Rose-Hulman Institute of Technology Course Catalog

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FAST TRACK CALCULUS

Integral and multivariable calculus, is offered during the summer (late July through late August) for selected members of our entering freshman class who have demonstrated outstanding ability in mathematics and studied a year of calculus during high school. Participants are expected to have scored at least 700 on the mathematics portion of the SAT or 31 on the mathematics portion of the ACT. Students, who have a 700 Math Score or 680 math/700 critical reading or better on the SAT, or a 30 mathematics score and at least a 31 English score on the ACT have also been admitted to the program. Participants who successfully complete Fast Track Calculus satisfy Rose-Hulman's freshman Calculus requirement, are awarded 15 quarter hours of credit toward graduation, and begin their college careers as "mathematical sophomores."

Admission to Fast Track Calculus is competitive. Interested students should contact the Head of the Mathematics Department or Director of Fast Track Calculus.

ACCELERATED MATH PHYSICS

An integrated calculus and physics course is offered during the summer (late July through late August) for selected members of our entering freshman class who have demonstrated outstanding ability in mathematics and physics having taken a year of college level calculus during high school and one year of high school physics. Participants are expected to have scored at least 700 on the mathematics portion of the SAT or 31 on the mathematics portion of the ACT. Students, who have a 700 mathematics score or 680 mathematics/700 critical reading or better on the SAT, or a 30 mathematics score and at least a 31 English score on the ACT have also been admitted to the program. Participants who successfully complete the Accelerated Math Physics Program will earn credit for MA113, PH111, and PH112. Selected students are expected to have the ability to place out of MA111 and MA112, so will start in the Fall quarter having credit for MA111, MA112, MA113, PH111, PH112 – effectively as sophomores. Admission to the Accelerated Math Physics Program is competitive. Interested students should contact the Directors of the Accelerated Math Physics Program.

NEW STUDENT ORIENTATION

To aid entering students in their adjustment to college life, a five-day orientation period for students precedes regular classroom instruction prior to the start of the academic year. Each freshman is required to be present for this program. The program offers a number of advantages to both the students and faculty. The students become acquainted with the facilities and surroundings, with each other, and with the regulations and routines of college life. Students learn about the various student organizations, opportunities for co-curricular activities and Rose-Hulman student traditions.

Further, students are introduced to the nature of science and engineering studies, and they meet with their faculty advisers and resident assistants. Talks and discussions offer them insight into the kinds of work engineers and scientists do and into the satisfactions to be derived from a career in science and engineering.

The orientation period also permits the faculty an opportunity to administer a number of diagnostic tests. These tests seek to determine achievement levels in academic areas and are useful for two purposes: they are tools to be used by the faculty advisers and counselors to do effective counseling, and they help to identify students who may need special attention.

Although Rose-Hulman uses the best available criteria to select its students, the undeniable fact is that students come to college with widely varying degrees of motivation and with widely differing qualities of high school preparation. The diagnostic efforts of the orientation period help to identify those students who could immediately qualify for advanced work in certain areas, and those who indicate a need for additional help. Students at Rose-Hulman normally complete their degree requirements in four years, but the Institute also wishes to provide for those students who, with encouragement and opportunity, do more than the normal student in four years and for those who may need special help or a slower pace of study.

SUSTAINABILITY MINOR

1. Curricular Requirement
    a. Core Courses (16 credits)
        i. GS130 Introduction to Sustainability (4 credits)
        ii. BIO191 Environmental Science (4 credits)
        iii. SV150 Microeconomics (4 credits)
        iv. MDS302 Sustainability in Practice (2 credits): prerequisites: GS130, BIO191, SV150
        This is a project-based course to provide hands-on experiences for student teams working on real-world problems related to sustainability. This could include design projects, scientific research, modeling-based projects, or studies to improve campus sustainability. The course instructor will mentor teams with routine assignments that relate to their design or research process through oral and written communication.
        v. MDS402 Seminar in Sustainability (2 credits): prerequisite MDS302
        This course provides students with the opportunity to examine, analyze, and reflect upon sustainability as it related to their project or research work. Course work includes weekly readings and discussions, individual essays, and in-class and public presentations. Successful completion of this course will require students to have completed the co-curricular requirements.

b. Three electives (4 credits each = 12 credits) Students must take a total of at least four credits from a list of Social courses and at least eight credits from a list of Technical and Scientific courses. Alternatively, students can design their own plan of study for elective courses that suit their particular interests and field of study with approval of the HERE Co-directors, Jenny Mueller Price and Mark Minster.
    i. Social (HSS requirement)
    SV201 Religion and Ecology
    SV303 Business and Engineering Ethics
    SV304 Bioethics
    SV322 Disasters and Modern Society
    SV 354 Environmental Economics
    SV339 Literature and the Environment
    GS 425 Cities and Technology in the Industrial Age
    ii. Technical and Scientific (Discipline Specific Tech Elective)
    BIO320 Ecology (prerequisite: BIO130)
    CE250 Sustainable Civil Engineering Design (2 credits)
    CE460 Introduction to Environmental Engineering
    CE471 Water Resources Engineering
    CHEM470 Green Chemistry (Special Topics)
    CHE465 Energy and the Environment
    CSSE241 Computing in a Global Society
    ECE371 Sustainable Energy Systems (prerequisite: ECE204)
    ECE398 Appropriate Technologies for Developing Countries (Special Topics)
    EMGT587 Systems Engineering
    ME408 Renewable Energy (prerequisite: ES202)

