AC 2009-508: DEVELOPING AN ENGINEERING AND TECHNOLOGY FUNDAMENTALS COURSE

Harry Franz, University of Houston, Downtown

Harry Franz is an Associate Professor in Control & Instrumentation and Fire Protection Engineering Technology at the University of Houston Downtown. He is a P.E. and member of the NSPE. He is a coauthor of an electrical engineering book and is a national board member of Tau-Alpha-Pi.

Recayi "Reg" Pecen, University of Northern Iowa

Recayi Pecen is an Associate Professor & Program Coordinator of Electrical Engineering Technology at the University of Northern Iowa.

Developing an Engineering & Technology Fundamentals Course

Abstract

The purpose of this paper is to describe the development of an up-to-date engineering and technology fundamentals course required for all engineering technology students in the University of Houston Downtown Bachelor of Science in Engineering Technology degree programs. The course is required for students that major in the Structural Analysis Design, Fire Protection, and Control & Instrumentation degree programs. The goal of the course is to impart an understanding of engineering and technology fundamentals. This includes the use of computer basics of Microsoft Office, LabVIEW and Multisim. The students also complete a group project using various software packages. The focus of this paper is on the teaching techniques and the subjects presented in the course. The varied topic choices for the student project work are also discussed.

Many engineering and technology programs have added and deleted a first year course that presents the fundamentals of engineering and technology. This type of course is usually added when the students entering an engineering technology program are found to lack the necessary preparation for the program courses. On the other hand, this type of fundamentals course is often deleted when programs are streamlined to reduce the total number of required program credits.

Learning strategies and teaching methods used in the fundamentals course are discussed. To make the course topics seem easier a variety of methods are used. These methods include linear and non-linear proportion methods, and short-cut methods.

Introduction

The goals for the Engineering and Technology Fundamentals course students are to obtain knowledge of standard engineering and technology methods, and learn software tools for applications. The knowledge of software gained in the course is used for technical report writing, project presentations, graphic visualization, engineering computation, and effective communication. Note that the students are not required to have previous knowledge of electrical circuits, digital logics, analog concepts, or software packages used in the course. The students ideally are first year students that take the course before any other engineering and technology courses, but often transfer students from higher levels take the course. In addition, the students come from varied backgrounds of diverse education and work experience. The students, nevertheless, smoothly work in teams on the course assignments and help each other learn the required topics.

Background

The students in the course have various levels of experience and academic backgrounds. The students come from a variety of high schools, two-year colleges, and transfer from four-universities. To assure all incoming students have the latest current skills needed, an engineering and technology fundamentals course has been added as a requirement for all of the University of Houston Downtown Engineering Technology programs. All students must take the course or must have previously taken courses that cover the various topics of the fundamentals course.

The Engineering and Technology Fundamentals course contains "an overview of techniques and fundamental principles used in engineering, science, and technology. Topics include dimensional analysis and units, measurements, representation of technical information, problem solving, and an introduction to selected science and engineering topics" [1]. The course also contains fundamental concepts and principles that are used in specific designs for real-world system applications. In addition, the course contains demonstrations of computer simulation of electrical circuits, spreadsheets, digital and analog control systems, and vectors with applications.

Details of the Engineering and Technology Fundamentals subjects include: course study for success; ethics; sources and reliability of information; engineering communication formats; fundamental dimensions and units; measurement error, accuracy, precision, and significant digits; length, time and other parameters; vectors and moment of force applications; nominal size vs. actual; graphs & coordinate systems; area, volume, and area moments; mass and related parameters; force and related parameters; statics; electricity; and related parameters.

The Engineering and Technology Fundamentals course also contains the following subjects: basics of serial circuits, parallel circuits, and combination circuits; basic digital logic gates and circuits; analog functions and circuits; and vector topics that include vector rectangular and polar conversion, vector arithmetic and vector applications for moment of force.

Methodology

Topics of the course are made simpler and easier to digest through the use of short-cut problem solving methods. The time required for coverage of each topic is reduced and consequently more topics can be covered in the overall course time allotted. The use of these methods allows assignment of more substantial student projects.

In addition, the use of these problem solving methods allows coverage of topics that may appear too advanced for a fundamentals course. The topics include vector math and an introduction to vector applications. The vector applications include use of vectors in statics and polyphase electric power systems.

The current Engineering and Technology Fundamentals course can be contrasted to a similar type course from previous times that also gave the basics of engineering and technology. The previous type course, however, did not have as much if any software that was user-friendly. A valuable tool for "learn-by-doing" was missing. The feeling of accomplishment that gives the student confidence and the desire to carry on was often missing in these past courses. The previous courses were often excessively replete with rote learning methods. The "fun-by-doing" factor was not present. While taking these past type courses, many students decided that the study of engineering and technology was not the path to be taken.

Basic Computer Skills

Basic Microsoft Office computer skills are covered in the Engineering and Technology Fundaments course. These include Word, PowerPoint, Outlook, and Excel.

Circuits

Basic circuits are learned through the use of simulation software. The concepts of serial, parallel, and combination circuits are learned by building examples. In this process examples are given by the instructor for the students to follow. The side-by-side learning of both the software and circuit concepts progresses from one example to another that is more advanced. The particulars of the software used for the electrical circuits are given later in student examples that follow.

Digital Logic

The fundamentals of digital logic are given starting from the basic gates on through combination logic circuits. The AND, OR, XOR, NOT, NAND, NOR, XNOR functions are covered. The logic functions are presented in a variety of ways. First logic functions are given using sentences containing everyday logic examples. Next truth-tables, Boolean algebra functions, and logic diagrams are given. Finally, the digital logic functions are learned by using software that has input controls, functions, and output indicators. A course handout on logic systems basics is also used by the students. The particulars of the software used for digital logic are given later in examples that follow.

