Session 2793

Web-based Exercises for a First-Year Electrical and Computer Engineering Course

Isaac Horn, Robert Reynolds, John Field
University of Maine

Abstract
A series of web-based exercises were developed to support a first-year introductory electrical and computer engineering class. The exercises provide asynchronous learning opportunities in the topics of resistive circuits, RC circuits, 555 timers, and combinational logic circuits. The exercises are described and student perceptions presented.

I. Introduction

The University of Maine offers ECE 101 *Introduction to Electrical and Computer Engineering*, a 4-credit, lab-based course, to all electrical and computer engineering students in the fall of their freshman year. A portion of the course involves the study of resistive circuits, RC circuits, 555 timers, and combinational logic circuits; topics that are covered in detail in later courses. Soon after this course was introduced it became apparent that some students needed more "time on task" than others did in order to really gain mastery of the material. Thus, like many others[1,2,3] we turned to using the web for asynchronous learning opportunities. Specifically, a series of web-based exercises were developed to give students a chance to test their understanding of these subject areas independent of homework and tests. The home page for these exercises is at http://hornet.eece.maine.edu/ece101/ECE101.htm. The exercises are described in the following sections followed by a discussion of student perceptions.

II. Exercises Home Page

The home page for the exercises is shown in Figure 1. A user can either go directly to one of the four exercise choices or review the instructions first. Not surprisingly, most people skip the instructions and go right to the exercises. Thus, we have found it useful to give a brief in-class demonstration before assigning an exercise. When first beginning a module, an exercise from that module's area is assigned as homework to encourage students to become familiar with what it tests and how to use it. Other than this first assignment, further use is up to the student.

The exercises will be discussed in this paper in the same order as they are presented in ECE 101. Resistive circuits are discussed first to present the concepts of voltage division and current flow. This leads nicely to RC circuits, time constants, exponential charging and

