Rose-Hulman / Foundation-Coalition Sophomore Engineering Curricula

Detailed Information

What is the Rose-Hulman Sophomore Engineering Curriculum?

An eight-course sequence that integrates core material in engineering science and mathematics.

- Designed for all engineering majors.
- Developed by a multi-disciplinary faculty team.
- Taught since 1995-1996.
- Required of all electrical, computer, and mechanical engineering students.

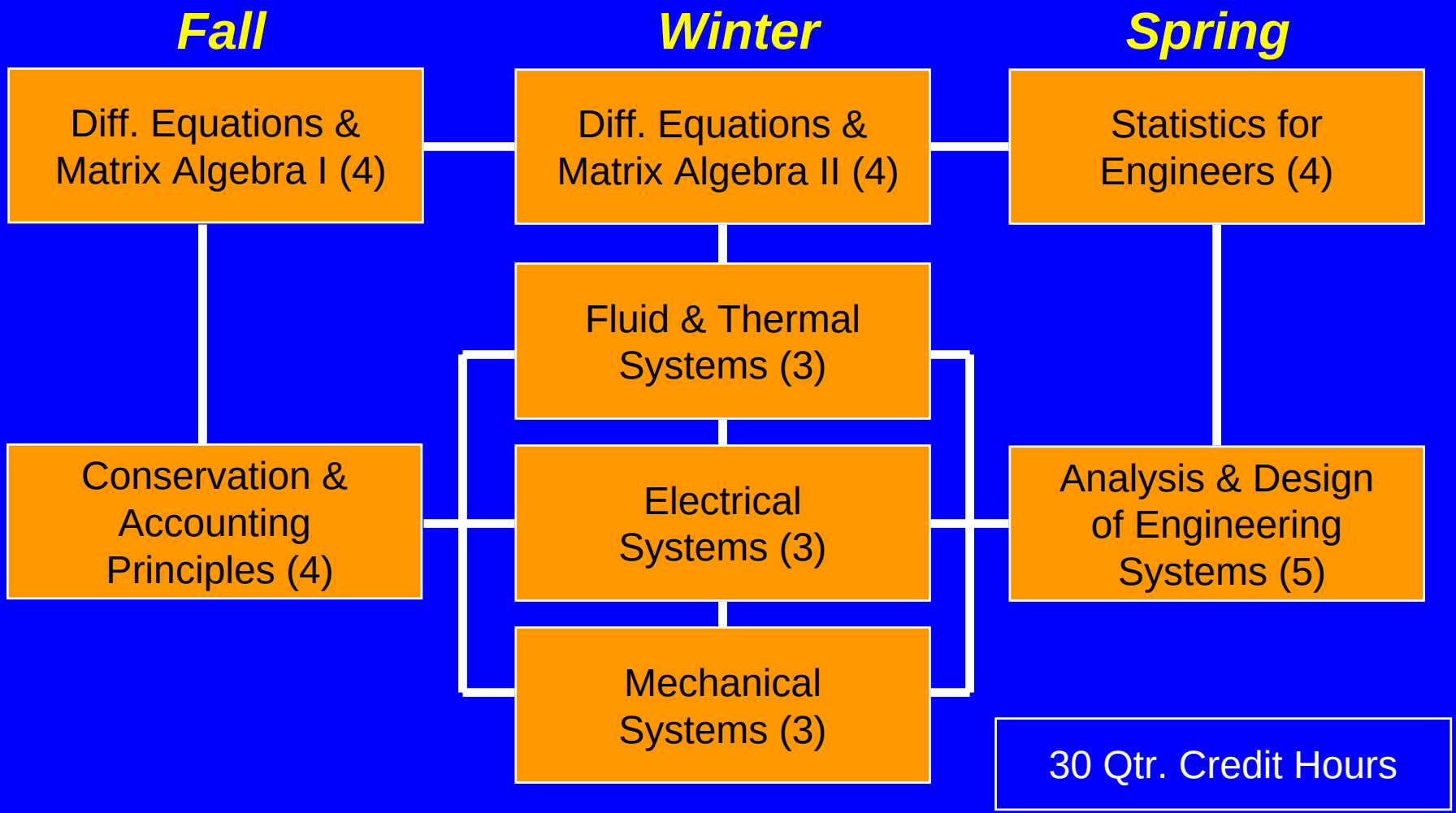
What's in our Core?