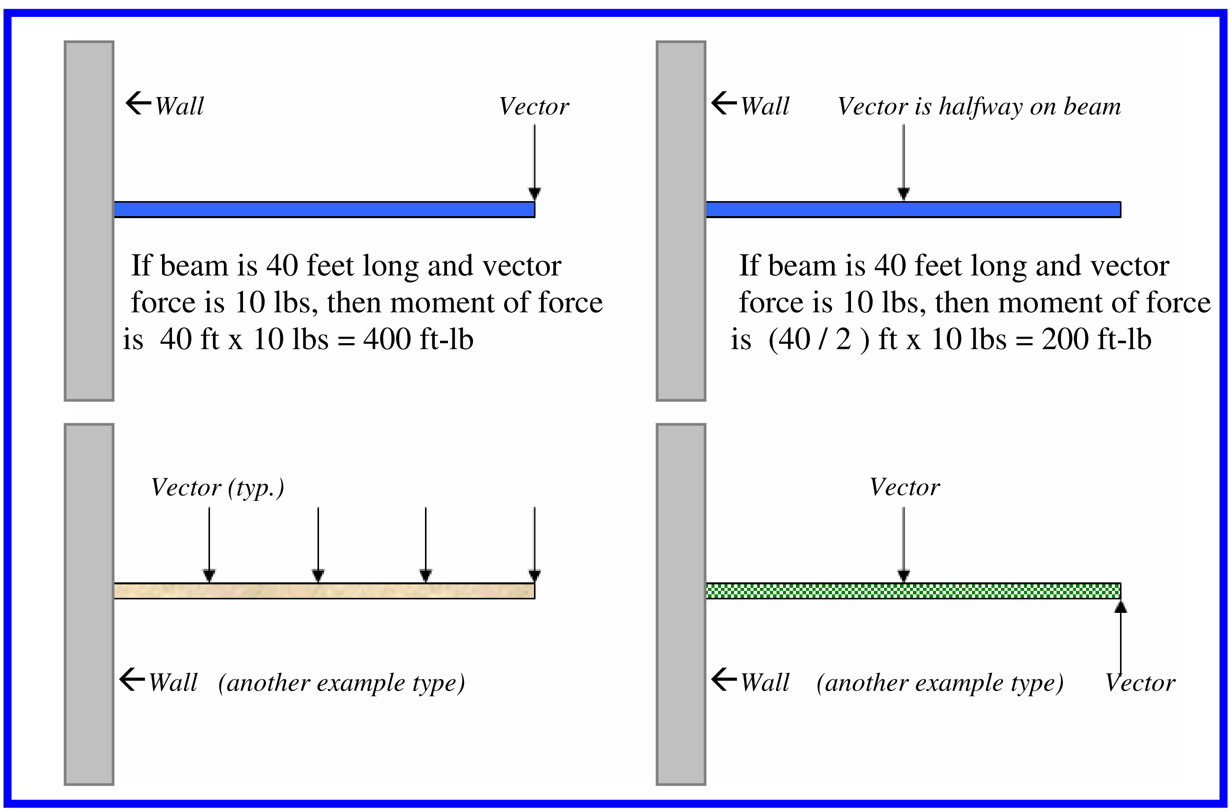
Analog Concepts

Basic concepts of analog functions and devices are presented. An example is given that uses a thermometer which feeds analog data to a comparator which compares the data to a desired set point. The greater-than function is used for comparison and if the data from the thermometer is greater than the set point value an alarm is activated. The particulars of the software used for the analog concepts are given later in examples that follow.

Vectors

The basic concepts of vectors are given. Magnitude and direction of a vector are discussed. A vector is compared to a scalar. The polar form and rectangular forms of the vector are given. Methods to convert vectors from one form to another are presented. The basic concepts of vectors are also taught by using north, south, east, and west points of a compass. The basic vector arithmetic operations for adding, subtracting, multiplying and dividing vectors are also used. In addition, the concepts of using vectors for moments of force are given. Shown in figure 1 are types of examples for vector forces on a beam attached perpendicular to wall.

Figure 1. Structural Design Example: Types of Vector Forces on a Beam



Shortcut Methods

The use of shortcut methods saves time and gives confidence to students. Indeed, students must learn to plug values into complex formulas and obtain correct results. The students, however, typically can better comprehend a problem by using a short-cut method than just “plugging and chugging” numbers for complex formulas. Simple methods that use linear and nonlinear proportions are utilized. Linear proportional and square proportional methods are used to allow a student to obtain a correct answer by using known values and making a minimal computation. There is a smaller chance for a mistake using this method rather than doing all calculations from scratch with many steps. Two student examples are shown. Note both are for figure 2.