2. Co-curricular requirements: Students record via Co-curricular Report on Banner Web. Students will need to complete these requirements to pass MDS402 Seminar, which is taken senior year. Requirements will be prorated for students joining the program after their freshman year.
    a. Three professional development activities per year (guest speakers; trips to St. Louis, Bloomington, Chicago, and Subaru plant each year; Terre Haute Farmer's Market; etc.)
    b. Six project hours per year (Campus garden and greenhouse, Ryves neighborhood, RHIT Campus Day of Service, RHIT Campus Beautification, Keep Terre Haute Beautiful, Student-led initiatives, etc.)

MULTIDISCIPLINARY MINOR IN COGNITIVE SCIENCE

The Multidisciplinary Minor in Cognitive Science has the following requirements:

1. Cognitive Psychology (IA 371).
2. Object-Oriented Software Development (CSSE 220) or Fundamentals of Software Development Honors (CSSE 221)
3. Philosophy of Mind (IA 301) or Philosophy of Science (IA 401) or Human Nature (SV 472)
4. Three additional courses from the list below. At least two courses must be from the same group. A course may not satisfy more than one requirement of the minor.
5. Substitutions may be made with the approval of the Minor Advisor.

Courses:

Mind and Behavior group

- IA 301 Philosophy of Mind
- IA 352 Game Theory
- SV 171 Introduction to Psychology
- SV 402 Human Nature
- SV 472 Studying Human Behavior

Computation and Artificial Intelligence group

- CSSE 290 Cognitive Computing
- CSSE 413 Artificial Intelligence
- CSSE 453 Topics in Artificial Intelligence
- CSSE 463 Image Recognition
- IA 471 Computational Psychology
- MA 490 Deep Learning

Neuroscience group

- BE 310 Analysis of Physiological Systems I
- BE 520 Introduction to Brain Machine Interfaces
- BE 543 Neuroprosthetics

CONSULTING ENGINEERING PROGRAM

Through the generosity of J. B. Wilson, a prominent consulting engineer of Indianapolis, a program was established in 1973 to emphasize career opportunities in the field of consulting engineering and to provide selected courses which would be beneficial to students interested in consulting engineering careers.

Listed below is a program guide of recommended courses for a student interested in consulting engineering. This is not a degree program but is a supplement to the normal engineering degree programs. Some of the courses are in addition to the normal engineering degree programs and may result in a student earning more credits than are required for the B.S. degree in a specific discipline.

Students desirous of pursuing the Consulting Engineering Program should enroll in the Program by filing a declaration-of-intent form with the Chairman of the Commission. In order to be certified as having completed the Program, a student is required to successfully complete the prescribed list of courses, complete the requirements for a degree in Engineering, and take the Fundamentals of Engineering examination prior to graduation.

Upon completion of the program, students will receive a Certificate of Completion at the time of their graduation from Rose-Hulman Institute of Technology. Completion of the program will be noted on the student's official transcript but not on the diploma. The Consulting Engineer Program advisor is Dr. Kevin Sutterer P.E., Ph.D., Department of Civil and Environmental Engineering.

Download the Consulting Engineering Intention Form

	Credit
EM102/EM104 Graphical Communications	2
RH330 Technical Communications	4
Or	
IA230 Fundamentals of Public Speaking	4
SV351 Managerial Economics	4
Or	
EMGT 432/532 Technical Entrepreneurship	4
CE303 Engineering Economy	4
Or	
CHE416 Design I: Process Economics and Equipment Design	4
EMGT552 Business Law for Technical Managers	4
CE420/CHE420/ECE466 or ME420 Consulting Engineering Seminar	2
Engineering Design (any senior Engineering design course)	4
Total	24
Exceptions to these program course requirements require approval by the Consulting Engineering Program Advisor.	
Registration for & sitting for the Fundamentals of Engineering Exam required.	

MULTIDISCIPLINARY MINOR IN DATA SCIENCE

Any student may obtain a Multidisciplinary Minor in Data Science by taking the following courses:

Introductory Statistics Course (4 credit hours):
One of the following courses

- MA223 Engineering Statistics I
- MA382 Introduction to Statistics with Probability

Introductory Computer Science Courses (8 credit hours):

- CSSE120 Introduction to Software Development
- CSSE220 Object Oriented Software Development

Electives (16 credit hours):
Two courses from the list below:

- MA386 Statistical Programming

- MA384 Data Mining
- CSSE 230 Data Structures & Algorithm Analysis

A minimum of two additional course from the list below: (See degree separation requirement below.)