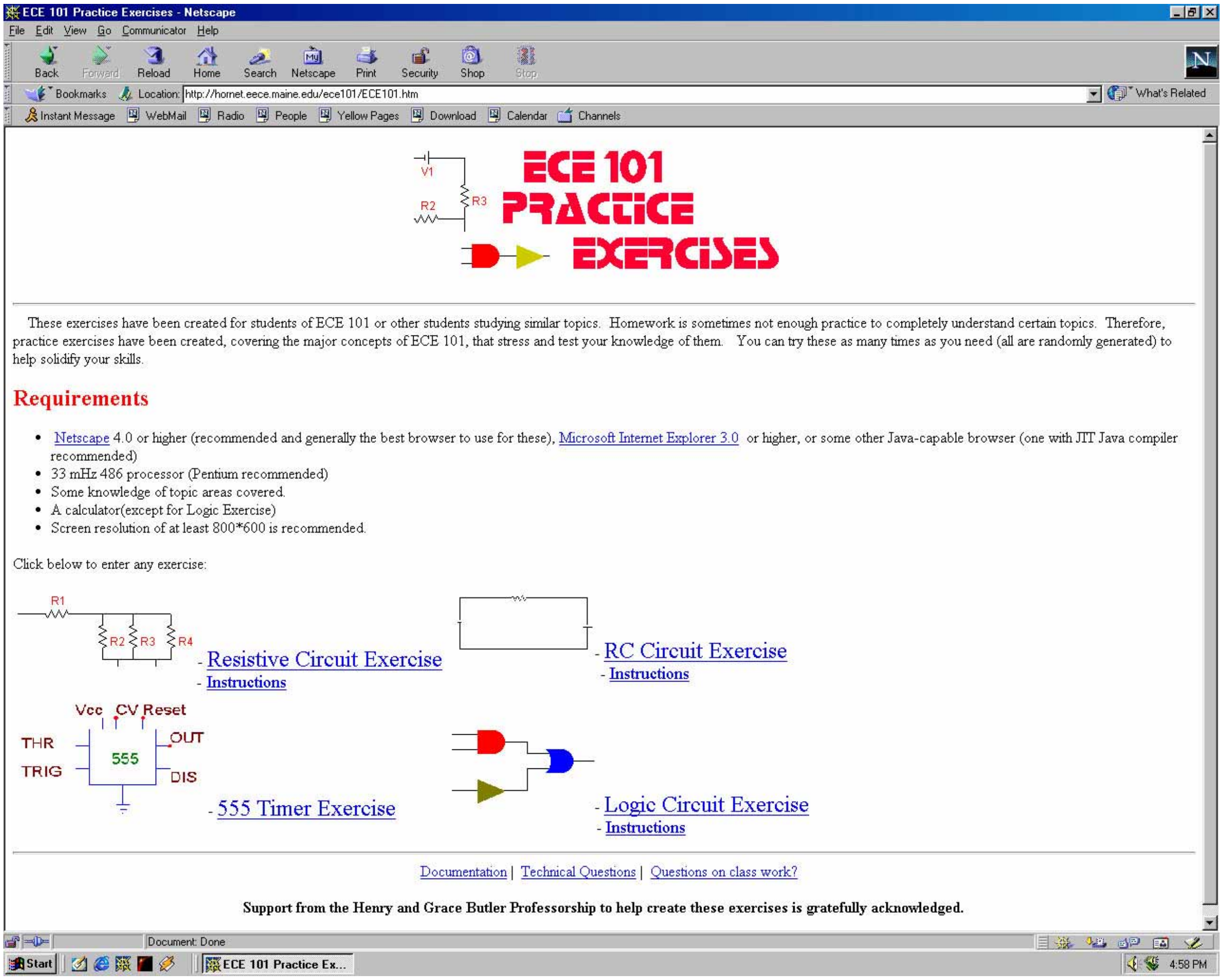

Figure 1. Home Page for ECE 101 web-based exercises

discharging, and energy storage. These topics give a good basis for 555 timers whose use serves as a good lead-in to digital circuits. We then discuss combinational logic, truth tables, Karnaugh maps and finally, state machines. We have developed web exercises for all topics except state machines.

III. Resistive Circuits

The resistive circuit software chooses from seven different prototype circuits, assigns random values to the components, and then asks the user to evaluate circuit parameters. These parameters include the equivalent resistance of the network, the current supplied to the circuit, as well as the voltages and currents associated with specific resistors. An example of a resistive circuit exercise is given in Figure 2.