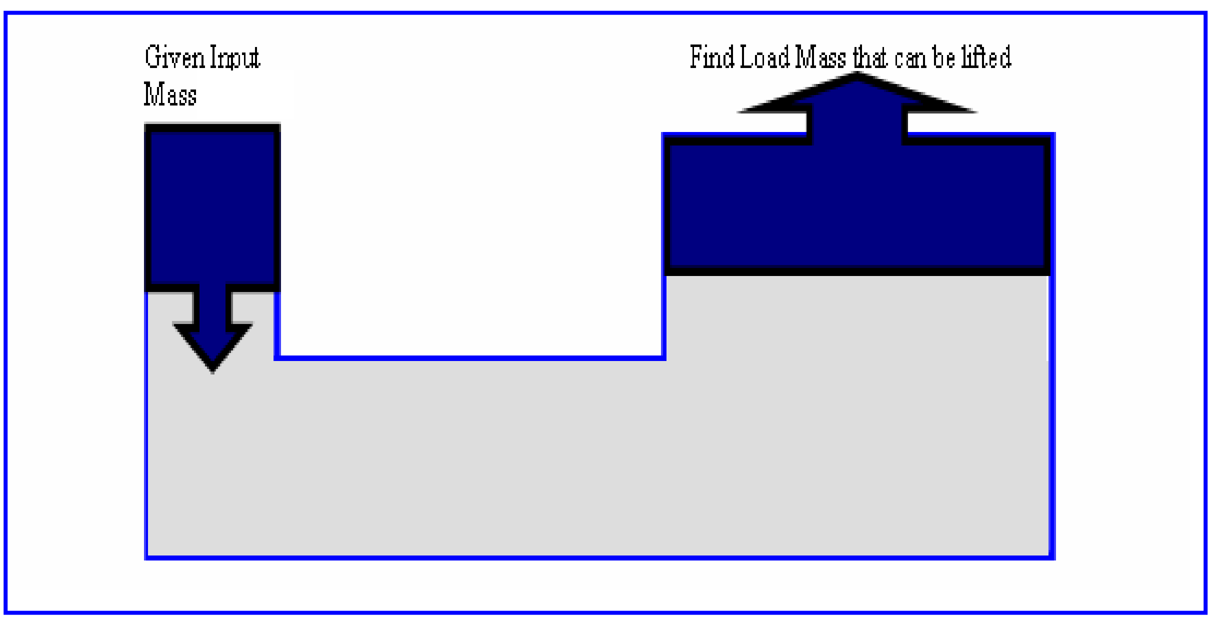
Student Example-A: Linear proportional method for a hydraulic system (reference figure 2).

Given input mass= 10 kg and input area=12 cm^2; load area = 120 cm^2. Find load mass that can be lifted. Force is proportional to area and load mass area is 10 times input area.
The load that can be lifted is 10 x 10 kg= 100 kg.

Student Example-B: Nonlinear proportional method for a hydraulic system (reference figure 2).

Given input mass= 50 kg and input area radius=2 cm; load radius= 6 cm. Find load mass that can be lifted. Force is proportional to area and area is proportional to the square of the radius. Load mass radius is 3 times input radius & the load mass that can be lifted is 3^2 x 50 kg= 450 kg.

Figure 2. Typical Hydraulic System



Software Used in the Engineering and Technology Fundamentals Class

The course software has been found to be a valuable learning tool. The software includes Microsoft Office, circuit simulation software, and LabVIEW. The initial task is to teach the basics of the course software and use the various aspects of the software to teach the course topics. The various software packages are also used to create a basis for teaching more complex concepts. The strategy is to have students learn the software basics and then apply the software to real-world problems. This strategy allows a creation of a "learn-by-doing" method which is used extensively for all of the course concepts, exercises and projects.

Circuit simulation Software

The electrical circuit basics are taught using circuit simulation software that includes Multisim / Electronics Workbench. The students learn only the basic symbols shown in figure 3 which are respectively: ground, DC voltage source, resistor, ammeter, voltmeter, and multimeter. The series circuit and the parallel circuit are shown respectively in figure 4. Students build and apply circuits in software exercises.

Figure 3. The Basic Circuit Symbols Used in the Course for Series and Parallel [2]

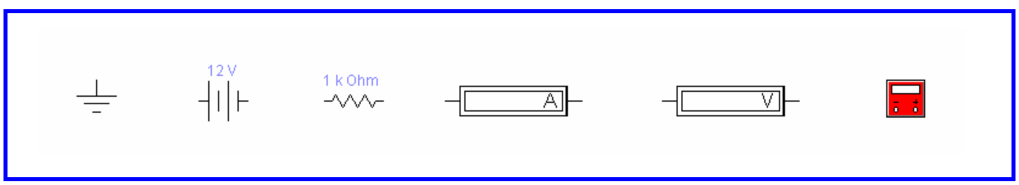
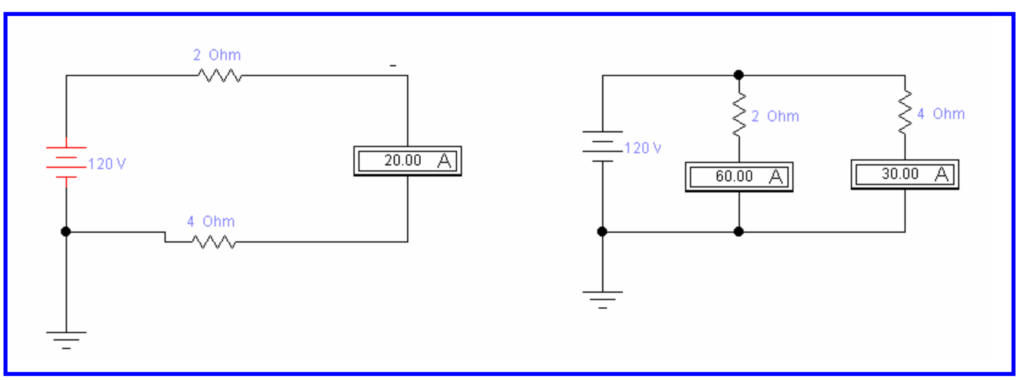


Figure 4. Basic Student Examples for Series and Parallel Circuits



Digital Logic Software Used for Fire Protection Fire Alarm System

The digital logic basics are taught using only the LabVIEW software logic gates shown in figure 5. The gates are used to build an Alarm Panel for a Fire Signature Detection & Alarm System project shown in figure 6. Figure 7 shows the logic diagram. If there is either smoke or high-heat then the local alarm is activated. If there is both smoke and high-heat then the general alarm is activated and the local alarm is deactivated. The logic is taught by having the students build and apply the gates in an exercise.

