

**AC 2009-222: THE DEVELOPMENT OF TEACHING MATERIALS FOR AN  
INTRODUCTORY COURSE IN ELECTRICAL AND MECHANICAL  
ENGINEERING TECHNOLOGY**

**JungHun Choi, Ohio University**

**Wieslaw Grebski, Pennsylvania State University, Hazleton**

**Kenneth Dudeck, Pennsylvania State University, Hazleton**

# **Development of Teaching Materials for an Introductory Freshman Courses in Electrical and Mechanical Engineering Technology**

## **Abstract**

This paper describes the content of two new introductory freshman courses used both the Electrical and Mechanical Engineering Technology programs at Penn State. These introductory courses are required in the first semester for both programs as part of a new curriculum composing of a “common freshman year” for both the Electrical and Mechanical Technology programs.<sup>1</sup> The rationale for creating these courses was to provide students with a better broad overview of both respective fields resulting in students making a more informed choice in selecting to pursue either an EET or MET degree. Additionally these courses will help inspire students for future concentrated study by recognizing the end result applications of both disciplines by studying systems comprising of electrical and mechanical elements.

## **1. Introduction**

Especially in the freshmen year, students in the departments of Electrical and Mechanical Engineering Technology have not much idea about Engineering Technologies and what kinds of professions they can pursue. Moreover, they do not know the scope of the various fields that each of these disciplines contain and which fields they may be interested in. Of course students will explore their entire selected major as they become junior and senior students and they will find and concentrate on their favorite fields.

By introducing introduce the freshmen students to a broad knowledge of each venue of both majors, students will develop an early interest and it will directly affect their motivations of knowledge achievement, and tracking down of their careers. Obviously, it is not possible to introduce all aspects of Electrical and Mechanical Engineering Technology, but it is feasible able to excerpt the basic and fundamental subjects which form the back bone of these disciplines, such as circuits, electricity, electronics, power and control in Electrical Engineering Technology; rigid bodies, kinematics, and fluid dynamics in Mechanical Engineering Technology. All of these sub-topics can also be shown to be interconnected and working together in a functional electrical or mechanical system.

Additionally, it is crucial to stress the importance of studying math by showing the use of math skills currently used in Engineering Technology and how they are applied. If students can appreciate why they learn math and how they apply the math skills to solve engineering-oriented

problems, it can increase their motivation and desire to study math while deepening their mathematical comprehension.

As part of a newly designed Engineering Technology Curriculum at the Pennsylvania State University, a common freshman year has been designed between EET and MET students<sup>1</sup>. As part of this common year, two new courses were designed that give freshmen students a wide but limited depth to each of these respective disciplines and achieves all of the educational objectives mentioned above.

These two new courses, *Introduction to Electrical Engineering Technology* and *Introduction to Mechanical Engineering Technology*, are taken simultaneously by both EET and MET freshman in their first semester of study. The details of each of these courses are discussed in greater detail below.

## **2. Introduction to Electrical Engineering Technology**

The *Introduction to Electrical Engineering Technology* course was created to provide students with an overview Electrical Engineering Technology as well as providing the basic concepts essential to the discipline such as applied math, circuit analysis, electricity and electronics, power, and control. The application of math is illustrated early in the course by the study of sine wave generation of voltages. The mathematical description of the sine function is used to characterize the waveform's amplitude and frequency. Another application of math is in the solution of simultaneous linear equations that arise from applying Kirchoff's voltage law around a circuit of two or more loops. In both examples, students have the opportunity to apply the math skills they are developing in their current math courses, thus increasing mathematical comprehension.

The course also covers the fundamentals of circuit analysis such as Kirchhoff's laws, parallel and series circuits, and then applies that knowledge to various common place electrical systems such as: appliances, vending machines, and garage door openers. More advanced circuit analysis techniques, such as Thevenin's theorem and nodal analysis are left for a follow on course. The course also introduces the students to the scope of electrical systems by including components and topics such as switches, relays, fuses, amplifiers, transformers and motors. The course also briefly introduces students to the concepts of radio frequency communications, control relay logic, and electrical power.