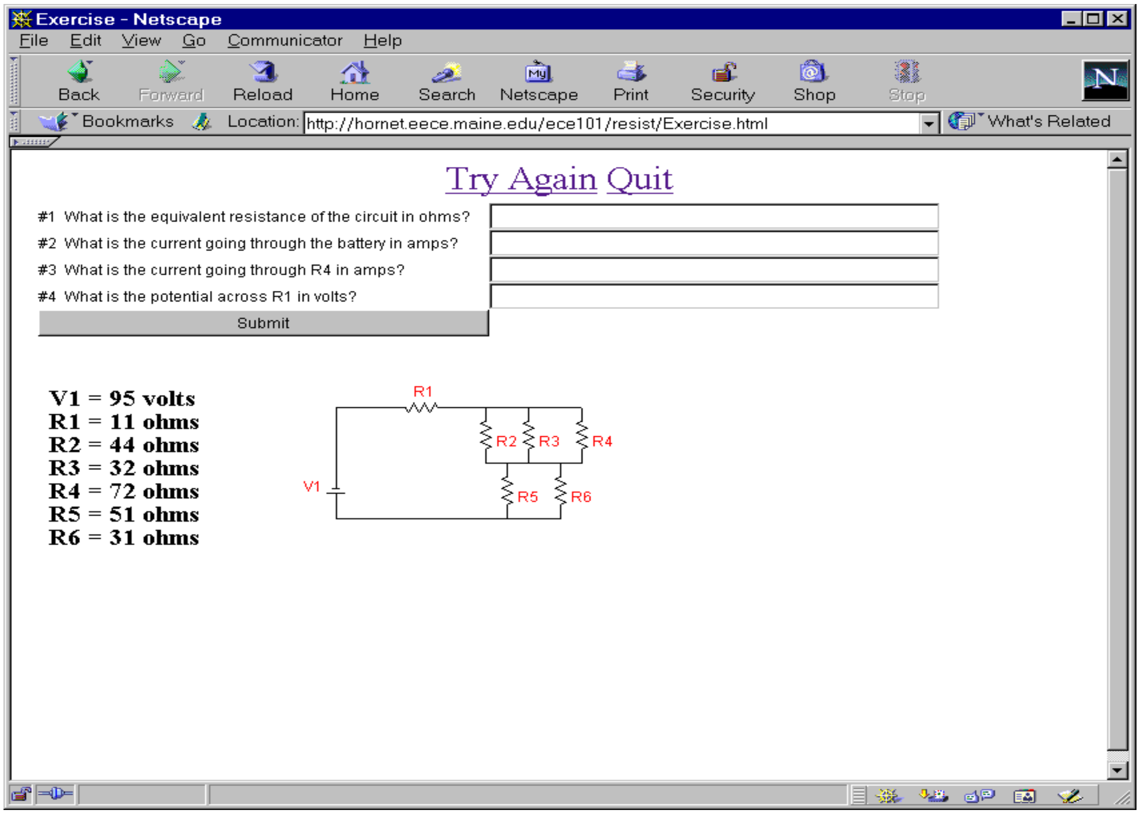

Figure 2. Typical screen seen by a user selecting a resistive circuit exercise.

The user responds to each question and then clicks on Submit to have the answers checked. Each question must have a response or the submission will not be accepted.

Figure 3. shows the screen presented when correct answers were entered for the exercise in Figure 2. (An answer within 5% of the correct answer is accepted as being correct.) Note that all the information from the original screen is preserved along with the answers. Asking for a printout of the answer screen together with the related calculations makes a good homework assignment as well as a useful archive for the student.

If wrong answers are submitted, the correct answers are presented beside the incorrect submission. This gives the user a chance to check his/her own calculations. Because the exercises are at a basic level, usually knowing the right answer is sufficient to allow the student to do the problem over correctly. However, if the student cannot find a mistake the solution screen can be printed out and brought to an instructor for help. For both correct and incorrect answers the user has the opportunity to work another problem or go back to the home page.