Figure 5. The Basic Logic Gates Used in the Course [3]

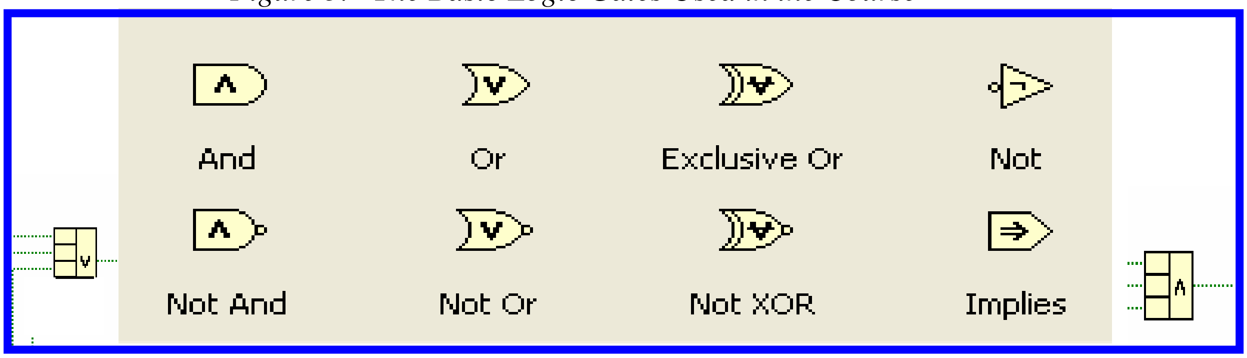


Figure 6. LabVIEW Panel Views of Fire Protection Fire Alarm System

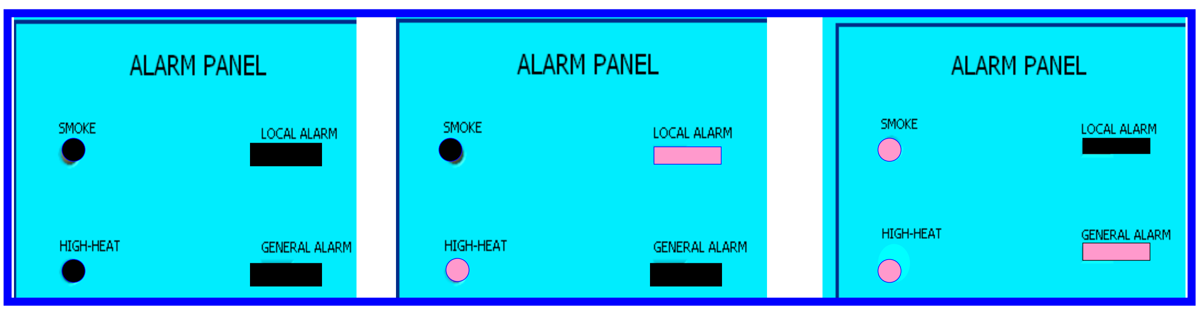
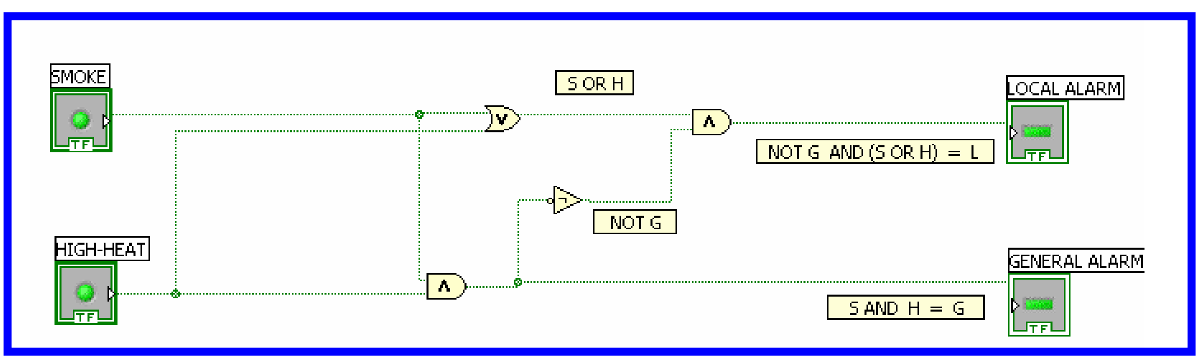


Figure 7. LabVIEW Logic Diagram View Logic Circuit for Figure 6



Analog Function Software Used for Fire Protection Heat Detector

The basic analog functions are taught using only the LabVIEW software items figure 8. The functions are taught by having the students build and apply an analog example. In the heat detector circuit for fire protection shown in figure 9 the analog data from the thermometer and set point value are compared, and if the thermometer is greater than the set point the warning light comes on.

Figure 8. The Lab VIEW Symbols Used for Basic Comparison of Analog Data [4]

