# 2006-1321: A COMPARISON BETWEEN THE ENGINEERING MECHANICS-STRENGTH OF MATERIALS COURSE IN THE ENGINEERING, AND ENGINEERING TECHNOLOGY PROGRAMS AT PENN STATE

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# A Comparison Between the Engineering Mechanics-Strength of Materials Course in the Engineering, and Engineering Technology Programs at The Pennsylvania State University


## Abstract

Strength of materials is a critical and essential course for both engineering and engineering technology students with a mechanical focus such as those in the mechanical, civil, industrial, and aerospace engineering and engineering technology disciplines. It provides a fundamental understanding of the mechanical properties of various materials which makes them useful for a multitude of applications. It also provides an introduction to the analysis of statically indeterminate structures which allows more complex problems to be solved than is possible with statics analysis alone. These important topics are, however, approached in different ways for traditional engineering, and engineering technology students here at Penn State. The similarities and differences in the two courses are addressed in this paper. The paper also explains the importance of this comparison to the students and the educators in both fields.


## Introduction

Engineering and engineering technology share many of the same attributes. Nonetheless, the two disciplines are distinct from each other in various ways. The main difference between the two programs at Penn State, is that engineering technology focuses more on hands on application of engineering principles while engineering is more focused on the theoretical side of the subject. For example, in the strength of materials course, while a traditional engineering student is more likely to simply learn the theory behind axial deformation due to a tensile load, and see a stress-strain curve in their textbook, the engineering technology student spends time in a lab using a tension tester, and generating his/her own stress-strain curve. The availability of these two different programs provides good options for students who have diverse needs in an academic program. For those looking to go on and run a lab, or attend a graduate program, the traditional engineering tract seems to be the better approach. But for the student who would prefer to "get their hands dirty", engineering technology provides an opportunity to learn the same concepts, but with an added component of direct application to well defined existing problems. This approach of teaching engineering and engineering technology courses is supported by ABET's criteria.[1,2]

Upon graduation, both groups of students go on to serve important roles in an industrial setting. The two groups end up working together in the same environment, sharing many of the same responsibilities. Each group also has strengths where the other has weaknesses. This allows for the two groups to have good synergy in an industrial environment with each one supporting the other. Details on the similarities and differences in the education of engineering and engineering technology are well established in the literature.[3]

There are several common courses in the curricula of the engineering and engineering technology programs at Penn State. Some of these courses are offered separately in each program to fulfill the needs of each group. For instance, the subject of Statics is offered as

EMCH 11-Engineering Mechanics/ Statics to the engineering students while engineering technology students take it as MCHT 111-Statics. The subject of Strength of Materials is a subsequent course to Statics. This course is offered as EMCH 13- Engineering Mechanics/ Strength of Materials to the engineering students, and as MCHT 213- Strength of Materials to the engineering technology students. This course is the focus of this paper.

**Strength of Materials**

Strength of materials introduces many important topics to the student. These topics include normal stress and strain, axial deformation, statically indeterminant problems, torsion, shear and moment diagrams, bending stress, shear stress, beam deflection, and stress transformations, amongst others. Comments will be stated below on several of these topics and the way in which they are presented to both engineering, and engineering technology students here at Penn State. While they share many similarities in their topics, the way in which they are approached varies between the engineering technology and engineering classes. In some cases the depth to which a particular topic is addressed is different. In other cases, the way by which the problem solving is approached is almost completely different.

**The Significance of the Comparison between the Engineering and Engineering Technology Strength of Materials courses**

It is critical to teach the Strength of Materials course to the engineering students to fit their present and future academic needs, and to instill the expected skills at and beyond graduation. Additionally, the way in which this course is offered to them should be based on their previous background and should be in line with the general expected outcomes of the engineering program.

Equally important, engineering technology students need also to learn the subject of Strength of Materials in a way which will fit their own distinctive present and future demands. The way in which this course is offered to this group of students should also support the general expected outcomes of their own programs.

It follows then that teaching the engineering Strength of Materials course, or any part of it, to engineering technology students is very harmful. By the same token, teaching the engineering technology Strength of Materials course, or any part of it, to engineering students is equally detrimental. A student from either group who is exposed to any concept within the Strength of Materials course in the wrong way will face serious consequences in his/her education. Accordingly, it is indeed important to understand the differences and similarities in the ways in which this course is offered to these two groups of students.

Generally speaking, many instructors in the engineering technology programs have engineering backgrounds. It is possible that some instructors in the engineering programs have engineering technology backgrounds. Mixing between the two Strength of Materials courses is therefore and unfortunately highly likely among instructors.

This paper intends to minimize this potential mix up among educators by providing a comparison in which the Strength of Materials course is offered in the engineering and engineering technology programs at Penn State.