The various topics are all introduced from a top down electrical systems view. The students are asked to study a common electrical system that they can relate to, for example, a garage door opener. By studying this electrical system, students learn about motors, power, power supplies, relays, control, RF communications, and basic electrical wiring. These individual concepts can first be shown as a block component in a larger operational system. The

details of these individual sub-systems can then be investigated deeper and shown how they relate to the larger system. By first looking at the larger system, these individual course elements are given context. This should aid in the students' motivation for learning more about each.

Lastly, students will gain an appreciation for breadth of the EET profession by looking a variety of technology companies, products and services they produce, and what kind of jobs EET graduates they hire do.

### 2.1 Main contents of the EET course materials.

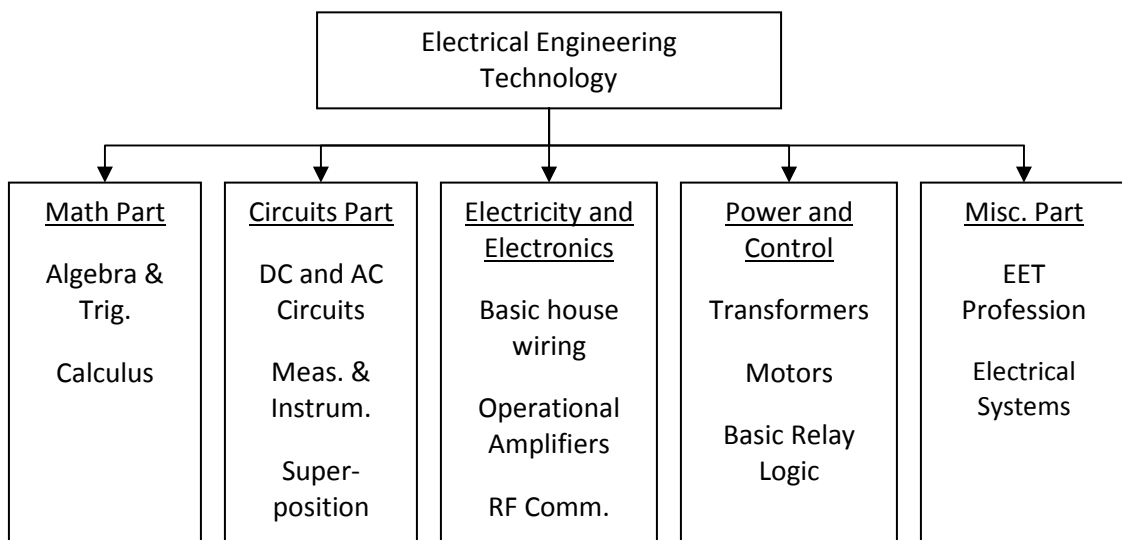


Figure 1: The Contents of *Introduction to Electrical Engineering Technology*

#### 2.1.1 Math Part: Linear Algebra and Calculus.

- One of the most difficult parts for the EET students.
- EET application examples will provide the motivation for students to study math.
- Examples of AC waveforms use trig functions and circuit analysis incorporates solutions to simultaneous equations.

#### 2.1.2 Circuits Part: DC and AC Circuits, Instrumentation and Measurement, Superposition.

- This part makes up one half the content of the course

- Basic DC circuit laws using resistors, independent sources, and resistors.
- Basic laws such as Ohm's Laws, Voltage & Current Division, and superposition.
- Kirchhoff's Voltage and Current Laws limited to two variables.
- Measurement of Voltage and currents using VOM and oscilloscopes.
- Basic concepts of capacitive and inductive reactance to AC sources.
- Superposition using an AC source with a DC offset.