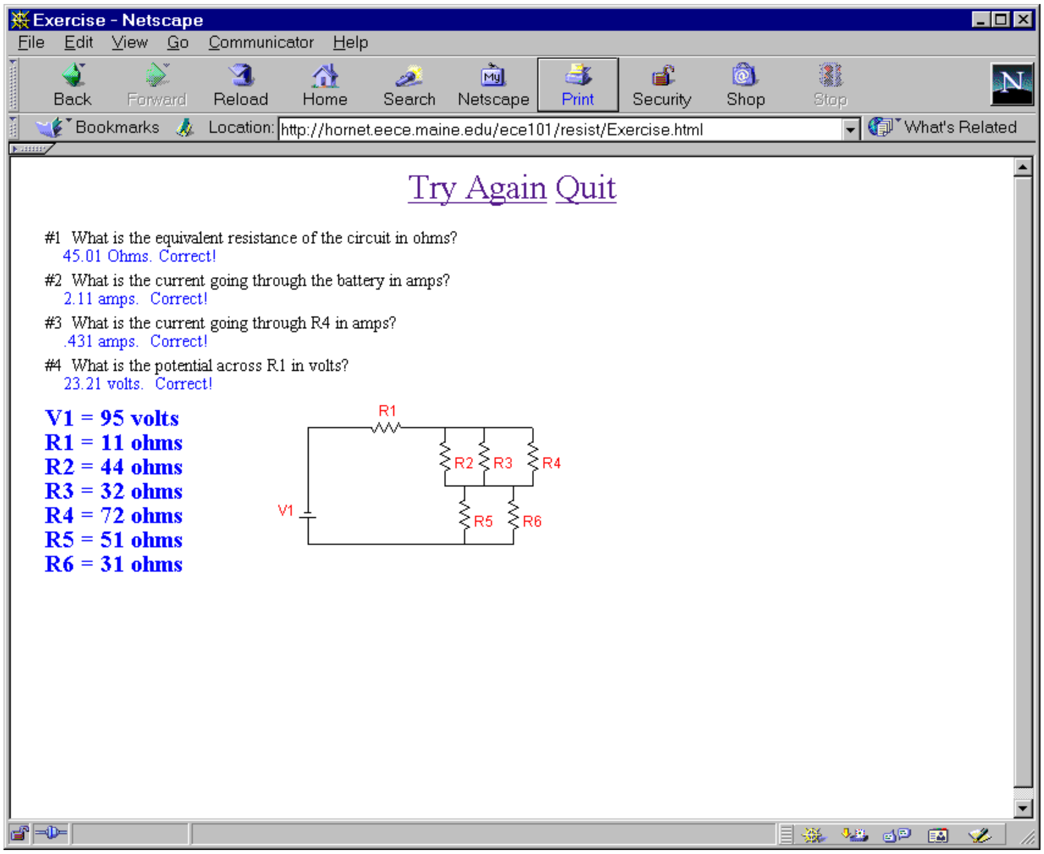

Figure 3. Screen seen after submitting correct answers for the exercise of Fig 2.

IV. RC Circuits

Similar to resistive circuit exercises, the RC circuit software chooses a prototype circuit (one of three), assigns random values to the components, and then asks the user to evaluate circuit parameters. In addition to voltages and currents, the user may be asked to evaluate charge, time constants, and the time it takes for a capacitor to charge or discharge between specified voltages. An example of an RC exercise is shown in Figure 4.

