# Web-Based Tutorial Environment for Undergraduate Engineering Students

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ABSTRACT: *This paper describes the development of a web based tutorial environment for use by undergraduate students enrolled in an engineering program at Southern Illinois University, Carbondale. This tutorial environment is specifically targeted to illustrate the applications of mathematical techniques in a number of electrical engineering disciplines. The material is intended to help an engineering student gather a better understanding of the applications and techniques of mathematics as he/she progresses through the calculus sequence, linear algebra, complex variables, probability and statistics, and the electrical and computer engineering (ECE) courses such as, electric circuits, signal and systems, controls, and communications. The tutorial environment will: (a) Provide illustrative examples of applications of calculus, linear algebra, complex analysis, and probability and statistics. (b) Develop simulation programs in C++ and MATLAB to illustrate the applications. (c) Provide examples for several electrical engineering courses, such as, Electric Circuits, Signals and Systems, Control Systems, and Communications. (d) Provide web links for additional resources. The tutorial tools will enable students for (a) Setting up the necessary equations for solving an engineering application problem. (b) Adjustment of parameters and solution approach. (c) Interactive simulation of the problem using MATLAB. (d) Graphical observation and verification of the simulated solutions. The web material will be housed by the Engineering server and it should be made available to all SIUC students.*

## 1 INTRODUCTION

It has been the experience of teachers of electrical engineering and mathematics that the students look for application examples as a motivation for learning mathematical techniques. Certainly it is expected that a student is adequately trained in mathematical tools before he/she starts learning a particular engineering discipline. The accreditation board of engineering and technology (ABET) in no uncertain terms emphasizes the mastery of mathematics as a component of successful engineering education. We believe that a web-based tutorial environment can offer an additional tool for students to learn engineering applications simultaneously while they learn mathematical tools.

While many examples could be made available in the finished product, we mention here a few examples.

(a) Symmetric n-section resistive network resulting in a "difference equation". Setting up of the difference equation and its solution. Sketching the solution of a difference equation as a function of n, using MATLAB.
(b) RLC network in electric circuits leading to a "differential equation". Illustration of the stability concepts. MATLAB plots and solutions. Displaying many graphical illustrations.
(c) Convolutional integral as a tool in system analysis. Students have difficulty in understanding running integrals, where a limit of integration is a variable. Graphical illustration of the concept using animation.
(d) Sinusoidal steady state analysis of electric circuits.
(e) Function approximation and transforms. Fourier series, Fourier transform, discrete-time Fourier transform and fast Fourier transform (FFT).

(f) Transient and steady state response of feedback control systems. Simulations of feedback control systems using Matlab and Simulink.
(g) Stabilization and pole placement. PID control, lead and lag compensation, root locus and frequency response techniques.
(h) Applications of simple trigonometric identities in modulation/demodulation methods in communications engineering.
(i) Simple one-variable optimization problems in controls and communications.
(j) Plotting complex numbers. Bode and Nyquist plots.
(k) Application of "difference equation" and "differential equation" in "probability" computations-Gambler's ruin and Poisson distribution. Illustration of "random walk" and "Markov chains". Applications in communications networks.

## 2 IMPLEMENTATION OF THE WEB-BASED TUTORIAL

The objective of the project described in this paper is to develop a web based material for use by undergraduate students enrolled in an engineering program. This material is specifically targeted to illustrate the applications of mathematical techniques in a number of electrical engineering disciplines. Specific objectives include:

(a) Preparing illustrative examples of applications of calculus, linear algebra, complex analysis, and probability and statistics.
(b) Development of simulation programs in C++ and MATLAB to illustrate the applications.
(c) Providing additional examples for each of the ECE courses, such as, Electric Circuits, Signals and Systems, Control Systems, and Communications.
(d) Providing web links for additional resources.

To achieve these objectives, Matlab and Simulink are considered as the primary tools for the development of a user friendly tutorial environment. Matlab and many of its toolboxes, including Simulink, can provide the necessary engine and the graphical user interface (GUI) for an interactive tutorial environment. When necessary, C++ can also be used to develop appropriate MEX files for particular user-defined Simulink blocks. In our web based tutorial environment, the GUI is implemented using Java, JavaScript, and Hypertext Markup Language (HTML) technologies, which are supported by popular web browsers. Our choice of Matlab as the primary tool for our development is partly due to the fact that this software has become a standard simulation package in both industry and academia. In addition, Matlab has been integrated into our curriculum and, hence, our junior and senior students in the college of engineering at SIU-C are quite familiar with it. Moreover, There are many reference books and tutorial websites that include various worked out examples in Matlab with engineering applications [MESSNER, W.C. AND TILBURY, D.M., 1999] and [PALM, W.J., 2001]. Furthermore, Matlab's animation toolbox can be used quite easily to demonstrate mathematical concepts and engineering examples in animated cartoon-like graphics. In some cases this can be augmented with QuickTime and Java to provide more complex animation examples.

In our web-based tutorial, interactive learning will be made possible through a point-and-click user-friendly graphical user interface (GUI) with context-sensitive help at each level of the tutorial. Knowledge of computer or programming will not be required for the use of this tutorial. A proficiency testing will be implemented to incorporate active learning. Learning and proficiency testing will be implemented as follows:

- The tutorial will be divided into sections with increasing levels of difficulty.
- The tutorial sections will be arranged in the order of increasing level of interactivity.
- One can proceed to next level after (s)he correctly answers questions at the end of each section.

For the implementation, each page of the tutorial will consist of a section, with the questions to be answered shown at the top of the page followed by the interactive tutorial material. This way, the students will not passively scan through the tutorial pages, but will be motivated to understand the illustrated concept and answer the questions correctly in order to move to the next section. For each part, the tutorial will provide the students with immediate feedback after answering a question and with helpful explanation if they could not answer the question correctly. This active approach improves the students' learning by providing pertinent feedback to the students.

Particular efforts will also be made to incorporate visual animated educational tools to convey ideas and concepts throughout the tutorial. Visual educational tools are especially effective since our ability to analyze, capture, and recall visual information significantly outperforms our ability to do the same tasks using other types of sensory information.

At the present, we are in the process of developing this web based tutorial. Details of the implementation and illustrative examples will be provided at the conference.

## 3 CONCLUSIONS

This paper considers the development of a web based tutorial environment illustrating the applications of mathematics to many electrical engineering problems. By studying this web material, it is hoped that an engineering student would gather a better understanding of the applications and techniques of mathematics as he/she progresses through the calculus sequence, linear algebra, complex variables, probability and statistics, and the electrical and computer engineering (ECE) courses such as, electric circuits, signal and systems, controls, and communications. The web based material is intended to be housed by the engineering server and it would be made available to all SIUC students.

## ACKNOWLEDGEMENTS

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## REFERENCES

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