**Prerequisites**

Strength of materials for engineering students requires that they have already passed statics as well as integral calculus. This implies that the student should have a good command of the fundamental problem solving methods needed to solve basic engineering mechanics problems, as well as a good background in mathematics.

For the engineering technologist, the student must pass a statics course before taking strength of materials, however, they are not required to have passed integral calculus before taking the course. The lack of the required calculus background changes the way that the course material is taught as will be shown below.

**Course Objectives**

Each course has its own learning objectives as laid out by the university. Below are the objectives for each of the two courses.

**Strength of Materials for Engineers Course Objectives**

- Using Strength of Materials analysis, students shall analyze and calculate the stresses at any point in basic structural components.
- Using Strength of Materials analysis, students shall determine the deformation of long thin members subjected to stretch, pressure, twist and bending.
- Using Strength of Materials analysis, students shall consider the possibility of buckling for a compressive member.
- Using Strength of Materials analysis, students shall determine whether or not a given loading is “safe” for a particular material.

**Strength of Materials for Technologists Course Objectives**

- Using Strength of Materials analysis students shall calculate the axial stress and deformation for a body whose axial loading and cross-sectional area are known.
- Using Strength of Materials analysis, students shall calculate the torsional shear stress and angle of twist for a circular shaft whose cross-section and applied torques are known.
- Using Strength of Materials analysis, students shall calculate the bending stress and beam deflection for a beam whose cross-section and loading are known.
- Using Strength of Materials analysis, students shall draw shear and bending moment diagrams for statically determinate beams whose load and method of support are known.
- Using beam tables and Strength of Materials analysis, students will correctly select standard beams for given allowable stresses and deflections as well as known loading and method of support.

- Students shall use a spreadsheet program to solve a Strength of Materials analysis or design problem as assigned by the instructor.

As can be seen from the above list, the engineering curriculum places more focus on combining the topics and forcing students to synthesize. The technology course work is more focused on taking a given system and analyzing the stresses and strains.

**Text Books**

Here at Penn State the book chosen for Strength of Materials for engineers is listed as Ref. 4. Because of the popularity of engineering mechanics, there are many suitable texts available for use in the strength of materials for the engineer's course. They include Refs. 5-8. Because engineering technology is a much smaller field, it is more difficult to find texts appropriate for the course. For the Penn State Altoona Campus, where L.J. Passmore is an instructor, Ref. 9 has been designated for use in the engineering technology program. Another text that has been approved by Penn State for the strength of materials for engineering technology students is Ref. 10. Another possible textbook for use in this case is listed as Ref. 11.

**Strength of Materials Topics**

Below we have broken out a few key topics and how they are addressed for engineering technology, and engineering students. There is a brief synopsis of each topic presented as well.

**Stress**

Stress analysis is at the core of the entire strength of materials course. From the first week of the course, the student begins to learn about stress, and he/she spends the rest of the semester working with it. Throughout the course a variety of different stresses are addressed including axial stress, thermal stress, torsional shear stress, direct shear stress, and bending stress. All of these topics are important in the solution of real world engineering problems.

For the introduction to stress the two courses are conducted in largely the same manner. In this portion of the course the biggest difference between the two is that for traditional engineering students the stress is calculated based on the internal force calculated at a given cross section, however in the technology class, the focus in the text is on the externally applied loads instead of the internal reactions. For the engineering student, the focus is on drawing proper free body diagrams, since the calculation of the axial stress is trivial. The important point for these students is to be able to find the internal forces through drawing proper free body diagrams. For the engineering technology students the focus is more on the actual calculation of the stresses based on the loadings. Part of the reason that this is important for them is the application of these stresses for proper material selection, or dimensioning. As an example of this, when calculating bearing stress, it is important for the technology student to be able to calculate the proper cross section for a column to ensure that it does not crush a gravel, or concrete base. For the traditional engineering student these problems are much more conceptual with less focus on the application to real world problems.

**Strain**

Strain relates the actual deformation of the structure to the stresses that the structure experiences. For the vast majority of the problems solved in these introductory courses, the materials deformation stays within the elastic portion of the stress strain curve. Strain analysis allows the student to see the interaction between the physical dimensions of the part in question, and the stresses it experiences. This is important for tolerancing based on geometric limits.

Here again the same nomenclature is used to address the topic, however the engineering technology student has much more focus on the axial strain component, at least in the introduction of the topic. The traditional engineering student spends a good portion of his/her time on shear strain as well. Further, the traditional engineering student spends time learning about shear strain for square elements in order to grasp the fundamentals of the strain analysis.

**Beam Deflection**

The analysis of beam deflection problems becomes important when designing structures that have tight tolerances on positioning. Using the knowledge gained in this portion of the course, the student can determine (at least from fairly simple problems) how much a member bends under applied loads. This allows the student to select a particular cross section or material (or combination of both) that will fit within the design criterion of a given problem.