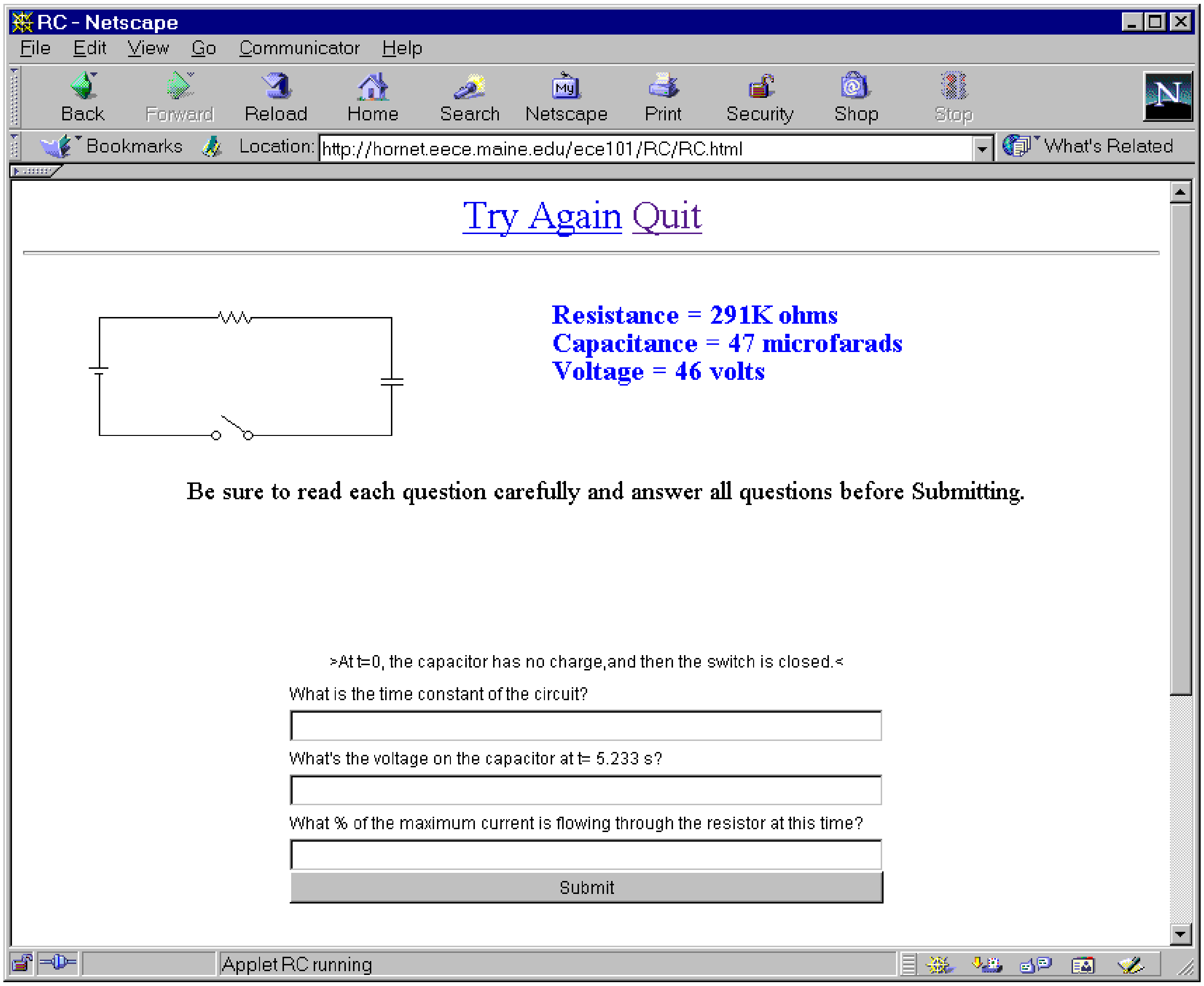

Figure 4. Typical screen seen by a user selecting an RC circuit exercise.

V. 555 Timer Exercises

The RC exercises lead naturally to a study of the 555 timer. The user will see a 555 timer configured in either monostable or astable mode with randomly assigned resistor and capacitor values. The user is asked to specify the mode of operation, the charging and discharging time constants, and the time for either a complete cycle if the 555 is astable or the width of the pulse if the 555 is in monostable mode. An example of an exercise involving a monostable 555 circuit is shown in Figure 5.