#### 2.1.3 Electricity and Electronics: House Wiring, Operational Amplifiers, RF Communications

- House wiring is demonstrated as an application of series and parallel circuits.
- Operational Amplifiers are shown as an example of dependent voltage controlled voltage source. Amplification of a low voltage from a proximity sensor used the integrated larger system is tied to this part.
- The basics of RF communication such as AM, FM, and pulse modulation are explored. Remote control of the larger system is tied to this part.
- The diode can be introduced and shown and tied to the power part as a major component in a power supply.

#### 2.1.4 Power and Control: Transformers, Motors, Basic Relay Logic

- Basic electromagnetic induction can be applied to transformers and along with the diode, tied to the study of a power supply.
- Basic motors and control can be shown. This can be tied to the larger system by studying electrical sizing requirements needed to provide the mechanical horsepower needed in the larger system, a garage door opener for example.
- Basic logic functions can be shown by switch and relays wired in series and parallel. Basic relay logic can be applied to the control of an electrical system.

#### 2.1.5 Miscellaneous Part: Electrical Engineering Technology Profession and Electrical Systems

- Early in the course outline the various fields in Electrical Engineering Technology Profession such as power, electronics, computers, robotics, and automation. It can be shown how the curriculum introduces students to the fundamentals of each. After graduation, students will be able to pursue their interests in greater detail by continuing the education toward a BS degree, or choosing employment in a company that specializes in the field that matches their interests.

- Seminars or lectures from industry people whose professions are in the field of Electrical Engineering Technology can provide insight into employment possibilities in the profession.
- The introduction of an electrical system shows how all the various sub systems function together in a working system. It also will demonstrate that a basic understanding of mechanical systems is essential since most industrial systems are electro-mechanical systems

### 3. Introduction to Mechanical Engineering Technology

The *Introduction to Mechanical Engineering Technology* course was created to provide students with the basic concepts which are essential to the Mechanical Engineering Technology field, such as, math, solid mechanics, motion, fluid part, and etc. In the math part the students are introduced to the math skills that are currently used in the Mechanical Engineering Technology field and are shown how they are applied. Exposure to the application of different mathematical concepts adds another dimension to the body of knowledge that they are gaining in their math courses. However, the focus points of the *Introduction to Mechanical Engineering Technology* course are statics, dynamics, and introduction to engineering materials. The students are also getting an exposure to engineering design, thermodynamics, heat transfer, and fluid dynamics. They are also being introduced to engineering software, such as, AutoCAD, SolidWorks, Matlab, Mathematica, and Ansys which are widely used in the field. Considering the wide variety of topics covered in the course, the coverage is not in depth. The course goal is to spark the students' interest and contribute to the students' success.

In the math part, the students are getting exposure to different math skills which are currently used in Mechanical Engineering Technology profession. The most important subject among the solid part is statics. After introducing the concept and need of statics, the students will be exposed to the advance applications of mechanics of materials, design of mechanical components, and material science. Motion part deals with dynamics, vibration, and controls of systems. Except for the advanced subject, we can introduce dynamics and the basic knowledge of vibration. Fluid part contains thermo-dynamics, heat-transfer, and fluid dynamics. Even though fluid part is also a bit advanced subject for the freshmen students, the course will give them an overview as engineering technology students such as its usage, applications, and basic theories. Except for the four parts, by explaining about the vocations of Mechanical Engineering Technology, students can set their goals according to their interests and skills. The explanations of widely used engineering software such as AutoCad, SolidWorks, Matlab, Mathematica, and Ansys will make students familiar with engineering technology environment.

