



Rose-Hulman / Foundation-Coalition Sophomore Engineering Curriculum

What is the Sophomore Engineering Curriculum (SEC)?

The Rose-Hulman/Foundation-Coalition Sophomore Engineering Curriculum (SEC) is a sequence of eight courses for the sophomore year that integrates core material in engineering science and mathematics. It was designed for all engineering majors by a multi-disciplinary team of faculty over a two-year period. Taught since the fall of 1995, it is currently required for electrical, computer, and mechanical engineers.

What guided the development of the SEC?

As part of the Foundation Coalition, we had the opportunity to examine how our curriculum could be improved. Four underlying beliefs guided the development of the SEC:

- There exists a *common core* of engineering science and mathematics that *all* engineers should learn.
- This core should serve as a *foundation* for discipline specific education, not just an add-on.
- Both horizontal and vertical *integration* of course material is important.
- Student learning can be improved if the core is built around a few *key concepts*.

The SEC is a response to the historical curriculum in which many basic courses are treated as add-ons and selected cafeteria style when and if a department desires. The SEC was designed to help students (and faculty) see and value the connections between what is often viewed and taught as unrelated material.

What are the common themes in the curriculum?

The SEC is built on a systems, conservation and accounting, and modeling framework. This conceptual framework unifies the presentation of physical laws, forms the basis for a common problem solving approach, helps students (and faculty) see connections between apparently unrelated topics, and helps students build connections and promotes transfer of learning.

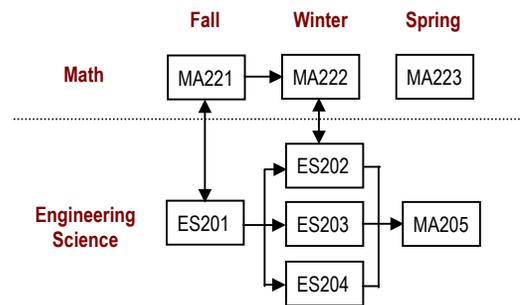
In addition, the SEC uses a common problem solving strategy that stresses

- the selection of a system,
- the identification of pertinent basic physical laws, and
- the application of modeling assumptions and physical constraints, and
- the need for constitutive relations

in engineering problem solving. We believe that this common approach in turn helps students tackle new problems and apply new concepts.

What are the SEC courses?

The SEC consists of eight courses arranged in an engineering science and a mathematics stream for a total of 30 credit hours on a quarter system:



Fall Quarter 8 credit hours

- MA221 Differential Equations and Matrix Algebra I (4)
- ES201 Conservation & Accounting Principles (4)

Winter Quarter 13 credit hours

- MA222 Differential Equations and Matrix Algebra II (4)
- ES202 Fluid & Thermal Systems (3)
- ES203 Electrical Systems (3)
- ES204 Mechanical Systems (3)

Spring Quarter 9 credit hours

- MA223 Statistics for Engineers (4)
- ES205 Analysis & Design of Engineering Systems (5)

What traditional courses does the SEC replace?

Rose-Hulman has always had a significant common core required of all engineering majors. The SEC is built around these courses:

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|-----------------------|---------------------------|
| Engineering Dynamics | Matrix Algebra |
| Fluid Mechanics | Differential Equations I |
| Thermodynamics I | Differential Equations II |
| Electrical Circuits I | Statistics |
| System Dynamics | |

Why did you pick this arrangement?

The current SEC sequence of courses incorporates the following features:

- parallel streams of mathematics and engineering science with opportunities for integration within and between quarters.
- a one-three-one engineering science sequence that goes from general to specific and then back to general.
Fall: Introduce common framework for physical laws and problem solving based on systems, conservation and accounting, and modeling.
Winter: Discipline and phenomena specific courses with a shared laboratory that builds on the fall courses.
Spring: Multi-disciplinary problems with an increased emphasis on system dynamics concepts. Lab component combines hands-on experiments and writing of design specifications.
- opportunities to demonstrate mathematics topics immediately in engineering science courses.
Fall: Matrix algebra and 1st and 2nd order ODE's.
Winter: Laplace transforms, systems of ODE's, and Fourier and Taylor series
Spring: Statistics building on engineering science material and laboratories.
- a focus on only one aspect of design process — writing design specifications.

What are the mechanics of the curriculum?

Although the material is integrated, the students progress through individual courses:

- Students take individual courses with a single professor for each course.
- Students receive a grade for each course.
- Curriculum integration is maintained through syllabi and faculty communication.
- Prerequisites are used to insure proper sequencing.
- Students who fail a course can drop back and repeat it without leaving the program.
- Students with advanced standing in mathematics may take the mathematics sequence before taking the engineering science courses.
- Currently administered outside traditional departments.

How does the mathematics relate to the engineering science courses?

The mathematics sequence recognizes that equations form the core of deterministic mathematical models of physical systems. The courses stress a three-part mathematics framework for studying equations:

- Classification of equations from physical problems
Linear / Nonlinear – Algebraic / Differential – Scalar / Vector
- Investigation of equations from physical problems
Existence and uniqueness of a solution
- Techniques for solving the resulting mathematics
Linearize – Discretize – Diagonalize

These themes run throughout the deterministic mathematics courses as students learn the mechanics of how to solve the equations generated in their engineering science courses.

The statistics course strives to help students see the importance of statistical and probabilistic models as a way to understand real world applications and attempts to build on their experience in engineering science laboratories.

What are the advantages of the SEC?

We believe that there are several advantages for students participating in this program that will help create an enduring foundation for further learning. These include

- participation in a coordinated curriculum that consciously and deliberately stresses the links between engineering science and mathematics,
- developing a common foundation of engineering science and mathematics knowledge for future learning,
- learning to apply a common framework for problem solving based upon a systems, conservation and accounting, and modeling framework.
- learning to handle open-ended and multi-discipline problems,
- learning in an active and cooperative fashion,
- learning to work in teams, and
- using appropriate computer technology across the curriculum.

In addition, the new arrangement of material in the curriculum allows to students to see material several times at increasing levels of difficulty. This “spiraling” is difficult in the historical courses because everything is included within a single course.

What kind of assessment and evaluation has been done of the SEC?

The experience of the students in the curriculum has been assessed through surveys and focus groups. These formative assessments have been used to change and improve the curriculum. Limited summative assessment has been done to compare the performance of students in the SEC versus those in the historical curriculum. To date the results indicate that student performance is as good and in some cases better than the comparison group. Additionally faculty reaction to student achievement in the SEC and in subsequent courses has been good.

How can I learn about the SEC?

We are very proud of the SEC and welcome the opportunity to share our experiences with you:

- learning to work as a faculty team,
- developing a new integrated curriculum from the historical curriculum
- using a systems, conservation and accounting, and modeling framework to build a curriculum.
- gaining faculty acceptance and institute approval.

For additional information about the SEC contact

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