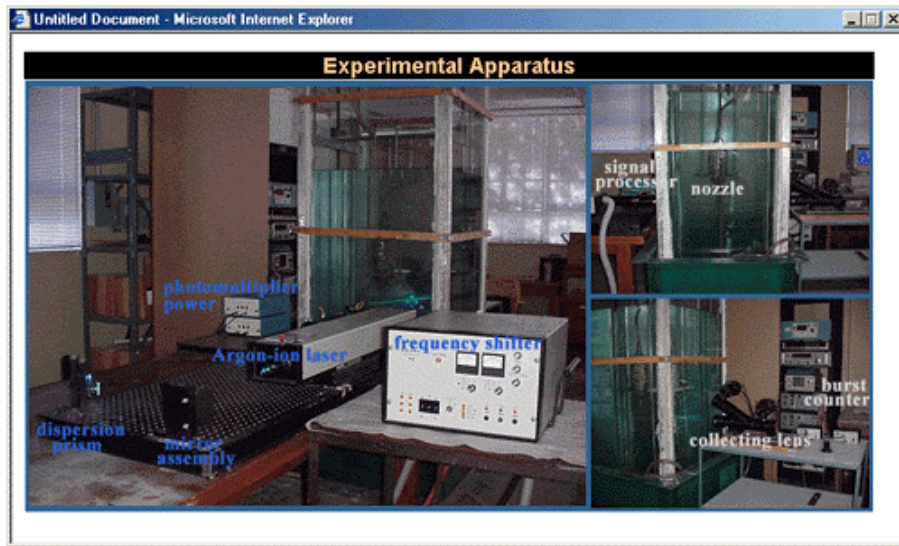


Figure 6. Experimental Apparatus for Special Project Using a LDV.

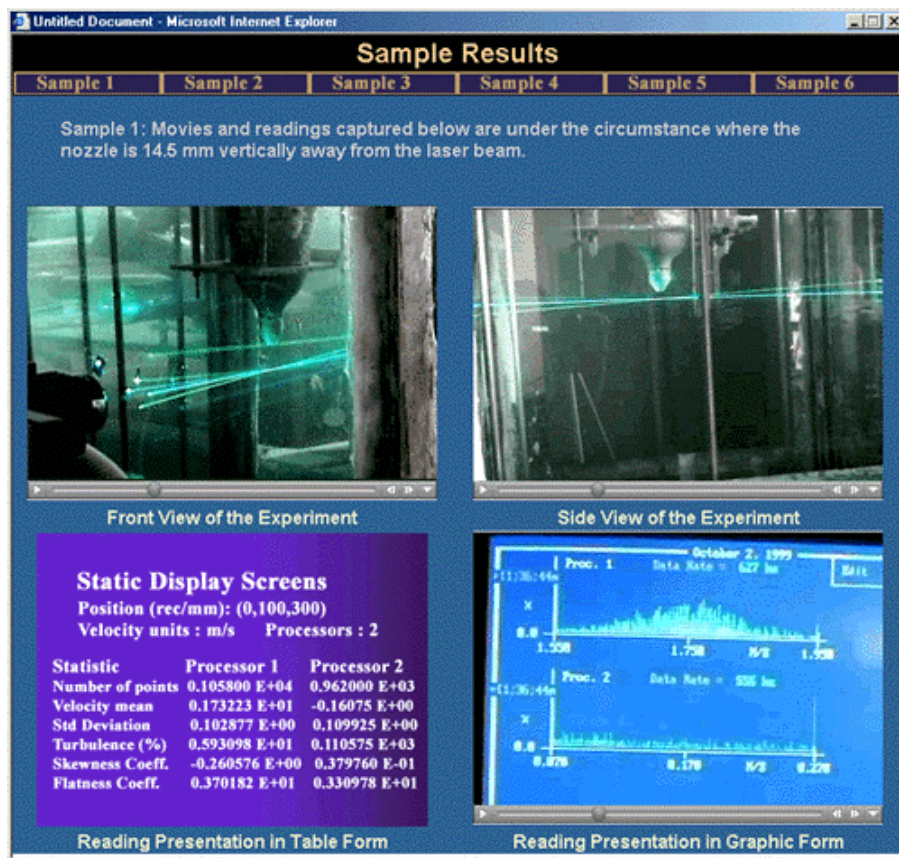


Figure 7. Sample Outputs from the LDV Measurements.

IV. Conclusions

Although this courseware has been designed for a specific lab course, the basic concepts employed are rather generic and can be apply to other lab courses. The courseware is scheduled to be tested in class in Spring 2002. For a typical enrollment, there are six lab sections offered for this course. It is proposed that students be voluntarily divided into two groups (three sections in each group). While one group of the students (Group A) is asked to use the courseware as part of the course requirement, the other group of the students (Group B) is denied for the access to the web information. In each lab assignment, the students' performance (in terms of the time for completing the assignment and the quality of the results obtained) will be evaluated. A correlation between the student's performance and courseware usage will be sought. In addition, selected students from Group A will be asked to operate the LDV in person. By asking a student to perform a basic flow measurement using LDV, the effectiveness of the instructional material can be assessed. The feedback from these students will be used to further improve the design of the courseware.

Acknowledgement

The authors gratefully acknowledge the support of this work from the Using Technology for the Improvement of Learning (UTIL) Program provided by the Office of the Senior Vice President and Provost at the University of Oklahoma.

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Biography

C. C. NGO

Mr. Ngo is currently a doctoral student in the School of Aerospace and Mechanical Engineering at the University of Oklahoma. He received his B.S. and M.S. in Mechanical Engineering from the University of Oklahoma (1997 and 1999, respectively). He is a member of the American Institute of Aeronautics and Astronautics (AIAA) and American Society of Mechanical Engineers (ASME).

M. J.-F. VOON

Mr. Voon is currently working for Exxon as a Mechanical Engineer in Malaysia. He received his B.S. and M.S. in Mechanical Engineering from the University of Oklahoma in 1998 and 2000, respectively.

F. C. LAI

Dr. Lai is currently a faculty member in the School of Aerospace and Mechanical Engineering at the University of Oklahoma. He received his bachelor degree from the National Tsing Hua University in Taiwan (1978), and M.S. and Ph.D. from the University of Delaware (1985 and 1988, respectively). He joined the faculty of the University of Oklahoma in 1992. He is a member of ASEE, ASME and AIAA.