#### 3.1 Main contents of the MET course materials.

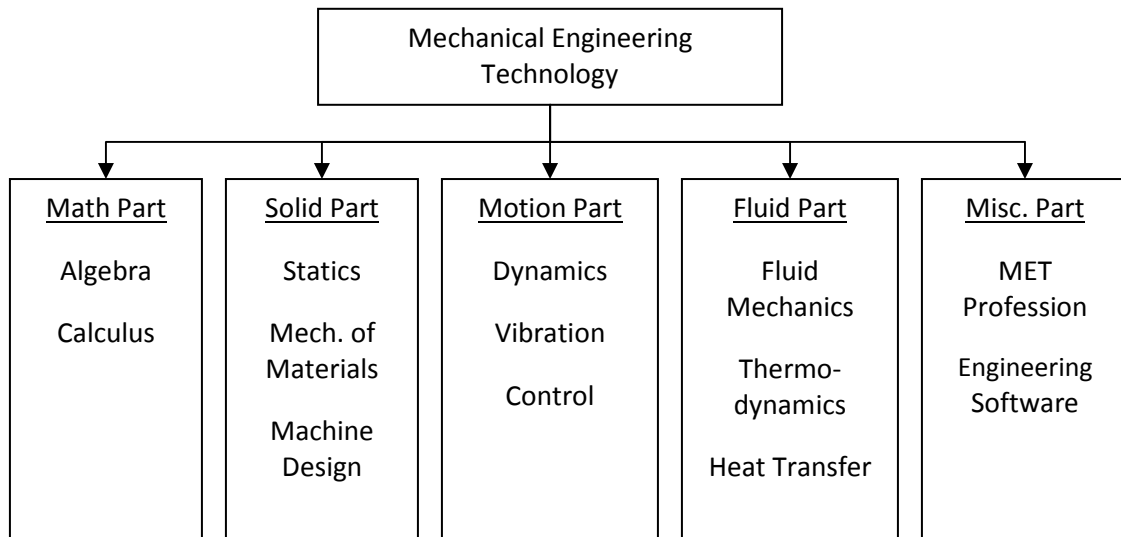


Figure 2. The Contents of *Introduction to Mechanical Engineering Technology*

### 3.1.1 Math Part: Linear Algebra and Calculus.

- One of the most difficult parts for the MET students.
- Good Motivation and examples will provide the students to the reason to study Math.
- Provide good example and strong motivation to study math through Solid, Motion, and Fluid Part.

### 3.1.2 Solid Part: Statics, Mechanics of Materials (Solid Mechanics), and Machine Design.

- Just include in Solid Part for the convenience but Statics is the basic course for the MET and other ET major students.
- Mechanics of materials (Solid Mechanics or Mechanics of deformable bodies) is the backbone of Solid Part.
- In this stage, Machine design can be omitted. We can show a good example of design problem in the section of Mechanics of materials.
- Introduction to Material Science can be a part of this chapter.
- Preliminary notion of FEM (Finite Element Methods) can be introduced with FEM software.

### 3.1.3 Motion Part: Dynamics, Vibration, and Control.

- Dynamics is the base course in Motion Part.
- Obviously, students need good understanding of Statics before taking Dynamics. This fact will give the students strong motivation to understand Statics comprehensively.
- Vibration and Control can be introduced broadly for the motivational purpose of studying Math (ODE and Matrices) and Dynamics.
- Robotics and Mechatronics are optional and can encourage studying Dynamics and Control.

### 3.1.4 Fluid Part: Fluid Mechanics, Thermo-dynamics, and Heat Transfer.

- Can be separated to Fluid/Thermo Part or not.
- Provide basic concepts to the students to inspire the study of Math and Statics, and students will be able to link basic mechanics to Fluid Part ahead of times.
- Examples of Laboratory experiments are easy to understand.
- Can be strong motivation to study Math. (PDE)

### 3.1.5 Miscellaneous Part: Mechanical Engineering Technology Profession and Engineering Software (AutoCad, SolidWorks, Matlab, Mathematica, and Ansys)

- Proper understanding of Mechanical Engineering Technology Profession will be the strongest motivation to the students to pursue Mechanical Engineering Technology degree.
- Students can target their studying track according to their interests of MET professions.
- Seminars or lectures from industry people whose professions are in the field of Mechanical Engineering or Mechanical Engineering Technology will be greatly supportive to determine students' goal toward Mechanical Engineering Technology degree.
- Using various engineering software for examples of each part, instructor can glow students' interests and explain the needs of computer skills.



