Rose-Hulman Institute of Technology Course Catalog

Minor in Artificial Intelligence

Multidisciplinary Minor in Cognitive Science

Multidisciplinary Minor in Data Science

Multidisciplinary Minor in Entrepreneurial Studies

Multidisciplinary Minor in Imaging

Minor in Internet of Things

Minor in Materials Science and Engineering

Multidisciplinary Minor in Robotics

Multidisciplinary Minor in Six Sigma

Multidisciplinary Minor in Systems Engineering

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MINOR IN ARTIFICIAL INTELLIGENCE

Advisor: Michael Wollowski

Students of any major may receive the Artificial Intelligence minor.

Required Coursework

Prerequisites: CSSE120, CSSE220, CSSE230

Basics: CSSE413 Artificial Intelligence.

Machine Learning: At least one of: CSSE415/MA415 Machine Learning or MA416 Deep Learning

Advanced Topics: At least 8 credits selected from CSSE453 Topics in AI, CSSE463 Image Recognition, or any upper level CSSE or MA course with a significant AI content and approved by the AI minor advisor.

Ethics: PHIL H202 Business & Engineering Ethics.

AI Project: A project with a significant AI component is required. This may be done in any discipline. Projects must be approved by the AI minor advisor. Projects must include both a written report and a public presentation, and be made available for future use. Students may meet this requirement in three ways: (1) A student may complete a 4-credit independent study, approved by the AI minor advisor; (2) A student may begin the project in a course and then extend and document the project and make a public presentation during an independent study approved by the AI minor advisor; (3) A student may complete an approved senior thesis or project involving AI and substitute a senior thesis or project course for the independent study.

Note: At most 8 credits of the AI course work (Basics, Machine Learning, and Advanced Topics) can be used to satisfy degree requirements for any major or any other minor sought by the student. The remaining credit hours can only be used to satisfy technical or free electives within the primary major.

MULTIDISCIPLINARY MINOR IN COGNITIVE SCIENCE

The Multidisciplinary Minor in Cognitive Science has the following requirements:

1. Cognitive Psychology (PSYC S210).
2. Introduction to Software Development (CSSE 120)
3. Philosophy of Mind (IPHIL H401) or Philosophy of Science (PHIL H402) or Human Nature (PHIL H403)
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

PHIL H401 Philosophy of Mind

- ECON S356 Game Theory
- PSYC S100 Introduction to Psychology
- PHIL S403 Human Nature
- PSYC S310 Methods for 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
- PSYC S410 Computational Psychology
- MA 416 Deep Learning

Neuroscience group

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

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
- CSSE230 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
  ECON S451 Econometrics
- MA384 Data Mining
- MA386 Statistical Programming
- MA415 Machine Learning
- MA416 Deep Learning
- MA482 Bioengineering Statistics
- MA483 Bayesian Data Analysis
- MA485 Applied Regression and Time Series
- ME447 Visualizing Data
- ME497 Reproducible Research
- PH327 Thermodynamics and Statistical Mechanics

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.

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 432 or 532 - Technical Entrepreneurship

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

EMGT 100 - Introduction to Entrepreneurship
EMGT 175 - Personal Finance
EMGT 520 - Accounting for Technical Managers
EMGT 521 - Financial Management in a Technical Envoronment
EMGT 523 - Marketing in New Product Development
EMGT 526 - Innovation Management & Forecasting
EMGT 527 - Project Management
ECON S151 - Introduction to Microeconomics
ECON S152 - Introduction to Macroeconomics
ECON S352 - Corporate Finance
ECON S350 - International Trade & Globalization
ECON S355 - International Finance
PHIL H202 - Business and Engineering Ethics

Note: There are no prerequisites for the EMGT courses, but the HSSA courses have prerequisites. 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 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 INTERNET OF THINGS

Internet of Things (IoT) is a broad field of study which has applications across many disciplines. The technologies which enable IoT range from material science for sensors and energy harvesting applications to complex real-time analysis of large, aggregated data sets. This encompasses fields such as embedded system design, sensor design, energy harvesting and storage, networking, wireless communications, distributed systems, databases, edge and cloud computing, machine learning, data analysis, security, and privacy. The applications for Internet of Things include agricultural monitoring and automation, infrastructure monitoring, traffic monitoring and control, environmental monitoring, smart retail logistics, industrial monitoring and automation, smart homes, smart cities, mobile health, and intelligent environments.

Students in any degree program are eligible for the minor. To earn the Minor in Internet of Things, a student must complete a minimum of 24 credit hours in a course plan approved by an internet of things minor advisor.

Advisors: Dr. Chris Miller, Dr. Yosi Shibberu, Dr. Sid Stamm, Dr. Alan Chiu, Dr. David Henthorn, Dr. Mark Yoder

Required Courses

MDS 210 Introduction to Internet of Things (4 cr)

Plus 20 additional credit hours in a plan approved by one of the minor advisors in collaboration with the student to suit their particular interests and field of study. To provide students with a breadth of knowledge in the Internet of Things, this plan should include courses in the areas of: hardware design of end devices, including sensors and actuation; software design and data analysis; and networks and security. The guidelines are designed to be flexible to accommodate students from any major; the tables below provide some examples of courses which fit these categorizations. No more than 8 credit hours from a named required course for the student's major may be counted toward the minor requirements.

