Incorporating Materials Science Projects in a Capstone Design Course

F. Xavier Spiegel and Paul J. Coyne, Jr.
Loyola College
Department of Electrical Engineering & Engineering Science

Abstract:

The format, goals, and philosophy of the Loyola College Engineering Science Program's capstone design course will be discussed in addition to particular projects based on course work in Materials Science that were attempted in recent years. Design projects in Materials can be particularly difficult to initiate for several reasons, among them the lack of facilities, adequate samples, equipment and limited funds. The authors have developed several projects that have overcome these difficulties and which have been well received by the students.

Introduction:

The Accreditation Board for Engineering and Technology (ABET) describes design as the process of devising a system, component, or process to meet desired needs[1]. A capstone design course is an integration of the entire engineering education as well an exercise in communication skills, all of which are brought to bear in the completion of a given design objective.

The Bachelor of Science in Engineering Science degree program allows students to concentrate in either materials science, digital science, or electrical science. Each student must complete a two-course sequence, four credits each semester, during the fourth year of the program that exercises prior course work in a design project. The goals of this course sequence are:

- students will engage in a large scale capstone design project;
- students will exercise written communication skills;
- students will develop oral presentation skills; and
- students will engage in discussions on engineering professionalism emphasizing ethical, social, and environmental aspects of design.

The course is run by a single faculty member who takes care of the administrative details, conducts in-class discussions, and works with all students on the refinement of their written and oral communication skills. Additionally, each student selects a faculty member who acts as a technical consultant during the year. Individual projects are approved by the course instructor in consultation with the student's technical consultant. During the first semester the student must complete a paper design of the final project. When appropriate students are encouraged to begin experimentation to help in making intermediate decisions in the design process.

The grading scheme during the first semester is a combination of the completion of administrative details, such as weekly progress reports and individual meetings with the instructor or technical consultant, and the paper design document that details the design analysis and construction details. Given the variation in design projects the instructor tries to balance the difficulty of the analysis task with the quality of the analysis. During the second semester the students complete the construction of their project. The semester concludes

with a demonstration of a completed, working, design and the formal oral presentation of the entire design project. Grading in the second semester again tries to balance the complexity of the project realization with the quality of the final design. A project that requires a moderate effort in the design analysis and design realization phases of the courses is expected to undergo a more extensive evaluation effort to ascertain the quality of the final design.

Example Design Project:

A Composite Tester

A Tensile Tester was constructed to measure the anisotropic deformation of polymer composites under a tensile stress[2]. The student designed a grip mechanism that would displace laterally to allow for the shear strain induced by off-axis loading of unidirectional fiber composites. The fabrication and analysis of various fiber orientations and number of laminae were investigated. The fabrication of composite specimens was developed by a previous student using relatively inexpensive materials, readily available aluminum screening and Ferris See Thru (a jeweler's polymer for making molds of small articles). This polymer cures at 350°F and is transparent when cured. Therefore the actual fiber, or in this case the screen, orientation can be observed, and any distortion of these fibers can be noted during testing. The actual lamina were produced by selectively removing some of the wires of the screen to produce layers of various orientations.

The results obtained on the tester were confirmed by comparison with another similar commercial device. Both in-house and commercially available samples were evaluated with comparable results.

An Impact Tester

A student designed and built a Drop-Weight Impact Tester for evaluating punch through in composite specimens. This device was compared to a commercially available instrument with excellent success. A second student improved the safety performance of this instrument by designing and building a simple "catch" mechanism that prevents the drop-weight from restriking a specimen in the case when the specimen is not penetrated, but the drop-weight bounces off the sulfate[5]. This mechanism works as designed and has been used successfully for over a year.

A Miniature Fatigue Tester

At the time of this writing, a student has developed the paper design of a miniature fatigue tester6. This device will be capable of testing specimens in symmetric oscillations up to 8 cm. in amplitude and up to 600 Hz. in frequency. The instrument will be battery powered and will automatically shut off when the sample breaks. Ideally this device will be useful both for demonstration and research purposes,

A Solids Permittivity Detector

At the time of this writing, a student has developed the paper design of an instrument that will display the relative permittivity of solids with a maximum permittivity of 157. The material under examination is placed between parallel metallic plates, each with an area of 49 cm.2, and then charged as a capacitor. After charging, the capacitor is discharged for a fixed period of time and this voltage is stored in a sample-and-hold device. An analog computation circuit uses the stored capacitor voltage, a measure of the sample thickness made by a slide-potentiometer, and the other physical constants represented by an analog voltage to compute a voltage that is proportional to the relative permittivity and which is displayed on a small analog panel meter.

Summary and Conclusion:

With a limited budget of $200. per project the student is given a realistic design experience that is within the budget of a typical undergraduate engineering department. The students rapidly learn the importance of the paper design and the iterative process that is essential to successfully engineered design. Each student is requested to make recommendations for the next iteration upon completion of the project and these ideas have given the next class some ideals for continuing and improving a design, as has happened with the Impact Tester.

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F. XAVIER SPIEGEL is an Associate Professor in the Department of Electrical Engineering and Engineering Science at Loyola College in Baltimore, Maryland. He has been teaching for over thirty years and has interests in the areas of undergraduate experimentation, nondestructive testing and composites.

PAUL J. COYNE, JR. is a Professor in the Department of Electrical Engineering and Engineering Science at Loyola College in Baltimore, Maryland. He has been teaching for twenty years and has interests in the areas of undergraduate design, nondestructive testing and digital signal processing.