#### 4. Results

The authors present the enrollment data as evidence for the outcomes of offering EET and MET 105. Table 1 contains the enrollment data of EDSGN 100, MET and EET 105, MCHT 111 and CMPET 117. The title and brief descriptions of the courses are below the table.

Table 1. Enrollment Comparison of Courses for the 2007 and 2008 Academic Years.

	2007 Fall	2008 Spring	2008 Fall	2009 Spring
EDSGN 100	48	N/A	56	N/A
MET&EET 105	N/A	N/A	28	N/A
MCHT 111	N/A	20	N/A	27
CMPET 117	N/A	6	N/A	26

EDSGN 100: Engineering Design and Graphics  
EET 105 : Electrical Systems  
MET 105 : Mechanical Systems  
MCHT 111 : Mechanics for Technology-Statics  
CMPET 117: Digital Circuits

EDSGN100 is an introductory design-driven course for the freshmen Engineering and Engineering Technology students and MCHT111 is a Statics course for the freshmen Engineering Technology students. Typically, some students will decide their paths (Engineering or Engineering Technology) after they took EDSGN 100.

In 2007 academic year, the total number of students in EDSGN100 course was forty-eight. During the same academic year, twenty students were enrolled in MCHT 111. Based on those numbers, approximately 41.7% chose to pursue the Engineering Technology pathway. After MET 105 and EET 105 were implemented, those numbers increased to 48.2%. Those numbers indicate that more freshmen students decided to pursue an Engineering Technology pathway after they took MET and EET105. Since EET 105 and MET 105 were implemented during the 2008 Fall semester, the authors will continue to do additional research related to the effectiveness of these courses. However by contrasting the Fall 2008 EET105/MET 105 enrollment and the Spring 2009 MCHT111/CMPET 117 shows a retention rate of 94% which is definitely promising.

#### 5. Conclusion

The purpose of the Mechanical Systems and Electrical Systems courses is to provide the students with a wide scope of knowledge related to the Mechanical Engineering Technology (MET) and Electrical Engineering Technology (EET) fields. Both courses need to be offered

simultaneously in order to demonstrate how the Mechanical and Electrical Engineering Technology fields can be integrated and jointly applied to solve “real world” engineering problems. Both courses have common laboratory and project components. The nature of the projects is electromechanical, for example, a garage door with an electrical opener. In the Mechanical Systems course, students will design the mechanical components of the garage door. The electrical aspect of the project, that is, selecting the electric motor, designing the control systems, will be addressed in the Electrical Systems course. The joint laboratory experience will reinforce the electromechanical approach to a problem solving strategy. After completing both courses, the students will have the necessary background to choose if they want to pursue either an MET or EET major. The other important objective of these courses is to spark the student interest in the engineering technology field, attract students to engineering technology, and increase their motivation.

## References

- [1] Dudeck, K., Grebski, W., “A New Vision for Engineering Technology Programs to Strengthen Recruitment and Retention”, Submitted to *Proceedings of the 2008 American Society for Engineering Education Annual Conference & Exposition*.
- [2] Undergraduate Degree Programs Bulletin of Pennsylvania State University, p.611-613.
- [3] Treuren, Ken Van, Steve Eisenbarth, and Cindy Fry, “Developing Engineering Student Success – A Retention Study at Baylor University,” *Proceedings of the 2002 ASEE Gulf-Southwestern Annual Conference*, March 20-22, 2002.
- [4] Dym, Clive L., et al. “Engineering Design Thinking, Teaching, and Learning” *Journal of Engineering Education*, January 2005, Vol. 94, No. 1, pp. 103-120.
- [5] ABET, 2006, “Criteria for Accrediting Engineering Programs: Effective for Evaluations During the 2007-2008 Accreditation Cycle,” Engineering Accreditation Commission, retrieved January 17, 2007 from [www.abet.org](http://www.abet.org).
- [6] Jonathan Wickert, *An Introduction to Mechanical Engineering*, Second Edition, Thomson, 2006.