A sampling of courses which could be used to satisfy minor requirements

Hardware design

Course	Description	Hours
BE202	Circuits, Sensors, and Measurements	4
ECE230	Introduction to Embedded Systems	4
EP408 / EP508	Microsensors and Actuators	4
MDS310	Appropriate Technology for Developing Communities	4
ME430	Mechatronic Systems	4

Software design and data analysis

Course	Description	Hours

CHE310	Numerical Methods for Chemical Engineers	4
MA335 / CSSE335	Introduction to Parallel Computing (cross-listed)	4
MA384 / CSSE384	Data Mining (cross-listed)	4
ME447	Visualizing Data	4

Networks and security

Course	Description	Hours
CSSE132	Introduction to Computer Systems	4
CSSE432	Computer Networks	4
CSSE442	Computer Security	4
ECE312	Communication Networks	4
MA479 / CSSE479	Cryptography	4

As is the case with any minor at Rose-Hulman, the Institute does not guarantee to any student that the courses that fulfill the minor will be available in all quarters to suit the student's plan of study.

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 &	4	EP 410 or equivalent course

	Packaging (cross-listed with CHE 419 and EP 411)		
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. Matthew Riley (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.

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 [1,2]
- 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.

[2] Note for ENGD students: CSSE120 is taught within ENGD 110/120.

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 [3]
- 8 credits of Robo Electives (see list below)

[3] 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
- ME404 Advanced Design of Mechanisms -or- ME445 Robot Dynamics and Control
- ME406 Control Systems [4]
- 4 credits of Robo Electives (see list below)

[4]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) ENGD majors - Additional required courses:

- ES214 Mechanical Systems 2
- ES205 Analysis and Design of Engineering Systems
- ME406 Controls
- ME430 Mechatronic Systems
- MDS410/20/30 Multidisciplinary Capstone - ENGD majors should select projects that build on robotics learning from earlier courses.

(6) 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] [5]
- 4 credits of Robo Electives (see list below)

[5] 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
- CSSE286 Machine Learning
- 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
- 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
- ECE497 Advanced Mobile Robotics
- ECE582/OE537 Advanced Image Processing
- ECE583 Pattern Recognition
- PHYC S410 Computational Psychology
- MA415 Macihne Learning
- MA416 Deep Learning
- ME304 Introduction to the Design of Mechanisms
- ME404 Advanced Design of Mechanisms
- ME406 Control Systems
- ME445 Robot Dynamics and Control
- ME497 Design of Mechanisms I
- ME497 Design of MEchanisms II
- ME497 Industrial Controls
- 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 SIX SIGMA

Six Sigma has been incorporated by statewide and national companies involved in manufacturing, health care, and service industries. The Six Sigma process has also been used to address environmental and sustainability concerns, such as recycling and food waste/share programs. This minor is designed for students who are interested in the Six Sigma statistical methodology for process improvement and quality enhancement. Students completing the minor will develop their analytical, managerial, and statistical skills, and gain a competitive advantage in the workplace.

Minor Advisor: Dr. Diane Evans

Six Sigma Minor versus Six Sigma Certification

Any student may obtain a minor in Six Sigma by taking six or more courses (24 credit hours) from the lists below. To additionally obtain a Green Belt Certification, the student must pass an external Six Sigma exam and submit a Six Sigma Green Belt project that must be approved by the Six Sigma minor advisor.

Introductory Statistics Course (4 credit hours):

One of the following courses:

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

Note: If MA 381 is taken before MA223/MA382, it is strongly recommended the student take MA382 instead of MA223.

Quality and Six Sigma Courses (12 credit hours):

- EMGT445 Quality Methods
- EMGT446 Statistical Methods in Six Sigma
- EMGT447 Six Sigma in Practice

Supporting Coursework (8 credit hours):

Two courses selected from the following list. Courses not on this list may count towards the minor if approved by the minor advisor.

- EMGT330 Introduction to Engineering Management
- EMGT335 Design and Value Creation
- EMGT427 Project Management
- EMGT462 Risk Analysis and Management
- EMGT467 Economic Analysis of Engineering Projects
- EMGT472 Reliability Engineering
- EMGT524 Production/Operations Management
- EMGT527 Project Management
- MA485 Applied Linear Regression
- MA487 Design of Experiments
- ME412 Lean Manufacturing

External Examination for Six Sigma Green Belt Certification

• Take an external exam that will give students an objective credential from a recognized agency (e.g. IISE, ASQ).

• The exam is provided at no additional cost in the EMGT448 course.

• If the student intends to obtain a minor only, then they do not need to take the external exam.

Approved Six Sigma Green Belt Project for Six Sigma Green Belt Certification

• The student must submit a Six Sigma Green Belt project to be approved by the Six Sigma advisor to obtain their certification.

• If the student intends to obtain a minor only, then they do not need to submit a project to be approved by the Six Sigma advisor.

Notes and Limitations on Requirements

1. Almost all students are required to take either MA223 or MA382 as a requirement for their major; therefore, only five "extra courses" are required for most students.
2. Electives not listed above may be substituted with other courses with the approval of the minor advisor for Six Sigma.
3. All minors must be approved by the minor advisor. The department has a form for the planning and approval of a minor.
4. All certifications must be approved by the minor advisor. The department has a form for the planning and approval of a certificate.

SUSTAINABILITY MINOR

1. Curricular Requirement
    a. Core Courses (16 credits)
        i. HUM H130 Introduction to Sustainability (4 credits)
        ii. BIO191 Environmental Science (4 credits)
        iii. ECON S151 Microeconomics (4 credits)
        iv. MDS302 Sustainability in Practice (2 credits): prerequisites: HUM H130, BIO191, ECON S151
        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 and Mark Minster.
        i. Social (HSS requirement)

ECON S351 Environmental Economics
ENGL H349 Nature and Literature
HIST H322 Disasters and Modern Society
HIST H425 Cities and Technology in the Industrial Age
PHIL H201 Bioethics
PHIL H202 Business and Engineering Ethics
RELG H101 Nature and Religion

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 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. Craig Downing

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