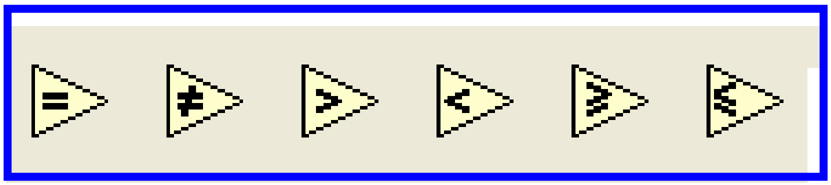
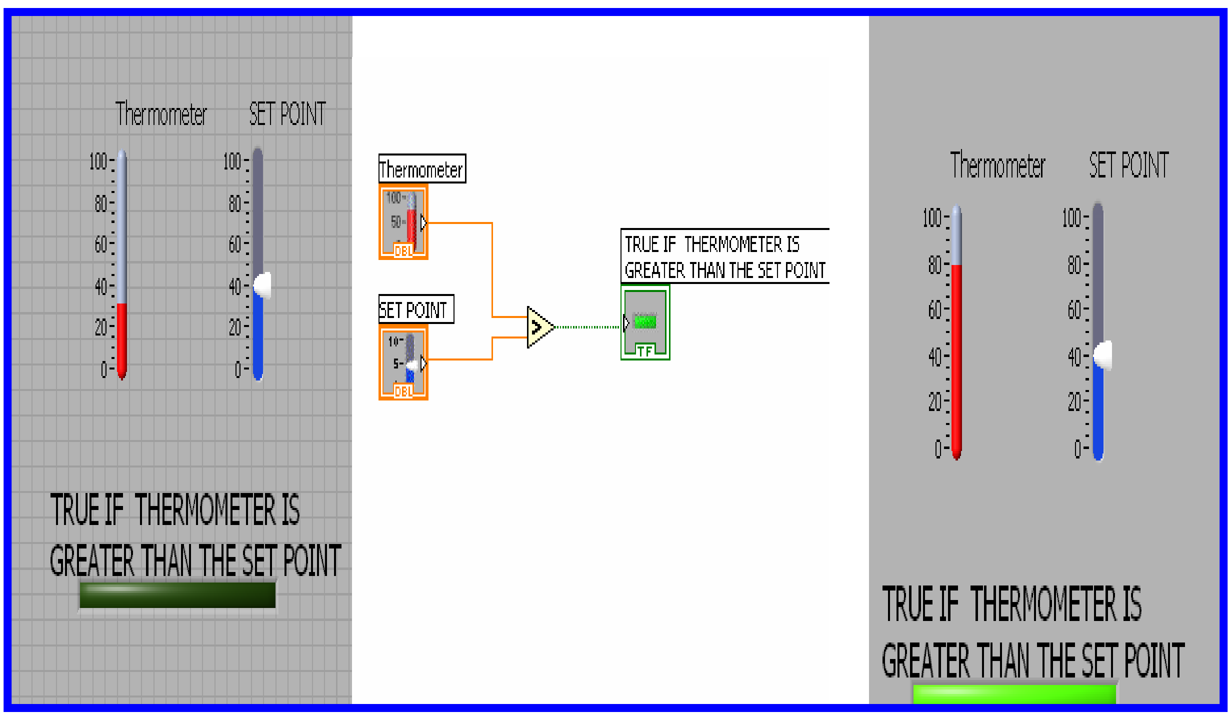


Figure 9. Lab VIEW Basic Analog Function for Fire Protection Heat Detector



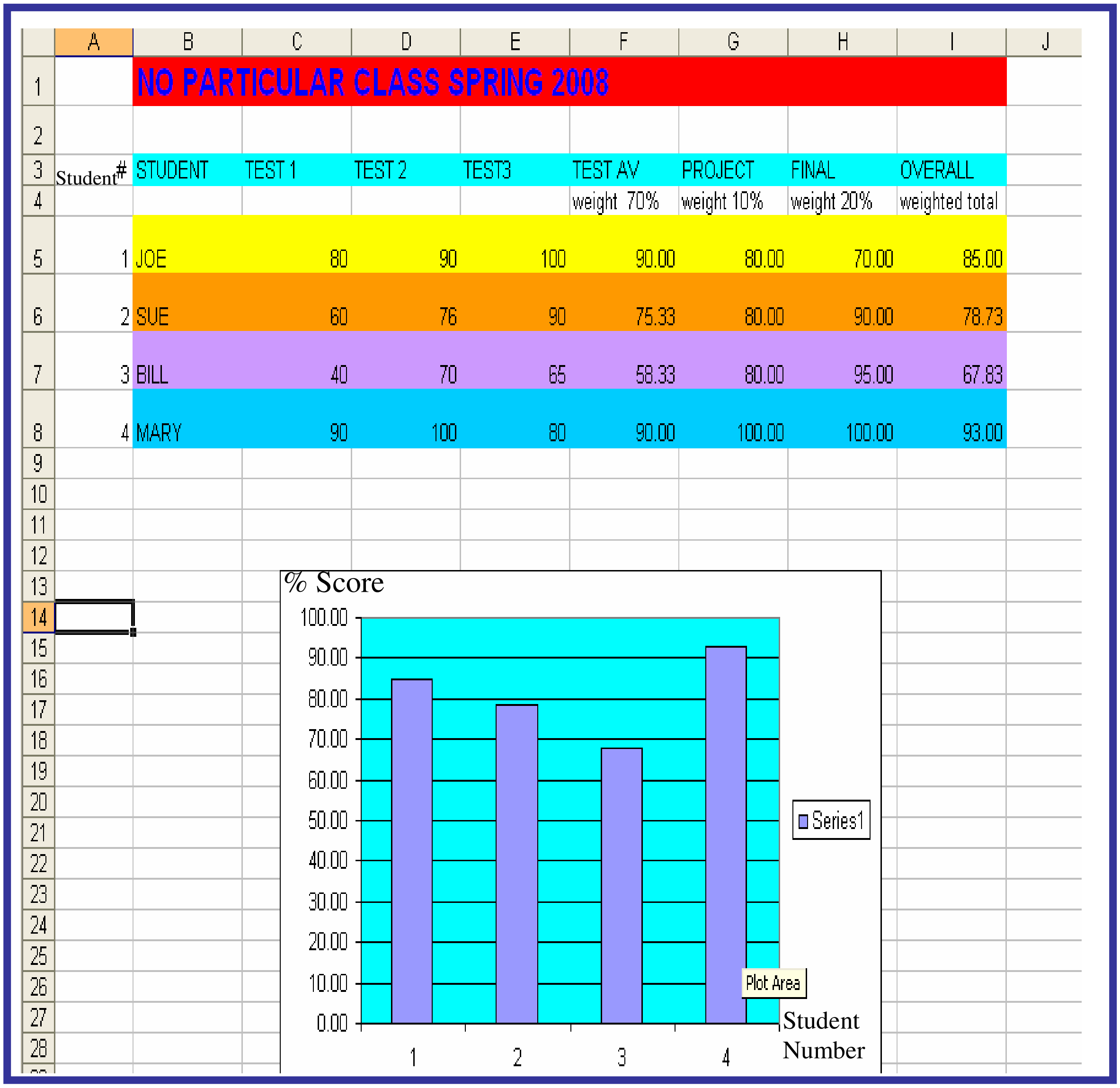
Description of the Engineering and Technology Fundamentals Student Course Projects

The students work individually on basic learning exercises and work in groups for the overall course projects. The course projects that follow use Microsoft Office Excel and LabVIEW.