- BMTH312 Bioinformatics
- CSSE333 Database Systems
- CSSE413 Artificial Intelligence
- CSSE433 Advanced Database Systems
- CSSE434 Introduction to the Hadoop Ecosystem
- CSSE463 Image Recognition
- CSSE481 Web-Based Info Systems
- CSSE490 Internet of Things
- CSSE335/MA335 Introduction to Parallel Computing
- MA384 Data Mining
- MA386 Statistical Programming
- MA482 Bioengineering Statistics
- MA483 Bayesian Data Analysis
- MA485 Applied Regression and Time Series
- MA490 Machine Learning
- MA490 Deep Learning
- ME447 Visualizing Data
- ME497 Reproducible Research
- PH327 Thermodynamics and Statistical Mechanics
- SV450 Econometrics

Notes and limitations on requirements:

- Degree Separation Requirement: The Multidisciplinary Minor in Data Science must be separated from any other minor and the named required courses of any major by a minimum of 16 credit hours. Exceptions to this requirement must be approved by the minor advisor for Data Science and the heads of both the Department of Mathematics and the Department of Computer Science and Software Engineering.
- Electives not listed above may be substituted with other courses with the approval of the minor advisor for Data Science.
- The minor plan of study must be approved by the minor advisor for Data Science and the student’s advisor.

STUDY ABROAD

Students are provided the opportunity to enhance their academic experience by studying at an institution abroad. The Office of Global Programs offers information and support for students interested in immersive study abroad. To ensure the integrity of the experience, the following policies have been established.

- Students with a cumulative grade point average of 2.75 or higher, and who will have completed at least 45 earned credit hours at Rose-Hulman by the time of study abroad may apply for approval to enroll in a study abroad program.
- Students must be in good academic standing to apply for study abroad, including dual degree programs. Students who fall out of good academic standing between

approval and the beginning of study abroad will be ineligible to study abroad until they are back in good standing.
- Students must remain in good standing during their study abroad program.
- Approved study abroad students will remain enrolled at the institute during the quarter or academic-year study abroad period.
- Students studying in a single location where English is not an official language are expected to study the official language of that country while studying abroad if they do not already have proficiency in that language.
- Students must maintain full-time status at the host institution and must receive a grade of “C” or better (converted to US system) in order for courses to be transferred in. Courses taken abroad for pass/fail credit will not be considered for transfer in.
- All study abroad credit, including dual degree, will be treated as transfer credit and will not be factored into cumulative GPA.
- Students may not have already graduated at the time of study abroad.
- Academic Misconduct will be taken into consideration as part of the approval process.
- Students will be subject to Rose-Hulman’s Code of Ethics while participating in study abroad.

Exceptions to the above policies may be considered for transfer students and on a case-by-case basis by the Office of Global Programs.

A full listing of study abroad opportunities is available from the Office of Global Programs.

INTEGRATED CIRCUIT TESTING CERTIFICATE

Testing integrated circuits is a critical element in the integrated circuit industry. In fact, testing has become the bottle-neck for many companies, with inefficient test programs preventing the release of products onto the market. With few colleges offering courses in this area, students at RHIT have a unique specialization opportunity, making them marketable and extremely valuable in the integrated circuit industry.

This certificate intends to provide the student with a solid background in test and product engineering and broaden that background with other courses pertinent to the test and product engineering field. A strong test/product engineer requires knowledge about integrated circuit design, systems design, board design, semiconductor fabrication, and statistics. Therefore, courses in these areas can be chosen for the elective portion of the certificate.

The test and product engineering certificate could be completed by an electrical or computer engineering student without overloading if the certificate courses are mapped to all but one of the Area, Technical, and Free electives. Electives have been chosen so that students can pursue the semiconductor certificate or a math minor in conjunction.

Certificate Requirements

ECE351: Analog Electronics is required.

Two of the three testing courses are required.

ECE557: Analog Test and Product Engineering
ECE558: Mixed-Signal Test and Product Engineering
ECE531: Digital Test and Product Engineering

Three of ten elective courses are required.

ECE551: Digital VLSI
ECE552: Analog Integrated Circuit Design
ECE553: RF Integrated Circuit Design
ECE343: High-Speed Digital Design (required for CPE program)
ECE416: Intro to MEMS
ECE419: Advanced MEMS
ECE454: System Level Analog Electronics
ECE557: Analog Test and Product Engineering (if not used for required testing course)
ECE558: Mixed-Signal Test and Product Engineering (if not used for required testing course)
ECE531: Digital Test and Product Engineering (if not used for required testing course)
PH405: Semiconductor Materials and Device I
EP406: Semiconductor Materials and Devices II
MA385: Quality Methods Engineering
MA387: Statistical Methods in Six Sigma

For further information about the certificate program, please contact Tina Hudson (hudson@rose-hulman.edu).