Diff. Equations I	**Dynamics**
Fluid Mechanics	**Circuits**
Thermodynamics	**Diff. Equations II**
Statistics	**System Dynamics**
Matrix Algebra	

32 Qtr. Credit Hours

Sophomore Engineering Curriculum

Our New Approach



Sophomore Engineering Curriculum
Advantages for Students

- Participate in a coordinated curriculum that consciously stresses the links between engineering science and mathematics.
- Provide a common foundation of engineering science and mathematics knowledge for future learning.
- Learn to apply a common framework for problem solving based upon an understanding of the conservation and accounting principles.
- Learn to handle open-ended problems.
- Work with multi-discipline problems.
- Learn cooperatively and work in teams.
- Use computer technology across the curriculum.

Sophomore Engineering Curriculum
A Brief History

Fall 1993

- Foundation Coalition funded by NSF.

1993-1994

- Institute considered various ideas for Sophomore Curriculum (Friday afternoon meetings)

Summer 1994

- Workshops on teaming, active learning, curriculum design. (Approximately 4 days total)
- Multidisciplinary faculty team developed overall framework for SEC. (12 faculty)

Sophomore Engineering Curriculum
A Brief History

1994-1995

- Met with departments and finalized proposal.
- Proposal for pilot approved by Institute.
- Required by electrical and computer engineering department.

Summer 1995

- Team of 12 faculty and 3 students developed detailed curriculum material for eight courses.

Sophomore Engineering Curriculum
A Brief History

1995-1996

- Offered RH/FC SEC for first time to 90 students
- Rose-Hulman required students to purchase a laptop computer.

1996-1997

- Adopted by mechanical engineering department for Fall 1998.

2000-2001

- Currently taken by 220-230 mechanical, electrical, and computer engineering students.

Sophomore Engineering Curriculum

Curriculum Structure

FALL Quarter . . . . . 8 Credit Hours

- MA 221 - Differential Equations & Matrix Algebra I (4)
- ES 201 - Conservation & Accounting Principles (4)

WINTER Quarter . . . . . 13 Credit Hours

- MA 222 - Differential Equations & Matrix Algebra II (4)
- ES 202 - Fluid & Thermal Systems (3)
- ES 203 - Electrical Systems (3)
- ES 204 - Mechanical Systems (3)

SPRING Quarter. . . . . 9 Credit Hours

- MA 223 - Engineering Statistics (4)
- ES 205 - Analysis & Design of Engineering Systems (5)

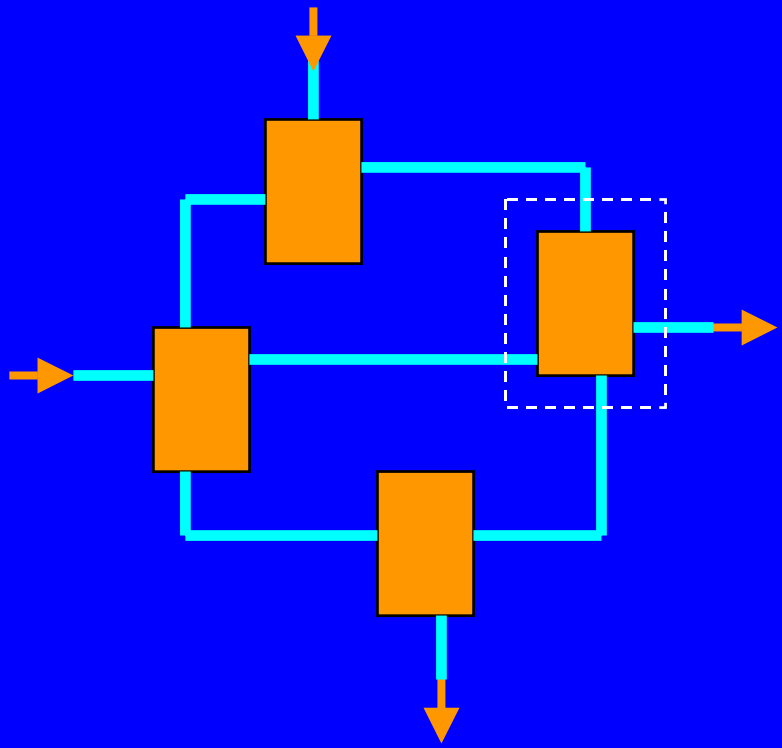
TOTAL CREDITS . . . . . 30 Credit Hours

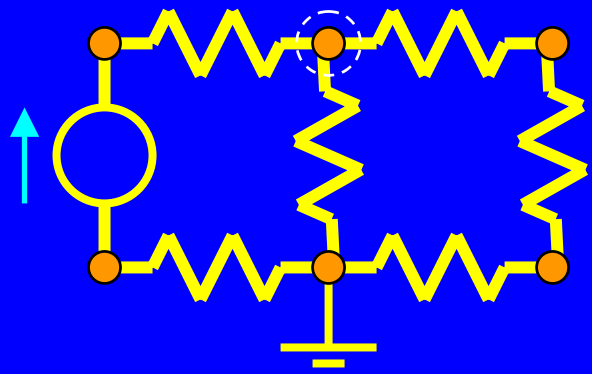
ES 201
Conservation & Accounting Principles