Beam deflection is a portion of the course where there seems to be a large divergence between the two courses. For the traditional engineering student much of the beam analysis portion of the course is spent on learning to perform double integration calculations to get the elastic curve for the beam. They spend a lot of time learning to use discontinuity functions, which allow for much faster solutions to beam deflection problems by drastically shortening the amount of algebraic steps to solve the problem using integral calculus. In the case of the engineering technology student, the textbook does not even address the issue of discontinuity functions. Instead, beam deflection analysis focuses on using superposition and beam deflection tables in order to solve the same types of problems. Beam deflection ~~are~~ tables are barely used in the engineering course, as they are viewed as more of a "cheat" since the method involving integration of the internal moment function does not require the loading to fit into any special case on a table. For the engineering technology student, knowing that there are very complete tables available to solve the vast majority of the beam deflection problems they will see in the field as an engineer is sufficient. Once they master the superposition technique by solving fairly simple problems from the text, they can then expand on the topic to address more realistic problems, when provided with a more complete beam deflection table.

**Stress Transformations**

Both engineering students and engineering technology students are exposed to stress transformations in their respective strength of materials classes. This topic is important to both groups because the stress levels in a structure are intimately related to what material should or can be used to build that structure. The topic of stress transformations is important, because in general when designing a structure the maximum shear and normal stresses are the important ones, not the stresses calculated using a convenient set of axis. Because of this, several different approaches to stress transformations are taught to both groups of students.

While the subject matter is the same for both groups, the method in which they receive instruction varies based on the needs of the students. For the engineering students, the presentation includes a derivation of where the stress transformation equations come from. This is done, because for these students, the "why" part is important. For the engineering technology students, the topic is presented as a tool to perform evaluations. The equations are presented on their own, with the disclaimer that the derivation is available, for anyone who is interested.

In the technology class, at Penn State, the focus is also almost entirely on calculating principal stresses, and maximum in-plane shear stress. The calculations for arbitrary angles are not emphasized to any significant degree in the technology course. This, however, is not true for the engineering course. For the engineers, the importance of being able to calculate stresses along any given plane is important. These arbitrary angle transformations are simply a more general tool, but this is one of the substantial differences between the two courses methods of approaching this topic. The engineering students gain a more general knowledge of the subject matter, while the engineering technology students gain a more practical education in the cases that are generally more important in application.

**Course Evaluation**

In order to determine whether or not course objectives have been met students are given homework, quizzes, and exams. For both courses it is at the discretion of the instructor to determine how this evaluation will take place. In the case of the technology course almost all course objectives were measured on the final exam (in addition to more real time evaluation using homework and midterms) by giving problems specifically targeted towards evaluating whether or not the students had met the course objectives directly. That is to say, the wording of the problems required the students to demonstrate a knowledge of each of the learning objectives. This was also true for the engineering course, as both, in their most recent iteration (and in general), had cumulative finals.

**Course Improvement**

In order to improve the quality of both courses from semester to semester and year to year. Students are encouraged to provide feedback on the course and the instructors strengths and weaknesses. In the case of the technology class, the students participate in an online course evaluation in addition to providing written feedback forms. Here the students are required to provide feedback as to whether or not they feel that they have achieved the learning objectives for the course. For the traditional engineering course, the students complete both a student rating teaching effectiveness (SRTE) form, and they fill out a feedback document stating what they liked and did not like about the course. This provides the students with an opportunity to influence the way the course is run for future generations of students. Also employed in both courses are mid-semester evaluations if the instructor so chooses. This allows the students an opportunity to provide feedback in a more timely manner so that there is an opportunity to implement changes while they will still have positive outcomes for the students currently enrolled in the course.

## Conclusion

While strength of materials is an important course for both engineering and engineering technology students, the depth to which certain subjects varies based upon the course objectives for these two distinct groups of students. While the engineering student is very focused on learning the theory behind the equations, the engineering technology student is much more driven to apply what they have learned to real world problems. The engineering technologist is also pushed towards really focusing on the part of the material that will be used to address the vast majority of issues that will arise in an industrial setting, while the engineer looks at the broader subject material. The approach to problem solving is also different between the engineering and engineering technology course. Because of their different backgrounds, the engineer spends much more time using more rigorous mathematics than the engineering technologist. These students use tables and charts much more of the time in order to maximize their efficiency in problem solving.

While virtually all of the topics are common to both classes, it is clear that the approach taken with the students in each group needs to be tailored to their specific needs. This responsibility falls on us, the educators. Failing to have a clear understanding on how we should teach this subject will have harmful consequences to our students in both groups.

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