MULTIDISCIPLINARY MINOR IN IMAGING

Imaging concerns the collection, manipulation, analysis, generation, understanding and processing of images. It includes computer graphics, computer vision, optical imaging and filtering, signal processing and aspects of artificial intelligence and machine learning. Imaging is used across all areas of science and engineering, for example, in the vision systems in self-driving cars, in robotics, and in automating medical diagnostics, even to the point of detecting a person's pulse from a video of their face.

Rose-Hulman Institute of Technology offers a multidisciplinary minor in imaging. The minor requires 24 credits (6 courses): three required courses and three imaging electives from the list below. Since imaging is a multidisciplinary minor, at least 12 of the 24 credits must be courses that are not named required courses for the student's major.

Students choose a track to pursue. Each track allows the student to gain depth in a different area. Each has its own required courses and suggested electives (although any electives from the list below are acceptable).

Track 1: **Medical Imaging**
Expected majors: **BE, EE, CPE, PH, OE, EP**
Required courses: **ECE584/BE541, ECE480, BE340 or ECE380**
Plus three electives from the **Imaging Electives** list below.
Recommended electives: **BE435/OE435, MA439, CSSE463**

Track 2: **Image Recognition**
Expected majors: **CS, SE, PH/OE/EP, EE/CPE, MA, ME**
Required courses: **ECE582/PH537, CSSE463, MA490 (Deep Learning)**
Plus three electives from the **Imaging Electives** list below.
Recommended electives: **MA490 (Machine Learning), ECE480/OE437, CSSE461**

Track 3: **Real-time Rendering**
Expected majors: **CS/SE, ECE, MA**

Required courses: **CSSE351, CSSE451, MA323**
Plus three electives from the **Imaging Electives** list below.
Recommended electives: **MA371 or MA373, ECE480, CSSE/MA325, IA142 or IA244**

Track 4: **Acquisition of Images**
Expected majors: **ECE, PHOE, BE**
Required courses: **ECE480/OE437, PH405, OE295**
Plus three electives from the **Imaging Electives** list below.
Recommended electives: **OE480, OE392**

Track 5: **Creative Imaging**
Expected majors: **CS/SE, ECE, MA**
Required courses: **IA142, ECE480, CSSE/MA325**
Plus three electives from the **Imaging Electives** list below.
Recommended electives: **CSSE351, MA323, IA244**

Imaging Electives (choose any 12 credits that are not required for your track, as long as at least 12 of the 24 credits for the minor are not named, required courses for your major)

BE340 Biomedical Signal Processing or ECE380 Discrete-Time Signal Processing (only one can be taken as a minor elective)

BE435/OE435 Biomedical Optics

CSSE325/MA325 Fractals and Chaotic Dynamical Systems

CSSE351 Computer Graphics,

CSSE413 Artificial Intelligence

CSSE451 Advanced Computer Graphic

CSSE461 Computer Vision

CSSE463 Image Recognition

ECE480/OE437 Introduction to Image Processing

ECE580 Digital Signal Processing

ECE582/PH537 Advanced Image Processing

ECE584/BE541 Medical Imaging Systems

IA142 Drawing or IA244 Design and Color (only one can be taken as a minor elective)

MA323 Geometric Modeling

MA371 Linear Algebra or MA373 Applied Linear Algebra

MA439 Mathematical Methods of Image Processing

MA490 Deep Learning

MA490 Machine Learning

OE295 Photonics Devices and Systems OE392 Linear Optical Systems.

OE480 Optical System Design

OE592 Fourier Optics and Applications

PH405 Semiconductor Materials and Applications

PH538 Introduction to Neural Networks

Any special topics course or independent study in any major that involves imaging (must be approved by the Imaging Program Director.

MINOR IN MATERIALS SCIENCE AND ENGINEERING

Materials science and engineering is a broad field of study. As the name implies, it encompasses foundational knowledge from the sciences (e.g. physics, chemistry, and biology) and it includes the engineering application of this knowledge to create new materials and to select, modify, and combine existing materials in novel and useful ways. Developments in materials science and engineering are critical to success in many areas of science and technology. The relationship between the structure, processing, and properties of materials is central to the discipline, and therefore the courses in this minor teach students about one or more of these areas. Rose-Hulman Institute of Technology offers a Minor in Materials Science and Engineering to recognize students who have gained experience in these areas while at Rose-Hulman. Students in any degree program are eligible for this minor, except students working toward the minor in Solid State Physics/Materials Science.

To earn the Minor in Materials Science and Engineering, a student must complete a minimum of 24 credit hours according to the guidelines below. These guidelines are designed to be flexible in order to accommodate students from different majors across the Institute. Consequently, some courses are listed in multiple categories even though any given course may only be counted once toward the minor. In some cases, a prerequisite may be waived if the instructor determines that the student has sufficient background knowledge from previous coursework taken in other departments. Prerequisites are included for reference but are subject to change; the course catalog contains the official prerequisites.