Student Excel Project for Calculation and Record of Hypothetical Class Grades [5]

Figure 10 shows the class has student numbers 1, 2, 3, 4 where each student has taken three tests. The test mean average is calculated where each test has equal weight. The test average, project grade, and final exam score are all weighted, and the overall weighted average for the total grade is calculated. Also shown is a bar graph of percent overall scores for the students.

Figure 10. Hypothetical Class Grades Project



NO PARTICULAR CLASS SPRING 2008

Student#	STUDENT	TEST 1	TEST 2	TEST3	TEST AV	PROJECT	FINAL	OVERALL
					weight 70%	weight 10%	weight 20%	weighted total
1	JOE	80	90	100	90.00	80.00	70.00	85.00
2	SUE	60	76	90	75.33	80.00	90.00	78.73
3	BILL	40	70	65	58.33	80.00	95.00	67.83
4	MARY	90	100	80	90.00	100.00	100.00	93.00

Control & Instrumentation Student LabVIEW Project: Automatic Motor Control [6]

The system of figure 11 has three motors A, B, C, where motors A and B both normally run. If either A or B stops, then motor C automatically starts to replace the stopped motor so that two motors will run. The control modes are: “normal” for motors “A” and “B” running; “trouble” if standby motor C starts up to replace either motor A or B; and “alarm” if two motors do not run. Note interlocks prevent all three motors from running. The logic diagram is shown in figure 12.

Figure 11. Motor Control Panel View States: Normal; Trouble-A; Trouble-B; Alarm

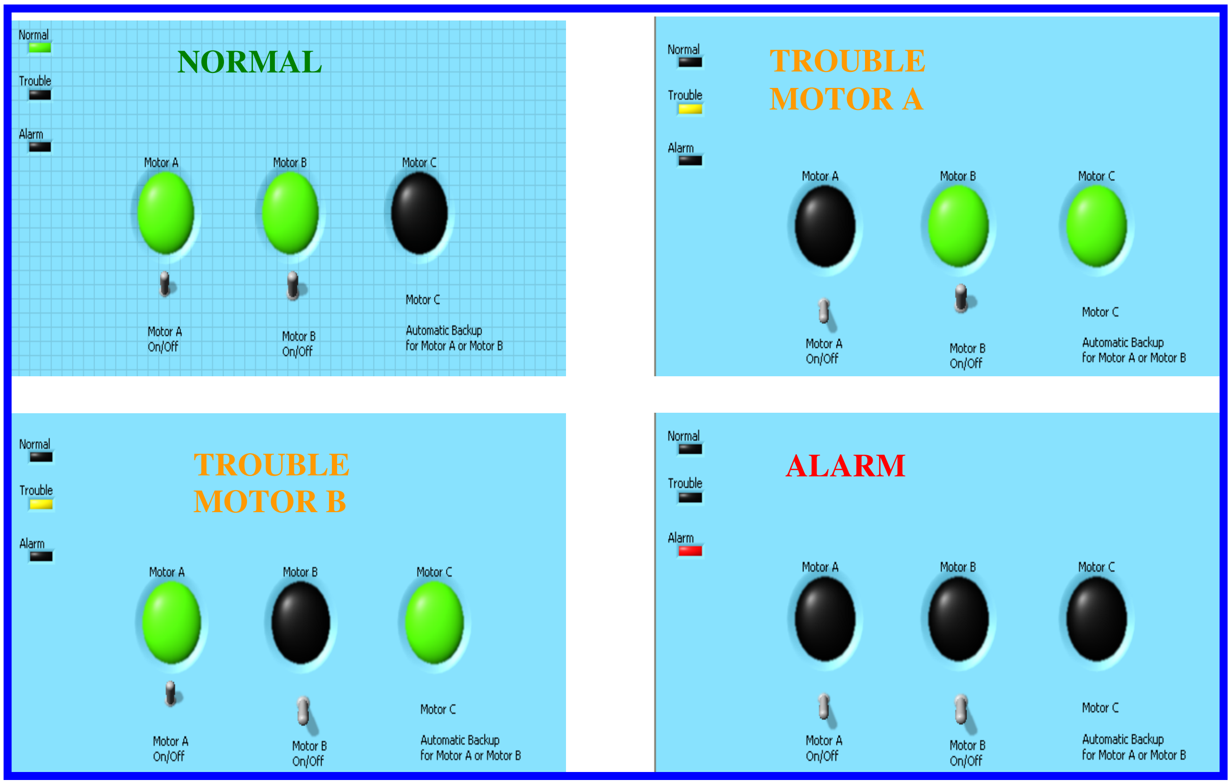
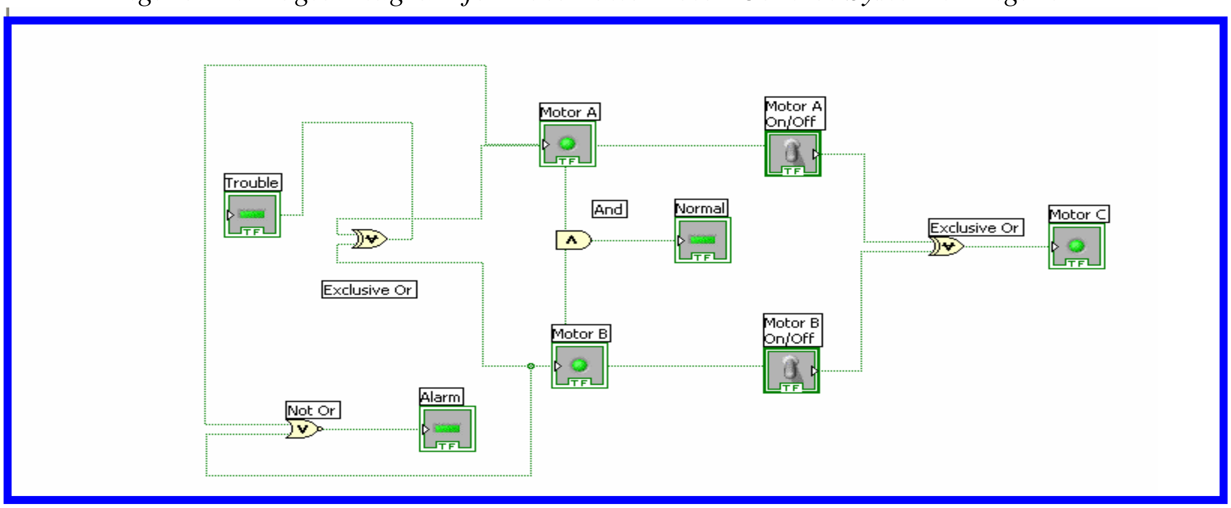