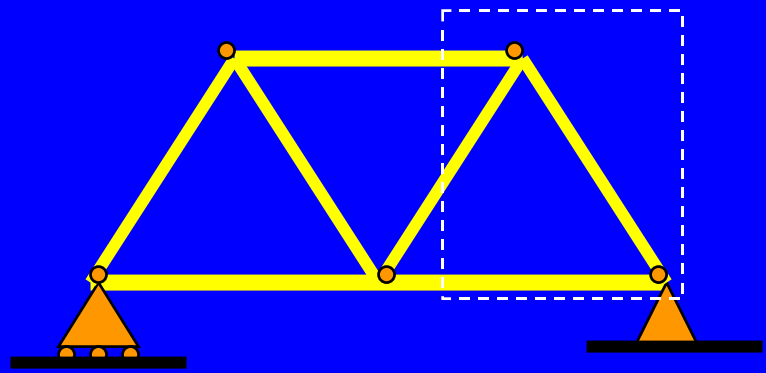
Fall Quarter - 4 credits

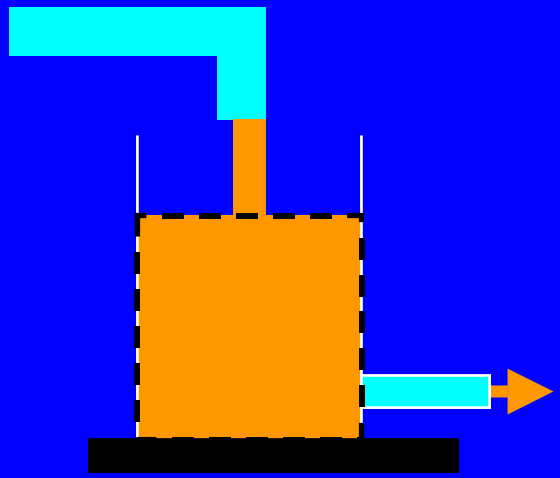
Conservation & Accounting Principles

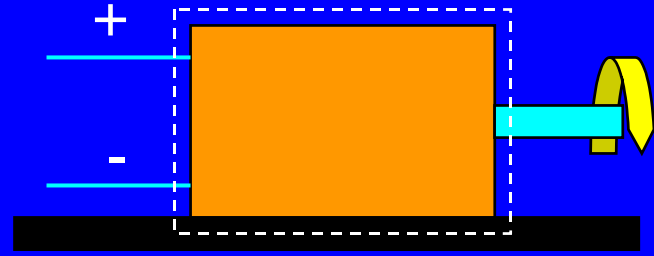
- Basic Systems, Accounting, and Modeling Concepts
- Laws
  - Conservation Laws: Mass, Charge, Energy, Linear & Angular Momentum
  - Accounting Principle: Entropy
- Simple open and closed systems