- **One of the following introductory courses (or course sequences):**

Course	Description	Hours	Prerequisites
BE 361 & BE 351	Biomaterials &	3	BE 331* and BE 361*
	Biomedical Engineering Lab	2	
CHE 315	Materials Science and Engineering	4	CHEM 115
ME 328	Materials Engineering	4	CHEM 111

**corequisite*

- **A total of 20 additional credit hours from one or both of the following categories.** Any course required for a student's major (excluding elective courses required for the major, and other exceptions as specified in the footnotes) does not count toward these 20 credit hours, nor does any course taken to satisfy requirement (1) above.
  - **A minimum of 12 credit hours of the following elective courses:**

Course	Description	Hours	Prerequisites
BE 361	Biomaterials	3	

BE 534	Soft Tissue Mechanics	4	EM 203, and EM 204 or BE 331**
BE 539	Multiscale Biomechanics	4	EM 203 or EM 204, and BE 331**
BE 560	Tissue-Biomaterial Interactions	4	BE 361**
CE 320	Civil Engineering Materials[1]	4	
CHE 315	Materials Science and Engineering[2]	4	CHEM 115
CHE 441	Polymer Engineering	4	CHE 404***, and CHEM 251**
CHE 515	Nanomaterials Science & Engineering	4	CHE 315** or ME 328**
CHEM 562	Physical Polymer Chemistry	4	CHEM 361 or CHE 303
ECE 416	Introduction to MEMS: Fabrication & Applications (cross-listed with CHE 405, EP 410, and ME 416)	4	Junior or Senior class standing
Course	**Description**	**Hours**	**Prerequisites**
ECE 419	Advanced MEMS: Modeling & Packaging (cross-listed with CHE 419 and EP 411)	4	EP 410 or equivalent course
ECE 543	Electromagnetic Metamaterials	4	ECE 341
EP 330	Material Failure	4	PH 112
ME 328	Materials Engineering[2]	4	CHEM 111
ME 414	Materials Selection in Mechanical Design	4	EM 204
ME 423	Fatigue	4	EM 204
ME 424	Mechanics of Composites	4	EM 204 and ME 328

ME 428	Materials Research and Instrumentation	4	CHEM 111 and Jr Standing
ME 517	Mechanics of Metal Forming	4	EM 204
OE 360	Optical Materials	4	PH 255 and PH 316
PH 255	Foundations of Modern Physics	4	PH 113 and MA 211*
PH 405	Semiconductor Materials & Applications	4	PH 113 or PH 255 or PH 265
PH 407	Solid State Physics	4	PH 255 or PH 265
PH 440	X-rays and Crystalline Materials	4	PH 255 or PH 265
CHEM 470	Absorption Spectroscopy	1	**
CHEM 470	Raman Spectroscopy	1	**
CHEM 470	Microfluidics	1	**
PH 113 OR EM 204	Physics III[3] Or Statics & Mechanics of Materials II[3]	4	PH 112 and MA 112 and MA 113* Or EM 121
With permission of a minor advisor, up to four credit hours of independent study and/or self-directed research		≤ 4	

[1]CE majors may count CE 320 toward fulfillment of the minor even though it is in category (2)

[2]CHE 315 and ME 328 cannot both count toward fulfillment of the minor

[3]PH 113 or EM 204 cannot be taken as a terminal course. A materials elective that requires

PH 113 or EM 204 as a prerequisite must also be taken in fulfillment of minor requirements.

corequisite course; **consent of instructor; * or concurrent registration*

- **A maximum of 8 credit hours of the following elective courses that focus on mechanics of materials:**

Course	Description	Hours	Prerequisites
EM 505	Theory of Elasticity	4	EM 203 or EM 204
ME 422	Finite Elements for Engineering Applications	4	EM 204
ME 522	Advanced Finite Element Analysis	4	ME 422

A student interested in pursuing a Minor in Materials Science and Engineering should consult with one of the following minor advisors: Dr. Patrick Cantwell (Department of Mechanical Engineering), Dr. Emma Dosmar (Department of Biology and Biomedical Engineering), or Dr. Marissa Tousley (Department of Chemical Engineering). Successful completion of this minor will be indicated on the student's transcript.

CERTIFICATE IN SEMICONDUCTOR MATERIALS AND DEVICES

The Certificate will consist of 20 credit hours of which 12 credit hours will be required courses. Students interested in pursuing this Certificate should see a PHOE certificate advisor (S. Kirkpatrick, Liptak, McInerney, Siahmakoun, Syed and Wagner). Students taking solid state/material science minor cannot take this certificate.