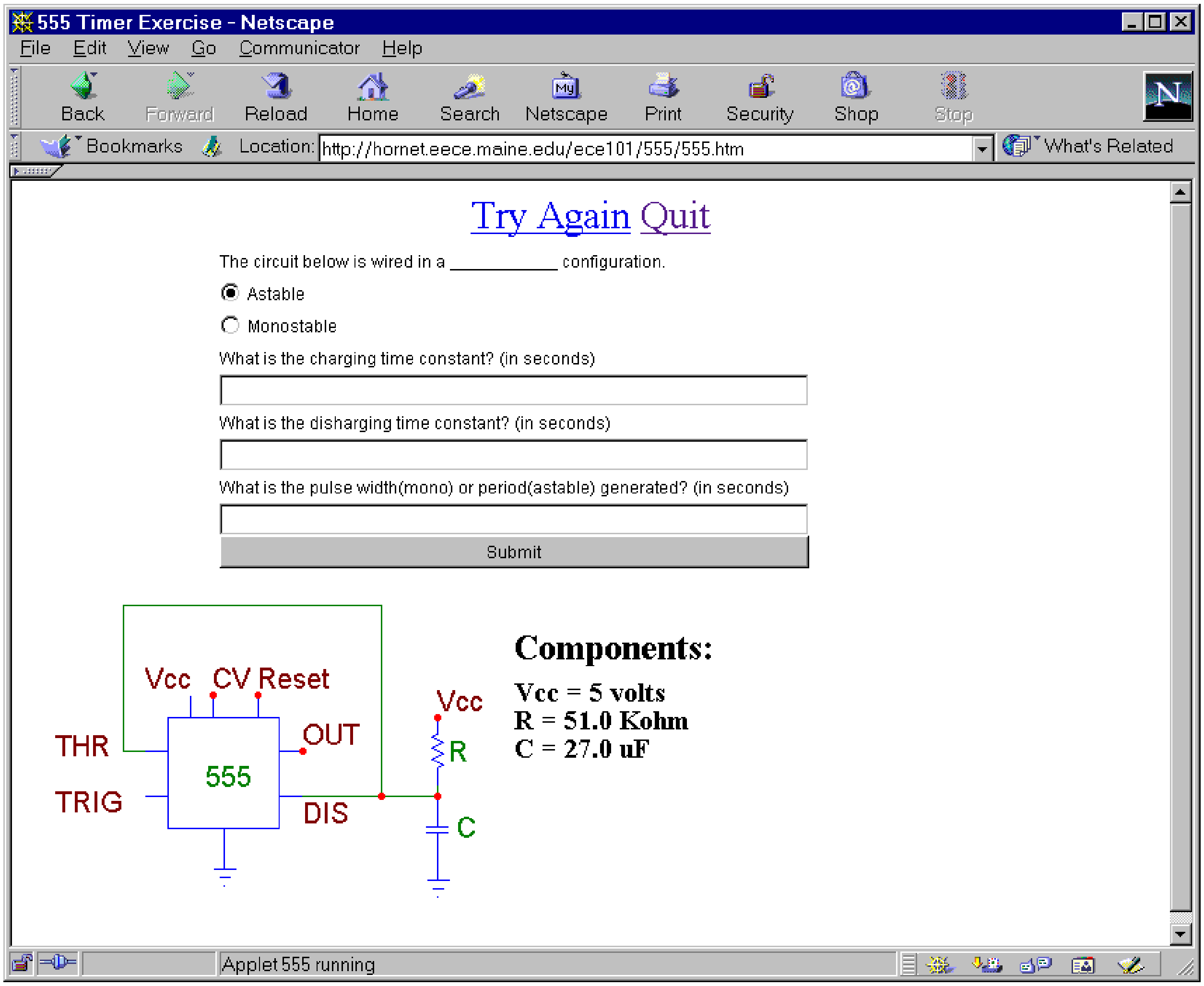

Figure 5. 555 Timer exercise showing questions for a monostable configuration. Note that the radio button defaults to the Astable setting and needs to changed for this case.

VI. Logic Circuit Exercises

Combinational logic circuit exercises present the user with a three-input Karnaugh map and ask for an equivalent logic circuit. The user then "builds" a hardware implementation of the Karnaugh map by dragging AND, Inverter, and OR gates from a palette onto a schematic area and connecting them. Figure 6 shows a typical exercise while Figure 7 shows one possible solution. Any combination of gates that satisfies the Karnaugh map is accepted; the program does not check for a minimum number of gates. When assigning homework problems, however, we ask for minimized solutions with the Karnaugh maps marked to indicate what inputs are being eliminated. If an incorrect answer is entered the user gets an opportunity to go back and edit the original submission. The program does not attempt to give a solution.

