Session 2793

A Freshman Course in Computer Applications

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Abstract

This paper describes a new course designed for engineering freshmen to be taken in the second semester of their curriculum. The intent of the course is to enhance the engineering student's problem solving skills and to expose the students to the various branches of engineering. It replaces a traditional programming course involving the C or C++ programming language. The use of software such as MATLAB for problem solving in this course is described and the use of such a package in plotting graphs and solving engineering problems is stressed. The use of other software to solve electrical circuits, to simulate mechanical systems, to analyze data statistically, and to study environmental problems is also described.

Introduction

Wilkes University offers ABET accredited degree programs in electrical, mechanical, and environmental engineering. These majors have a common curriculum during the first three semesters of study. Students had been taking a 4-credit programming course involving C+ in the second semester. The new 3-credit course, here described, was introduced in the Fall of 2001 as an alternative to the existing course with the intent to expose our freshmen to the different software packages commonly used in industry. The packages used were MS Office, SYSTAT, CITYgreen, ANSYS, PSpice, and MATLAB. Faculty in each of the three programs were involved in developing and teaching the course. An explanation of the various aspects of the course follows.

Internet Applications and MS Office

The students are introduced to using an Internet browser and search engines to locate information and write a report using MS Word. For example, students are assigned to research one of three engineering processes (ball mill, screw pump, or steam turbine) using searchable keywords in an Internet search engine. Students are shown methods to use the search engines and how to evaluate the information that is found. It is emphasized that just because information was placed on the Internet does not ensure that the information is correct. Students are shown the meaning of the URL tag (.com, .org, .gov, .edu, etc.) and the class discussed the relative confidence in the information.

Students are asked to complete a written report using MS Word summarizing the information found from the Internet. This document is to be written by the student and not copied from the Internet. The report requires specific tasks to be completed. These tasks include creating a table of information, inserting a figure from the Internet, creating a flow chart, using the equation writer, and formatting the report text, pagination and appearance.

Students use MS Excel to create a spreadsheet model and use the Chart Wizard to create a graphical display. For example, they are provided monthly precipitation, water demand (with or without drought warnings), and climate data needed to create a water budget model for a municipal water reservoir. The water budget model is used to determine if drought warnings should be issued to the community, which requires that water conservation practices be followed until the water in the reservoir is replenished. Data is provided such that a drought warning is issued around mid-summer but then lifted in late autumn. The students are shown how to input values and complete the calculations within the spreadsheet. The mathematical function tools and in-cell tags (e.g. $) are explained. Students discuss the use of models to simplify the "real-world" and how models benefit society. They are shown methods to create different types of graphs (line, pie, and column) using the Chart Wizard. Each graph must have a specific format when presenting the results of the water budget model.

Introduction to Exploratory Data Analysis using SYSTAT

Two one-week sessions are devoted to statistical analysis. SYSTAT is used to conduct both graphical and numerical exploratory data analysis (EDA). For example, students are provided a data set of soil properties (e.g. effective size, sphericity coefficient, porosity) to analyze statistically. Students are shown how descriptive statistics and various plotting techniques can provide significant insight to the structure of the data, possible abnormalities (outliers), and general relationships that are present. Different plotting techniques are used to show the shape of the data set (frequency histogram and box plot) and indicate possible outliers. The four parametric distribution moments, mean, variance, skew and kurtosis, are computed and their significance discussed in class. In addition, non-parametric distribution moments (median and range) are computed and contrasted to the parametric distribution moments. The students are also introduced to the characteristics of a normal distribution and are asked to compare each data set to a normal distribution both numerically (skew = 0 and adjusted kurtosis = 0) and graphically (normal probability plot). Finally students created scatterplots to find any possible correlation between data sets. Students wrote a memo (using MS Word) addressed to the instructor summarizing their EDA of the provided data sets. The students are given a list of questions to answer to help structure what should be in the memo.

In the second session, graphical EDA and correlation analysis capabilities of SYSTAT are covered. As an example, students are provided with a data set of the chemical concentration of dissolved metal cations and total hardness from different well waters. They are required to analyze the relationship between variables in the multi-variant data set to the water's total hardness. The Pearson correlation coefficient is computed and is tested to determine if a significant correlation exists between the dissolved metal cation concentration and total hardness.

The students are introduced to the concept of the test confidence level and the meaning of the alpha error. The dissolved metal cations that are significantly correlated with the total hardness are used to create a multi-variant regression model to predict the total hardness. They are introduced to the meaning of the R^2 value (goodness-to-fit) and how Analysis of Variance (ANOVA) is used to determine if the model is significant. The class discussed the need for models and their uses in engineering applications. The students are introduced to the benefits and potential problems of using models. The students write a memo (using MS Word) addressed to the instructor summarizing their analysis and use the equation editor to write the computed model equation.

Engineering Problem Solving Using MATLAB

MATLAB was originally developed in the 1970s for applications involving matrices, linear algebra, and numerical analysis. Thus the language's numerical routines have been well tested and improved through many years of use. Its interactive environment allows one to manage variables, import and export data, perform calculations, generate plots, and develop and manage files for use with MATLAB. About four one-week sessions are devoted to teach MATLAB. Session one covered the basics of MATLAB, mathematical functions and operations, arrays and matrices, and plotting. Mathematical functions and operations include scalar arithmetic operations, complex numbers, exponential, logarithmic, trigonometric, and hyperbolic functions. Also, symbolic processing of algebraic functions is introduced. All the computations are done interactively and the results are lost once the person quits the program. This is avoided by writing script files. Session two covered the problem-solving methodologies, writing script files and function files, and relational and logical operators. The script files 'store' all the commands needed to execute a given problem. They can be run at any time and edited as desired. Function files are similar to subroutines; they perform a specific task and can be 'called' by the main program as needed. Session three introduced conditional statements (*if*, *else, elseif, while,* and *for*) and methods of debugging the program. Session four focused on applications. Assignments covered a wide range of topics such as, aortic pressure model in biomedical engineering, current and power distribution in resistors, batch distillation process for chemical and environmental engineers, flight of an instrumented rocket, earthquake-resistant building design, lift-to-drag ratio of an airfoil etc.,

Computer Added Engineering Software ANSYS

Students are introduced to Computer Aided Engineering (CAE) via the commercially available software ANSYS. Three one-week sessions are spent on this topic with the objectives to familiarize students with structural, thermal, and electromagnetic engineering problems and provide an overview of different solution approaches to the above problems. The importance of numerical solution techniques, computer modeling, and design are emphasized.

