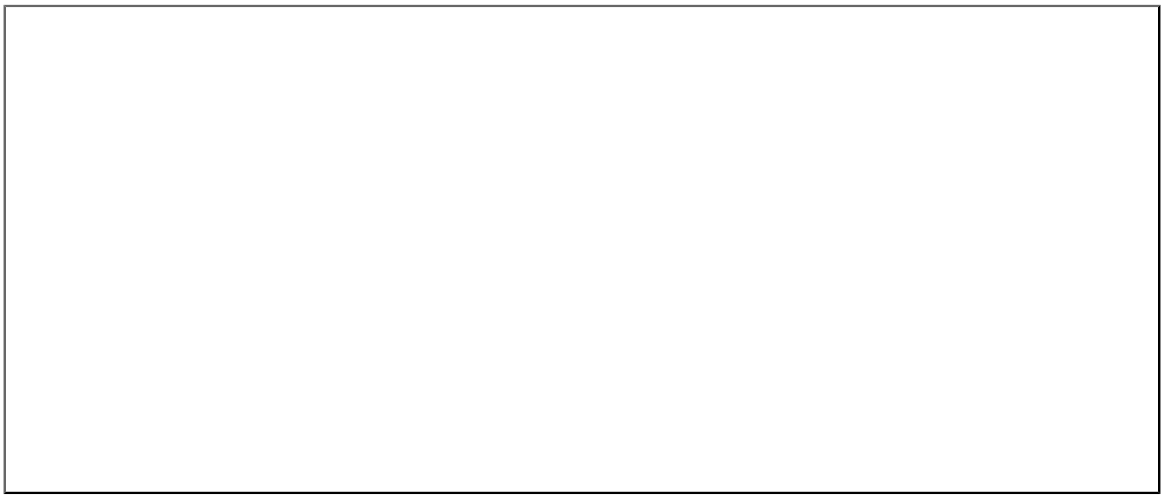
Rose-Hulman Institute of Technology Course Catalog



- MA386 Statistical Programming
- MA384 Data Mining
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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, Csrh16aH, O, EEP] TJ 1 0 0 -1 0 634's pulse fromHSSA coursep21 pR**

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 Spencer

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

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 Applicationpn12.IIfm BT /1 0 0 1 218 241.32 cm BT /F1 12 Tf Q q 1 0 0 1 576 0 c		

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 Analys3e1Tr Conspea-to88 students 24 438 Tm [(to trol Systems (ME425.1 0 /F1 1 0 0 -k

- 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

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