Required Courses

1. PH405 Semiconductor Materials and Applications -- 3R-3L-4C F Pre: PH113 or PH255 or PH265 or consent of instructor.
2. EP406 Semiconductor Devices and Fabrication -- 3R-3L-4C W Pre: PH405 or consent of instructor.
3. EP410 Intro to MEMS: Fabrication and Applications -- 3R-3L-4C S Pre: JR or SR standing or consent of the instructor.
   or:
   CHE440 Process Control 4R-0L-4C W Pre: CHE202

Electives

Course	Hours	Course Title
OE 450	4	Laser Systems and Applications
OE 485	4	Electro-Optics and Applications
PH 330	4	Material Failure
PH 401	4	Introduction to Quantum Mechanics
PH 440	4	X-rays and Crystalline Materials
EP 408	4	Microsensors
EP 411	4	Advanced Topics in MEMS
ECE 351	4	Analog Electronics

ECE 551	4	Digital Integrated Circuit Design
ECE 552	4	Analog Integrated Circuit Design
ME 302	4	Heat Transfer
ME 328	4	Materials Engineering
ME 424	4	Composite Materials & Mechanics
ME 415	4	Corrosion and Engineering Materials
CHE 314	4	Heat Transfer
CHE 315	4	Material Science and Engineering
CHE 440	4	Process Control
CHE 441	4	Polymer Engineering
CHEM 441	4	Inorganic Chemistry I
CHEM 451	4	Organic Structure Determination
CHEM 457	4	Synthetic Polymer Chemistry
CHEM 462	4	Physical Polymer Chemistry
MA 381	4	Intro to Probability with Applications to Statistics
MA 385	4	Quality Methods
MA 487	4	Design of Experiments

Overall aim of the Certificate

A certificate holder will understand how semiconductor devices work, have practical experience in the main stages of device production, have practical experience in the more common forms of device testing and characterization, and have broad understanding of the mechanical and chemical properties of the material used.

A Certificate holder will be well suited for jobs requiring an understanding of semiconductor devices and their production. These jobs include not only those directly related to device fabrication, but also those involved with testing and trouble-shooting electronic equipment and the design of machines that contain electronic equipment. The experience in simple device fabrication that the Certificate provides is particularly useful for future engineers in “process” industries.

THE MANAGEMENT STUDIES PROGRAM

The Management Studies Program is a selected group of courses which develops a broad understanding of management in business and society. Like the Rose-Hulman Technical Translators Program, the Management Studies Certificate is a supplement to an engineering or science degree. The curriculum is a core of required courses in ethics, engineering management, economics, and technical communication

with electives dealing with the role of management in society and specific tools for managers.

Statement of Objectives

The Management Studies Program broadens the education of engineers and scientists through a curriculum which:

- teaches the quantitative and economic concepts needed in management decision-making;
- promotes productivity through people;
- stresses communication skills required in management;
- examines intended and unintended impacts of management decisions;
- explores the social, legal, and ethical contexts of management.

Although the nine courses necessary to receive the certificate are a challenging addition to the undergraduate's academic load, many of them may simultaneously be used to fulfill Humanities and Social Science, technical elective, and other degree requirements. Science majors should be able to complete the program easily within the regular four year pattern, but engineering majors may have to overload. In order to minimize conflicts and meet individual needs, each student will design a specific program with the Management Studies Adviser in the first quarter of the sophomore year.

Requirements:

1. All of the following core Courses:
   SV151 Principles of Economics
   SV303 Business and Engineering Ethics
   RH330 Technical and Professional Communication
   SV350 Managerial Accounting or SV356 Corporate Finance
   SV351 Managerial Economics

2. Two of the following Management in Society Courses (in addition to the core courses):
   SV171 Principles of Psychology
   EMGTXXX Engineering Management
   SV304 Bioethics
   EMGT533 Intercultural Communication
   GS432 Literature and Film of the Global Economy
   SV353 Industrial Organization
   SV357 Labor Economics
   IA352 Game Theory
   SV463 Seminar on America's Future
   IA453 The Entrepreneur
   EMGT526 Technology Management and Forecasting

3. Two courses from the following list. The student may choose to emphasize a strength area such as quantitative analysis, economics, or engineering management. Courses not included in this list may be approved by the Management Studies Advisor:
   CE303 Engineering Economy
   SV353 Industrial Organization

IA350 Intermediate Microeconomics
IA351 Intermediate Macroeconomics
GS350 International Trade: Globalization
GS351 International Finance
CE441 Construction Engineering
CE442 Cost Engineering
MA444 Deterministic Models in Operations Research
MA445 Stochastic Models in Operations Research
CSSEXXX Courses beyond CSSE 120 in Computer Science
MAXXX Any statistics courses
EMGTXXX Any engineering management course

GERMAN TECHNICAL TRANSLATOR'S CERTIFICATE PROGRAM

A student may earn, in addition to one of the regular degree programs in science or engineering, a certificate of proficiency in German technical translation. Successful completion of this non-degree program partially fulfills the graduation requirements in humanities and social sciences.

Certificate Requirements

A student must have a 3.0 in the first two years of the foreign language and in his/her major, as well as permission of the instructor, to enter the third year language courses. Exceptions may be made by the instructor in charge of the program.

