Rose-Hulman Institute of Technology Course Catalog

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- 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

- 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.
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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**

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

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 & Biomedical Engineering Lab	3 2	BE 331* and BE 361*

PH 440

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

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- 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 And8i0FdAppElcalion Aevelopment

- ECE420 Discrete-time Control Systems
- ECE480/PH437 Image Processing
- ECE483 Digital Signal Processing System Design
- ECE582/PH537 Advanced Image Processing
- ECE583 Pattern Recognition
- PHYC S410 Computational Psychology
- MA415 Macihne Learning
- MA416 Deep Learning
- 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]
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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
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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)