Figure 12. Logic Diagram for Automatic Motor Control System in Figure 11



The fire alarm system is shown in figure 13. The modes are: "normal" for no detection; "local alarm" for a single fire signature detected, and "evacuation" for multiple fire signatures detected. Figure 14 shows the logic diagram for the fire detection and alarm system.

Figure 13. Multiple Fire Signatures Detected and Evacuation Alarm Panel View

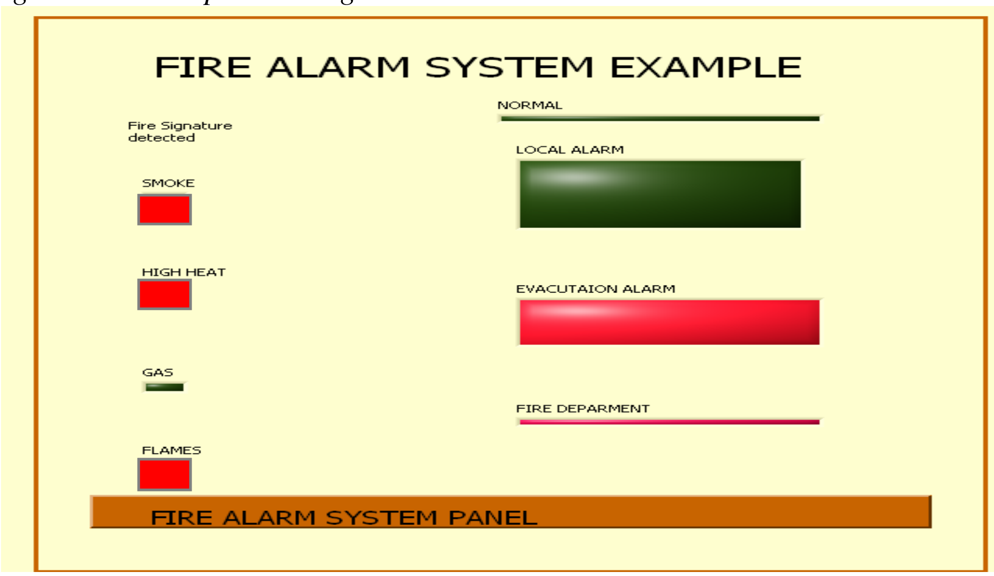
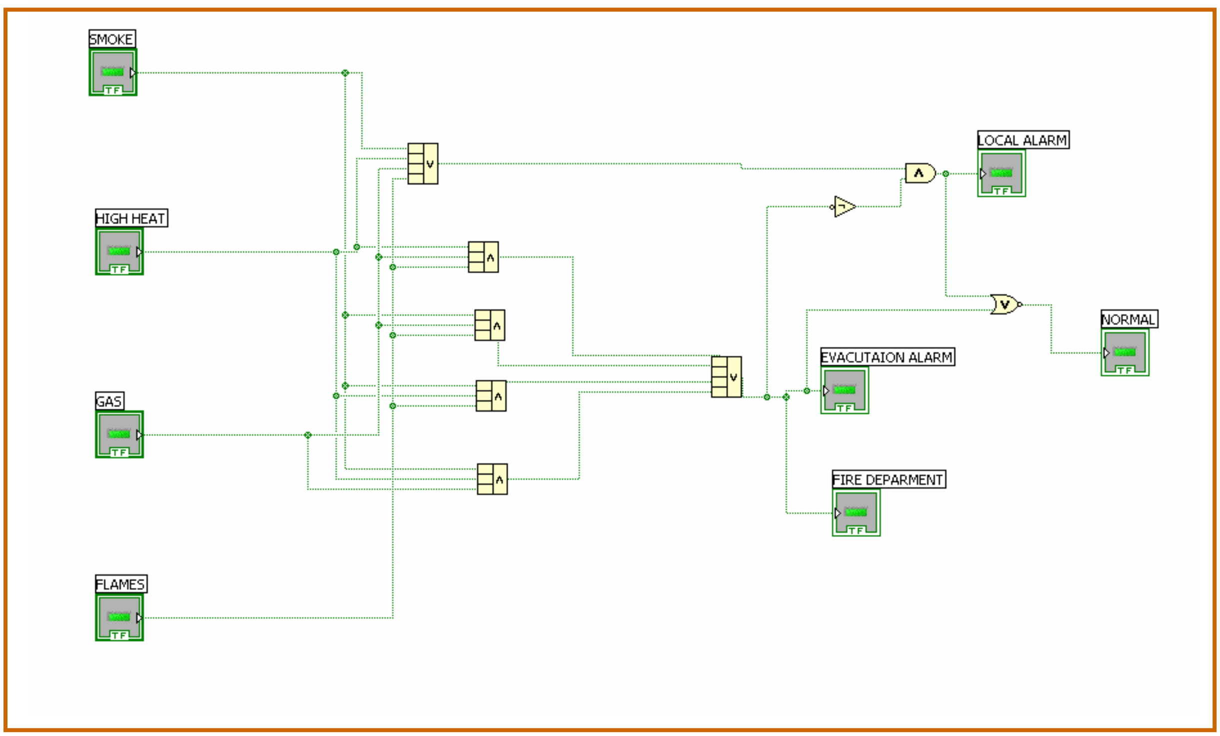