1. A student must complete all the technical courses required by one of the Institute's degree-granting programs.
2. A student must successfully complete the third and fourth year courses of the German Studies program (GE 311/312/313 and GE 411/412/413). See the Humanities and Social Sciences (HSS) section of this catalogue for a description of these courses.
3. A student who successfully completes the requirements for the German Technical Translator Certificate is exempted from RH 131 Rhetoric and Composition, and from both courses in Global Studies (GS). This generally means that the student will only need to take thre HSS courses other than German (one IA, one SV, and RH330 Technical and Professional Communication).

Commentary

A student who qualifies through the Foreign Language Examination administered at Rose-Hulman during Freshman orientation week, will be permitted to enroll in the appropriate level of German as determined by the foreign language faculty. A student who successfully completes a quarter of more advanced language at Rose-Hulman with a grade of C or better will be granted 4 hours of Credit by Examination for each quarter of language by-passed. (Note: a minimum of two terms of college language must be completed in order to receive HSS graduation credit.)

1. A student who is in the German Studies Program in Culture and Technology is not required to take RH131, Rhetoric and Composition.
2. In order to obtain the Translator's Certificate, some students in some curricula may have to take more than the minimum number of credits required for graduation.
3. Due to scheduling requirements of some regular degree programs, a student may also have to carry an overload in some terms. This means that the student will

have to maintain a better-than-average grade point average to meet the Institute requirements permitting an overload. See the Student Handbook for details.

4. A student is strongly urged, but not required, to spend at least one summer studying in an approved program for foreigners in Germany. Some small grants may be available to help defray expenses.

Summary	Credits
First Year German (GE 111, 112, and 113 or approved equivalent)	12
Second Year German (GE211, 212, 213 or approved equivalent)	12
Third Year German (GE311 Topics in German Culture I; GE312 Reading German Texts; and GE313 Advanced Grammar and Translation Methods	12
Fourth Year German (GE411 Technical Translation; GE412 Topics in German Culture II; and GE413 Contemporary Germany)	12
One IA course (any)	4
One SV course (any)	4
RH330 (required for most majors)	4
TOTAL	**60**

MULTIDISCIPLINARY MINOR IN ROBOTICS

Robotics is a fast-growing field that is inherently multidisciplinary, incorporating mechanical systems, electrical systems, and software. It includes mobile robotics, mechatronics, and assistive technologies. Rose-Hulman Institute of Technology offers a multidisciplinary minor in robotics to recognize students who have gained experience in these areas while at Rose-Hulman.

To earn the Multidisciplinary Minor in Robotics, a student needs to complete the three courses listed below plus additional courses listed below per the student's major.

Courses that all majors must complete [12 credit hours]

- CSSE120 Introduction to Software Development[1]
- ME435/CSSE435 Robotics Engineering
- ECE425 Introduction to Mobile Robotics

[1] Note for ME and BE students: CSSE120 can be used as a course substitution for the required introduction to programming course (ME123 or BE100). However, ME and BE students may take both the required class AND CSSE120. CSSE120 will then count as a free elective.

In addition to the courses listed above students completing the robotics minor need to complete the courses below that apply to their major. (Students with a double major or double degree may choose which major to use. If a student decides to switch majors, that student must complete a track below appropriate for their final degree. These degree requirements are evaluated only at the time of your graduation.)

(1) CS and SE majors - Additional required courses:

- ME430 Mechatronic Systems
- 8 credits of Robo Electives (see list below)

(2) CPE majors - Additional required courses:

- CSSE463 Image Recognition
- ECE320 Linear Control Systems[2]
- 8 credits of Robo Electives (see list below)

[2] Note, the list of additional required CPE courses appears to be 1 course longer than other tracks, but CPE students are required to take either Linear Control Systems (ECE320) or Discrete-Time Signals and Systems (ECE380) already, so the requirement to take ECE320 should not cause the CPE track to be any longer.

(3) EE majors - Additional required courses:

- CSSE220 Object-Oriented Software Development
- 8 credits of Robo Electives (see list below)

(4) ME majors - Additional required courses:

- CSSE220 Object-Oriented Software Development
- ME403 Kinematics of Machinery -or- ME497 Robot Dynamics and Control
- ME406 Control Systems[3]
- 4 credits of Robo Electives (see list below)

[3]Note, the list of additional required ME courses appears to be 1 course longer than other tracks, but ME students are required to take either Control Systems (ME406) or Vibration Analysis (EM406) already, so the requirement to take ME406 should not cause the ME track to be any longer.

(5) For majors not listed above - Additional required courses:

- CSSE220 Object-Oriented Software Development
- ME430 Mechatronic Systems
- BE350 or ECE 320 or ME 406 [or a Controls course from any major][3]
- 4 credits of Robo Electives (see list below)

[3] For BE majors, a controls course will fill an area requirement. So, much like the ME track, the requirement to have a controls course should not cause this track to be longer for BE majors than tracks for other majors.

Robotics Electives

Students choose Robotics Electives from the list below subject to the restrictions that a student's Robotics Elective courses(s) cannot be any course listed above as an additional required course for the student's major, and cannot be a course listed as a named requirement for the student's major.