Students are introduced to ANSYS by modeling a cantilever beam with a concentrated load at the tip of the free end. This problem is physically modeled in the classroom using an aluminum rod and a weight that hangs at one end while the other end is clamped. For example, a 0.3175 cm thick aluminum rod of length 30.48 cm, and width 3.81 cm was considered. Three different loads of 9.81 N, 14.715 N, and 19.62 N were applied at the free end. The vertical deflection caused by each load was measured. Students then modeled this cantilever beam problem using ANSYS and noted that the computer generated results for deflections were very close to the experimentally measured values. For instance, the computer generated deflection at the free end of the beam for the 19.62 N load was 2.654 cm, which is very close to the experimentally measured value of 2.69 cm. Students are shown the importance of proper modeling to get accurate results. Modeling of cantilever beams using nodes and elements was also discussed. A simply supported beam with a concentrated load applied at the mid-length was presented. Students were asked to measure the vertical deflection at the mid-length, model the beam using ANSYS and compare the results. Finally, students were assigned a moderately complicated truss subjected to constraints such as deformation, loading, etc., and were asked to determine the cross-sectional area of the truss members using a trial and error technique.

In session two, modeling of a thermal system that involved one-dimensional conduction was discussed. A furnace wall, insulated pipe, and wall of a house were presented as examples that may be solved analytically or by computer modeling. A wall made of three different layers of known thermal conductivity with known outer temperature was assigned. Students were asked to model the problem using ANSYS to obtain the temperature at each inner layer juncture. Also, references were made to the convection and radiation modes.

In session three, modeling of basic magnetic system was discussed. A current carrying square loop was modeled to determine the magnetic filed of a point above the loop. The emphasis was on modeling and not on analysis.

Geographic Information Systems (GIS) and Applications Software

Environmental engineering is a dynamic profession where the primary goal is to protect human health and the environment. One of the tools available to environmental engineers is the computer model. Models can be used to simulate various scenarios, or they can be used to evaluate the potential environmental impact of a decision. In order to introduce freshman engineering students to the environmental engineering field, as well as the tools available for their use, a two-week computer utilization module was developed. The software chosen was CITYgreen developed by American Forests (Washington, DC). CITYgreen is software for mapping urban ecology and measuring the economic benefits of trees, soils and other natural resources. It is an application for ARCVIEW (ESRI, Redlands, CA), desktop Geographic Information Systems (GIS) software.

The students are given an overview of how the software operates and how it is applied – they are shown how to digitize a study area, how to input data, and how to analyze and model various scenarios. After the students become familiar with the basic operations of the software, they are given a "real-world" problem and asked to act as consultants. In this exercise, the students are to use the CITYgreen software to evaluate different scenarios for property development, and then make recommendations to a city government for implementation.

Electrical Circuit Modeling Using PSpice

A one-week session was devoted to this topic. Analysis of electrical circuits is a common problem addressed by students of all disciplines. Simple electrical circuits are analyzed using basic electrical circuit analysis techniques. The same circuits are modeled using the software PSpice and the results are compared. The ease with which element values can be changed to analyze different circuits is emphasized. Methods to obtain the frequency response of simple AC (alternating current) electrical circuits are outlined. Students are encouraged to build a DC (direct current) circuit in the lab and compare the experimental results to the simulation results. Though complex cases involving controlled sources and electronic devices are not considered, students are expected to have gained sufficient knowledge to model and analyze such circuits later in their study without much difficulty.

Course Assessment

This course has been offered only once and is likely to be modified based upon the feedback from students and faculty. The students are surveyed at the end of the course to assess how the course objectives are met. In addition, specific course outcomes developed using the Accreditation Board for Engineering and Technology (ABET) Criteria 2000 program outcomes (a through k) were assessed. Based on one year of data, it appears that students would like more examples using the discipline specific software (PSpice, ANSYS). However, results indicate that students did not see the need to learn software from disciplines other than their own. When introducing software, we plan to provide more emphasis to how the software would be useful for all engineering disciplines. In addition, the results are mixed for the desire to have assignments using MS Word and Excel. Some students thought more sessions using Word and Excel would be needed while others thought it was a waste of time. This is likely a result based upon the individual student's experience using these software programs. Students who have a lot of experience using these programs may not find these sessions useful.

Conclusion

A new course for engineering freshmen in computer applications has been described. This course is designed to integrate different computer software programs with a focus on their use in the engineering profession. Faculty from the mechanical, electrical, and environmental engineering programs developed and taught the course with the objective that the students would observe examples from the different engineering professions. A common theme throughout this course was the use of computer software to develop and use models. These models were used to analyze and evaluate systems of varied size from physical objects (e.g. power distribution in resistors, thermal conductivity of a wall, loads on a cantilever beam) to large-scale systems (e.g. water availability from a reservoir). By introducing statistical analysis, it is hoped that while students are using models they will start to recognize the uncertainty and error inherently within the model's results.

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Biographies

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