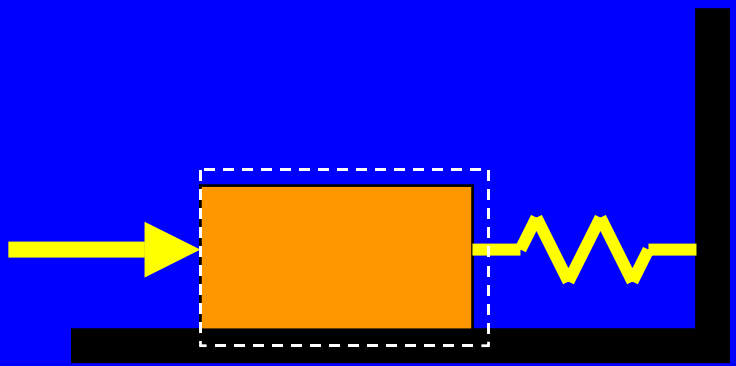


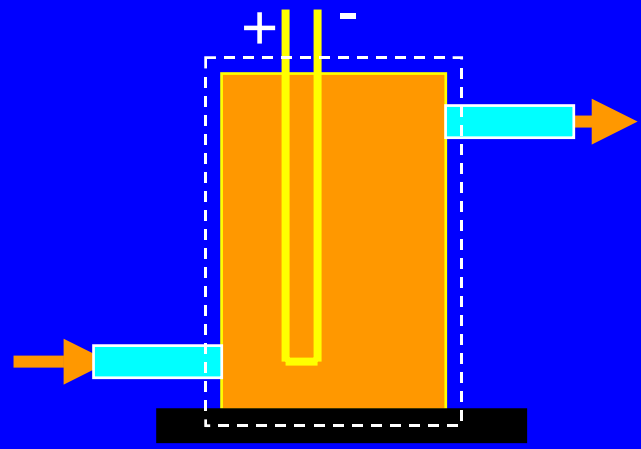












ES 202
Fluid & Thermal Systems

Winter Quarter - 3 credits

Shared 3-hr Laboratory

Fluid & Thermal Systems

- Thermodynamic Properties
  - Pure simple compressible substances
  - Gases: ideal gas & Z-Chart
  - Solids/Liquids: incompressible substance
- Applications to Open and Closed Systems
- Simple Cycles

Fluid & Thermal Systems

- Dimensional Analysis
- Mechanical Energy Equation
  - Bernoulli Equation
  - Pipe Flow of Incompressible Fluids
  - Pump/Turbine Efficiencies
- Lift and Drag
- Hydrostatics

Fluid & Thermal Systems

Laboratory Experiences

Lab 1 - Dimensional Analysis

Lab 2 - Torricelli's Principle, Friction Factors, Water-Wall Exhibit

Lab 3 - Back-pressure steam turbine

ES 203
Electrical Systems

Winter Quarter - 3 credits

Shared 3-hr Laboratory

Electrical Systems

- Circuit Elements
- Kirchhoff's Laws
- Equivalent circuits and Voltage and current dividers
- Operational amplifiers
- First, second, and higher order circuits
- Transient and steady-state behavior
- AC circuits and power

ES 204
Mechanical Systems

Winter Quarter - 3 credits

Shared 3-hr Laboratory

ES204 - Mechanical Systems

- More Kinematics
  - Normal-Tangential coordinates
  - Radial - Transverse coordinates
  - Dependent motion
  - Relative motion
  - Rigid bodies
- Impacts (coefficient of restitution)

Mechanical Systems (cont.)

- Use Working Model, Maple, Concept maps
- Three labs
- Immediate application to kinetics problems
- Combination problems

Assessment - Is it worse?

- Year 2 - Gave 17 identical multiple choice and 1 identical workout problem to ES204 and to dynamics students
  - 4 ES204 sections/3 professors
  - 5 Dynamics sections/3 professors
- Year 3 - Gave identical finals to ES204 and to dynamics students (20 multiple choice, 3 workout)
  - 4 ES204 sections/2 professors
  - 5 Dynamics/3 professors

Year 2 - Multiple Choice

Prob. #	First Assessment			Second Assessment		
	SEC - ES204	Dynamics	Difference	SEC - ES204	Dynamics	Difference
1	45.7	43.0	2.7	40.2	32.0	8.2
2	24.7	48.6	-23.9	56.3	61.0	-4.7
3	88.9	90.8	-2.0	94.3	94.0	0.3
4				87.4	81.0	6.4
5	80.2	45.8	34.5	71.3	56.0	15.3
6	72.8	66.9	5.9	82.8	79.0	3.8
7	91.4	62.7	28.7	82.8	76.0	6.8
8	59.3	47.2	12.1	57.5	55.0	2.5
9	87.7	85.2	2.4	87.4	94.0	-6.6
10	74.1	28.9	45.2	78.2	49.0	29.2
11	95.1	95.8	-0.7	90.8	93.0	-2.2
12	48.1	33.8	14.3	46.0	57.0	-11.0
13				96.6	98.0	-1.4
14	92.6	88.0	4.6	90.8	95.0	-4.2
15	90.1	80.3	9.8	66.7	63.0	3.7
16				62.1	54.0	8.1
17	61.7	52.1	9.6	50.6	79.0	-28.4
18	45.7	39.4	6.2	41.4	47.0	-5.6
19				9.2	47.0	-37.8
20	71.6	44.4	27.2	63.2	56.0	7.2

Workout problems*

Year 2			
Prob. #	**SEC - ES204**	**Dynamics**	**Difference**
1	33.3	23.3	10

Year 3			
Prob. #	**SEC - ES204**	**Dynamics**	**Difference**
1	35.8	17	19.8
2	70.1	22	48.1
3	46	6	40