- BE350 Biocontrol Systems
- BE520 Brain Machine Interfaces
- BE543 Neuroprosthetics
- CSSE413 Artificial Intelligence
- CSSE480 Web App Frameworks with AppEngine
- CSSE483 Android Application Development
- CSSE484 iOS Application Development
- CSSE461 Computer Vision
- CSSE463 Image Recognition
- CSSE490 Swarm Intelligence
- CSSE290/490 Teamwork and Robotics
- CSSE290/490 Software Challenges in Robotics
- ECE320 Linear Controls
- ECE300 Continuous Time Signals and Systems
- ECE414 Wireless Systems
- ECE420 Discrete-time Control Systems
- ECE480/PH437 Image Processing
- ECE483 Digital Signal Processing System Design
- ECE582/PH537 Advanced Image Processing
- ECE583 Pattern Recognition
- IA471 Computational Psychology
- ME403 Kinematics of Machinery
- ME406 Control Systems
- ME445 Robot Dynamics and Control
- ME497 Three Dimensional Dynamics
- ME506 Advanced Control Sys
- ME518 Advanced Kinematics
- EM502 Advanced Dynamics
- EP408 Microsensors
- CSSE490/ME497/ECE497 Robotics Studio
- Independent study courses in robotics [requires approval BEFORE the course is taken]

MINOR IN ENTREPRENEURIAL STUDIES

In a globally competitive environment, the need to rapidly transition from an innovative idea to a viable product necessitates that 21st Century engineers and scientists think and act in an entrepreneurial manner. Not everyone must be interested in starting a technology-based company, but it is important to understand the business requirements of technology commercialization. These skills help students become leaders.

To prepare students for this new workplace, the Department of Engineering Management offers a minor in Entrepreneurial Studies to complement their undergraduate technical education. The five course curriculum (20 credits) introduces students to the fundamentals of an entrepreneurial mindset.

Two required courses (total of 8 credits):

EMGT 330 - Introduction to Engineering Management
EMGT 532 - Technical Entrepreneurship

Three elective courses (total of 12 credits) from the following:

EMGT 100 - Introduction to Entrepreneurship
EMGT 520 - Accounting for Technical Managers
EMGT 523 - Marketing in New Product Development
EMGT 526 - Innovation Management & Forecasting
EMGT 527 - Project Management
SV 150 - Introduction to Microeconomics
SV 152 - Introduction to Macroeconomics
SV 303 - Business and Engineering Ethics
SV 356 - Corporate Finance
GS 350 - International Trade
GS 351 - International Finance

Note: There are no prerequisites for the EMGT courses, but the GS and SV courses have prerequisites of either SV 150 or SV 152. Please refer to the course catalog.

With approval from the Department Head of Engineering Management, course substitutions may be considered to align with a student's professional aspirations. No more than one course may be transferred in to count toward the minor.

MULTIDISCIPLINARY MINOR IN SYSTEMS ENGINEERING

According to INCOSE – International Council on Systems Engineering, a system is a construct or collection of different elements that together produce results not obtainable by the elements alone. By this definition, everything is a system, including what engineers design. Systems Engineering is an engineering discipline whose responsibility is creating and executing an interdisciplinary process to ensure that the customer and stakeholder's needs are satisfied in a high quality, trustworthy, cost efficient and schedule compliant manner throughout a system's entire life cycle. As the systems that engineers design become exponentially more complex, the task of ensuring that solutions satisfy stakeholder needs is becoming exponentially more difficult. The field of systems engineering provides a broad spectrum of tools that can be used to help engineers manage complexity, predict and address risk, ensure safety, gather and manage information, and provide solutions with greater value to the intended stakeholders. The purpose of the Minor in Systems Engineering is to provide a more in-depth exposure to systems engineering concepts than students would see in their traditional engineering courses. The minor also requires students to identify the relationships between these systems engineering topics and what they learned in their traditional engineering or science curricula.

Minor Advisor: Dr. Simoni

Students are required to take the following courses:

- EMGT587 –Systems Engineering
- EMGT584 – Systems Thinking and Evaluation
- MA223 or MA381
- MDS440 - Systems Engineering Capstone

Students must take additional three courses from the following list of electives

- EMGT472 – Reliability Engineering
- EMGT445 – Quality Methods
- EMGT561 – Failures of Engineered Systems
- EMGT564 – Systems Architecture
- EMGT567 – Economic Analysis of Engineering Projects
- EMGT562 – Risk Analysis and Management
- EMGT589 – Manufacturing Systems
- MA444 – Deterministic Models in Operations Research
- MA445 – Stochastic Models in Operations Research
- MA341 – Topics in Mathematical Modeling

Special Topics Courses can be approved as SE Minor Electives by SE Minor Advisor

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Rose-Hulman
Institute of Technology
5500 Wabash Avenue
Terre Haute, IN 47803
812-877-1511