Figure 14. Logic Diagram for Fire Detection and Alarm System in Figure 13



Student Excel Project: Rating and Comparing Automobiles [8]

A table of automobile data is shown in figure 15. Performance data is given for acceleration, braking, cornering, and top speed. Horsepower and torque are included. In addition, purchase price, fuel efficiency, and insurance costs are given. For each category a ranking of the cars is determined. Buttons when pushed show car data or delete car data, and give images of each car. In addition, an overall ranking is determined and a button displays the overall winner.

Figure 15. Student Excel Project for Rating and Comparing Automobiles

Show Chart | Delete Chart | Images

	1st Place	2nd Place	3rd Place	4th Place	5th Place	6th Place	7th Place	8th Place	9th Place
Acceleration	Mustang Shelby	BMW M3	Chevy Corvette	Nissan 350Z	Prosche Boxter	Mazda RX-8	Cadillac CTS	Honda Civic CI	Volkswagen GTI
	4.5 Seconds	4.6 Seconds	4.7 Seconds	5.1 Seconds	5.1 Seconds	6.2 Seconds	6.3 Seconds	6.7 Seconds	7.2 Seconds
Braking	BMW M3	Cadillac CTS	Mustang Shelby	Mazda RX-8	Nissan 350Z	Porsche Boxter	Volkswagen GTI	Chevy Corvette	Honda Civic SI
	100 Feet	109 Feet	110 Feet	112 Feet	117 Feet	119 Feet	122 Feet	126 Feet	128 Feet
Cornering	Mazda RX-8	Nissan 350Z	Volkswagen GTI	Porsche Boxter	Mustang Shelby	Honda Civic SI	Cadillac CTS	BMW M3	Chevy Corvette
	17.4 Feet	17.7 Feet	17.9 Feet	18.2 Feet	19.5 Feet	35.6 Feet	37.9 Feet	38.4 Feet	39 Feet
Fuel (City)	Volkswagen GTI	Honda Civic SI	Porsche Boxter	Nissan 350Z	Mazda RX-8	Cadillac CTS	BMW M3	Chevy Corvette	Mustang Shelby
	22 MPG	21 MPG	20 MPG	18 MPG	18 MPG	16 MPG	15 MPG	15 MPG	15 MPG
Fuel (Highway)	Honda Civic SI	Volkswagen GTI	Porsche Boxter	Chevy Corvette	Nissan 350Z	Cadillac CTS	Mazda RX-8	BMW M3	Mustang Shelby
	29 MPG	29 MPG	28 MPG	25 MPG	25 MPG	25 MPG	24 MPG	22 MPG	21 MPG
Horse Power	Mustang Shelby	Chevy Corvette	BMW M3	Nissan 350Z	Cadillac CTS	Porsche Boxter	Mazda RX-8	Volkswagen GTI	Honda Civic SI
	500 HP	436 HP	414 HP	306 HP	304 HP	245 HP	232 HP	200 HP	197 HP
Insurance	Cadillac CTS	Honda Civic SI	Nissan 350Z	BMW M3	Porsche Boxter	Chevy Corvette	Volkswagen GTI	Mazda RX-8	Mustang Shelby
	$1,030	$1,078	$1,197	$1,372	$1,498	$1,629	$1,695	$1,930	$3,395
MSRP	Volkswagen GTI	Honda Civic SI	Mazda RX-8	Nissan 350Z	Cadillac CTS	Mustang Shelby	Chevy Corvette	BMW M3	Porsche Boxter
	$22,764	$23,695	$24,098	$28,120	$33,245	$40,950	$46,110	$57,275	$64,900
Top Speed	Chevy Corvette	Porsche Boxter	BMW M3	Cadillac CTS	Nissan 350Z	Mustang Shelby	Mazda RX-8	Honda Civic SI	Volkswagen GTI
	190 MPH	170 MPH	155 MPH	155 MPH	155 MPH	150 MPH	148 MPH	135 MPH	130 MPH
Torque	Mustang Shelby	Chevy Corvette	BMW M3	Cadillac CTS	Nissan 350Z	Volkswagen GTI	Porsche Boxter	Mazda RX-8	Honda Civic SI
	480 Torque	428 Torque	295 Torque	273 Torque	268 Torque	207 Torque	201 Torque	159 Torque	139 Torque

Overall Winner

Student Assessment Survey Results

Every semester an assessment of the Engineering and Technology Fundamentals course has been done. A survey of the students is taken and the students rate each subject taught in the course by what they perceive they have learned. The possible ratings range from "excellent" to "significantly below average". The surveys by the students have consistently shown the perceived learning of the various subjects taught in the course to be well above average. The ratings by the students for each subject taught in the Engineering and Technology Fundamentals course have shown a range of average to excellent. The combined rating of all the subjects is well above average. Even though none of the course subjects has ever been rated below average by the students, subjects in the course that are rated lower are enhanced before being taught the next semester.

Conclusions

The Engineering and Technology Fundamentals students greatly benefit from extensive use of various course software packages. The students gain knowledge of engineering and technology subjects by use of software exercises. Once the basics of the course software are learned, the students progress rapidly from rudimentary levels to higher levels. User-friendly software allows successful completion of exercises and gives the students the wherewithal to carryon. In addition, the Engineering and Technology Fundamentals students gain experience with software packages that are used in later courses. The Engineering and Technology Fundamentals course students advance further than students that have been in a similar course of the past that had little or no user-friendly software.

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