* Essentially an “A” solution

ES 205
Analysis & Design of Engineering Systems

Spring Quarter - 5 credits

3-hr Laboratory

ES205 - Analysis & Design of Engineering Systems

- Pre-vibrations/controls
- Mechanical, Electrical , Electro-mechanical, Hydraulic, Fluid, Thermal systems
- Governing differential equations
- System Response
- System identification

Systems Concepts in ES205

- Modeling of system elements
- Equations of motion
  - Natural frequency, Damping ratio, Static gain
  - 2nd order matrix form, state space form
- Transfer functions
- Free response
  - log decrement

Systems Concepts in ES205 (cont.)

- Forced Response
  - Step input
    - performance specifications
  - Harmonic input
    - Frequency response plots
  - General periodic forcing
    - Fourier Series
- Simulink,Matlab and Maple

Analysis & Design of Engineering Systems

Laboratory

- Introduction to the design process.
- Teams of students study and develop *design specifications*** for products.
- Includes written and oral presentations.

**S. Pugh. *Total Design*, Addison Wesley, 1991.

K. T. Ulrich and S. D. Eppinger. *Product Design and Development*, McGraw-Hill, 1995.

Mathematics Sequence

- Differential Equations & Matrix Algebra I
- Differential Equations & Matrix Algebra II
- Statistics for Engineers

Sophomore Engineering Curriculum

Mathematics

- Stresses Linear Structures
  - systems of algebraic equations (Ax=b)
  - 1st & 2nd order differential equations
  - systems of differential equations
  - Laplace transforms
  - Fourier series
  - linearization
- Applications of Statistics
- Students have laptops with access to MAPLE, MATLAB, and MINITAB.

Differential Equations & Matrix Algebra I

- Basic Matrix Algebra
  - systems of linear equations (algebraic and geometrical viewpoints)
  - least squares
  - eigenvalues and eigenvectors
- Differential Equations
  - Review of first-order de's
  - Second-order linear de's with constant coefficients (homogeneous and non-homogeneous cases)
- Introduction to Complex Arithmetic

Differential Equations & Matrix Algebra II

- Laplace Transforms
- Systems of First-Order Linear DE's
  - solution using Laplace transforms
  - investigation of solution structure determined by eigensystems.
- Phase Portrait Analysis and Stability of Critical Points for Systems of Equations
- Approximation of Functions
  - Taylor and Fourier series

Statistics for Engineers

- Introductory course in statistical data analysis emphasizing
  - hypothesis testing
  - analysis of variance
  - quality control charts
  - simple and multiple regression
  - simple experimental designs
- Computer Tools: MINITAB and Excel

Experience with SEC at RH

- Reduced engineering credit hours from 20 to 18 without sacrificing material.
- Faculty like
  - common problem solving approach that does not reinforce “plug and chug.”
  - emphasis on modeling assumptions and mathematics that apply across disciplines.
  - ability to restructure material and “spiral” back, e.g. dynamics in two courses.

Experience with SEC at RH

- Students comment favorably on “integration” and “big picture” view of curriculum.
- Quantitative comparisons
  - SEC students did better than traditional students on final exam “workout” problems in dynamics, e.g. 20-40% more SEC students got problems right.

Student Comments after Completing the SEC

Student A

"ES201 was an excellent foundation to start on. A solid handle on this class is a must for success in the following classes. All classes were connected to this class."

Student Comments

Student B

“The sophomore curriculum has won me over. At first, I thought it was a complete waste of time. Then during winter quarter I saw the importance of it. Now, I am glad to have gone through it. The book didn’t help much, it was vague and made the class more difficult.”

Student Comments

Student C

"I was very pessimistic about the course (ES205) at the beginning of the quarter. This course defeated every pessimistic premise I had before it was completed. This course brought all the engineering disciplines together and, at the very least, made this skeptical EE a believer in the SEC. Not only was the course an eye-opener, but it also enhanced my ability to solve general complex-system problems regardless of what discipline they came from?

Student Comments

Student D

"Perhaps one of my other gripes with the class is that it is *so* different from freshman physics. I actually prefer this method of teaching when it comes to frictions, tensions, angular momentum, etc. These are all topics with which I felt uncomfortable during freshman physics although I understand them better now. In the future, I would appreciate seeing the ConApps and Physics curriculums more closely integrated so that students only have to learn concepts once.

For additional information about the RH Sophomore Engineering Curricula *or* the Systems, Accounting, and Modeling Approach contact ---

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