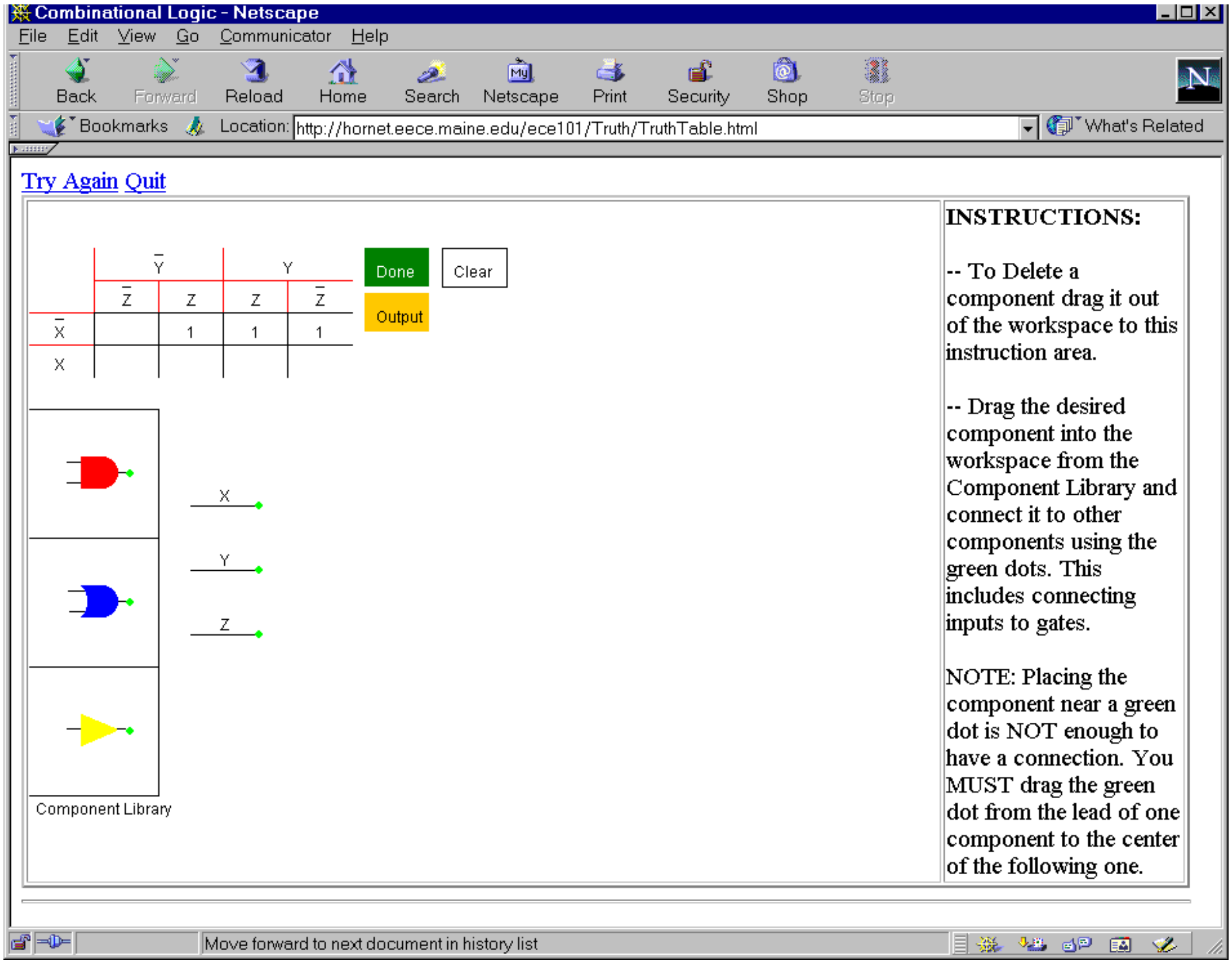

Figure 6. A typical logic circuit exercise.

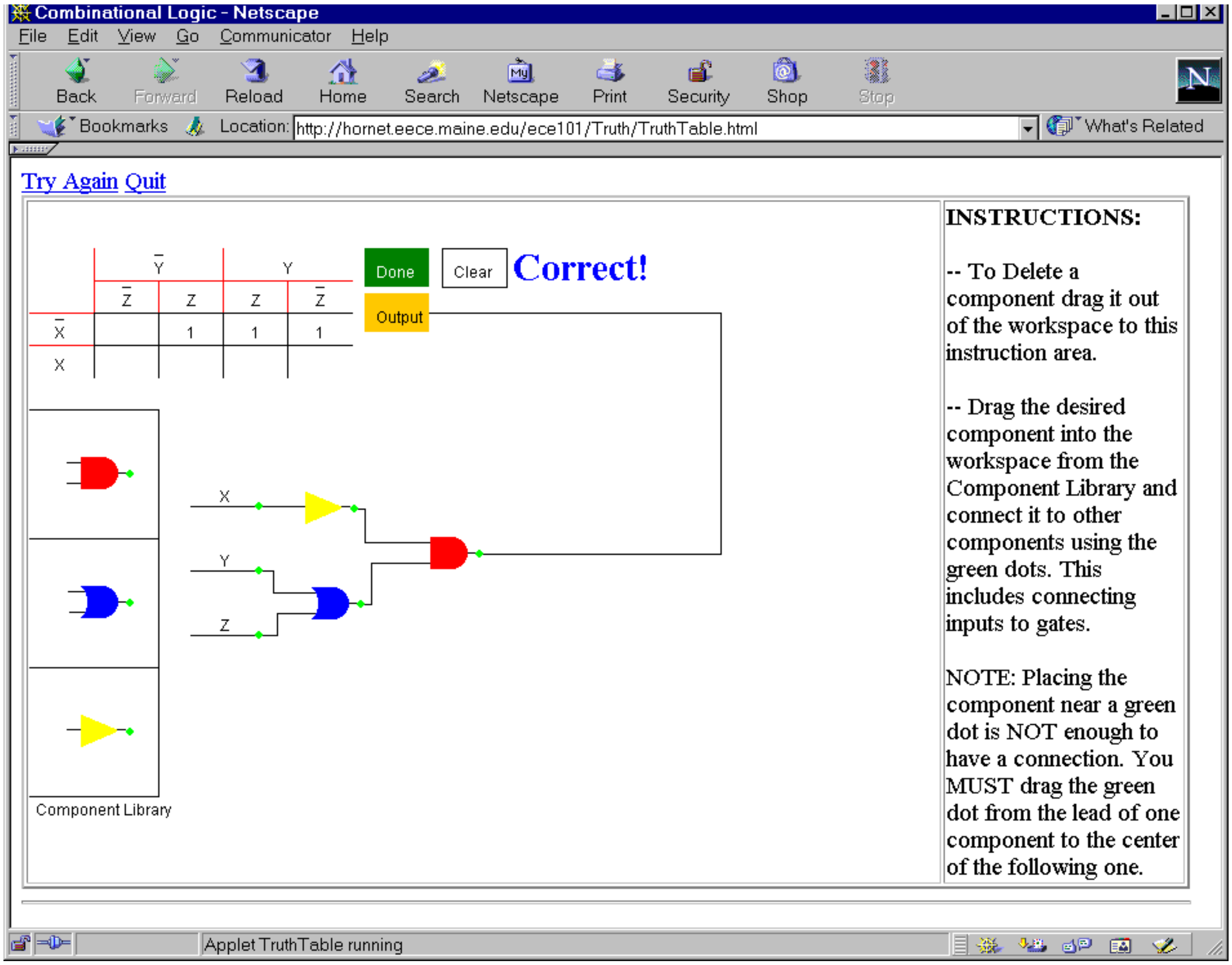

Figure 7. One solution to the logic circuit problem posed in Figure 6.

VII. Student Perceptions

The exercises have been in development for approximately three years with the Fall 2000 semester being the first semester where they were in relatively final form. Thus, it is difficult to quantitatively compare student performances from one year to another. However, Fall 2000 student evaluations were very favorable, for example, giving an average response of 4.4 to the following question.

	Not at all				Very
Overall, the exercises were helpful	1	2	3	4	5

Faculty agree that the exercises are helpful, particularly for students that are reluctant to ask for help or that need additional examples to really grasp the material. One student comment from the evaluations gives another view, “Great study tools to prepare for quizzes”.

VIII. Conclusion

A series of web-based exercises were developed to support an introductory electrical and computer engineering class for first-year students. These exercises give students an opportunity for asynchronous learning in the topics of resistive circuits, RC circuits, 555 timers, and combinational logic circuits. Student and faculty evaluations are very favorable.

Bibliography

1. I. Batarseh, Q. Zhang, R. Eaglin, Z Qu, P. Wahid, *Multi-Media Enhancement of the Electrical Engineering Core Course*. 2000 ASEE Annual Conference Proceedings, St. Louis, MO.
2. D. H. Linder. *Experimenting with Web-Based, Personalized Homework Assignments*. 1999 ASEE Annual Conference Proceedings, Charlotte, NC.
3. D. R. Johnson, *An Integrated Web Site for a Digital Logic Design Laboratory*. 1999 ASEE Annual Conference Proceedings, Charlotte, NC.

JOHN FIELD

John Field is the Henry and Grace Butler Professor of Electrical and Computer Engineering. He was ECE Department Chairperson for 12 years before stepping down in 1999. His interests are computers, education, and microprocessor applications.

ISAAC HORN

Isaac Horn is a sophomore at the University of Maine majoring in electrical engineering and is a Butler Scholar working in the ECE Department's Instrumentation Research Laboratory. In addition to working on the web-based teaching tools for ECE 101 he was a teaching assistant during labs and class work exercises for this course.

ROBERT REYNOLDS

Robert Reynolds is in the first year of an MS in computer engineering program at the University of Maine. He did the first work on these web-exercises almost three years ago. He currently works in the ECE Department's Intelligent Systems Laboratory